

A Motor Program Based on Applied Behavior Analysis (ABA) Principles for Improving Motor Performance in Children with Level 1 Autism Spectrum Disorder

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Received: 08/02/ 2026; Accepted: 28/07/2026; Published:30/08/2026

Abstract

This study aimed to examine the effectiveness of a motor program based on the principles of Applied Behavior Analysis (ABA), delivered through small games, in improving balance and fine motor control among children with Level 1 Autism Spectrum Disorder (ASD). An experimental design was employed with a purposive sample of 30 children aged 5–8 years, divided into an experimental group (n = 15) and a control group (n = 15). The Dayton Perceptual-Motor Scale was used to assess balance and fine motor control at pre- and post-test. Results confirmed baseline equivalence between the two groups on both dimensions ($p > .05$). Pre-post comparisons for the experimental group revealed statistically significant improvement in balance ($t = 3.500$, $p = .002$), with a large effect size (Cohen's $d = 0.904$), and in fine motor control ($t = 1.784$, $p = .048$), with a below-medium effect size ($d = 0.461$), whereas no significant change was observed in the control group. These findings support the effectiveness of an ABA-based motor program in improving motor performance in children with ASD and suggest its wider application in educational and rehabilitative settings, alongside further research with larger samples and follow-up designs.

Keywords: Applied Behavior Analysis (ABA); Autism Spectrum Disorder; Motor Performance; Balance; Fine Motor Control.

1. Introduction

Motor development is fundamental to an individual's interaction with the environment. As children acquire crawling, pointing, and walking skills, new opportunities for social interaction with their surroundings emerge (Iverson, 2022).

Neurodevelopmental disorders are defined as a diverse group of conditions characterized by delays or impairments across multiple developmental domains, including motor skills, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Association, 2013). Autism Spectrum Disorder (ASD) is classified among these disorders and is primarily diagnosed on the basis of core deficits in social communication skills. Motor impairment is particularly common in this population and may even represent an early marker of atypical developmental trajectories, as recent evidence indicates that motor deficits

often emerge and are observed before the classic social and communicative symptoms characteristic of autism become apparent (Iverson, 2022).

Early intervention is therefore essential before such deficits substantially affect the child's developmental trajectory. Applied Behavior Analysis (ABA) offers a flexible scientific framework that can be adapted to the needs of children with ASD in designing training programs targeting skill development (Cooper et al., 2007), through identifying responses to stimuli and applying a hierarchical system of support and prompting, while relying on systematic training records to track data, evaluate clinical progress, and continuously adjust the intervention strategy in order to achieve optimal performance and independence for the individual (da Silva et al., 2023).

Building on this evidence, there is a clear need to design a structured motor training program that directly and proactively targets this deficit—particularly the balance and fine-motor impairments commonly observed in children with ASD—rather than offering random motor activities. Such a program should rest on a scientific basis that is measurable, replicable, and continuously adjustable according to each child's response, and should incorporate small games to sustain the child's engagement and prevent boredom. Applied Behavior Analysis (ABA) emerges as an appropriate methodological framework for constructing such a program. This raises the following research question: What is the effectiveness of a motor program based on the principles of Applied Behavior Analysis (ABA) in developing selected aspects of motor performance in children with Autism Spectrum Disorder? More specifically:

- Are there statistically significant differences between the pre-test and post-test of the experimental group in the balance dimension?
- Are there statistically significant differences between the pre-test and post-test of the experimental group in the fine motor control dimension?

1.1 Hypotheses

- There are statistically significant differences between the pre-test and post-test of the experimental group in the balance dimension, in favor of the post-test.
- There are statistically significant differences between the pre-test and post-test of the experimental group in the fine motor control dimension, in favor of the post-test.

1.2 Objectives of the Study

- To test the effectiveness of a motor program based on the principles of Applied Behavior Analysis (ABA) in modifying and improving motor performance skills in children with mild Autism Spectrum Disorder.
- To provide a practical model for educators and specialists illustrating how behavior-analytic strategies (e.g., reinforcement and modeling) can be used within motor sessions to enhance children's physical and mental fitness in an engaging and motivating manner.
- To enable children with ASD to better use their motor skills in daily functioning, thereby reducing motor stereotypy.

2. Literature Review / Theoretical Background

2.1 The Proposed Program

Abdel Hamid Sharaf defines a program as “the executive steps of a pre-planned process, including the time allocation, implementation methods, and feasibility required for its execution” (Tarek, 2017–2018).

A motor program is defined as a representation, or an organized set of motor commands, stored in memory, that are retrieved and organized prior to movement execution in order to control motor performance. According to Schmidt's schema theory, the generalized motor program represents an abstract motor structure that can be applied to a class of similar movements, with certain parameters—such as force, speed, and movement duration—adjustable according to situational demands (Schmidt & Lee, 2019).

2.2 Applied Behavior Analysis (ABA)

Applied Behavior Analysis has been defined as a scientific approach aimed at systematically applying behavioral principles to produce meaningful behavior change, with experimental verification that the observed changes are functionally related to the intervention procedures used. Baer, Wolf, and Risley identified the defining dimensions of ABA, including that it be applied, behavioral, analytic, technological, conceptually systematic, effective, and generalizable (Baer et al., 1968).

2.3 Motor Performance

Motor performance refers to the observable and measurable motor behavior displayed during the execution of a given task or motor skill, reflecting the quality of movement execution in a specific situation. Motor performance differs from motor learning: performance represents the observable changes in movement execution, whereas motor learning refers to relatively permanent changes in the capacity to perform a skill as a result of practice and experience (Schmidt & Lee, 2019).

2.4 Fine Motor Control

Fine motor control is defined as the coordination of muscles, bones, and nerves to produce small, precise movements, such as picking up a small object using the index finger and thumb; it is the counterpart of gross motor control (Simard & Cerqueira, 1992).

2.5 Balance

Balance is defined as the control of body position in space with the aim of achieving stability and orientation, in order to maintain and restore equilibrium (Shumway-Cook & Woollacott, 2012).

2.6 Autism Spectrum Disorder (ASD)

Autism Spectrum Disorder is defined as a neurodevelopmental disorder characterized by persistent difficulties in communication and social interaction across multiple contexts, together with restricted and repetitive patterns of behavior, interests, or activities. Symptoms appear during the early developmental period and cause clinically significant impairment in social, academic, occupational, or other important areas of functioning (American Psychiatric Association, 2013).

3. Methods

3.1 Research Design

This study adopted an experimental design, in which a motor program was implemented with a sample divided into an experimental group and a control group. The experimental method is defined as the approach used by the researcher to identify and control the various conditions

and variables that arise while investigating a given phenomenon (Kandelji & Al-Samarrai, 2008).

3.2 Participants / Sample

The sample consisted of 30 children, selected through purposive sampling and divided into an experimental group (n = 15) and a control group (n = 15).

3.2.1 Sample Characteristics

- Age: Children aged between 5 and 8 years (with comparable mental age) were selected, and age groups were matched across the experimental and control groups.
- Diagnosis of Level 1 support needs, established at least two years prior to the study, using the same diagnostic instrument.
- Average motor abilities.
- No co-occurring disabilities.
- A specified intelligence level $IQ \geq 70$. Stanford-Binet Intelligence Scales, Fifth Edition SB5 (Roid, 2003)

3.3 Instruments

Quantitative data were obtained through the collection, classification, quantification, and analysis of children's test scores.

3.3.1 Test

Dayton Perceptual-Motor Scale (Taylor, 1988, p. 153)

This test is designed to measure sensorimotor perceptual competence, which depends on a range of motor factors that contribute to identifying and developing perceptual-sensory abilities. Among the factors targeted by the Dayton scale are:

- Fine motor control
- Balance

3.3.2 Psychometric Properties of the Test

The availability of sound scientific foundations for the tests used is an essential condition for the credibility of a study, as it establishes the validity, reliability, and objectivity of the instrument.

Validity. Saleh states that “a test is considered valid if it measures only what it was designed to measure; if it is designed to assess one behavior but measures another, it does not meet the criteria of validity” (Saleh, 1989, p. 42). Validity is considered one of the most important psychometric requirements, referring to a test's ability to measure the trait or phenomenon for which it was designed (Abdel-Majid, 2000, p. 43).

Face validity. This type of validity establishes whether a scale appears, on its surface, to measure what it was designed to measure, reflecting the overall appearance of the instrument.

Panel (expert) validity. The study instrument was submitted to a panel of experts to obtain their judgment regarding its dimensions and its suitability for measuring the constructs of interest in the study sample.

Internal validity. This refers to the validity of the experimental scores relative to true scores and is calculated as the square root of the instrument's reliability coefficient.

Reliability. Reliability refers to obtaining approximately the same results upon re-administration to the same group; a good test is characterized by producing consistent, or near-

identical, results when administered more than once under the same conditions (Abdel-Majid, 2000, p. 42).

Table 1: *Reliability and Validity Coefficients (Test–Retest) for the Pilot Sample*

Variable	Reliability Coefficient	Validity Coefficient
Balance	0.87	0.93
Fine Motor Control	0.80	0.89

3.4 Procedures

Temporal framework: the study was conducted from October to March 2024.

Spatial framework: the Wilaya (provincial) Association “Israr,” Bouchegouf.

3.5 Program Construction Principles Aligned with ABA

The motor program integrated the following construction principles with corresponding ABA concepts:

- 1. Accounting for individual differences and the sample's preferences.** This aligns with the ABA principle of Individual Assessment, which stipulates that any behavioral intervention program must be built following a thorough assessment of each individual's abilities, strengths, and weaknesses, rather than applying a uniform program to all individuals (Cooper et al., 2007).
- 2. Ease of movement, security, and safety.** This falls under what is known in ABA as Environmental Arrangement—that is, controlling environmental stimuli (antecedents) in a way that facilitates the emergence of the desired response and reduces unwanted behaviors resulting from a lack of safety.
- 3. Variation in games, methods, and tools.** This is related to the principle of Satiation Control: repeated use of the same reinforcer or activity diminishes its reinforcing value, so ABA prescribes varying stimuli and reinforcers to maintain motivation (Cooper et al., 2007).
- 4. Tools with bright, appealing colors to stimulate motivation.** This is a direct application of the Reinforcers principle in ABA, whereby attractive (visual) sensory stimuli are used as primary or conditioned reinforcers to increase the likelihood that the target behavior will recur.
- 5. Beginning with areas of strength (the spiral method).** This reflects two fundamental ABA principles together: (a) Shaping—reinforcing gradual progress toward the target behavior, starting from an already-mastered behavior; and (b) Task Analysis—breaking a complex skill down into small, sequential steps that can be built upon (Cooper et al., 2007).
- 6. Skill consolidation (feedback and follow-up assessment).** This corresponds to the principle of Reinforcement and Maintenance: providing immediate feedback following a correct response, then measuring the durability of the behavior over time (maintenance) to ensure the skill persists after direct intervention ends—also known as a fading reinforcement schedule.
- 7. Progression from easy to difficult / from simple to complex.** This is Task Analysis itself, one of the pillars of ABA, together with the principle of Chaining—ascending or descending—used to link sub-steps until they form the complete skill.

- 8. Partial (segmented) teaching method.** This corresponds to Backward/Forward Chaining in ABA, whereby a skill is taught in separate parts that are then gradually integrated.
- 9. Accounting for fatigue and rest periods.** This relates to the principle of Motivating Operations: sensory or motor fatigue weakens the effectiveness of the reinforcer, so ABA recommends structured rest periods to preserve the potency of the reinforcing stimulus.
- 10. Realistic, flexible, and achievable objectives.** This matches one of the essential conditions of ABA as defined by Baer, Wolf, and Risley (1968) in their foundational paper: behavioral objectives must be “technological”—that is, written in clear, procedural language, and observable and measurable, rather than general or vague (Baer et al., 1968).
- 11. Reliance on positive reinforcement.** This is the central principle underlying ABA as a whole: positive reinforcement is the procedure delivered immediately following a desired behavior to increase the likelihood of its future recurrence, a principle grounded in the work of Baer, Wolf, and Risley (1968) and in Skinner's theory of operant conditioning.

4. Results

Table 2: *Differences Between the Experimental and Control Groups in Balance Prior to the Program*

Domain	Group	Mean	SD	t	Sig.	Decision
Balance (on tiptoe)	Experimental	0.800	1.014	0.787	0.438	Not significant at 0.05
	Control	0.533	0.834			

Table 2 shows no statistically significant difference between the experimental and control groups in the balance domain, as the t-value for two independent samples was 0.787, which is not statistically significant at the 0.05 level, since the associated Sig. value (0.438) exceeds the significance threshold ($\alpha = 0.05$). This confirms baseline equivalence between the two groups in the balance domain prior to the start of the program.

Table 3: *Differences Between the Experimental and Control Groups in Fine Motor Control Prior to the Program*

Domain	Group	Mean	SD	t	Sig.	Decision
Fine Motor Control	Experimental	1.267	0.884	1.931	0.064	Not significant at 0.05
	Control	0.667	0.816			

Table 3 shows no statistically significant difference between the experimental and control groups in the fine motor control domain, as the t-value for two independent samples was 1.931, which is not statistically significant at the 0.05 level, since the Sig. value (0.064) exceeds $\alpha = 0.05$. This confirms baseline equivalence between the two groups in fine motor control prior to the program.

Table 4: *Pre-test/Post-test Differences and Program Effect Size for the Experimental Group — Balance*

Domain	Test	Mean	SD	t	Sig.	Decision	Cohen's d	Effect Size	95% CI	
									Lower	Upper
Balance	Post-test	1.733	0.704	3.500	0.002	Significant at 0.01	0.904	Large	0.383	∞
	Pre-test	0.800	1.014							

Table 4 shows a statistically significant difference between the post-test and pre-test scores of the experimental group in the balance domain, as the t-value for two related (paired) samples was 3.500, significant at the 0.01 level ($\text{Sig.} = 0.002 < \alpha = 0.01$). These differences favored the post-test, since the post-test mean for balance (1.733) exceeded the pre-test mean (0.800).

Accordingly, the program had a significant effect on balance, and this effect was large, as the Cohen's d value (0.904) exceeds 0.80. This effect is also statistically meaningful at the 95% confidence level, as the confidence interval for d ranged from 0.383 to ∞ and did not include zero.

Table 5: *Pre-test/Post-test Differences and Program Effect Size for the Experimental Group — Fine Motor Control*

Domain	Test	Mean	SD	t	Sig.	Decision	Cohen's d	Effect Size	95% CI	
									Lower	Upper
Fine Motor Control	Post-test	1.600	0.737	1.784	0.048	Significant at 0.05	0.461	Below medium	0.005	∞
	Pre-test	1.267	0.884							

Table 5 shows a statistically significant difference between the post-test and pre-test scores of the experimental group in the fine motor control domain, as the t-value for two related (paired) samples was 1.784, significant at the 0.05 level ($\text{Sig.} = 0.048 < \alpha = 0.05$). These differences favored the post-test, since the post-test mean for fine motor control (1.600) exceeded the pre-test mean (1.267).

Accordingly, the program had a significant effect on fine motor control; however, the effect size was below medium (Cohen's d = 0.461), and remained statistically meaningful at the 95% confidence level, as the confidence interval for d ranged from 0.005 to ∞ and did not include zero.

5. Discussion

5.1 Balance

Results from the pre-test comparison between the experimental and control groups (Table 2) showed no statistically significant differences in the balance domain, confirming the equivalence of the two groups prior to the program's implementation—a methodological

prerequisite for validly attributing any subsequent change to the independent variable (the program) rather than to pre-existing differences between groups.

The comparison between the pre-test and post-test of the experimental group (Table 4), however, revealed statistically significant differences in favor of the post-test. This is attributed to the adapted motor program based on the principles of Applied Behavior Analysis (ABA), delivered through small games, which included purposeful motor activities such as drawing ground pathways and having children walk along them while maintaining body alignment and stability during performance.

This finding is consistent with recent field studies that used obstacle course exercises to improve dynamic balance in children with autism, reporting statistically significant improvement in balance-test completion time after a relatively short training period (Devi, n.d.). It is further supported by another study that used straight-line walking exercises as an effective means of improving balance in children with ASD attending specialized care centers (Febriani et al., 2023).

"Balance has been defined as the ability to maintain equilibrium in a gravitational field by keeping the body's center of mass over its base of support" (Horak, 1987, p. 1881).

These theoretical considerations are consistent with recent studies confirming that postural control disorders in children with ASD are closely linked to impaired fundamental motor skills, and that structured training programs targeting static and dynamic balance can produce measurable improvements in postural stability, even within short-term programs lasting only a few weeks (Roşca et al., 2022).

By contrast, the comparison between the post-test and pre-test of the control group showed no statistically significant differences, confirming that the improvement observed in the experimental group cannot be attributed to natural maturation or any confounding variable, but rather to the effect of the program itself. This is further corroborated by the post-test comparison between the experimental and control groups, which showed significant differences in favor of the experimental group—providing strong evidence that the ABA-based motor program had a genuine, attributable effect on balance in children with Level 1 ASD.

5.2 Fine Motor Control

Results from the pre-test comparison between the experimental and control groups (Table 3) confirmed the absence of statistically significant differences in fine motor control, establishing baseline equivalence between the groups prior to program implementation—an essential methodological condition for attributing any subsequent change exclusively to the independent variable (the program).

The comparison between the pre-test and post-test of the experimental group (Table 5) revealed statistically significant differences in favor of the post-test. This result is attributed to the content of the games incorporated within the ABA-based motor program and their suitability for children with Level 1 ASD, particularly activities involving grasping and controlling a ball, together with games directed toward developing the fine muscles and the ability for precise control of finger movements and limb-stabilizing muscles.

This finding is consistent with recent studies that used ball combination training as an effective means of improving motor disorders in children with ASD, reporting statistically significant improvement following a 12-week training program (Qi et al., 2025). It is further supported by

a study that employed play therapy to develop fine motor skills in children with autism (Dallman, 2013), which observed noticeable improvement in grasping and in opening and closing the hands, and in finger movement, following a play-based intervention (Marlina & Rizka, 2016). In the same context, a study of the Fit Families Program, directed at families, found that throwing and catching activities within structured sessions produced measurable improvement in motor performance in this population (Columna, 2022).

"Fine motor skills refer to the coordination of small muscle movements in the hands and fingers, involving precise control that enables tasks such as writing, drawing, and playing musical instruments" (Khramtsov et al., 2021, p. 250)

By contrast, the comparison between the post-test and pre-test of the control group showed no statistically significant differences, confirming that the improvement observed in the experimental group cannot be attributed to natural maturation or any confounding variable, but rather to the effect of the program applied. This is corroborated by the post-test comparison between the experimental and control groups, which showed significant differences in favor of the experimental group, from which it can be concluded that the program had a genuine effect on fine motor control in children with Level 1 ASD.

6. Hypothesis Testing

First Hypothesis: There are statistically significant differences between the pre-test and post-test of the experimental group in the balance dimension, in favor of the post-test.

The results showed statistically significant differences between the pre-test and post-test of the experimental group in the balance dimension, in favor of the post-test, indicating an improvement in balance following implementation of the adapted motor program. The first hypothesis is therefore confirmed.

Second Hypothesis: There are statistically significant differences between the pre-test and post-test of the experimental group in the fine motor control dimension, in favor of the post-test.

The results showed statistically significant differences between the pre-test and post-test of the experimental group in the fine motor control dimension, in favor of the post-test, indicating the effectiveness of the ABA-based motor program in improving fine motor control among the experimental group's participants. The second hypothesis is therefore confirmed.

7. Conclusion

7.1 Key Findings

- Results showed baseline equivalence between the experimental and control groups in both balance and fine motor control, with no statistically significant differences between them.
- Results showed statistically significant differences between the pre-test and post-test of the experimental group in balance, in favor of the post-test, indicating an improvement in balance following implementation of the program.
- Results showed statistically significant differences between the pre-test and post-test of the experimental group in fine motor control, in favor of the post-test, indicating an improvement in this domain following implementation of the program.
- Results showed statistically significant differences in the post-test between the experimental and control groups, in favor of the experimental group, in both balance

and fine motor control, confirming the effectiveness of the ABA-based motor program, delivered through small games, in improving motor performance among children with Level 1 ASD. The overall hypothesis of the study was thus confirmed.

7.2 Concluding Discussion

This study aimed to examine the effectiveness of a motor program based on the principles of Applied Behavior Analysis (ABA), delivered through small games, in developing balance and fine motor control among children with Level 1 Autism Spectrum Disorder. The results obtained were consistent with the study's hypotheses and with the broader scientific literature documenting the close link between motor development and social/communicative development in this population.

Regarding baseline equivalence, the results showed no statistically significant differences between the experimental and control groups in either balance or fine motor control, providing a sound methodological basis for attributing any subsequent change to the effect of the program alone. Regarding post-intervention effects, the comparison between the pre-test and post-test of the experimental group revealed statistically significant differences in favor of the post-test in both dimensions, with a large effect size for balance (Cohen's $d = 0.904$) and a smaller effect size for fine motor control (Cohen's $d = 0.461$), while no significant differences were observed in the control group—ruling out natural maturation or other confounding variables as explanations for the improvement and attributing it with confidence to the ABA-based intervention.

These findings affirm that employing ABA techniques—including positive reinforcement, gradual shaping, task analysis, and structured step sequencing—within a game-based format enjoyable to children constitutes an effective and replicable approach in educational institutions and specialized centers for improving motor performance in children with ASD, particularly during the early developmental period, which represents a critical window for intervention.

Several limitations of the study should nonetheless be noted, including the limited sample size (30 children) and its restriction to a single institution, which constrains the generalizability of the findings to the broader population of children with ASD or to other support levels. Additionally, the short duration of the intervention warrants caution when assessing the stability of the observed effect after the program ends.

8. Practical Implications and Recommendations

- Implementing similar ABA-based motor programs within educational and rehabilitative sessions for children with ASD, adapted to each child's support level and type of motor impairment.
- Conducting follow-up studies with larger samples across multiple institutions, including follow-up measurement to verify the durability of the effect after the intervention ends.
- Expanding the motor performance dimensions studied in future research to include additional aspects such as visual-motor coordination, motor speed, and dynamic balance.
- Training educators and specialists in core ABA tools (reinforcement, modeling, prompting, task analysis) to enable their effective use within motor sessions.

In closing, this study opens avenues for further research into the integration of human movement science with Applied Behavior Analysis as a promising scientific approach for serving children with ASD, with success remaining contingent on the continuity and individualization of intervention according to each child's needs.

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