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BALANCE-ORIENTED INTERVENTION IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A PRE-POST CLINICAL STUDY

Nicolae Horaţiu POP[1*], Albertina-Amalia GHERGUŢ[2]

ABSTRACT. *Objective***.** This paper investigates the effect of two classes of interventions (balance exercises and motor/obstacle-course activities) on balance in children with autism spectrum disorder (ASD). *Method***.** Six children (ages 6–14) diagnosed with ASD attended, between 10/01/2023 and the present, one weekly physiotherapy session (~60 min), alternating balance exercises with motor obstacle courses. Baseline and post-intervention assessments included: a Motor Assessment Form (30 items, Yes/No), the BOT-2 Balance subtest (9 items; total score 0–37), the Flamingo test (number of attempts to maintain 60 s on one leg), and a Proactive Balance Assessment (7 tasks rated "with assistance" M.A. vs. "without assistance" M.F.A.). *Results***.** All participants improved. The number of "Yes" responses on the Motor Form increased and "No" decreased for every child. BOT-2 scores rose (two children reached 37/37 at post-test). On the Flamingo test, all four eligible children reduced their number of attempts (lower score = better performance). In the proactive assessment, all shifted from M.A. to M.F.A. on most/all tasks. *Conclusions***.** A structured weekly program combining balance exercises with motor obstacle courses is associated with significant improvements in static and dynamic balance in children with ASD.

Keywords: autism spectrum disorder, balance, BOT-2, Flamingo, motor obstacle courses, physiotherapy

[1] Department of Individual Sports, Babeş-Bolyai University, Cluj-Napoca, Romania.
[2] Department of Kinesiotherapy and Theoretical Disciplines, Babeş-Bolyai University, Cluj-Napoca, Romania.
[*] Corresponding author: nicolae.pop@ubbcluj.ro

INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental condition marked by persistent difficulties in social communication and interaction, alongside restricted interests and repetitive behaviors (Hodges et al., 2020). Onset typically occurs in the first years of life, underscoring the importance of timely screening and intervention to support developmental outcomes (Wang et al., 2023). Global estimates place point prevalence near 0.76%, and reliable diagnostic determinations are feasible by 18–24 months (Baxter et al., 2015; Zeidan et al., 2022).

Neurobiological findings implicate distributed brain systems rather than a single locus of dysfunction. Differences have been reported across prefrontal and temporal cortices, limbic structures such as the amygdala, and the cerebellum and hippocampus (Sauer et al., 2021), with classic observations of hypoplasia in central lobules of the cerebellar vermis (Donovan & Basson, 2017). Imaging work further suggests atypical growth trajectories an accelerated early expansion followed by relative deceleration in later childhood affecting frontal and temporal regions and the amygdala in at least a subset of children (Beopoulos et al., 2022; Askham, 2020).

Mechanistically, ASD is often framed as a disorder of neural connectivity and synaptic function arising from the interplay of genetic and environmental influences (Hodges et al., 2020; Styles et al., 2020). Beyond the defining social–communication features, motor difficulties are common and clinically meaningful estimates suggest that roughly half to three quarters of children present with clumsiness, poor coordination, and postural instability (Bhat, 2020; Kaur et al., 2018; Licari et al., 2020; Odeh et al., 2020). Given that postural control underpins daily functioning and participation, balance represents a pragmatic and high-value target in pediatric intervention.

In this context, the present study examines whether a structured weekly program integrating balance exercises with progressive motor obstacle courses is associated with gains in static and dynamic balance among children with ASD. A complementary aim is to evaluate the feasibility and clinical utility of tailoring the therapeutic plan to each child's characteristics.

Theoretical background

Physiology and neuroanatomy in ASD

Across neuroimaging and developmental studies, ASD is linked to atypical anatomy and function in large-scale networks that include the insula, anterior cingulate/medial prefrontal cortex, and nodes of the default-mode,

sensory, and motor systems (Guo et al., 2024; Weber et al., 2024). Building on classic reports of cerebellar vermis abnormalities (Donovan & Basson, 2017), newer genetic imaging work associates higher polygenic susceptibility for ASD with volumetric differences in cerebellar and brainstem regions, underscoring cerebellar contributions to cognition and social behavior (Mohammad et al., 2024; Lu et al., 2023). Longitudinal infant MRI further suggests disorder relevant timing: infants later diagnosed with ASD show accelerated amygdala growth beginning between 6 and 12 months, which relates to social deficits at 24 months pointing to early emerging subcortical trajectories that precede overt symptoms (Shen et al., 2022; NIH, 2022).

Pathology, prevalence, and diagnosis

Network-level accounts characterize ASD as a disorder of connectivity and communication across cortical–subcortical circuits; recent work shows reduced "connectivity diversity," particularly in paralimbic and heteromodal association systems, consistent with long-range underconnectivity and altered hub organization (Guo et al., 2024; Weber et al., 2024). In epidemiology, the WHO's 2023 fact sheet estimates ASD affects about 1 in 100 children globally (WHO, 2023), while U.S. surveillance data from CDC's ADDM Network for surveillance year 2022 report a prevalence of 32.2 per 1,000 (≈1 in 31) among 8-year-olds across 16 sites, with a ~3.4-fold higher rate in boys than girls and increases versus 2020 at most sites (CDC, 2025). Although diagnosis remains behavioral, progress on scalable biomarkers is notable: eye-tracking measures of social visual engagement (16–30 months) showed clinician-level diagnostic performance in specialty settings (Jones et al., 2023), and a 2024 primary-care study found that combining eye-tracking indices with pediatrician ratings improved sensitivity and specificity, potentially shortening time-to-diagnosis (Keehn et al., 2024).

Motor deficits and balance

Motor differences including clumsiness, coordination difficulties, and postural instability are common in ASD and have functional impact on participation (Bhat, 2020; Licari et al., 2020; Kaur et al., 2018; Odeh et al., 2020). Balance relies on multisensory integration (visual, vestibular, proprioceptive); foundational human posture research demonstrates how these channels jointly govern upright stance and how disruptions can degrade stability principles relevant to ASD motor phenotypes (Maurer et al., 2006). In the last five years, evidence has grown for practical assessment and intervention: a 2024 systematic review concluded that targeted balance-control interventions (e.g., task-specific balance

training, structured play, multisensory activities) generally improve postural outcomes in ASD (Date et al., 2024), while a 2024 reliability study showed that common field tests of static and dynamic balance (including Flamingo, modified BESS, beam walking) can be administered with acceptable between-session reliability in primary school-aged autistic children useful for tracking change in clinics and schools (Baldwin et al., 2024).

MATERIAL AND METHODS

Pre–post clinical study (no control group) conducted in a private practice in Cluj-Napoca, 10/01/2023–30/06/2025. Frequency: 1 session/week, ~60 minutes/session.

Participants

N = 6 children (ages 6–14) with an ASD diagnosis. Interventions were delivered by a physiotherapist.

Procedure

Mixed program: balance exercises (e.g., stance on unstable surfaces, walking on a balance beam, controlled squats, BOSU tasks) and progressive motor obstacle courses (14 sample courses described in the source material), targeting static/dynamic balance, coordination, and postural control. Sessions included a warm-up (treadmill, bicycle, stepper).

Materials

- **Motor Assessment Form for children**
  The form includes 30 balance-related items and was used for both the initial and final assessments. Each item was scored dichotomously ("yes" or "no"), with "yes" indicating successful task completion and "no" indicating failure. The assessed tasks included activities such as turning while walking, stepping over or around obstacles, walking on uneven surfaces, riding a bicycle, or standing on one leg for 3–6 seconds.
- **BOT-2—Balance subtest**
  Assesses gross and fine motor skills in individuals aged 4–21 years and is widely used to evaluate motor competence in children with autism. The short form requires 15–20 minutes, while the complete version takes 45–60 minutes to administer (Baharudin, Harun, & Kadar, 2020).

BOT-2 includes 53 items grouped into eight subtests, with progressively increasing difficulty. In this study, only the balance subtest was administered, consisting of nine tasks evaluating static and dynamic balance under different conditions (e.g., standing or walking on a line or balance beam, with eyes open or closed). Each task was scored from 0 to 4 points based on performance time or number of steps. A second trial was conducted only if the maximum score was not achieved on the first attempt. The maximum total score for the balance subtest was 37 points.

- **Flamingo test (Eurofit)**
  The Flamingo Test, part of the Eurofit test battery, assesses static and overall body balance by measuring the ability to maintain single-leg stance (Chand, Dusabeyezu, van Niekerk, & Magtibay, 2025). It is widely used in children and adults and serves as a practical tool for monitoring balance during therapeutic, educational, or sports interventions.
  The participant stands barefoot on a balance beam in the flamingo position for one minute. Timing is paused after each loss of balance and resumed once balance is restored. The final score represents the number of attempts required to complete one minute. Scores of 16–25 indicate poor balance, 9–15 good balance, and fewer than 9 very good balance.
- **Proactive Balance Assessment** (7 tasks: balance board rocking, walking on a line/bench, over obstacles, course, climbing/descending stall bars, trampoline jumps), rated M.A. = "with assistance" / M.F.A. = "without assistance" (Ţicărat & Ciobanu, 2012).

Data analysis

Baseline evaluation prior to the program and re-evaluation after the intervention period. Descriptive analysis of scores (baseline–post comparison) at the participant level.

RESULTS

The findings of this pre–post clinical study indicate a clear improvement in motor and balance abilities among participating children with ASD following the physiotherapy-based balance program. Statistical analyses across multiple measures consistently support the effectiveness of the intervention.

Motor Assessment Form

The number of positive ("Yes") responses increased significantly from baseline to post-intervention ($t(5) = -10.24, p < .001$), indicating enhanced performance across a broad range of motor tasks. Table 1.

Table 1. Baseline and post-intervention results on the Motor Assessment Form (number of "Yes" items)

	Std. Deviation	t	df	Sig. (2-tailed)
Yes (baseline) - Yes (post)	3.34664	-10.247	5	.000

Correspondingly, the number of "No" responses decreased significantly ($t(5) = 10.25, p < .001$), suggesting a meaningful overall improvement in functional motor abilities after the program. These changes reflect better coordination, body control, and execution of motor activities in daily and therapeutic contexts Tabel 2.

Table 2. Baseline and post-intervention results on the Motor Assessment Form (number of "No" items)

	Std. Deviation	t	df	Sig. (2-tailed)
No (baseline) - No (post)	3.34664	10.247	5	.000

BOT-2 Balance Subtest

Scores on the BOT-2 balance subtest improved significantly across all participants ($t(5) = -15.06, p < .001$), with two children achieving the maximum possible score. This finding demonstrates substantial progress in both static and dynamic balance control. The BOT-2 results are consistent with the observed improvements on other measures, confirming the positive impact of targeted balance training within the program Tabel 3.

Table 3. BOT-2 results (two trials/administrations), baseline vs. post

	Std. Deviation	t	df	Sig. (2-tailed)
BOT Trial 2 (baseline) - BOT Trial 2 (post)	1.87083	-15.057	5	.000

Flamingo Test (Eurofit)

Among the four participants who were able to perform the test, the number of attempts required to maintain balance for 60 seconds decreased significantly (*t(3) = 7.55, p = .005*). This improvement reflects a better ability to stabilize the body in a single-leg stance, an important indicator of postural control and neuromotor coordination. The two younger children who could not complete the test likely required developmental adaptations to appropriately assess balance at their age Tabel 4.

Tabel 4. Flamingo Test (Eurofit) results

	Std. Deviation	t	df	Sig. (2-tailed)
Flamingo baseline - Flamingo post	1.25831	7.550	3	.005

Proactive Balance Assessment

Descriptive results from this measure further support the quantitative findings. For G.N., S.C., S.T., A.M., Ş.G., and N.B., there was a predominant transitioned from performing tasks *with assistance (M.A.)* to *without assistance (M.F.A.)* across the majority of balance and coordination exercises (e.g., balance board, obstacle course, trampoline jumps). This qualitative shift reflects increased confidence, independence, and functional balance control in dynamic movement contexts.

Together, these findings provide strong evidence that a structured, mixed physiotherapy program emphasizing balance and coordination can produce measurable improvements in children with ASD, even over a relatively short period (weekly sessions since October 2023). The consistent pattern of significant gains across multiple standardized tools supports the clinical relevance of this intervention. Improvements in both quantitative and qualitative indicators suggest enhanced postural stability, motor planning, and adaptive control key developmental domains often affected in ASD.

DISCUSSION

The results of this study demonstrate that a structured physiotherapy program focused on balance, coordination, and postural control can lead to significant improvements in children with Autism Spectrum Disorder (ASD). The consistent gains observed across multiple standardized measures **Motor Assessment Form, BOT-2 Balance Subtest, Flamingo Test,** and **Proactive Balance Assessment** highlight the program's effectiveness in enhancing both static and dynamic balance, as well as overall motor function.

Our pre–post analysis showed consistent gains in static and dynamic balance after a structured weekly program that combined targeted balance drills with progressively challenging motor obstacle courses. Improvements on standardized outcomes higher BOT-2 balance scores and fewer Flamingo attempts align with recent syntheses reporting measurable benefits from postural-control–oriented interventions in autistic children, while also noting heterogeneity in protocols and limited follow-up (Date et al., 2024; Roșca et al., 2022). In our cohort, the shift on the proactive balance tasks from "movement with assistance" to "movement without assistance" reflects not only motor progress but also growing autonomy and task confidence, which is a central goal of task-oriented pediatric rehabilitation.

Reviews emphasize that multi-week, task-specific practice is associated with clearer gains in postural control, though optimal dosing remains under investigation (Date et al., 2024). Beyond conventional balance drills, technology-assisted training is accumulating supportive evidence: randomized trials of immersive/interactive virtual reality report improvements in center-of-pressure stability and motor function over short, focused programs, suggesting an engaging, feedback-rich complement to usual physiotherapy (Falivene et al., 2025; Ghafar et al., 2025). These findings are consistent with our observation that varied practice and progressive challenge features common to motor learning paradigms track with improved performance on clinic-friendly measures.

Human balance depends on efficient integration and reweighting of visual, vestibular, and proprioceptive inputs (Maurer et al., 2006). Contemporary studies in autistic samples point to central integration differences rather than uniform peripheral vestibular deficits: preschool to adolescent cohorts often show reduced stability especially when visual cues are altered or removed despite largely typical peripheral vestibular findings (Fears et al., 2023; Chisari et al., 2024). Our program deliberately manipulated base of support, surface compliance, visual conditions, and head/segment orientation, thereby taxing reweighting processes that likely underpin the observed improvements. Converging evidence from sensory-integration training adds that structured multisensory tasks can boost both balance and executive functions, with neuroimaging (fNIRS) hints of enhanced prefrontal engagement, consistent with better top-down regulation during postural tasks (Deng et al., 2023).

Motor obstacle courses embed balance in goal directed, rule based sequences (stepping over/around, narrow base walking, compliant surfaces), approximating real-world mobility challenges. This ecological emphasis is increasingly visible in clinical research, including a registered randomized trial of a standardized walking obstacle course for children with ASD (NCT06943274).

Our weekly format alternating isolated balance drills with progressively harder circuits was designed to facilitate transfer to daily activities (e.g., navigating uneven terrain, pivoting, dual-task mobility).

Using the BOT-2 balance subtest together with Flamingo is consistent with pediatric practice; recent data show that several field-based balance tests (e.g., beam/tandem walking, modified BESS) reach acceptable between-session reliability in primary-school autistic children, supporting their use for progress monitoring in clinics and schools (Baldwin et al., 2024). Where feasible, augmenting checklists and timed/score-based tasks with instrumented measures (e.g., force-plate center-of-pressure features) can increase sensitivity to change, as shown in clinic-based balance programs (Roşca et al., 2022).

Taken together, current evidence and our findings support multi-component, play-based balance programs that:

1. run for several weeks with progressive overload of postural demands;
2. systematically manipulate sensory conditions (eyes open/closed, visual flow, compliant/unstable surfaces) to train reweighting;
3. embed balance within ecologically valid, structured tasks (obstacle circuits) to drive generalization; and
4. consider VR/exergaming as an adjunct to enhance engagement and real-time feedback. These elements align with the neurodevelopmental profile of ASD and may also support executive and participation outcomes.

Limitations and future directions

This real-world study lacked a concurrent control group and involved a modest sample, limiting causal inference and generalizability limitations common to the field (Date et al., 2024). Future work should use controlled designs with longer follow-up, stratify by age, cognitive profile, and co-occurring conditions, and adopt standardized outcome batteries (including instrumented metrics) to refine dose–response and identify moderators of benefit. Ongoing and planned RCTs of obstacle-course paradigms and VR-augmented balance training will help specify who benefits most and at what dose.

Clinical implications

- Combined programs (balance + obstacle courses) can be integrated into routine therapy for children with ASD.
- Individualization by level and sensory profile is essential.
- Standardized assessments (BOT-2, Flamingo) can finely monitor progress and guide difficulty progressions.

CONCLUSIONS

This study provides preliminary but compelling evidence that a structured, physiotherapist-led balance training program can significantly improve motor and postural control abilities in children with Autism Spectrum Disorder. Statistically significant gains across all assessment tools, combined with observed qualitative progress, indicate enhanced static and dynamic balance, coordination, and functional independence.

These findings underscore the importance of individualized, engaging, and progressive physiotherapy interventions in supporting motor development in children with ASD. Continued research with larger cohorts and controlled designs is recommended to confirm these effects and refine best-practice guidelines for clinical implementation.

Limitations and Future Directions

Although the present findings are encouraging, several limitations should be noted. The study involved a **small sample size (N = 6)** and lacked a **control group**, which limits the ability to generalize results and attribute improvements solely to the intervention. Additionally, the relatively short intervention period and ongoing nature of the program make it difficult to assess the long-term sustainability of the observed gains. Two younger participants were unable to complete the Flamingo Test, indicating the need for more **age-appropriate assessment tools** in future research.

Subsequent studies should aim to include **larger and more diverse samples**, incorporate **control or comparison groups**, and perform **follow-up evaluations** to determine whether the motor and balance improvements are maintained over time. Exploring the **neurophysiological mechanisms** underlying these changes, as well as the potential effects on daily functioning, social participation, and cognitive outcomes, would also strengthen the evidence base for physiotherapy interventions in children with ASD.

AUTHOR CONTRIBUTIONS
All the authors contributed equally to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST
There are no conflicts of interest to declare concerning this study

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