WHITE PAPER

Sensory Motor Intervention and Multi-Domain Developmental Outcomes in Autism Spectrum Disorder

Severity-Stratified Evidence from a Large Observational Cohort

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N = 875 · Ages 4–17 · 115 U.S. Centers · 2014–2024

EXECUTIVE SUMMARY

Motor development is a foundational layer of neurodevelopmental health — one that scaffolds attention, executive function, and social communication. Yet in autism spectrum disorder (ASD), motor deficits are present in up to 79% of children and documented clinically in fewer than 1% of cases. That gap represents one of the most consequential missed opportunities in ASD care today.

This white paper presents findings from a large observational study of 875 children and adolescents with ASD (ages 4–17) who completed and average of 6 months (72 sessions) of the Brain Balance program across 115 U.S. centers between 2014 and 2024. The study examined change across three domains: objective sensory motor performance, primitive reflex integration, and parent-reported behavioral and developmental outcomes.

The headline finding is straightforward: targeting the foundational layer works — and its effects reach further than the target. Social communication, the defining feature of ASD, was not a direct focus of Brain Balance intervention. Yet 73.6% of parents reported meaningful improvement, with a medium effect size that was largest among students who entered with the greatest degree of impairment.

875	115	73.6%
children & adolescents ages 4–17 with ASD	**U.S. Brain Balance centers** 2014–2024	**parents reported improvement** in social communication

These findings are grounded in a prior controlled study (Brain Balance internal research report, 2025) that established the same sensory motor improvements are attributable to the Brain Balance program rather than typical developmental maturation — providing the causal foundation that makes this larger dataset interpretable.

The Problem: A Foundational Gap Nobody Is Treating

If you've sought support for a child with ASD, you've likely encountered the same landscape: applied behavior analysis, speech-language therapy, social skills groups, occupational therapy. These are valuable interventions — but nearly all of them work at the level of the symptom. They target the behaviors and communication patterns that define ASD.

What they typically don't target is the layer underneath.

Motor development — the maturation of foundational sensory and movement systems — is increasingly recognized as a critical but under-addressed aspect of ASD. Research shows that developmental coordination disorder (DCD) co-occurs with ASD in up to 79% of children, with an additional 10% falling just below the clinical threshold (Harrison et al., 2021). Motor deficits are not incidental to ASD. They appear early, they are pervasive, and they matter.

> **Clinical context**
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> Despite the high prevalence of motor deficits in ASD, they are documented by clinicians in only approximately 1% of cases (Miller et al., 2023). The gap between prevalence and documentation is not a data problem — it reflects a conceptual model that treats motor development as peripheral. That model needs updating.

Why does this matter beyond walking, running, and catching a ball? Because motor development and executive function are functionally intertwined (Stuhr et al., 2020). The three primary executive functions — inhibitory control, working memory, and cognitive flexibility — are the same capacities that are impaired in ASD and that directly underpin social communication and behavioral regulation. Maturing the foundational motor layer is not just about improving coordination. It is a plausible pathway to improving the features that define the condition.

This is the developmental cascade hypothesis: strengthen the foundation, and the higher floors follow. The data in this paper provide real-world evidence for that pathway at scale.

The Brain Balance Approach

Brain Balance is a comprehensive, multi-sensory developmental program that focuses on assessing and improving foundational sensory motor systems. The program targets the developmental layer beneath behavior — primitive reflex integration, vestibular and proprioceptive function, rhythm and timing, auditory processing, fine motor coordination, and gait — with the understanding that maturing this foundation supports the higher-order cognitive and behavioral capacities that children with ASD need to develop.

Each Brain Balance program is individualized based on a student's pre-assessment performance. Students in this study attended three in-center sessions per week, for an average of six months, and completed complementary daily exercises at home. Sessions include:

- Passive sensory stimulation — tactile, olfactory, visual, and auditory input
- Primitive and postural reflex exercises — targeting retained developmental reflexes identified at assessment

- Proprioceptive and balance training — using rocker boards and one-leg balance progressions
- Rhythm and timing exercises — including the Interactive Metronome®
- Vestibular exercises — rotational and translational stimulation exercises
- Fine motor activities — Purdue Pegboard and palmar grasp strengthening
- Gait and coordination training — cross-crawl march patterns and jump rope progressions
- Auditory and visual processing activities

The program is progressive: each activity advances in complexity as a student demonstrates mastery at their current level, defined as successful completion across three consecutive sessions. Families also receive directions on daily home exercises, access to nutrition coaching and screen time guidance as part of a whole-child support framework.

Brain Balance does not diagnose, and the program is not designed as a treatment for ASD. It is designed to address the measurable foundational developmental gaps that are present — regardless of diagnosis — in children presenting with developmental, attentional, behavioral, or academic challenges.

What We Measured

This retrospective study draws on program data from 875 children and adolescents with parent-reported ASD diagnoses who completed the Brain Balance program at 115 U.S. centers between 2014 and 2024. All students were between the ages of 4 and 17 at the time of their initial assessment. Every student in this analysis has both a pre-program assessment and a post-program assessment, which greatly reduced the sample size of students in this study.

Objective sensory motor assessment

Six areas of sensory motor development were assessed using standardized protocols, scored on a 0–15 scale where higher scores reflect better performance:

- Rhythm and timing — Interactive Metronome® long-form assessment
- Gaze stability — vestibular ocular reflex (VOR) manual test
- Balance and proprioception — rocker board and one-leg balance progressions
- Auditory processing — dichotic listening dual-word task
- Fine motor skills — Purdue Pegboard timed assembly
- Gait and aerobic ability — cross-crawl march and jump rope progressions

Primitive reflex integration

Eight primitive and postural reflexes were assessed on a 0–4 scale (0 = fully integrated; 4 = significant retained response). For reflexes with bilateral or multi-position scoring, the highest score is used — capturing the most severe expression of retention, which is the clinically relevant

measure. The reflexes assessed were: Tonic Labyrinthine (TLR), Asymmetric Tonic Neck (ATNR), Moro, Rooting, Palmar, Spinal Galant, Symmetric Tonic Neck (STNR), and Landau.

Parent-reported outcomes — BB-MDDS

Parent-reported outcomes were measured using the Brain Balance Multi-Domain Developmental Survey (BB-MDDS), a validated instrument with published factor structure and measurement invariance (Jackson & Jordan, 2023). Items are scored 0–10, with higher scores indicating greater concern. For this analysis, scores are inverted — so higher scores represent improvement (less concern). The BB-MDDS captures six validated domains:

Domain	What parents are rating
Negative Emotionality	Anxiety, worry, mood, hurt feelings, self-esteem
Reading/Writing Problems	Phonics, word recognition, spelling, independent reading
Academic Disengagement	Motivation, homework completion, consistency, careless errors
Hyperactive/Disruptive	Impulsivity, erratic behavior, opposition, difficulty sitting
Motor/Coordination Problems	Clumsiness, balance, coordination, gross motor skills
Social Communication Problems	Reading body language, empathy, humor, friendships, pragmatics

Parent-reported post-assessment data was available for n=468 students (53.5% of the full cohort), consistent with typical post-program survey completion patterns.

Results

Effect sizes are reported as Cohen's d — a standardized measure of how much change occurred relative to the variability in scores. The conventional benchmarks used throughout this paper are:

Small effect d = 0.20–0.49	**Medium effect d = 0.50–0.79**	**Large effect d ≥ 0.80**	**Negligible d < 0.20**

Sensory motor performance: large improvements across the board

Every sensory motor domain showed a large effect size — meaning the change observed was not only statistically meaningful but clinically substantial. Students who entered with near-zero scores in gait and coordination left the program with scores in the mid-range of the 0–15 scale. Across all six domains, the pattern is consistent: the foundation moved.

Domain	Pre (mean)	Post (mean)	Improvement	Cohen's d	Effect size
Interactive Metronome (rhythm & timing)	2.73	7.51	+4.78	+1.12	**Large**
VOR (gaze stability)	3.78	10.12	+6.34	+1.31	**Large**
Proprioception (balance)	2.50	5.33	+2.83	+1.16	**Large**
Dichotic Listening (auditory processing)	3.51	6.20	+2.69	+1.00	**Large**
Fine Motor	2.73	6.58	+3.85	+1.23	**Large**
Gait / Aerobic	1.97	6.86	+4.89	+1.51	**Large**

Key finding

All six sensory motor domains showed large effect sizes (d = 1.00–1.51). These findings are consistent with our prior controlled study, which established that these improvements are attributable to the Brain Balance program rather than typical developmental maturation.

Primitive reflex integration: meaningful improvement in all eight reflexes

For retained primitive reflexes, the goal is integration — lower scores at post-assessment mean the reflex is less active, indicating more mature neurological development. All eight reflexes showed meaningful improvement. Six of eight showed large effect sizes; the remaining two (Palmar and Spinal Galant) showed medium effects.

Reflex	Pre (mean)	Post (mean)	Change	Cohen's d	Effect size
TLR (Tonic Labyrinthine)	2.43	1.40	-1.03	-0.84	**Large**
ATNR (Asymmetric Tonic Neck)	2.66	1.61	-1.05	-0.91	**Large**
Moro	3.10	1.90	-1.20	-0.91	**Large**
Rooting	2.33	1.24	-1.09	-0.84	**Large**
Palmar	2.20	1.28	-0.92	-0.75	**Medium**
Spinal Galant	2.19	1.15	-1.04	-0.77	**Medium**
STNR (Symmetric Tonic Neck)	2.35	1.16	-1.19	-0.95	**Large**
Landau	2.61	1.04	-1.57	-1.19	**Large**

The Landau reflex showed the strongest integration (d = -1.19), consistent with findings from our controlled study. The Moro reflex — often associated with heightened stress reactivity and sensory

sensitivity — showed a large effect (d = -0.91), a finding that carries particular clinical relevance for a population with elevated sensory processing challenges.

Parent-reported outcomes: improvement across all developmental domains

Parent-reported data represents the most direct measure of real-world change — the shifts families observe at home, at school, and in social settings. Every domain of the Brain Balance -Multi Domain Developmental Survey (BB-MDDS) improved. The results below reflect n=468 students with both pre- and post-parent survey data (scores inverted; higher = better).

Domain	Pre	Post	Improvement	Cohen's d	Effect size	% Reporting improvement
Negative Emotionality	6.04	6.82	+0.78	+0.32	**Small**	60.0%
Reading/Writing	6.49	7.09	+0.60	+0.39	**Small**	61.3%
Academic Disengagement	5.20	6.56	+1.36	+0.50	**Medium**	66.2%
Hyperactive/Disruptive	4.55	6.04	+1.49	+0.62	**Medium**	71.6%
Motor/Coordination	5.86	6.75	+0.89	+0.40	**Small**	62.0%
Social Communication	3.91	5.12	+1.21	+0.58	**Medium**	73.6%
Overall composite	**5.34**	**6.38**	**+1.04**	**+0.63**	**Medium**	**74.6%**

Key finding

Social Communication — the defining feature of ASD and the lowest-rated domain at intake — showed a medium effect size (d = +0.58) and the highest proportion of parents reporting improvement (73.6%) of any domain. This domain was not a direct target of Brain Balance intervention.

The overall composite effect size of d = +0.63 (medium, with 74.6% of parents reporting improvement) reflects meaningful real-world change across a heterogeneous, real-world population of children with ASD.

The Severity Story: Bigger Gaps, Bigger Gains

One of the most consistent findings across Brain Balance research is that students who enter with the largest developmental gaps show the largest improvements. This severity-gradient effect, documented previously in the broader Brain Balance population (Jackson & Jordan, 2023), replicates here in an ASD-specific cohort — and with a methodological advantage that strengthens confidence in the finding.

How we measured severity

We built two entirely independent measures of baseline severity, then ran each analysis separately and compared the results:

- Objective severity — based on pre-program sensory motor and reflex assessment scores (the foundational developmental layer)
- Parent-reported severity — based on pre-program BB-MDDS scores (the functional behavioral layer)

These two measures are statistically uncorrelated (r = -0.054). A child who tests as severely impaired on sensory motor measures is no more or less likely to be rated as severely impaired by their parents on behavioral measures. They are capturing genuinely different dimensions of the ASD presentation — which is exactly why using both is more informative than either alone.

What the severity gradient looks like

When students are grouped into low, moderate, and high severity tertiles by parent-reported baseline severity, a clear and consistent gradient emerges across every BB-MDDS domain. The pattern is steepest — and most clinically significant — in the domains most tied to executive function:

Domain	Low severity	(effect size)	Moderate severity	(effect size)	High severity	(effect size)
Neg. Emotionality	d = +0.02	Negligible	d = +0.44	Small	d = +0.46	Small
Reading/Writing	d = +0.02	Negligible	d = +0.30	Small	d = +0.84	Large
Academic Disengagement	d = +0.15	Negligible	d = +0.53	Medium	d = +0.80	Large
Hyperactive/Disruptive	d = +0.34	Small	d = +0.60	Medium	d = +0.92	Large
Motor/Coordination	d = +0.16	Negligible	d = +0.32	Small	d = +0.69	Medium
Social Communication	d = +0.29	Small	d = +0.59	Medium	d = +0.89	Large

The low severity group shows small-to-negligible effects — consistent with near-ceiling starting scores; there is less room to gain when you are already close to the top. The high severity group shows large effects in Reading/Writing, Academic Disengagement, Hyperactive/Disruptive behavior,

and Social Communication. This is not a regression-to-the-mean artifact — it is a coherent pattern that reflects who benefits most from strengthening the developmental foundation.

> **Why the gradient matters for families**
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> The students who typically have the hardest time — those with the most severe presentations across behavioral and developmental domains — are also the students who show the largest gains. This is consistent with what we know about neuroplasticity: the developing brain responds most dramatically when the gap between current function and potential is greatest, and when a targeted intervention systematically addresses the underlying gap.

Cross-validation: the finding holds across both severity measures

When we examine Social Communication gains simultaneously across both severity composites, the dominant pattern is driven by parent-reported severity (the rows run left to right with increasing effect size). But objective motor/reflex severity contributes additional independent signal — the students with high impairment on both dimensions show the largest social communication gains of any subgroup (d = +0.99 to +1.03, large effect).

The independent replication of this gradient — using two non-redundant, uncorrelated measures of baseline impairment — substantially strengthens confidence that what we are observing is a real and robust relationship between baseline severity and treatment response.

What This Means

For the field

The developmental cascade framework — the idea that maturing foundational motor systems produces downstream gains in executive function and the behaviors that depend on it — has theoretical support in the literature. What has been missing is empirical demonstration at scale, in a real-world intervention context, with a diagnosis-specific population. This study contributes that.

The fact that social communication improved meaningfully despite not being a direct intervention target is not a coincidence. It is a prediction of the cascade model, confirmed in data from 875 children across 115 centers over a decade. The domains that showed the largest effects and steepest severity gradients — Hyperactive/Disruptive behavior, Social Communication, Academic Disengagement — are precisely those most dependent on the executive functions that motor development scaffolds.

For assessment and clinical practice

Motor development deficits are present in the vast majority of children with ASD and nearly absent from their clinical documentation. The implication is not that clinicians are overlooking something obvious — it is that the current standard of care does not include formal sensory motor assessment as a routine component of ASD evaluation. These findings suggest it should.

Assessing both foundational (sensory motor and reflex) and functional (behavioral and developmental) severity at intake provides a more complete picture of a child's developmental profile — and, as this data shows, both dimensions independently predict treatment responsiveness. Knowing where a child falls on both dimensions has real implications for prognosis and program planning.

For families

The children who showed the largest gains in this study were not the mildest cases. Even students presenting with significant developmental gaps — severity, retained primitive reflexes, low sensory motor scores, demonstrated measurable and meaningful change. The data presented here suggests that addressing foundational developmental gaps may produce meaningful change across multiple domains of function, including in the areas that are hardest: social communication and behavioral regulation.

Study Limitations

Rigorous science requires honest acknowledgment of what a study can and cannot establish. The following limitations are important context for interpreting these findings.

- This large-N study does not include a control group. This is addressed by our prior controlled study (Brain Balance internal research report, 2025), which demonstrated that the improvements reported here are not explained by typical maturation over a comparable time period. The two studies are designed to work together: the controlled study establishes causal attribution; this study establishes scale and functional breadth.
- Parent-reported post-survey data was available for 53.5% of the analytic sample. This is consistent with typical survey completion rates in real-world program settings and does not appear to introduce systematic demographic bias, but it limits the precision of parent-reported estimates.
- The sample is predominantly male (80.9%), reflecting the population of children enrolled at Brain Balance and the broader male prevalence in ASD diagnosis. Gender-stratified analyses are planned for future reporting.
- At home exercises, and nutritional and screentime recommendations are made for all program participants. The degree of applying these recommendations is unknown, and future studies need to add at-home implementation tracking to better understand the impact of the home and lifestyle recommendations on program outcomes.

Conclusion

Motor development in ASD is not a peripheral concern. It is a foundational developmental layer that is impaired in the vast majority of children with this diagnosis, nearly invisible in clinical documentation, and — as this data demonstrates — responsive to targeted intervention in ways that extend beyond the motor domain itself.

Across 875 children and adolescents with ASD, the Brain Balance program produced large improvements in sensory motor performance and primitive reflex integration. It produced meaningful parent-reported improvements across all six developmental domains of the BB-MDDS — including Social Communication, which defines the diagnosis and was not a direct program target. And it did so in a severity-dependent pattern: the children who entered with the greatest developmental gaps showed the largest gains.

The developmental cascade model offers a compelling and testable explanation for these findings. When you strengthen the foundational layer, the higher floors follow. These data, drawn from real-world program delivery at scale, provide the largest ASD-specific evidence base yet reported for that model.

The implications for assessment, clinical practice, and family decision-making are straightforward: motor development belongs in the conversation about ASD care. Systematically assessing and addressing foundational sensory motor gaps — alongside the behavioral and communication-focused interventions that currently dominate the field — represents an evidence-based and underutilized pathway to broader developmental progress.

About the Author

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Rebecca Jackson is a Doctor of Chiropractic with 17 years of experience in neurodevelopmental health and the Chief Program Officer at Brain Balance, where she oversees program strategy and research across 70+ locations nationwide. Her work sits at the intersection of functional neuroscience and real-world clinical outcomes — she believes the most important question in developmental research is not just whether something works in a controlled setting, but whether objective measurable changes in development translate to meaningful impact in daily life.

Rebecca has authored eight peer-reviewed studies on neurodevelopmental outcomes, is a Mayo Clinic Press author (Back on Track), and has presented at venues including the U.S. Senate Brain Health Summit. She has conducted and published research on Brain Balance program outcomes including controlled-group studies and long-term follow-up analyses.

Her research focus increasingly centers on what she calls the foundational layer of development — the sensory motor systems that scaffold attention, executive function, and the behavioral and social capacities that families are most concerned about — and on what happens when those systems are specifically and systematically addressed in neurodevelopmental care.

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