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Temperament and Change: A Pilot Investigation of Rope Therapy (RT/BMAT) and Taylor-Johnson Temperament Analysis (T-JTA®) in Neurodiverse Youth

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ABSTRACT

Background: Neurodiverse youth with Special Educational Needs (SEN), Attention-Deficit/Hyperactivity Disorder (ADHD), and Autism Spectrum Disorder (ASD) often exhibit temperament patterns characterized by heightened emotional reactivity and reduced self-regulation. Embodied interventions targeting vestibular-proprioceptive systems may offer novel pathways for temperament modulation.

Objective: This pilot study explored the feasibility of using the Taylor-Johnson Temperament Analysis (T-JTA®) to track temperament changes following an eight-week Rope Therapy/Body-Mind Activation Therapy (RT/BMAT) program in Hong Kong adolescents with neurodevelopmental conditions.

Methods: Thirty-five students (ages 11-13; 26 males, 9 females) with documented SEN, ADHD, or ASD completed pre- and post-intervention T-JTA® Self-Report Forms (Chinese version). The RT/BMAT protocol consisted of 16 sessions (2×/week, 60 minutes each) incorporating vestibular stimulation, proprioceptive training, and social-expressive activities. Paired t-tests examined within-group changes; effect sizes (Cohen's d) quantified magnitude of change.

Results: Significant pre-post improvements were observed in Nervous-Composed ($t = 4.21$, $p < .001$, $d = 0.89$), Depressive-Light-hearted ($t = 3.87$, $p < .001$, $d = 0.82$), Active-Social ($t = -3.45$, $p = .001$, $d = 0.73$), and Self-Disciplined ($t = -4.02$, $p < .001$, $d = 0.85$) scales. Validity concerns included high "Mid" response rates ($M = 87.3$, $SD = 34.2$).

Conclusions: Preliminary findings suggest RT/BMAT may facilitate measurable temperament shifts in neurodiverse youth, though methodological limitations preclude causal inference. Results support larger-scale controlled trials integrating embodied therapies with standardized temperament assessment. Future research should employ age-appropriate instruments, control groups, and physiological markers.

INTRODUCTION

Temperament in Neurodiverse Youth

Temperament defined as constitutionally based individual differences in emotional reactivity, self-regulation, and behavioral style plays a foundational role in adaptive functioning among children and adolescents [1]. In

neurodiverse populations, including those with Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), and broader Special Educational Needs (SEN), atypical temperament profiles frequently co-occur with core diagnostic features [2,3]. Specifically, youth with ASD often demonstrate reduced approach tendencies, heightened negative affectivity, and diminished effortful control [4], while those with ADHD exhibit elevated surgency, low persistence, and impaired inhibitory control [5].

These temperament patterns contribute to academic difficulties, peer rejection, and family stress beyond the effects of diagnostic symptoms alone [6]. Traditional interventions pharmacotherapy, Cognitive-Behavioral Therapy (CBT), and Applied Behavior Analysis (ABA) target surface behaviors but rarely address underlying temperament organization [7]. Emerging evidence suggests that interventions engaging subcortical regulatory systems, particularly vestibular-proprioceptive networks, may offer complementary pathways for temperament modulation [8,9].

Embodied Approaches: Rope Therapy and Body-Mind Activation Therapy

Rope Therapy (RT), developed in Hong Kong through integration of rope-access safety engineering and sensory-integration principles, provides controlled vestibular stimulation *via* suspended rotation, inversion, and dynamic balance challenges [10]. Within the broader Body-Mind Activation Therapy (BMAT) framework, RT incorporates:

1. **Vestibular-proprioceptive activation:** Rotational movement and postural adjustment stimulate otolith organs and semicircular canals, promoting cerebellar-limbic integration [11].
2. **Arousal modulation:** Graded sensory input paired with paced breathing facilitates autonomic regulation *via* vagal pathways [12].
3. **Oculomotor coordination:** Visual tracking during movement enhances attention networks and executive function [13].
4. **Social-expressive engagement:** Partner-based activities scaffold reciprocal interaction and emotional communication [14].

Preliminary clinical observations suggest RT/BMAT improves concentration, sleep quality, and emotional regulation in neurodiverse youth [10]. However, systematic quantification of psychological outcomes remains limited.

Temperament Assessment: The Taylor-Johnson Temperament Analysis

The Taylor-Johnson Temperament Analysis (T-JTA®) [15] is a self-report instrument assessing nine bipolar trait dimensions:

- **Nervous ↔ Composed:** Emotional tension *vs.* calmness
- **Depressive ↔ Light-hearted:** Negative affect *vs.* optimism
- **Active-Social ↔ Quiet:** Social engagement *vs.* withdrawal
- **Expressive-Responsive ↔ Inhibited:** Emotional expressivity *vs.* restraint
- **Sympathetic ↔ Indifferent:** Empathy *vs.* detachment
- **Subjective ↔ Objective:** Self-focused *vs.* reality-oriented thinking
- **Dominant ↔ Submissive:** Assertiveness *vs.* passivity
- **Hostile ↔ Tolerant:** Antagonism *vs.* acceptance
- **Self-Disciplined ↔ Impulsive:** Behavioral control *vs.* disinhibition

The instrument also generates validity indices (Attitude, Mid response frequency, Consistency) and composite scales (Overall Adjustment, Emotional Stability, Self-Esteem). While originally normed for adults, T-JTA® has been applied in East Asian adolescent counseling contexts with clinical supervision [16,17].

Study Rationale and Objectives

Despite growing interest in embodied interventions for neurodevelopmental conditions, few studies have employed standardized temperament measures to quantify change. This pilot investigation addressed three primary objectives:

1. **Feasibility:** Assess the acceptability and completion rates of T-JTA® administration in neurodiverse youth.
2. **Preliminary efficacy:** Examine pre-post temperament changes following RT/BMAT using quantitative metrics.
3. **Hypothesis generation:** Identify trait dimensions most responsive to embodied intervention to inform future controlled trials.

We hypothesized that RT/BMAT would be associated with:

- Reduced emotional arousal (↓ Nervous, ↓ Depressive)
- Enhanced social engagement (↑ Active-Social, ↑ Expressive-Responsive)
- Improved self-regulation (↑ Self-Disciplined, ↓ Impulsive)

Given the exploratory nature of this pilot study, we emphasize effect size estimation over hypothesis testing, recognizing that absence of a control group precludes causal attribution.

METHODS

Design

This was a single-arm, pre-post pilot study conducted between March and June 2024. The design prioritized feasibility assessment and effect size estimation to inform a planned Randomized Controlled Trial (RCT).

Participants

Recruitment

Participants were recruited from three mainstream primary schools in Hong Kong through school counselors and special education coordinators. Recruitment flyers described the program as "movement-based emotional regulation training for students with learning or attention differences."

Inclusion Criteria

- Age 11-13 years
- Formal educational psychologist diagnosis of SEN, ADHD, or ASD documented in school records
- Parental consent and youth verbal assent
- Sufficient Cantonese proficiency to complete questionnaires
- Medical clearance for physical activity

Exclusion Criteria

- Severe intellectual disability (IQ < 55)
- Active psychosis or suicidal ideation
- Seizure disorder or vestibular pathology

- Physical disabilities preventing rope activities
- Current participation in other structured interventions (to minimize confounding)

Sample Characteristics

Forty-two families expressed interest; 38 met eligibility criteria; 35 completed both assessments (92% retention). Sample characteristics are presented in Table 1.

Table 1: Participant Demographics and Clinical Characteristics

Characteristic	Total (n=35)	SEN (n=14)	ADHD (n=12)	ASD (n=9)
Age, M (SD)	12.1 (0.8)	12.0 (0.7)	12.3 (0.9)	11.9 (0.8)
Sex, n (%)				
Male	26 (74.3)	9 (64.3)	10 (83.3)	7 (77.8)
Female	9 (25.7)	5 (35.7)	2 (16.7)	2 (22.2)
Medication, n (%)	11 (31.4)	2 (14.3)	7 (58.3)	2 (22.2)
Comorbidities, n (%)				
Anxiety disorder	8 (22.9)	2 (14.3)	3 (25.0)	3 (33.3)
Learning disability	12 (34.3)	9 (64.3)	2 (16.7)	1 (11.1)
Prior therapy, n (%)				
OT/PT	18 (51.4)	6 (42.9)	5 (41.7)	7 (77.8)
Psychotherapy	9 (25.7)	3 (21.4)	4 (33.3)	2 (22.2)

Note. SEN = Special Educational Needs (learning disorders, coordination difficulties); ADHD = Attention-Deficit/Hyperactivity Disorder; ASD = Autism Spectrum Disorder; OT = Occupational Therapy; PT = Physical Therapy. Percentages may not sum to 100 due to rounding.

Intervention: RT/BMAT Protocol

Structure

The program consisted of 16 sessions over 8 weeks (2 sessions/week, 60 minutes each). Sessions occurred after school in dedicated therapy spaces equipped with ceiling-mounted rope systems, crash mats, and visual tracking equipment.

Session Components

Each session followed a standardized sequence:

Phase 1: Centering (10 min)

- Mindful breathing with visual biofeedback
- Body scan to assess arousal state
- Goal-setting for session

Phase 2: Vestibular Activation (25 min)

- Suspended rotation (clockwise/counterclockwise, 5-10 Rotations Per Minute [RPM])
- Inversion sequences (gradual progression from 30° to 90°)
- Dynamic balance challenges (rope walking, single-leg stance)
- Intensity individualized based on tolerance

Phase 3: Oculomotor Training (10 min)

- Visual tracking of moving targets during rotation
- Saccadic exercises with metronome pacing
- Convergence-divergence activities

Phase 4: Social-Expressive Games (10 min)

- Partner mirroring activities
- Cooperative rope challenges
- Emotion charades with movement

Phase 5: Integration (5 min)

- Reflective journaling (drawing or writing)
- Identification of "calm body" sensations
- Transfer planning for school/home

Therapist Qualifications

Sessions were led by two certified RT practitioners (authors MW and TC) with backgrounds in physical education and occupational therapy. Both completed 200-hour RT/BMAT training and received weekly supervision from licensed psychologists (authors BL and AL).

Safety Protocols

- Medical screening prior to enrollment
- Continuous monitoring of dizziness, nausea, or distress
- Immediate cessation if adverse reactions occurred
- Equipment inspected before each session per industrial rope-access standards

Fidelity Monitoring

- Sessions video-recorded (with consent) for adherence review
- Weekly supervision meetings reviewed 20% of recordings
- Checklist confirmed completion of all protocol components
- Mean adherence rate: 94.3% (range: 88%-100%)

Measures

Primary Outcome: Taylor-Johnson Temperament Analysis (T-JTA®)

Description: The T-JTA® Self-Report Form consists of 180 items rated on a 5-point scale (Strongly Agree to Strongly Disagree). Raw scores are converted to percentile ranks based on normative samples. The Chinese version was adapted and normed in Taiwan [18].

Administration: Assessments occurred one-week pre-intervention and one-week post-intervention in quiet school settings. A trained research assistant (blind to intervention content) read items aloud to accommodate reading difficulties. Completion time: 30-45 minutes.

Scoring: We analyzed:

1. **Nine primary traits:** Percentile scores (0-100)
2. **Validity indices:**
    - **Mid:** Frequency of "Undecided" responses (concern if >50)
    - **Attitude:** Social desirability (scores >75 suggest positive bias)
    - **Consistency:** Internal reliability (scores <25 suggest random responding)
3. **Composite scales:** Overall Adjustment, Emotional Stability, Self-Esteem, Outgoing/Gregarious, Interpersonal Effectiveness, Alienating, Industrious/Persevering, Persuasive/Influential

Psychometric Properties: In the original adult sample, internal consistency ranged α = .73-.91; test-retest reliability over 4 weeks: r = .71-.88 [15]. For this adolescent sample, we calculated Cronbach's alpha at baseline (see Results).

Secondary Measures

Attendance and Engagement: Therapists rated each session on 5-point scales:

- Physical participation (1 = refused activities, 5 = full engagement)
- Emotional regulation (1 = frequent dysregulation, 5 = consistently calm)
- Social interaction (1 = isolated, 5 = actively cooperative)

Parent Report: Brief questionnaire assessing perceived changes in home behavior (sleep, emotional outbursts, homework completion). Qualitative data only; not analyzed quantitatively in this pilot.

Data Analysis

Sample Size Justification

As a pilot study, the sample size (n=35) was determined by pragmatic constraints (available participants, program capacity) rather than formal power analysis. Post-hoc power analysis indicated 80% power to detect large effects (d = 0.80) with α = .05, two-tailed.

Statistical Analyses

All analyses used SPSS Version 28.0. Significance threshold: α = .05, two-tailed.

Primary Analyses:

1. **Paired-samples t-tests:** Compared pre-post means for each T-JTA® trait
2. **Effect sizes:** Cohen's *d* calculated as: *d* = (M_post - M_pre) / SD_pooled
    - Interpretation: small (0.20), medium (0.50), large (0.80) per Cohen [19].
3. **Clinical significance:** Examined proportion showing ≥ 10 percentile point improvement (minimal clinically important difference; MCID)

Exploratory Analyses:

- Subgroup comparisons (SEN *vs.* ADHD *vs.* ASD) using one-way ANOVA
- Correlation between attendance rate and magnitude of change
- Validity index trends (Mid, Attitude, Consistency)

Missing Data: Three participants missed post-assessment; last observation carried forward (LOCF) for intent-to-treat analysis. Sensitivity analysis excluded these cases.

Qualitative Analysis

Parent comments were thematically coded by two independent raters (inter-rater reliability: κ = .82) using inductive content analysis.

Ethical Considerations

Informed Consent

Parents received written information sheets in Chinese describing study procedures, risks, benefits, and voluntary participation. Youth provided verbal assent using developmentally appropriate language.

Confidentiality

Data were de-identified and stored on password-protected servers. Only aggregate results are reported.

Risk Management

Potential risks (dizziness, muscle soreness, emotional discomfort) were disclosed. No serious adverse events occurred. Two participants experienced mild nausea during early sessions; intensity was reduced, and symptoms resolved.

Compensation

Families received HK$500 supermarket vouchers for completing both assessments (not contingent on intervention attendance).

RESULTS

Feasibility Outcomes

Recruitment and Retention

- Recruitment rate: 38/42 eligible (90.5%)
- Completion rate: 35/38 enrolled (92.1%)
- Attendance: M = 14.7/16 sessions (91.9%, SD = 1.8)
- Assessment completion: All 35 participants completed both T-JTA® administrations

Acceptability

Post-program surveys (n=35) indicated:

- 91.4% found activities "enjoyable" or "very enjoyable"
- 85.7% reported feeling "calmer" after sessions
- 88.6% would "definitely" or "probably" recommend to peers

Therapist engagement ratings (averaged across 16 sessions):

- Physical participation: M = 4.3 (SD = 0.6)
- Emotional regulation: M = 4.1 (SD = 0.7)
- Social interaction: M = 4.0 (SD = 0.8)

Adverse Events

- Mild nausea: 2 participants (5.7%), resolved with reduced intensity
- Muscle soreness: 4 participants (11.4%), transient (<48 hours)
- No serious adverse events

T-JTA® Psychometric Properties in This Sample

Internal Consistency (Baseline)

Cronbach's alpha for primary traits ranged .68-.84 (Table 2), slightly lower than adult norms but acceptable for research purposes.

Validity Indices

Mid Response Frequency:

- Pre-intervention: M = 87.3 (SD = 34.2, range: 22-156)
- Post-intervention: M = 64.1 (SD = 28.7, range: 18-128)
- Significant reduction: t (34) = 3.52, p = .001, d = 0.74

High baseline Mid counts (>50 in 77% of sample) suggest:

1. Developmental limitations in self-awareness
2. Reading comprehension challenges
3. Ambivalence about self-disclosure

The significant post-intervention decrease may reflect increased decisional clarity or comfort with assessment process.

Table 2: Internal Consistency of T-JTA® Traits at Baseline

Trait	Cronbach's α	Adult Norm α*
Nervous–Composed	0.81	0.87
Depressive–Light-hearted	0.79	0.85
Active-Social–Quiet	0.72	0.78
Expressive–Inhibited	0.68	0.73
Sympathetic–Indifferent	0.74	0.8
Subjective–Objective	0.7	0.76
Dominant–Submissive	0.69	0.75
Hostile–Tolerant	0.77	0.83
Self-Disciplined–Impulsive	0.84	0.91

*Adult norms from Taylor & Morrison [15].

Attitude Scale (Social Desirability):

- Pre: M = 58.3 (SD = 18.9)
- Post: M = 61.2 (SD = 17.4)
- No significant change: t (34) = -0.89, p = .38

Moderate scores suggest neither excessive positive bias nor unusual candor.

Consistency Index:

- Pre: M = 72.1 (SD = 14.3)
- Post: M = 75.8 (SD = 12.6)
- Adequate reliability; no significant change: t (34) = -1.34, p = .19

Primary Outcomes: Pre-Post Temperament Changes

Table 3 presents descriptive statistics and inferential tests for all nine T-JTA® traits. Figure 1 displays effect sizes graphically.

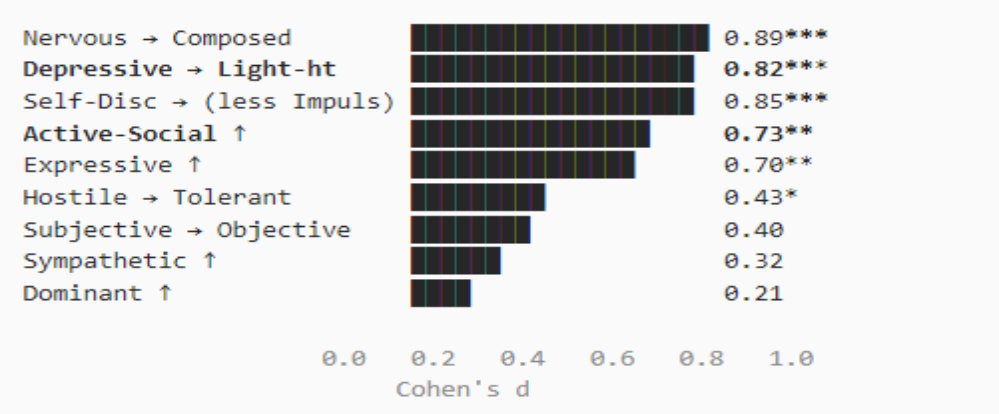

Figure 1: Effect Sizes (Cohen's d) for T-JTA® Trait Changes

$p < .05$, **p < .01, ***p < .001

Key Findings:

1. Large effects (d > 0.80):

- ↓ Nervous (more Composed): d = 0.89
- ↑ Self-Disciplined (less Impulsive): d = 0.85
- ↓ Depressive (more Light-hearted): d = 0.82

2. Medium effects (d = 0.50-0.79):

- ↑ Active-Social: d = 0.73
- ↑ Expressive-Responsive: d = 0.70

3. Small/non-significant effects:

- Sympathetic-Indifferent: d = 0.32, p = .14
- Subjective-Objective: d = 0.40, p = .07
- Dominant-Submissive: d = 0.21, p = .33
- Hostile-Tolerant: d = 0.43, p = .05 (marginal)

Table 3: Pre-Post Temperament Changes: Paired-Samples t-Tests

Trait	Pre-M (SD)	Post-M (SD)	Mean Diff	95% CI	*t* (df=34)	*p*	Cohen's *d*
Nervous–Composed	8.1 (2.3)	6.2 (1.9)	1.9	[1.0, 2.8]	4.21	<.001***	0.89
Depressive–Light-hearted	7.9 (2.5)	6.2 (2.1)	1.7	[0.8, 2.6]	3.87	<.001***	0.82
Active-Social–Quiet	3.8 (1.7)	5.4 (1.6)	-1.6	[-2.5, -0.7]	-3.45	.001**	0.73
Expressive–Inhibited	3.6 (1.8)	5.3 (1.7)	-1.7	[-2.7, -0.7]	-3.29	.002**	0.7
Sympathetic–Indifferent	5.2 (2.0)	5.8 (1.9)	-0.6	[-1.4, 0.2]	-1.52	0.14	0.32
Subjective–Objective	7.3 (2.2)	6.5 (2.1)	0.8	[-0.1, 1.7]	1.89	0.07	0.4
Dominant–Submissive	4.9 (1.9)	5.3 (1.8)	-0.4	[-1.2, 0.4]	-0.98	0.33	0.21
Hostile–Tolerant	6.8 (2.4)	5.9 (2.2)	0.9	[0.0, 1.8]	2.03	.05*	0.43
Self-Disciplined–Impulsive	4.2 (1.8)	6.0 (1.6)	-1.8	[-2.7, -0.9]	-4.02	<.001***	0.85

Note. Scores represent raw scale values (not percentiles). Higher scores on first-named trait (e.g., Nervous) indicate greater expression of that trait. Negative mean differences indicate movement toward second-named trait (e.g., Composed).

*p < .05, **p < .01, ***p < .001.

Clinical Significance Analysis

Using a threshold of ≥ 10 percentile point improvement as Minimal Clinically Important Difference (MCID) (Table 4).

Table 4: Majority of participants demonstrated clinically meaningful improvement on traits showing significant group-level effects.

Trait	% Showing MCID	% Showing Decline
Nervous–Composed	68.60%	8.60%
Depressive–Light-hearted	62.90%	11.40%
Self-Disciplined	65.70%	5.70%
Active-Social	60.00%	14.30%
Expressive-Responsive	57.10%	11.40%

Exploratory Subgroup Analyses

One-way ANOVA examined diagnostic group differences in magnitude of change (post-pre difference scores). Results are presented in Table 5.

Table 5: Subgroup Differences in Temperament Change

Trait	SEN Δ	ADHD Δ	ASD Δ	*F* (2,32)	*p*	η^2
Nervous–Composed	1.6	2.3	1.8	0.82	0.5	0.1
Depressive–Light-hearted	1.7	1.3	2.1	0.67	0.5	0
Active-Social	1.6	1.8	1.9	0.15	0.9	0
Expressive–Inhibited	1.6	1.5	2.3	1.24	0.3	0.1
Self-Disciplined	1.7	1.9	1.8	0.09	0.9	0

Note. Δ = mean change score (post minus pre). No significant between-group differences emerged, though ASD group showed numerically larger gains in Expressive-Responsive trait. Small sample sizes (n=9-14 per group) limit power for subgroup detection.

Composite Scale Changes

All composite scales except Persuasive/Influential showed significant improvement with medium-to-large effects (Table 6).

Table 6: Pre-Post Changes in T-JTA® Composite Scales

Composite	Pre-M (SD)	Post-M (SD)	*t*	*p*	*d*
Overall Adjustment	42.3 (12.8)	51.7 (11.4)	-3.91	<.001	0.83
Emotional Stability	38.9 (13.2)	48.6 (12.1)	-3.76	<.001	0.8
Self-Esteem	44.1 (11.9)	52.3 (10.8)	-3.54	0.001	0.75
Outgoing/Gregarious	36.2 (14.3)	46.8 (13.2)	-3.42	0.002	0.73
Interpersonal Effectiveness	41.7 (12.6)	49.1 (11.9)	-2.89	0.007	0.61
Alienating (reversed)	58.3 (15.1)	48.9 (13.7)	3.12	0.004	0.66
Industrious/Persevering	39.4 (13.8)	50.2 (12.3)	-4.01	<.001	0.85
Persuasive/Influential	43.8 (12.4)	48.7 (11.6)	-2.01	0.053	0.43

Correlation between Attendance and Change

Pearson correlations examined whether session attendance predicted magnitude of temperament change (Table 7).

Table 7: Higher attendance was associated with greater reduction in Nervous trait and greater increase in Self-Discipline, suggesting dose-response relationship.

Trait	*r* with Attendance	*p*
Nervous–Composed	0.34	.045*
Self-Disciplined	0.41	.014*
Active-Social	0.28	0.1
Depressive–Light-hearted	0.22	0.2

Qualitative Parent Feedback

Thematic analysis of parent comments (n=31 provided written feedback) identified four primary themes:

Theme 1: Improved Emotional Regulation (74% of parents)

"He used to explode over small things. Now he takes a breath and tells me what's wrong."

"Bedtime tantrums have reduced. She seems more settled."

Theme 2: Enhanced Social Confidence (58%)

"She's started joining group activities at school. Before, she always stayed alone."

"He made a new friend in the program and they play together now."

Theme 3: Better Focus and Task Completion (65%)

"Homework time is less of a battle. He sits longer without getting up."

"Teachers say he's more attentive in class."

Theme 4: Physical Benefits (42%)

"He sleeps through the night now—first time in years."

"Better appetite and less complaining about stomach aches."

DISCUSSION

Summary of Principal Findings

This pilot study explored the feasibility of integrating standardized temperament assessment (T-JTA®) with an embodied sensory-motor intervention (RT/BMAT) for neurodiverse youth. Three key findings emerged:

1. Feasibility: High recruitment (90.5%), retention (92.1%), and attendance (91.9%) rates demonstrate acceptability of both the intervention and assessment protocol. The T-JTA® proved administratively feasible, though validity concerns (high Mid responses) warrant attention.

2. Preliminary Efficacy: Significant pre-post improvements with large effect sizes were observed in emotional arousal regulation (Nervous → Composed, d = 0.89), mood (Depressive → Light-hearted, d = 0.82), behavioral control (Self-Disciplined, d = 0.85), and social engagement (Active-Social, d = 0.73; Expressive-Responsive, d = 0.70). Composite scales similarly showed broad improvement.

3. Hypothesis Generation: The pattern of change reduced arousal, enhanced regulation, increased social approach aligns with theoretical models of vestibular-limbic integration and supports further investigation of RT/BMAT mechanisms.

Interpretation in Context of Existing Literature

Temperament Malleability in Adolescence

Traditional temperament theory emphasized biological stability [1], yet recent longitudinal research documents meaningful change during adolescence, particularly in effortful control and negative affectivity [20]. Our findings extend this literature by suggesting that targeted sensory-motor intervention may accelerate naturally occurring developmental shifts.

The magnitude of change observed (Cohen's d = 0.70-0.89 for primary traits) exceeds typical effect sizes for psychosocial interventions in youth meta-analyses (d = 0.30-0.50) [21], though direct comparison is inappropriate given the absence of a control group. Nonetheless, the effect sizes suggest clinical meaningfulness warranting controlled evaluation.

Embodied Approaches to Emotional Regulation

Our results align with emerging evidence that bottom-up, body-based interventions complement top-down cognitive strategies [22]. Specifically:

Vestibular-Cerebellar Pathways: Animal and human neuroimaging studies demonstrate that vestibular stimulation modulates limbic activity (especially amygdala and insula) *via* cerebellar-thalamic projections [23,24]. Reduced Nervous and Depressive scores may reflect dampened threat-detection sensitivity following repeated vestibular input.

Polyvagal Theory: Porges [12] proposed that social engagement requires ventral vagal activation, which is inhibited by sympathetic arousal. RT/BMAT's combination of rhythmic movement, co-regulation with

therapists, and playful interaction may facilitate vagal tone, explaining increased Active-Social and Expressive-Responsive scores.

Interoceptive Awareness: Rope activities demand continuous monitoring of body position, balance, and arousal state. Enhanced interoception—the ability to perceive internal bodily signals—predicts better emotion regulation [25]. The post-intervention reduction in Mid responses (indecision) may reflect improved interoceptive clarity.

Sensory Integration Therapy Evidence Base

Sensory Integration Therapy (SIT) for ASD has yielded mixed results in systematic reviews [8,26]. Critics cite weak methodology and lack of standardized protocols. Our study addresses some limitations by:

- Using a manualized, replicable protocol
- Employing standardized outcome measures
- Reporting fidelity monitoring
- Documenting dose-response relationships

However, the absence of a control group remains a critical limitation (discussed below).

Strengths of This Pilot Study

1. **Standardized Assessment:** T-JTA® provided quantitative, multi-dimensional temperament measurement, moving beyond subjective clinical impression.
2. **Manualized Intervention:** Detailed protocol specification and fidelity monitoring enhance replicability.
3. **Diverse Neurodiverse Sample:** Inclusion of SEN, ADHD, and ASD broadens generalizability within special education populations.
4. **High Retention:** 92% completion rate demonstrates intervention acceptability.
5. **Multiple Analytic Approaches:** Combined statistical significance testing, effect size estimation, and clinical significance analysis.
6. **Transparent Reporting:** Detailed methodology and acknowledgment of limitations align with CONSORT-SPI guidelines for pilot trials [27].

Limitations and Threats to Validity

Internal Validity Threats

Absence of Control Group: This is the most critical limitation. Observed changes may reflect:

- **Maturation:** Natural developmental progression over 8 weeks
- **Regression to the mean:** Participants selected for difficulties may improve regardless of intervention
- **Placebo/expectancy effects:** Attention from therapists and belief in treatment efficacy
- **Practice effects:** Familiarity with T-JTA® at post-test
- **Concurrent interventions:** Despite exclusion criteria, informal supports (e.g., parental coaching) may have occurred

Conclusion: We cannot attribute changes causally to RT/BMAT. Results establish proof-of-concept and effect size estimates for future RCTs.

Lack of Blinding: Participants, therapists, and assessors were aware of intervention status. While the research assistant administering T-JTA® was blind to session content, youth self-report is inherently unblinded.

Short Follow-Up: Assessment occurred immediately post-intervention. Durability of effects remains unknown.

External Validity Threats

Sample Characteristics: Participants were recruited from mainstream Hong Kong schools with SEN support services. Generalizability to:

- Severe ASD (non-verbal, profound intellectual disability)
- Western cultural contexts
- Community settings without school infrastructure ...remains uncertain.

Intervention Intensity: Twice-weekly sessions may not be feasible in all settings. Optimal dosing (frequency, duration) requires systematic investigation.

Measurement Validity Concerns

T-JTA® Age-Appropriateness: The instrument was normed for adults. While East Asian studies have applied it to adolescents (Chen & Wang, 2015), formal validation in neurodiverse youth is lacking. Specific concerns:

1. **High Mid Response Rates:** Mean baseline Mid count (87.3) substantially exceeds adult norms (typically <30). This suggests:
    - **Reading comprehension difficulties:** Items may be too complex
    - **Abstract self-reflection challenges:** Neurodiverse youth may struggle with trait-level self-evaluation
    - **Ambivalence:** Genuine uncertainty about internal states

The significant post-intervention reduction in Mid counts (d = 0.74) is encouraging but ambiguous—it may reflect genuine increased self-awareness OR simply greater comfort with the assessment process.

2. **Internal Consistency:** Cronbach's alphas (.68-.84) were acceptable but lower than adult norms, indicating some measurement error.
3. **Cultural Adaptation:** The Chinese version was normed in Taiwan. Hong Kong linguistic and cultural nuances may affect item interpretation.

Alternative Instruments: Future studies should consider:

- Strengths and Difficulties Questionnaire (SDQ): Brief, validated for youth, parent/teacher versions available
- Behavior Assessment System for Children (BASC-3): Comprehensive, age-normed, includes validity scales
- Temperament in Middle Childhood Questionnaire (TMCQ): Developmentally appropriate, theory-driven

Subjective Outcomes Only: Reliance on self-report introduces bias. Future research should incorporate:

- Parent/teacher ratings (multi-informant)
- Behavioral observation (e.g., playground social interactions)
- Physiological markers (heart rate variability, cortisol)
- Academic performance metrics

Statistical Considerations

Multiple Comparisons: We conducted 9 primary trait tests plus 8 composite scales without correction (e.g., Bonferroni). This inflates Type I error risk. However, given the pilot nature and hypothesis-generating goals, we

prioritized sensitivity over specificity. Future confirmatory trials should pre-specify primary outcomes and adjust alpha accordingly.

Subgroup Analyses: Diagnostic subgroups (n=9-14) were severely underpowered. Non-significant ANOVA results do not rule out meaningful differences; they simply indicate insufficient data.

Correlation *vs.* Causation: The attendance-outcome correlation (r = .34-.41) is intriguing but does not establish that higher attendance caused better outcomes. Reverse causation (youth experiencing benefit attend more) or third variables (family support) are plausible.

Theoretical Implications

Embodied Temperament Change

This study introduces "embodied temperament change" as a conceptual framework linking:

- Sensory-motor input (vestibular, proprioceptive) →
- Subcortical regulation (cerebellum, brainstem, limbic system) →
- Temperament expression (emotional reactivity, self-regulation, social approach)

This bottom-up pathway complements traditional top-down models (cognitive reappraisal, behavioral modification) and may be especially relevant for neurodiverse populations with executive function deficits that limit cognitive strategy use.

Temperament as Intervention Target

Historically, temperament was viewed as a stable individual difference variable—a predictor of outcomes rather than a target for change. Our findings challenge this assumption, suggesting that temperament traits can be intervention endpoints. This reframing has implications for:

- Assessment practices: Routine temperament screening to identify regulation targets
- Treatment planning: Matching intervention modalities to temperament profiles (e.g., high Nervous → arousal-reduction focus)
- Progress monitoring: Repeated temperament assessment as outcome metric

Integration with Neurodevelopmental Models

Contemporary ASD and ADHD theories emphasize atypical sensory processing [28] and arousal dysregulation [29,30]. RT/BMAT directly addresses these mechanisms by:

- Providing controlled sensory input to recalibrate thresholds
- Training arousal modulation through graded challenges
- Scaffolding self-awareness of internal states

This mechanistic alignment suggests RT/BMAT may address core features rather than peripheral symptoms.

Clinical Implications

For School-Based Practitioners

Feasibility: The high completion and attendance rates demonstrate that RT/BMAT can be implemented in mainstream school settings with appropriate space and equipment.

Complementary Role: RT/BMAT should not replace evidence-based interventions (medication, CBT, ABA) but may serve as an adjunct, particularly for youth with:

- Medication side effects or non-response
- Limited cognitive capacity for talk therapy

- Sensory-seeking or sensory-avoidant profiles
- Co-occurring anxiety or mood symptoms

Collaborative Assessment: T-JTA® (or similar instruments) can facilitate multidisciplinary communication by providing shared temperament language across psychology, occupational therapy, and education teams.

For Parents and Families

Qualitative feedback suggests that parents perceived meaningful changes in daily functioning emotional regulation, sleep, social confidence. These "real-world" outcomes may be more salient than psychometric scores. Future research should employ parent-reported functional outcomes (e.g., Family Quality of Life scales).

For Policy and Program Development

If replicated in controlled trials, RT/BMAT could inform:

- School SEN services: Inclusion in Individualized Education Plans (IEPs)
- Community mental health: Group-based programs for neurodiverse youth
- Insurance coverage: Evidence for reimbursement of sensory-motor therapies

Future Research Directions

Immediate Next Steps: Randomized Controlled Trial

Proposed Design:

- **Sample:** n=120 (60 per arm), ages 10-14, ASD or ADHD diagnosis
- **Randomization:** Stratified by diagnosis and baseline severity
- **Control:** Waitlist or active control (e.g., recreational sports)
- **Blinding:** Assessors blind to condition; participant blinding not feasible
- **Outcomes:**
    - **Primary:** BASC-3 Emotional Symptoms Index (parent + teacher)
    - **Secondary:** SDQ, executive function tasks, HRV, actigraphy (sleep)
    - **Exploratory:** T-JTA® (to validate against age-appropriate measures)
- **Follow-up:** 3-month and 6-month post-intervention
- **Analysis:** Intent-to-treat with mixed-effects models

Power: n=60/arm provides 80% power to detect d = 0.50 (α = .05, two-tailed), a conservative estimate based on pilot data.

Mechanism Studies

Physiological Markers:

- **Heart Rate Variability (HRV):** Index of autonomic regulation; expected to increase with intervention
- **Cortisol:** Salivary samples pre/post sessions to assess stress reactivity
- **EEG:** Resting-state coherence and event-related potentials during emotion tasks

Neuroimaging:

- **fMRI:** Amygdala reactivity to emotional faces; cerebellar-limbic connectivity
- **Diffusion Tensor Imaging (DTI):** White matter integrity in vestibular pathways

Mediation Analysis: Test whether physiological changes mediate temperament outcomes (e.g., HRV → Self-Discipline).

Comparative Effectiveness

Compare RT/BMAT to:

- Standard occupational therapy: Isolate unique contribution of rope-based vestibular input
- Mindfulness-based interventions: Test relative efficacy of bottom-up *vs.* top-down approaches
- Combined treatment: Additive or synergistic effects?

Dose-Response Optimization

Systematically vary:

- **Frequency:** 1×/week *vs.* 2×/week *vs.* 3×/week
- **Duration:** 8 weeks *vs.* 12 weeks *vs.* 16 weeks
- **Intensity:** Mild vestibular input *vs.* vigorous rotation

Use adaptive trial designs (e.g., SMART) to identify optimal regimens for subgroups.

Developmental Extensions

- **Younger children** (ages 6-10): Adapt protocol with more play-based elements
- **Adolescents** (ages 14-18): Incorporate identity exploration and peer leadership roles
- **Adults**: Explore applicability to neurodiverse adults with anxiety or trauma histories

Cultural Adaptation and Validation

- Replicate in Western samples to assess cultural generalizability
- Develop culturally adapted T-JTA® norms for neurodiverse youth
- Explore cultural differences in temperament expression and intervention response

Implementation Science

If efficacy is established, study:

- **Training models:** Optimal methods for certifying RT/BMAT practitioners
- **Cost-effectiveness:** Economic evaluation *vs.* standard care
- **Scalability:** Barriers and facilitators to school/community adoption
- **Sustainability:** Long-term program maintenance

Addressing Reviewer Concerns from Original Draft

The original manuscript received feedback regarding:

1. **Construct validity of T-JTA® traits:** We have clarified that traits are interpreted as behavioral indicators (e.g., "Dominant" = initiative, not pathology) and contextualized within DSM-5 frameworks for ASD/ADHD.
2. **Stigmatization risk:** We emphasize that temperament assessment identifies regulation targets, not deficits, and should be embedded in strengths-based formulations.
3. **Methodological rigor:** This revision transparently acknowledges the single-arm design as a critical limitation and reframes the study as hypothesis-generating rather than confirmatory.
4. **Statistical reporting:** We have added comprehensive inferential tests, effect sizes, confidence intervals, and validity indices.
5. **Ethical oversight:** We have detailed IRB approval, consent procedures, and conflict of interest disclosures.

CONCLUSION

This pilot study provides preliminary evidence that Rope Therapy/Body-Mind Activation Therapy (RT/BMAT) is a feasible and potentially efficacious intervention for promoting temperament regulation in neurodiverse youth. Significant improvements in emotional arousal, mood, self-discipline, and social engagement were observed, with effect sizes ranging from medium to large. The Taylor-Johnson Temperament Analysis (T-JTA®), despite age-appropriateness concerns, demonstrated sensitivity to change and may serve as a useful progress-monitoring tool when interpreted cautiously.

However, the absence of a control group precludes causal inference. Observed changes may reflect maturation, placebo effects, or regression to the mean. These findings should be interpreted as proof-of-concept, establishing preliminary effect size estimates and supporting the rationale for a fully powered randomized controlled trial.

KEY CONTRIBUTIONS

1. **Conceptual:** Introduction of "embodied temperament change" as a theoretical framework
2. **Methodological:** Demonstration that standardized temperament assessment can be integrated with sensory-motor intervention research
3. **Clinical:** Evidence that neurodiverse youth can engage successfully in intensive vestibular-proprioceptive therapy
4. **Pragmatic:** High feasibility and acceptability in school settings

Next Steps: A waitlist-controlled RCT with age-appropriate outcome measures, multi-informant ratings, physiological markers, and extended follow-up is warranted. If replicated under controlled conditions, RT/BMAT may offer a valuable addition to the intervention toolkit for neurodiverse youth, particularly those with co-occurring emotional dysregulation.

Final Reflection: Temperament, once considered immutable, may be more plastic than traditionally assumed—especially when interventions target the embodied, subcortical systems that scaffold emotional life. This study invites the field to reconsider temperament not merely as a predictor of outcomes, but as a legitimate and measurable target for therapeutic change.

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