CONTROL GROUP STUDY

Developmental Outcomes of the Brain Balance® Program in Autism Spectrum Disorder (ASD) in Children and Adolescents

A Control Group Study Examining Sensory Motor Development

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N = 86 · Ages 4–17 · Brain Balance Centers · 2022–2023

EXECUTIVE SUMMARY

Autism spectrum disorder (ASD) affects 1 in 36 children in the United States, yet a critical aspect of the condition remains largely unaddressed: motor development. While developmental coordination disorder (DCD) is formally identified in 79% of children with ASD, motor deficits are documented by clinicians in only approximately 1% of cases (Harrison et al., 2021; Miller et al., 2023). This striking gap represents a significant missed opportunity, as motor coordination maturation scaffolds higher-order cognitive functions including attention, working memory, and executive functioning—capacities often impaired in ASD.

This control group study examined whether a comprehensive sensory motor intervention could measurably improve developmental coordination in children and adolescents with ASD. Eighty-six participants (ages 4-17) with a parent-reported diagnosis of ASD were evaluated: 48 completed an average of 7.6 months in the Brain Balance program, while 38 served as a non-intervention control group.

86	7.6	5 of 6
total participants ages 4–17 with ASD	**months average program duration** Brain Balance group	**sensory motor domains** showed significant improvement

Key Findings:

- **Developmental Reflexes:** The Brain Balance group demonstrated statistically significant improvements in the maturation of primitive and postural reflexes including the asymmetric tonic neck reflex, Landau reflex, and Moro reflex compared to controls ($p < .001$).
- **Sensory Motor Skills:** Participants showed significant gains in five of six assessed domains: body coordination, balance (proprioception), gaze stability (vestibular ocular reflex), rhythm and timing, and fine motor skills ($p < .001$ to $p < .01$).
- **Foundational Impact:** These improvements in foundational sensory motor systems may support broader developmental outcomes, potentially mitigating both core and associated features of ASD.

This study provides evidence that targeting sensory motor development represents a viable, evidence-based approach to support children with ASD—one that addresses an under-recognized but consequential aspect of the condition and complements existing behavioral and communication-focused interventions.

Introduction

Autism spectrum disorder (ASD) interventions have traditionally centered on social communication and the management of restricted and repetitive behaviors. Yet a striking discrepancy in the literature points to an under-recognized need: while motor deficits are documented by clinicians in only ~1% of ASD cases, developmental coordination disorder (DCD) is identified in 79% of cases when formally assessed (Harrison et al., 2021). DCD—immaturity in the acquisition and execution of coordinated motor skills—may therefore be not only common in ASD, but consequential to a greater degree than previously recognized.

Although motor coordination delays are not a core diagnostic criterion for ASD, they are increasingly recognized as a critical attribute of the condition (Miller et al., 2023). Sensory motor maturation does more than improve gross and fine motor performance; it scaffolds higher-order cognition, including attention, working memory, response inhibition, and broader executive functions (Stuhr et al., 2020). Given that ASD's core features—deficits in social communication; restricted, repetitive behaviors; and hyper- or hypo-sensory reactivity (American Psychiatric Association, 2013)—draw heavily on executive functioning, strengthening foundational sensory motor systems represents a plausible, underused approach to impact core symptoms.

Our perspective at Brain Balance

We focus on the foundational layer: assessing and improving sensory motor coordination to support downstream gains in cognition, attention, behavior, and social communication. Across multiple studies of students with measurable sensory motor gaps, comprehensive Brain Balance programming has been associated with maturation of sensory and motor skills in addition to improvements in cognition (attention, working memory, response inhibition) in both in-center and at-home delivery models (Jackson & Wild, 2021; Jackson & Meng, 2024). Teacher-reported outcomes (Vanderbilt Teacher Survey) indicate better classroom attention and behavior (Jackson & Glanz, 2023), and parent-reported outcomes (Multi-Domain Developmental survey; Brown's ADHD Scale) show improvements in anxiety, emotional regulation, social/communication, academic engagement, and follow-through (Jackson & Jordan, 2022; 2023).

Addressing the gap

Prior cohorts combined students with varied diagnoses (from none to ADHD, ASD, anxiety, and learning disabilities). To directly test the relevance of sensory motor intervention for ASD, the present study narrows the sample to children with a parent-reported ASD diagnosis and compares outcomes with a non-intervention control group. Our objective is to evaluate whether a comprehensive sensory motor program can measurably improve developmental coordination

> in this population—thereby advancing a targeted, foundational approach that complements existing ASD interventions.

The Challenge: Motor Development in Autism Spectrum Disorder

The Complexity of ASD

Autism spectrum disorder is a neurodevelopmental condition characterized by deficits in social communication and the presence of restricted interests and repetitive behaviors, as well as hyper- or hypo-reactivity to sensory input (American Psychiatric Association, 2013). With rates continuing to climb to 1 in 36 eight-year-olds in the U.S. being diagnosed with ASD in 2020, there is an urgent need to provide improved support for individuals with this complex condition (Maenner et al., 2020). This heterogeneous condition is influenced by both genetic and environmental factors affecting the developing brain (Hodges et al., 2020), and its impact extends far beyond the core features to affect sensory, motor, and cognitive development (Bradshaw et al., 2022).

The Hidden Motor Development Crisis

While much research and intervention have focused on the core features of autism, developmental coordination disorder (DCD) and the relevance of motor development are also considered critical attributes, beyond the core features (Miller et al., 2023). A meta-review found that infants later diagnosed with autism displayed differences in motor, fine motor, and balance development. A co-occurrence of DCD and ASD can be found in up to 79% of children diagnosed with ASD, and an additional 10% fall just shy of the threshold for DCD diagnosis (Harrison et al., 2021).

While the importance of motor development in achieving key motor milestones is accepted, motor development's significance extends beyond these milestones. The development of motor coordination is attributed to supporting higher-level developmental abilities, as motor coordination and executive functions are considered functionally intertwined (Stuhr et al., 2020). The three primary executive functions—inhibition, working memory, and cognitive flexibility—are top-down functions that require the integration of many aspects of development (Hatoum, 2023). The ability to inhibit thoughts and actions, hold information in working memory, and maintain fluidity and flexibility throughout the day directly impacts the core features of autism. Simply put, motor development has been shown to contribute to the maturation of executive functions which support our actions and abilities.

> **Clinical context**
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> Despite understanding that motor development is key to higher-level brain functions and is impacted in ASD, motor development deficits are estimated to be documented by clinicians in merely 1% of cases (Miller et al., 2023). The high occurrence of developmental motor deficits present in ASD, combined with the under-documentation of immature motor development, provides an urgent need for improved measurement and evidence-based programs to improve motor development in children and adolescents diagnosed with ASD.

The Broader Impact: Comorbidities and Barriers

Beyond the direct symptoms of ASD, individuals also experience higher rates of co-occurring medical conditions, with 74% having at least one comorbidity compared with their non-ASD siblings (Khachadourian et al., 2023). Children with diagnosed ASD are more likely to have received mental health diagnoses including:

- **ADHD:** 61.2% of children with ASD
- **Conduct disorder:** 19.8%
- **Obsessive-compulsive disorder:** 5.4%
- **Anxiety disorder:** 4.7% (Kilicaslan, 2022; Cantor et al., 2020)

Gastrointestinal concerns are also more prevalent, with a four-fold increase in GI issues compared to non-ASD peers. The most reported symptoms include constipation, diarrhea, and abdominal pain (Madra et al., 2020). If GI distress goes undetected or untreated, it has been linked to increased concerns with sleep, behavior, and psychiatric disorders (Fergason et al., 2019). Coinciding with GI complications can be eating challenges and nutrient gaps, with greater food selectivity, picky eating, and food avoidance commonly reported (Baraskewich et al., 2021). Vitamin deficiencies are frequently detected, with the most common gaps seen in levels of vitamins B1, B6, B12, A, and D (Robea et al., 2020).

Care Coordination Challenges

The combination of areas impacted by ASD—including sensory, motor, and cognitive development, behavior, communication, nutrient deficiency, and GI complications—makes treatment and support complex. This complexity inherently contributes to increasing barriers to care. A survey of ASD caregivers reported that in 92% of cases, mothers are the care coordinators, and mothers reported experiencing a barrier to accessing care 44% of the time. The two most reported barriers were waitlists and lack of coverage (Monzu et al., 2019).

The multiple domains impacted by ASD often require coordination of multiple care services throughout a 12-month period, which can increase absenteeism for both the parent from work and the student from school. Across four weeks, children with ASD missed the equivalent of 6 full days of school, with full-day absences most attributed to refusal, comorbid concerns, and bullying (Nordin et al., 2024). Half-day absences were reported most for medical/therapy appointments (Adams, 2022).

Care coordination can involve appointments with a physician for overall health, GI support, and medication; mental health/counseling for emotional support; Applied Behavioral Analysis (ABA) for behavioral support; and developmental support from interventions such as occupational therapy (OT) or speech and language therapy (SLT). These support services often require consistent visits over months, if not years. Despite the high comorbidity rates of ASD with ADHD, anxiety, and depression, inadequate mental health and behavioral support specific to children with ASD exists today. In a survey of over 8,000 U.S. mental health treatment facilities, fewer than half reported providing behavioral health care for children with ASD, and only 37% were accepting children diagnosed with ASD (Cantor et al., 2020).

Study Rationale

With the increasing prevalence of ASD and the complexity of the condition, the under-documentation of motor development, and the need for evidence-based intervention models that address underlying developmental aspects contributing to complex symptoms and behaviors is pressing. To that end, this study evaluated the impact of the Brain Balance program on maturing motor measures of development in children and adolescents diagnosed with ASD versus a non-intervention control group.

In previous studies, the Brain Balance program has demonstrated statistically significant improvement in measures of development including maturation of developmental reflexes (primitive and postural reflexes), and improved balance, coordination, fine motor skills, auditory processing, gaze stability, and rhythm and timing (Jackson & Glanz, 2023; Jackson & Jordan, 2023). While students with ASD were included in these studies, they included the full range of students who enrolled at Brain Balance and were not specific to measuring outcomes in children and adolescents with ASD. Brain Balance does not require parents to report a diagnosis at the time of assessment or enrollment. Forty-four percent of parents report a diagnosis, with 5.5% of total enrollments including children and adolescents diagnosed with ASD as reported by parents.

To better understand the impact of the comprehensive Brain Balance program on children and adolescents with ASD, this study analyzed retrospective program data on students with ASD who completed an average of 7.6 months of the Brain Balance program in-center compared to students who were assessed at baseline but did not complete any intervention prior to a second assessment. The results confirm previous findings of improving measures of sensory motor development including body coordination, balance, rhythm and timing, fine motor skills, auditory processing, and visual motor tasks in students with an ASD diagnosis after completing the Brain Balance program.

Study Design and Methods

Ethical Approval

Approval for this retrospective data review was granted by an institutional review board (IRB) at Advarra (Columbia, Maryland, USA), an independent organization accredited by the U.S. Office for Human Research Protections and the Association for the Accreditation of Human Research Protection Programs. The Advarra IRB determined that this retrospective data review met the requirements for exemption from IRB oversight, according to the Department of Health and Human Services regulations found at 45 CFR 46.104(d)(4). Informed parental consent was obtained for any participants prior to general enrollment in the Brain Balance program.

Participants

Study participants consisted of 86 students, among which 48 enrolled in the Brain Balance program for an average of 7.6 months, then completed a post-program assessment. These students were assigned to the treatment group (BB). The remaining 38 students did not enroll but volunteered to be assessed a second time as part of the control group data. These students were assigned to the control (CTRL) group.

Group	N	Age range	Mean age (SD)	% Female	Duration
Brain Balance (BB)	48	4–17 years	10.10 (2.95)	27.1%	Avg 7.6 months
Control (CTRL)	38	4–17 years	9.82 (3.43)	31.6%	6.8 months between assessments

Inclusion Criteria

Prior to enrolling in the Brain Balance program, prospective students were evaluated by trained assessors who had completed training in the centers' protocols. For inclusion in the active study group, parent paperwork was required to disclose an autism spectrum diagnosis. Additional program enrollment criteria remained in place for this study, which includes:

- No known genetic disorders
- Tested below age-appropriate levels in functional measurement
- Parents presenting with concerns in development, attention, cognition, behavior, and/or emotional regulation
- Demonstrated developmental readiness for the program, defined by the ability to engage with instructors and follow a one-step direction, attempt the tasks requested, and continue to work throughout the duration of the assessment (redirection and repetition of instructions both visually and verbally were allowed in the definition of readiness)

Assessment Measures

The Brain Balance comprehensive assessment was administered before and after participation for the active group and at two distinct time points with no program intervention for the control group. Testing took place at Brain Balance centers and was administered by certified Brain Balance coaches. The Brain Balance assessment protocols were consistent with previous studies in measuring primitive reflexes and sensory motor development (Jackson & Jordan, 2023; Jackson & Glanz, 2023).

Developmental Reflexes

Students were assessed for developmental reflexes including both primitive and postural reflexes:

- Asymmetric tonic neck reflex
- Landau reflex
- Moro reflex
- Palmar reflex
- Rooting reflex
- Spinal galant reflex
- Symmetric tonic neck reflex
- Tonic labyrinthine head reflex

All reflexes were scored on a scale from 0 to 4, with no response being 0 (indicating that the reflex has been normally integrated) and a 4 being a significant response (Chandradasa & Rathnayake, 2020).

Sensory Motor Skills

Six areas of sensory motor development were assessed:

Domain	Assessment tool	What is measured
Fine Motor Skills	Purdue Peg Board	Timed completion using dominant, non-dominant, and both hands; pegs completed counted
Gait and Aerobic Ability	Cross-Crawl March and Jump Rope	Sequential levels of difficulty: cross-crawl march patterns, lateral skater, jump rope progressions
Proprioception	Rocker Board and One-Leg Balance Test	Sequential levels: two-foot rocker board, one-leg balance on ground, one-leg balance on rocker board (eyes open/closed)
Rhythm and Timing	Interactive Metronome® Long-Form Assessment	Auditory/visual cues; student hits trigger in time; tasks using both hands, each hand, feet, alternating
Gaze Stability	Vestibular Ocular Reflex Manual Test	Eyes fixed on target while head turns side to center, 15x right and 15x left; accuracy monitored
Auditory Processing	Dichotic Listening	Headphones; two words/phrases simultaneously, one per ear; student repeats back; 1–3 syllables, progresses to phrases

Students were given verbal and visual instructions for all tasks.

The Brain Balance Program

Program Structure

Participants in the Brain Balance program attended three in-center sessions per week for a minimum of 3 months. Each program session lasted 1 hour and consisted of multi-sensory stimulation while completing exercises to mature developmental reflexes, core strength, balance, coordination, fine motor skills, rhythm and timing, visual motor, auditory and visual processing, and activities to improve attention and memory.

In-Center Training Protocols

All participants went through the same series of stations, which consisted of the following exercises and activities:

- **Passive Sensory Stimulation** Tactile, olfactory, visual, and auditory stimulation (Woo et al., 2015).
- **Developmental Reflex Exercises** Targeting primitive and postural reflexes (Chandradasa & Rathnayake, 2020), which were assigned based on indicators of a retained reflex at the time of the initial assessment.
- **Core Muscle Exercises** Strengthening activities for foundational trunk stability (Myer et al., 2011).
- **Proprioceptive and Balance Training** Using rocker boards and one-leg balance exercises (Fong et al., 2016; Kobel et al., 2020).
- **Gait Exercises** Including cross-crawl march patterns (Surburg & Eason, 1999) and jump rope progressions (Trecroci et al., 2015).
- **Vestibular Exercises** Including rotational, translational, and anterior-to-posterior movements.
- **Fine Motor Activities** Including palmar grasp exercises to increase muscle strength and Purdue Peg Board activities to improve dexterity and speed (Squillace et al., 2015).
- **Rhythm and Timing Exercises** Whole-body coordination activities and use of the Interactive Metronome®, a training tool that combines the concept of a musical metronome with a computerized program that measures and improves rhythm and timing (Shaffer et al., 2001).
- **Auditory and Visual Processing Activities** Exercises aimed at enhancing processing abilities and coordination and endurance of eye movements (Robert et al., 2014; Fisher et al., 2015). Auditory engagement consisted of exposure to varying levels of auditory stimulation and activities targeting the ability to filter and rapidly process auditory information. Visual stimulation was achieved through exposure to color and light stimulation, as well as exercises that require eye coordination, timing, and speed of processing perceived information.
- **Reading and Listening Comprehension** Students complete a reading comprehension activity or a listening comprehension activity with remaining time at the end of each session, appropriate to their skill level.

Individualization and Progression

While all participants engage with the same activity stations, each participant's program is individualized based on their performance on the initial assessment to determine the appropriate starting level for each exercise. Each exercise/activity was progressive in nature and changed in duration, quantity, and complexity as the participants' functional abilities improved over the course of the program.

The criteria for making changes in the duration, quantity, and complexity of the program were based on a student achieving mastery of each level. We defined mastery as the student successfully completing the task over three consecutive sessions. For example, during the sensory stimulation component, if a student cooperatively wears tactile sensory gear for three consecutive sessions, tactile vibration will be increased to the higher increment of stronger vibration for the next session. Similarly, for fine motor tasks such as the Purdue Peg Board, once the student achieves mastery by reaching their current goal target for three consecutive sessions, the next session's goal will be increased to place additional pegs into the pegboard holes in the same amount of time.

Home Program

In addition to the in-center activities, parents were asked to assist their children in completing daily exercises at home. The home exercises consisted of:

- 0–8 primitive and postural reflex exercises (assigned if the developmental reflex was present at the time of assessment)
- Physical fitness activities (push-ups and sit-ups)
- Manual eye strengthening exercises

To ensure consistency in parental implementation of the at-home portions of the program, parents received in-center training on how to perform the home exercises and were provided access to an online parent portal that included videos on each of the exercises as well as written instructions with photos. Any verbal and written instructions given to parents are provided in plain language that is short and simple, as education levels may vary among the participants' parents.

Nutrition Support

The Brain Balance program provides access to two personalized nutrition coach sessions to provide parents education and support around the importance of healthy eating to support development and performance. Information regarding the healthy nutrition recommendations is on the parent portal and includes:

- Encouraging families to increase the amounts and variety of whole foods their student consumes
- Minimizing added sugars, ultra-processed foods, artificial food dyes and preservatives
- Guidance on how to identify if a food is a trigger for a possible food sensitivity reaction that could result in increased systemic inflammation

Supplementation is recommended for all students, with an additional emphasis on this recommendation if a child is a picky eater or is not consuming a large variety of healthy foods. Supplementation is recommended in the form of a multi-vitamin, fish oil, probiotic, and vitamin D.

Screen Time Guidance

The Brain Balance program also provides education and support around the importance of balancing entertainment-based screen time with physical activity, as increased screen time has been correlated with a negative impact on development, cognition, and emotional regulation (Muppalla et al., 2023).

Results

Data Analysis Overview

All analyses were performed using R (R Core Team, 2023). Age was calculated as the whole number of years that had passed since birth until the date the students completed the first assessment. Scores measuring primitive reflexes and sensory motor skills were standardized to have a mean of 0 and a standard deviation of 1 for each measure. The transformed primitive reflex data and sensory motor data were analyzed in two separate mixed-design ANCOVAs with age as a covariate. The model also included measurement name and time point (time point 1, time point 2) as within-subject factors and treatment group (BB, CTRL) as a between-subject factor.

Developmental Reflexes: Significant Maturation

For the primitive reflex data, there was a main effect of age [$F(1, 76) = 25.00$, $p < .001$, $\eta^2 = 0.248$], a main effect of time point [$F(1, 76) = 10.81$, $p < .005$, $\eta^2 = 0.125$], and a main effect of measurement name [$F(6.09, 462.68) = 3.66$, $p < .005$, $\eta^2 = 0.045$]. There were also an interaction between time point and treatment group [$F(1, 76) = 61.20$, $p < .001$, $\eta^2 = 0.446$] and an interaction between treatment group and measurement name [$F(6.09, 462.68) = 10.10$, $p < .001$, $\eta^2 = 0.117$].

Age was significantly negatively correlated with reflex scores for asymmetric tonic neck reflex, Landau reflex, palmar reflex, rooting reflex, spinal reflex, symmetric tonic neck reflex, and tonic labyrinthine head reflex. However, for Moro reflex, this correlation was not significant.

The three-way interaction among treatment group, time point, and measurement name was significant [$F(6.18, 469.57) = 2.51$, $p < .05$, $\eta^2 = 0.032$]. In the post-hoc tests, we fixed the level of measurement name to each of the six primitive reflexes, then probed the two-way interaction between time point and treatment group. The two-way interactions were significant for all reflexes but symmetric tonic neck reflex [$F(1, 82) = 3.28$, $p = .07$, $\eta^2 = 0.038$].

Key Findings by Reflex Type

Reflex	Time Point 1 (baseline)	Time Point 2 (post)	Result
Asymmetric tonic neck reflex	Groups equivalent ($p = .10$)	BB significantly lower than CTRL [$t(1333) = -4.56$, $p < .001$]	Significant improvement in BB group
Landau reflex	Groups equivalent	BB significantly lower than CTRL [$t(1333) = -5.34$, $p < .001$]	Significant improvement in BB group
Moro reflex	Groups equivalent ($p = .11$)	BB significantly lower than CTRL [$t(1333) = -4.77$, $p < .001$]	Significant improvement in BB group
Palmar reflex	BB higher than CTRL [$t(1333) = 3.66$, $p < .001$]	No difference ($p = .68$)	BB normalized to CTRL level
Rooting reflex	BB higher than CTRL [$t(1333) = 2.59$, $p < .01$]	No difference ($p = .27$)	BB normalized to CTRL level
Spinal reflex	BB higher than CTRL [$t(1333) = 3.42$, $p < .001$]	No difference ($p = .05$)	BB normalized to CTRL level
Symmetric tonic neck reflex	Groups equivalent ($p = .84$)	No difference ($p = .11$)	Not significant ($p = .07$)

Tonic labyrinthine head reflex	BB higher than CTRL [t(1333) = 3.22, p < .005]	No difference (p = .90)	BB normalized to CTRL level

Figure 1 displays mean and confidence intervals of raw scores for each of the eight reflexes at both time points for both groups.

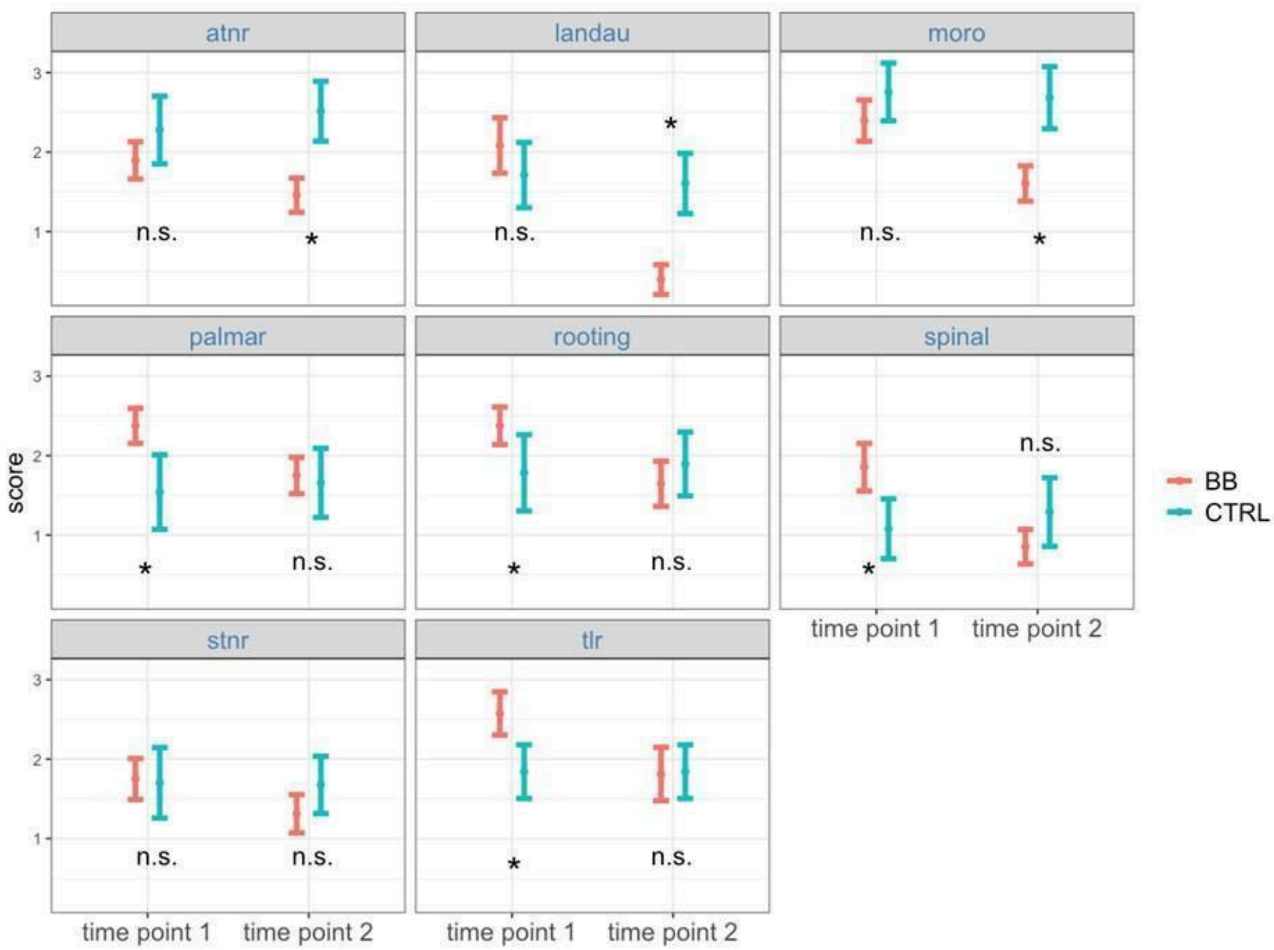

Figure 1. *Post-hoc pairwise comparisons, plot shows mean and confidence intervals of raw scores for each of the eight reflexes. atnr: asymmetric tonic neck reflex, landau: Landau reflex, moro: Moro reflex, palmar: palmar reflex, rooting: rooting reflex, spinal: spinal reflex, stnr: symmetric tonic neck reflex, tlr: tonic labyrinthine reflex.*

Sensory Motor Skills: Broad Improvements

ANCOVA on the sensory motor data revealed main effects of age [$F(1, 75) = 62.58$, $p < .005$, $\eta^2 = 0.046$], treatment group [$F(1, 75) = 20.83$, $p < .001$, $\eta^2 = 0.217$], and time point [$F(1, 75) = 8.15$, $p < .01$, $\eta^2 = 0.098$]. The two-way interaction between treatment group and time point was significant [$F(1, 76) = 353.77$, $p < .001$, $\eta^2 = 0.823$], as well as the interaction between treatment group and measurement name [$F(4.21, 319.82) = 3.40$, $p < .01$, $\eta^2 = 0.043$].

Age interacted with time point and measurement name [$F(4.46, 339.00) = 3.40$, $p < .01$, $\eta^2 = 0.042$]. In the post-hoc tests, we first compared scores measured at two time points for each of the two groups. The difference between two time points was significant for the BB group [$t(1021) = 18.70$, $p < .001$] but not for the CTRL group [$t(1021) = -1.87$, $p = .061$].

Key Findings by Sensory Motor Domain

To probe the interaction between treatment group and measurement names, we compared scores between the two treatment groups separately for each of the sensory motor measures. The difference in scores between the BB group and the CTRL group was significant in five of six tasks:

Sensory motor domain	Result	Significance
Vestibular ocular reflex (gaze stability)	Significant difference BB > CTRL	$t(1013) = 7.32$, $p < .001$
Proprioception (balance)	Significant difference BB > CTRL	$t(1013) = 3.33$, $p < .001$
Fine motor skills	Significant difference BB > CTRL	$t(1013) = 2.74$, $p < .001$
Gait and aerobic ability	Significant difference BB > CTRL	$t(1013) = 3.81$, $p < .001$
Interactive Metronome (rhythm and timing)	Significant difference BB > CTRL	$t(1013) = 3.18$, $p < .001$
Dichotic listening (auditory processing)	No significant difference	$t(1013) = 0.82$, $p = .41$

Figure 2 illustrates the significant interaction between treatment group and time point in sensory motor tasks.

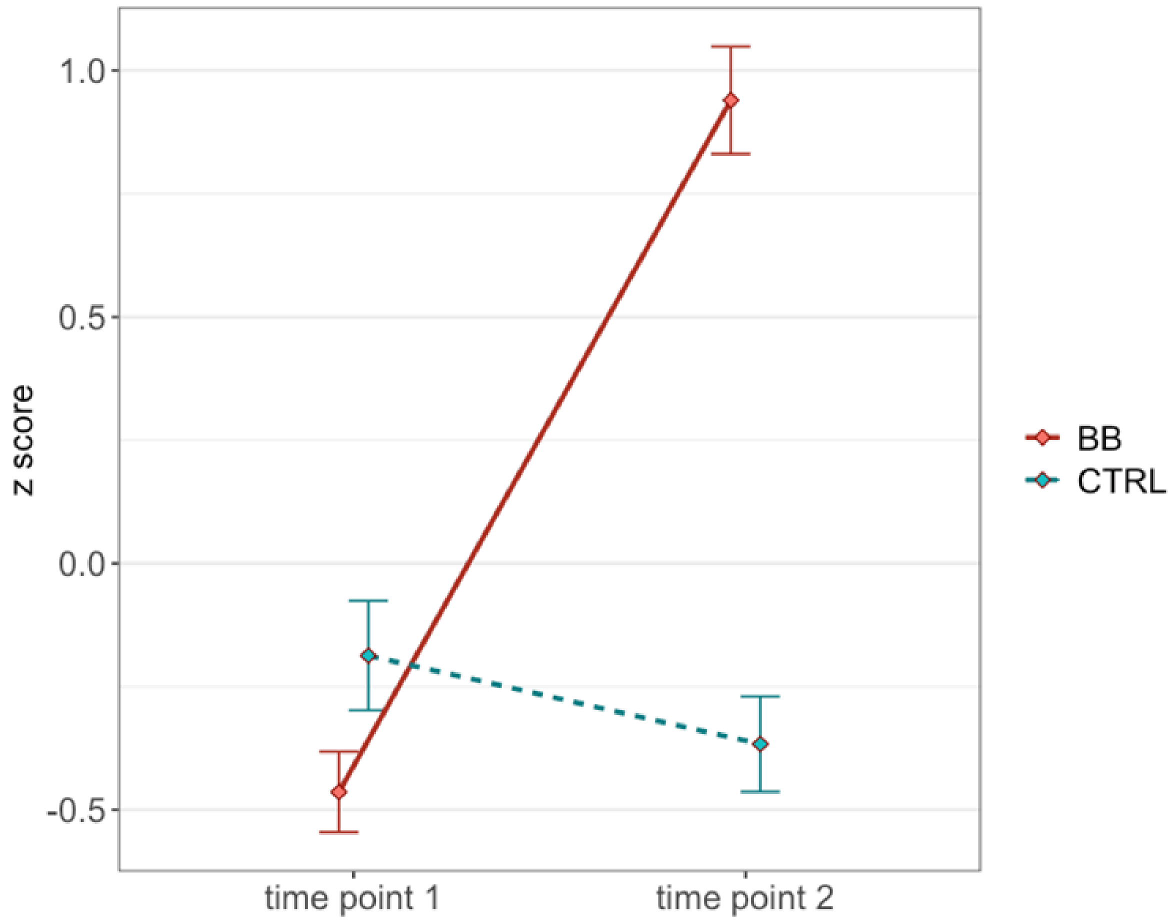

Figure 2. *Significant interaction between treatment group and time point in sensory motor tasks.*

Figure 3 displays the interaction between measurement name and treatment group in sensory motor scores.

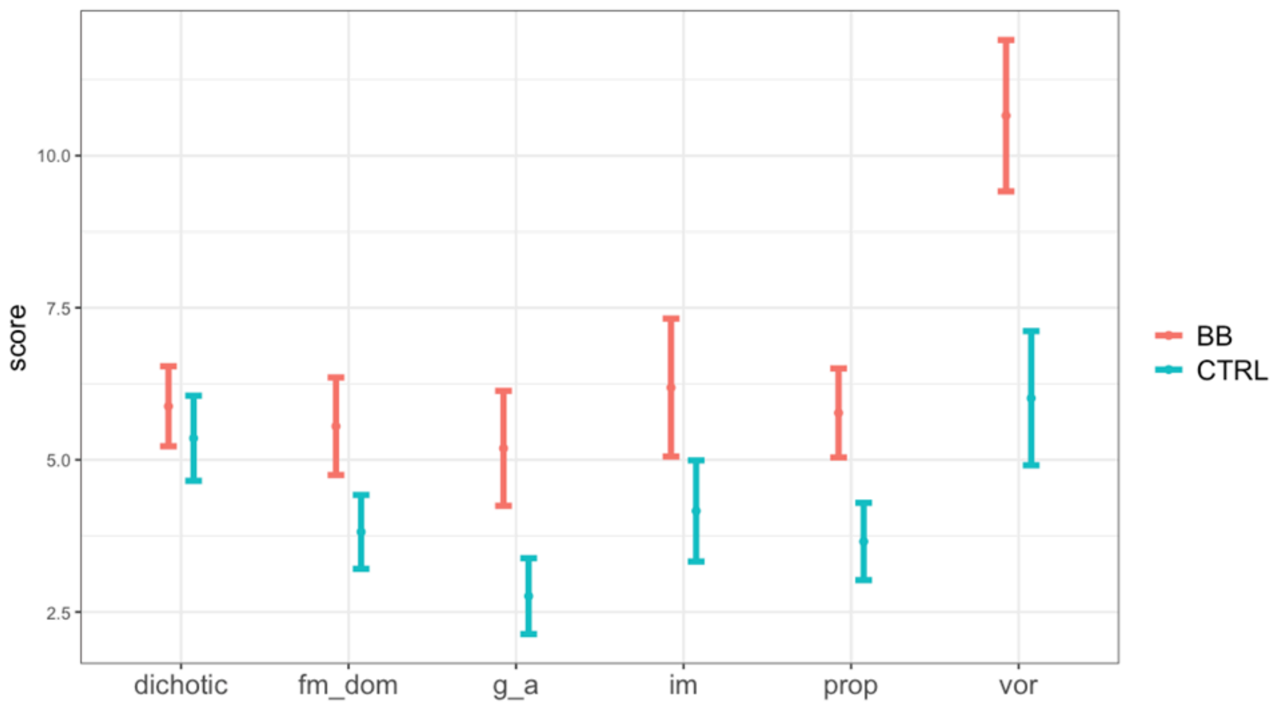

Figure 3. *Interaction between measurement name and treatment group in sensory motor scores.*

Discussion

This study evaluated developmental sensory motor outcomes in children and adolescents with ASD who participated in the Brain Balance program, an integrative, multimodal training program. Participants in the Brain Balance (BB) group demonstrated statistically significant improvements compared to a non-intervention (CTRL) group in two domains: maturation of developmental reflexes and sensory motor outcome measures.

Developmental Reflex Maturation

Participants in the Brain Balance group exhibited marked improvements in the maturation of the asymmetric tonic neck reflex, Landau reflex, and Moro reflex at post-training when compared to the baseline measured prior to the start of the program, whereas the CTRL group did not exhibit significant integration for any of these reflexes in the follow-up assessment. More importantly, such improvements were achieved while baselines from the two groups did not differ significantly, suggesting training positively impacted postural control and sensorimotor integration (Chandradasa & Rathnayake, 2020).

In contrast, the BB group had retained more of the palmar, rooting, spinal, and tonic labyrinthine reflexes than the CTRL group at baseline but was able to decrease to the same degree after training. Improvements in these reflexes may be particularly meaningful given their associations with motor coordination, attention, and emotional regulation in early childhood development (Hatoum, 2023; Stuhr et al., 2020).

Sensory Motor Skills Enhancement

Among sensory motor measures, the BB group showed significant gains in tasks assessing body coordination, balance, gaze stability, rhythm and timing, and fine motor skills. These domains are known to be disrupted in ASD and are thought to be linked to higher-order cognitive and executive functions (Miller et al., 2023; Deng et al., 2023).

Notably, the dichotic listening task did not show significant improvement, highlighting potential limitations of the current intervention in addressing auditory processing skills, or suggesting that longer intervention duration or complementary auditory-based therapies may be required for this domain.

Relationship to Existing Research

These findings are consistent with and extend prior research on the Brain Balance program, which reported similar improvements across a broader population (Jackson & Jordan, 2023; Jackson & Glanz, 2023). The current study is the first to focus specifically on a cohort with a confirmed ASD diagnosis, thereby contributing novel data to the literature on motor development interventions in this population.

The positive changes observed in vestibular and sensory motor functions align with the growing body of literature supporting the interdependence between motor development and cognitive-emotional outcomes in neurodevelopmental disorders (Bradshaw et al., 2022; Hatoum, 2023). Improvements in foundational sensory motor systems could enhance the development of executive functions such as inhibitory control, working memory, and cognitive flexibility—capacities often impaired in ASD and closely tied to daily functioning and adaptive behavior.

Clinical Implications

Although ASD is a complex neurodevelopmental condition with far-reaching impacts, evidence that improving key measures of foundational sensory motor development in students presenting with immaturity in these measures is possible provides another evidence-based option to support and mature development to better support outcomes in higher-level development for students with ASD.

Key finding

The results of this study suggest that children and adolescents with ASD who have measurable sensory motor developmental delays can experience significant improvements in these foundational areas through comprehensive, targeted intervention. Because sensory motor development scaffolds higher-order cognitive functions—including attention, working memory, and executive functioning—gains in these foundational areas may support broader developmental progress. This approach represents a complement to existing ASD interventions, addressing an aspect of development that is present in the vast majority of children with ASD (79%) yet rarely documented or treated. Families seeking comprehensive support for their children with ASD may benefit from assessments that include developmental reflexes and sensory motor skills, followed by targeted intervention when immaturity in these areas is identified.

Limitations

While the present study provides promising evidence for the efficacy of the Brain Balance program in enhancing motor development in children with ASD, it is important to interpret the results in light of several limitations.

First, as a retrospective analysis, the study lacks random assignment and may be subject to selection bias. Families who chose to enroll in the Brain Balance program may differ in meaningful ways from those who did not, including motivation, resources, or severity of symptoms.

Second, parent-reported outcomes, academic performance, and direct cognitive assessments of attention, memory, logic, and verbal ability were not included, limiting the ability to assess functional generalization of motor gains to real-world outcomes. While improvements in foundational sensory motor systems are theoretically linked to higher-order cognitive functions, this study did not directly measure whether motor gains translated to improvements in daily functioning, academic performance, or core ASD symptoms.

Third, although families were encouraged to implement home-based exercises and nutritional guidance, adherence to these components was not systematically tracked, leaving their contribution to the observed effects unclear. The multi-component nature of the program makes it difficult to determine which specific elements were most responsible for the improvements observed.

Future Research Directions

Future randomized controlled trials should address these limitations by incorporating:

- Standardized cognitive and behavioral outcome measures
- Parent and teacher reports of functional skills and core ASD symptoms
- Academic performance metrics
- Systematic tracking of fidelity of home program implementation
- Long-term follow-up to assess maintenance of gains
- Exploration of the potential mediating role of motor development in broader functional improvements

It would also be valuable to examine individual differences in treatment responsiveness to identify subgroups of children who may benefit most from this intervention approach. Investigating dose-response relationships (e.g., optimal program duration and frequency) could help optimize intervention protocols.

Conclusions

In conclusion, this study adds to the emerging evidence base suggesting that interventions targeting sensory motor development may offer meaningful benefits for children with ASD. By improving foundational sensory motor functions, the Brain Balance program may support broader developmental outcomes, potentially mitigating core and associated features of ASD.

The findings are particularly noteworthy given that 79% of children with ASD have developmental coordination disorder, yet only approximately 1% have motor deficits documented by clinicians. This study demonstrates that when these delays are formally assessed and systematically addressed through comprehensive, multimodal intervention, significant improvements are possible.

Continued investigation of multimodal developmental interventions holds promise for addressing the complex, multifactorial needs of individuals with ASD across developmental stages. As the field moves toward more comprehensive approaches to ASD intervention, attention to foundational sensory motor development—and its relationship to higher-order cognitive and behavioral functioning—represents an important and underutilized avenue for supporting children and families affected by autism spectrum disorder.

Author Contributions

This work was carried out in collaboration between both authors. Author RJ designed the study, provided the Brain Balance protocol, and contributed to the manuscript. YM performed the statistical analyses and interpretation of the data, creation of figures and tables, and manuscript writing. Both authors read and approved the final manuscript.

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