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Comparison of Task-Oriented Motor Training and Sensory Integration Technique on Balance and Gait in Children with Autism Spectrum Disorder

Abira Imtiaz[1], Muhammad Naveed Babur[2], Saima Riaz[3]

[1] Superior University, Lahore, Pakistan.

[2] Dean, Department of Physical Therapy and Rehabilitation Sciences, Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan.

[3] Professor, Department of Physical Therapy and Rehabilitation Sciences, Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan.

Corresponding Author: Abira Imtiaz

Correspondence: abiraimtiaz460@gmail.com

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ABSTRACT

Background: Children with autism spectrum disorder (ASD) may experience balance and gait difficulties, but comparative evidence for motor rehabilitation approaches remains limited. **Objective:** To compare Task-Oriented Motor Training (TOMT) and Sensory Integration Technique (SIT) for balance, gait, and health-related quality of life. **Methods:** A single-centre randomized controlled trial at Rehabilitation Centre, Lahore, Pakistan, allocated 40 children aged 5–12 years to TOMT or a structured sensory-motor SIT programme (20 per group). Both groups received three sessions weekly for eight weeks. Outcomes were the Pediatric Balance Scale (PBS), Observational Gait Scale (OGS), and parent-proxy Pediatric Quality of Life Inventory (PedsQL). Analysis of covariance adjusted post-intervention comparisons for baseline scores. **Results:** All participants completed follow-up. Adjusted differences favoured TOMT for PBS (3.54 points; 95% CI 0.38–6.71; p=0.029) and OGS (1.76 points; 95% CI 0.35–3.16; p=0.016). Only OGS remained statistically significant at the post hoc Bonferroni threshold of 0.025. The PedsQL difference was not statistically significant (4.10 points; 95% CI −1.27 to 9.47; p=0.130). **Conclusion:** TOMT demonstrated a short-term comparative advantage for observed gait performance, with less robust evidence for balance and no established quality-of-life advantage. Clinical importance remains uncertain. **Keywords:** Autism Spectrum Disorder; Exercise Therapy; Gait; Postural Balance; Quality of Life; Rehabilitation.

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by differences in social communication and interaction alongside restricted or repetitive patterns of behaviour and interests. Beyond these defining features, children with ASD may experience substantial motor difficulties that affect their capacity to engage in everyday activities. A systematic review and two meta-analyses identified gross motor impairment and its association with social skills, supporting the relevance of motor function within comprehensive ASD assessment and rehabilitation (1). Balance is a particularly important rehabilitation target because maintaining stability during standing, stepping, and movement transitions contributes to functional mobility. Evidence synthesized in a meta-analysis of exercise-based interventions indicates that balance performance in children with ASD can improve following structured intervention, although treatment approaches and responses vary across studies (2).

Balance and gait involve coordinated motor responses to changing task and environmental demands. For children with ASD, rehabilitation directed at these abilities must consider both movement execution and the sensory information used to regulate posture. Research examining physical activity programmes for balance rehabilitation has highlighted the importance of designing activities around the postural-control needs of this population (3). Broader evidence also supports the potential of exercise interventions to improve fundamental motor skills in children with ASD (4). However, evidence that physical activity is beneficial does not establish which therapeutic approach should be prioritized when functional balance and walking performance are the principal treatment goals.

Task-Oriented Motor Training (TOMT) addresses these goals through repeated practice of purposeful functional activities. In the present study, these activities included sit-to-stand transitions, reaching, weight shifting, stepping, walking, turning, obstacle negotiation, and stair practice. The rationale is that practising movements closely related to everyday mobility may facilitate improvements in the skills required to perform those activities. Research on an occupational therapy programme incorporating fundamental motor skills training has examined functional performance in children with ASD, providing a relevant context for investigating structured motor practice (5). Nevertheless, findings from other motor-training programmes cannot establish the comparative effects of the specific TOMT programme evaluated here.

Sensory-focused rehabilitation provides a different, although partly overlapping, approach. It emphasizes graded sensory experiences intended to support adaptive responses during movement and activity. A systematic review and meta-analysis examined sensory integration therapy across paediatric populations, while research on intervention features in autistic children emphasized the importance of clearly describing treatment content and delivery (6,7). More directly relevant to motor outcomes, Deng and colleagues reported improvements in balance following sensory integration training in children with ASD (8). These findings provide a rationale for examining sensory-focused intervention as an active comparator, while also highlighting the need to distinguish specific treatment programmes rather than treating all sensory-based approaches as interchangeable.

This distinction is important because the sensory integration technique (SIT) evaluated in the present trial comprised a structured programme of vestibular, proprioceptive, and tactile activities; it was not a manualized Ayres Sensory Integration intervention. Consequently, evidence from programmes such as the SenITA randomized controlled trial provides contextual information but cannot be assumed to apply directly to this comparator (9). Similarly, the range of physical activity interventions considered in a recent systematic review and network meta-analysis illustrates the breadth of available approaches without resolving the specific comparison between the

TOMT and SIT programmes used in this study (10). A direct comparison with similar treatment frequency, duration, and therapist attention can therefore help clarify their relative effects on defined motor outcomes.

The precise question addressed by this study was whether functional task practice produces different short-term balance and gait outcomes from a structured sensory-motor programme in children with ASD. The cited literature supports investigating both approaches but does not establish their relative effects under the treatment conditions evaluated here. Assessing parent-proxy health-related quality of life alongside motor outcomes also allows examination of whether differences in clinical performance are accompanied by differences in broader perceived functioning and well-being. Accordingly, this randomized controlled trial compared the effects of eight weeks of TOMT and SIT, delivered three times weekly, in children with ASD aged 5–12 years. The primary objective was to compare baseline-adjusted post-intervention balance and gait performance, measured using the Pediatric Balance Scale and Observational Gait Scale, respectively. The secondary objective was to compare parent-proxy health-related quality of life measured using the Pediatric Quality of Life Inventory.

Material and methods

A single-centre, two-arm, parallel-group randomized controlled trial compared Task-Oriented Motor Training (TOMT) with a structured sensory-motor programme termed Sensory Integration Technique (SIT) in children with autism spectrum disorder (ASD). The active-comparator design evaluated the relative effects of the two approaches under comparable treatment schedules. The study was conducted at Rehabilitation Centre in Lahore, Pakistan, over four months following synopsis approval. Each participant underwent an eight-week intervention, with assessments performed before randomization and immediately after the intervention period. Functional balance and gait performance were the co-primary outcomes, and parent-proxy health-related quality of life was the secondary outcome.

Children attending the centre were recruited through non-probability convenience sampling. Eligible participants were boys and girls aged 5–12 years with a confirmed diagnosis of ASD who could understand and follow simple verbal instructions and stand and walk independently or with minimal assistance. Exclusion criteria were severe musculoskeletal deformities interfering with standing or walking; hearing or visual impairments substantially affecting balance or assessment performance; uncontrolled seizures; another neurological disorder affecting motor function, such as cerebral palsy or muscular dystrophy; and participation in another structured sensory or motor rehabilitation programme. Stable medication use and concurrent speech or behavioural therapy were documented and monitored during the study.

Parents or legal guardians received an explanation of the study objectives, procedures, anticipated benefits, foreseeable risks, and voluntary nature of participation. Interested children were screened for eligibility, and written parental or guardian consent was obtained before enrolment. Assent was sought according to each child's age, communication ability, and cognitive capacity. The target sample comprised 40 children, with 20 participants allocated to each intervention group. Demographic and clinical information was recorded using a standardized data-collection form, including age, sex, height, weight, ASD-related clinical characteristics, mobility status, relevant medical and neurological history, medication use, and concurrent therapy.

Baseline assessments were completed before randomization. An independent individual who was not involved in recruitment, treatment delivery, or outcome assessment generated a computer-based random allocation sequence using a fixed block size of four and a 1:1 allocation ratio. Allocation was concealed using sequentially numbered, opaque, sealed envelopes prepared according to the sequence. After eligibility confirmation, consent, and baseline assessment, the treatment coordinator opened the next envelope and informed the treating physiotherapist of the allocation.

Blinding of children, caregivers, and treating physiotherapists was not feasible because the intervention activities were distinguishable. Post-intervention balance and gait assessments were conducted by an assessor who had not delivered either intervention and was not informed of treatment allocation. Children and caregivers were asked not to disclose their intervention to the assessor. Gait recordings, when obtained, were labelled with participant identification codes without group information. Caregivers completing the quality-of-life questionnaire were aware of the intervention received.

Functional balance was assessed using the Pediatric Balance Scale (PBS). This 14-item instrument evaluates static and dynamic balance during activities such as sit-to-stand transitions, unsupported standing, standing with eyes closed, forward reaching, retrieving an object from the floor, alternating feet on a step, and single-leg standing. Each item was scored from 0 to 4, yielding a total score of 0–56, with higher scores indicating better functional balance. Instructions, equipment, testing conditions, and scoring procedures were standardized across baseline and post-intervention assessments.

Gait performance was assessed using the Observational Gait Scale (OGS). Participants walked along a level, pre-marked pathway under standardized conditions. Observations included knee position during midstance, initial foot contact, foot contact during midstance, timing of heel rise, hindfoot position, base of support, and assistive-device use where applicable. Higher recorded OGS scores represented better observed gait performance. Baseline and post-intervention assessments used comparable walking and observation conditions.

Health-related quality of life was assessed using the Pediatric Quality of Life Inventory Version 4.0 Generic Core Scales (PedsQL 4.0). An age-appropriate parent-proxy form was used for every participant to maintain a consistent respondent type across the study age range. The instrument comprises 23 items covering physical functioning, emotional functioning, social functioning, and school functioning. The same parent or primary caregiver was asked to complete both assessments whenever possible. Responses were reverse-scored and transformed to a 0–100 scale according to the instrument's scoring instructions, with higher scores indicating better health-related quality of life. Scale scores were calculated when the required proportion of items had been completed.

Both groups were scheduled to receive three sessions weekly for eight consecutive weeks, providing a maximum of 24 sessions. Each session lasted approximately 40–45 minutes. Planned intervention duration, session frequency, therapist attention, and rest opportunities were kept comparable between groups. Qualified physiotherapists with paediatric rehabilitation experience delivered the programmes. Attendance, session duration, activities performed, progression, assistance requirements, participant tolerance, adverse events, and protocol deviations were recorded using standardized treatment forms.

The TOMT programme used repetitive, goal-directed practice of functional movement, consistent with the focus on structured motor activity in the supplied ASD rehabilitation literature (4,5). Sessions began with approximately five minutes of familiarization and simple functional movement, followed by 30–35 minutes of task-oriented activity and approximately five minutes of slower movement and

recovery. Activities included repeated sit-to-stand practice, standing reach and weight transfer, stepping towards targets, multidirectional stepping, walking on level and mildly varied surfaces, crossing low hurdles, negotiating obstacles, turning, climbing steps or stairs, and transitioning between sitting, standing, and walking.

Task difficulty was individualized according to functional ability, movement quality, assistance requirements, safety, and tolerance. Progression involved increasing repetitions or walking distance, reducing external assistance, increasing stepping height within safe limits, introducing more complex obstacles or direction changes, and combining functional components. Tasks were progressed when the child performed them consistently and safely with decreasing assistance. Excessive fatigue, instability, distress, pain, or unsafe performance prompted a reduction in task demands, additional support, or a rest period of approximately one to two minutes.

The SIT programme provided structured vestibular, proprioceptive, and tactile activities. It was a sensory-motor intervention rather than a manualized Ayres Sensory Integration programme; this distinction was maintained because sensory intervention content and delivery are important to treatment interpretation and reproducibility (7). Each session included low-intensity sensory preparation and familiarization, approximately 30–35 minutes of sensory-motor activities, and a brief recovery period. Vestibular activities included controlled linear swinging, gentle rocking, and graded multidirectional movement. Proprioceptive activities included pushing or pulling weighted therapeutic objects, resisted movement, jumping, crawling, and joint-compression activities. Tactile activities involved graded exposure to surfaces and materials with different textures. The inclusion of sensory-focused activities was consistent with previous investigation of sensory integration training and balance in children with ASD (8).

Sensory activities were selected and progressed according to each child's sensory response, adaptive motor response, safety, and tolerance. Vestibular input began with slow, predictable movement and was increased only when tolerated. Progression could involve greater movement range, resistance, task complexity, or sensory challenge. Dizziness, nausea, discomfort, marked avoidance, distress, or behavioural dysregulation prompted immediate reduction of the activity's intensity or complexity, or discontinuation of the activity.

Intervention components were separated as far as clinically feasible to limit contamination. Repetitive gait drills, structured stair practice, obstacle-course walking, and repeated sit-to-stand training were restricted to TOMT. Structured swinging, rocking, tactile stimulation, deep-pressure activities, and specifically directed sensory-input activities were restricted to SIT. Movement necessary to perform sensory activities was not classified as task-oriented training unless it was repeatedly practised as a functional goal. Standardized treatment checklists were used in both groups, and the principal investigator or research supervisor periodically reviewed a sample of treatment records to monitor protocol fidelity and identify crossover between intervention components.

Caregivers were asked to maintain the child's usual daily activities and not initiate another structured sensory, balance, gait, or task-oriented rehabilitation programme during the intervention. Changes in medication or concurrent services were documented. Treatment adherence was calculated as the percentage of the 24 planned sessions attended. Attendance at least 20 sessions, together with completion of the final assessment, defined eligibility for the supportive per-protocol analysis. Adverse responses were documented during treatment, together with the action taken. PBS, OGS, and PedsQL assessments were repeated after eight weeks under conditions comparable with baseline.

Data were entered and analysed using IBM SPSS Statistics version 26.0. Each participant was assigned a unique identification code. Before analysis, records were checked for missing values, duplicate entries, implausible values, coding errors, outliers, and inconsistencies with the original data-collection forms. A proportion of electronic records was cross-checked against source forms. Continuous variables were summarized using means and standard deviations when approximately normally distributed, with medians and interquartile ranges reserved for substantially skewed distributions. Categorical variables were summarized as frequencies and percentages. Baseline characteristics were described by randomized group, with clinical comparability assessed from the magnitude and relevance of observed differences rather than baseline significance testing.

The primary analyses followed the intention-to-treat principle, retaining participants in their assigned groups. Separate analysis of covariance models compared eight-week PBS and OGS scores between groups, with treatment allocation entered as a fixed factor and the corresponding baseline outcome entered as a covariate. PedsQL was analysed using the same model structure as a secondary outcome. Treatment effects were expressed as adjusted mean differences for TOMT minus SIT, with 95% confidence intervals, two-sided p-values, and partial eta-squared estimates. Adjusted post-intervention group means were also reported.

Model assessment considered the linear relationship between baseline and follow-up scores, homogeneity of regression slopes, residual normality, homoscedasticity, and influential observations. Homogeneity of slopes was examined using treatment-by-baseline interaction terms. Residual plots provided the principal assessment of model assumptions, with the Shapiro–Wilk test used as supplementary evidence. The final models included treatment group and the corresponding baseline score without interaction terms. Given the small sample, these models were kept parsimonious. Recorded characteristics such as age, sex, medication use, ASD-related characteristics, and concurrent therapy were used to describe the sample rather than routinely entered as additional covariates. No confirmatory subgroup analyses were undertaken.

Paired-samples t-tests described within-group changes, and unadjusted between-group change-score comparisons were treated as supplementary analyses. Comparative treatment interpretation was based primarily on the baseline-adjusted models. The original analyses used a two-sided significance threshold of 0.05 without a prespecified multiplicity adjustment. A post hoc Bonferroni sensitivity assessment applied a threshold of 0.025 to the two primary outcome comparisons. Reported 95% confidence intervals were not multiplicity-adjusted. The secondary PedsQL analysis was interpreted separately, with attention to effect magnitude and uncertainty.

Outcome completeness was examined by treatment group before analysis. All randomized participants had baseline and eight-week measurements for PBS, OGS, and PedsQL; consequently, no outcome imputation was required. All participants also met the attendance threshold and completed the final assessment, so the intention-to-treat and per-protocol populations coincided.

Ethical approval was obtained from the Institutional Review Board of Superior University, Lahore, Pakistan, under reference IRB/FAHS/REHAB/04/26/MS/RS-4011. Study procedures were conducted in accordance with the Declaration of Helsinki. Parents or guardians were informed that participation was voluntary and that withdrawal would not affect usual care. Assessments and interventions were supervised, and activities were modified or discontinued when adverse responses occurred. Identifying information was excluded from the analytical dataset, and access to study records was restricted to authorized research personnel.

Results

Forty-six children were assessed for eligibility. Six were excluded: three did not meet the eligibility criteria, two were participating in another structured sensory or motor rehabilitation programme, and one parent declined participation. Forty children were randomized equally to TOMT and SIT. All participants completed the eight-week outcome assessment and were analysed in their assigned groups.

Baseline demographic and clinical characteristics are presented in Table 1. Mean age was 8.35 ± 2.06 years in the TOMT group and 8.50 ± 2.05 years in the SIT group. Male participants accounted for 75.0% and 70.0% of the respective groups. Stable medication use was reported in seven TOMT participants and six SIT participants, while concurrent speech or behavioral therapy was reported in 14 and 13 participants, respectively.

Table 1. Baseline demographic and clinical characteristics

Characteristic	TOMT (n = 20)	SIT (n = 20)
Age (years), mean ± SD	8.35 ± 2.06	8.50 ± 2.05
Male sex, n (%)	15 (75.0)	14 (70.0)
Female sex, n (%)	5 (25.0)	6 (30.0)
Height (cm), mean ± SD	128.6 ± 12.1	130.1 ± 11.7
Weight (kg), mean ± SD	28.9 ± 7.4	29.6 ± 7.1
Mild ASD characteristics, n (%)	12 (60.0)	11 (55.0)
Moderate ASD characteristics, n (%)	8 (40.0)	9 (45.0)
Stable medication use, n (%)	7 (35.0)	6 (30.0)
Concurrent speech/behavioural therapy, n (%)	14 (70.0)	13 (65.0)

ASD, autism spectrum disorder; SD, standard deviation; SIT, Sensory Integration Technique; TOMT, Task-Oriented Motor Training.

Table 2. Baseline and eight-week outcome scores and within-group changes

Outcome	Group	n	Baseline, mean ± SD	Eight weeks, mean ± SD	Change, mean ± SD	Paired t (df = 19)	Within-group p
PBS (points)	TOMT	20	37.80 ± 5.46	47.60 ± 4.78	9.80 ± 6.57	6.674	<0.001
PBS (points)	SIT	20	38.20 ± 5.12	44.10 ± 5.02	5.90 ± 7.00	3.772	0.001
OGS (points)	TOMT	20	13.60 ± 2.70	18.40 ± 2.08	4.80 ± 3.41	6.303	<0.001
OGS (points)	SIT	20	13.90 ± 2.51	16.60 ± 2.31	2.70 ± 3.96	3.047	0.007
PedsQL (points)	TOMT	20	56.70 ± 8.86	68.90 ± 8.18	12.20 ± 12.57	4.340	<0.001
PedsQL (points)	SIT	20	57.40 ± 9.08	64.70 ± 8.54	7.30 ± 13.70	2.384	0.028

Change = eight-week score − baseline score. Within-group comparisons used two-sided paired-samples t-tests. PBS, Pediatric Balance Scale; OGS, Observational Gait Scale; PedsQL, Pediatric Quality of Life Inventory; SD, standard deviation; SIT, Sensory Integration Technique; TOMT, Task-Oriented Motor Training.

Table 3. Baseline-adjusted between-group comparisons at eight weeks

Outcome	Adjusted TOMT mean (n = 20)	Adjusted SIT mean (n = 20)	Adjusted mean difference	95% CI	F (1, 37)	p	Partial η^2
PBS (points)	47.62	44.08	3.54	0.38 to 6.71	5.148	0.029	0.122
OGS (points)	18.38	16.62	1.76	0.35 to 3.16	6.391	0.016	0.147
PedsQL (points)	68.85	64.75	4.10	−1.27 to 9.47	2.394	0.130	0.061

Adjusted meaning difference = TOMT − SIT. Separate ANCOVA models included treatment group and the corresponding baseline outcome score. Confidence intervals and p-values are unadjusted for multiplicity. The original two-sided significance threshold was 0.05; the post hoc Bonferroni threshold for PBS and OGS was 0.025. ANCOVA, analysis of covariance; CI, confidence interval; PBS, Pediatric Balance Scale; OGS, Observational Gait Scale; PedsQL, Pediatric Quality of Life Inventory; SIT, Sensory Integration Technique; TOMT, Task-Oriented Motor Training; η^2, eta-squared.

Table 4. Supplementary unadjusted between-group comparisons of change scores

Outcome	TOMT change, mean ± SD (n = 20)	SIT change, mean ± SD (n = 20)	Mean difference in change	95% CI	p
PBS (points)	9.80 ± 6.57	5.90 ± 7.00	3.90	−0.44 to 8.24	0.077
OGS (points)	4.80 ± 3.41	2.70 ± 3.96	2.10	−0.27 to 4.47	0.080
PedsQL (points)	12.20 ± 12.57	7.30 ± 13.70	4.90	−3.52 to 13.32	0.246

Change = eight-week score − baseline score; mean difference in change = TOMT − SIT. CI, confidence interval; SD, standard deviation; PBS, Pediatric Balance Scale; OGS, Observational Gait Scale; PedsQL, Pediatric Quality of Life Inventory; SIT, Sensory Integration Technique; TOMT, Task-Oriented Motor Training.

Table 5. Treatment attendance, outcome completion, and adverse events

Variable	TOMT (n = 20)	SIT (n = 20)
Sessions attended, mean ± SD	23.15 ± 1.53	22.85 ± 1.81
Treatment adherence (%), mean ± SD	96.46 ± 6.38	95.21 ± 7.56
Attendance ≥20 sessions, n (%)	20 (100.0)	20 (100.0)
Eight-week outcome assessment completed, n (%)	20 (100.0)	20 (100.0)
No adverse event, n (%)	19 (95.0)	18 (90.0)
Fatigue, n (%)	1 (5.0)	0 (0.0)
Dizziness, n (%)	0 (0.0)	1 (5.0)
Sensory discomfort, n (%)	0 (0.0)	1 (5.0)
Serious adverse events, n (%)	0 (0.0)	0 (0.0)

Treatment adherence = sessions attended ÷ 24 × 100. SD, standard deviation; SIT, Sensory Integration Technique; TOMT, Task-Oriented Motor Training.

Scores increased from baseline to eight weeks in both groups across all three outcomes (Table 2). Mean PBS changes were 9.80 ± 6.57 points with TOMT and 5.90 ± 7.00 points with SIT. Corresponding OGS changes were 4.80 ± 3.41 and 2.70 ± 3.96 points, while PedsQL changes were 12.20 ± 12.57 and 7.30 ± 13.70 points. Within-group comparisons yielded p-values below 0.05 for each outcome in both groups.

Baseline-adjusted comparisons favoured TOMT for PBS and OGS at the original significance threshold of 0.05 (Table 3). The adjusted PBS difference was 3.54 points (95% CI 0.38–6.71; p=0.029; partial η^2=0.122), and the adjusted OGS difference was 1.76 points (95% CI 0.35–3.16; p=0.016; partial η^2=0.147). Under the post hoc Bonferroni threshold of 0.025 for the two primary outcomes, the OGS comparison remained statistically significant, whereas the PBS comparison did not. The adjusted PedsQL difference was 4.10 points (95% CI −1.27 to 9.47; p=0.130; partial η^2=0.061), with the confidence interval encompassing zero.

Supplementary unadjusted comparisons of change scores did not reach statistical significance (Table 4). Between-group differences were 3.90 PBS points (95% CI −0.44 to 8.24; p=0.077), 2.10 OGS points (95% CI −0.27 to 4.47; p=0.080), and 4.90 PedsQL points (95% CI −3.52 to 13.32; p=0.246).

Mean attendance was 23.15 ± 1.53 sessions in the TOMT group and 22.85 ± 1.81 sessions in the SIT group, corresponding to adherence of 96.46% and 95.21%, respectively (Table 5). All participants attended at least 20 sessions and completed the final assessment. One TOMT participant experienced transient fatigue; one SIT participant experienced transient dizziness, and another experienced sensory discomfort. No serious adverse events were reported in either group.

Discussion

This randomized trial compared task-oriented motor training with a structured sensory-motor programme in children with ASD. The baseline-adjusted findings favoured TOMT for balance and gait at the original significance threshold, although only the gait comparison remained statistically significant under the post hoc multiplicity assessment. The quality-of-life comparison was inconclusive. These findings suggest a possible short-term advantage of task-oriented practice for observed gait performance, with less robust evidence for balance and no established advantage for parent-proxy health-related quality of life (10).

The motor findings are consistent with literature identifying motor impairment as a relevant component of ASD and a potential target for rehabilitation. Wang and colleagues documented gross motor impairment and its relationship with social skills, supporting assessment beyond the defining social-communication and behavioural features of ASD (11). Meta-analytic evidence also indicates that exercise-based interventions can improve balance and fundamental motor skills in children with ASD (12-14). The present trial extends this clinical question to a comparison between two active programmes. However, agreement in the direction of findings does not establish that different rehabilitation approaches have equivalent effects, particularly when intervention content, participant characteristics, and outcome measures differ.

The comparatively stronger gait finding may reflect the relationship between the TOMT activities and the assessed motor tasks. Repeated stepping, walking, turning, obstacle negotiation, and stair practice directly challenged locomotor control. These activities provided opportunities to practise weight transfer, movement sequencing, and adaptation to changing task demands. This interpretation is compatible with the functional emphasis of motor-skills training investigated in children with ASD (15). Nevertheless, motor-learning processes were not directly measured, and the observed difference cannot establish a specific mechanism. Close correspondence between training activities and assessment requirements may also produce task-specific gains without demonstrating transfer to unrestricted community mobility.

Balance performance similarly increased in both groups, but evidence of a comparative TOMT advantage was sensitive to the statistical threshold applied. Previous work on physical activity design and balance rehabilitation supports the relevance of structured movement experiences, while the balance-intervention meta-analysis provides broader evidence that this outcome can respond to exercise (16). In the present trial, the nominally significant PBS result warrants cautious interpretation because it did not meet the post hoc Bonferroni threshold. Furthermore, neither statistical significance nor partial eta-squared establishes whether the difference was large enough to matter to children and families. An ASD-specific threshold for interpreting the between-group PBS difference was not established.

The changes observed in the SIT group are also compatible with previous investigation of sensory-focused rehabilitation. Deng and colleagues reported balance benefits following sensory integration training in children with ASD, providing a rationale for activities that challenge the use of sensory information during movement (17). Vestibular, proprioceptive, and tactile experiences could plausibly influence body awareness, postural responses, and tolerance of movement. These explanations remain hypothetical in the present study because sensory processing and physiological responses were not assessed. Moreover, the comparator was a structured sensory-motor

programme rather than manualized Ayres Sensory Integration. Evidence from broader sensory integration reviews and the SenITA trial therefore provides context rather than a directly interchangeable treatment comparison (18). Research examining intervention features further reinforces the importance of distinguishing treatment content and delivery when interpreting sensory intervention findings (7).

The absence of a statistically significant quality-of-life difference should not be interpreted as equivalence between the programmes. The confidence interval encompassed both little or no comparative benefit and a potentially larger TOMT advantage. PedsQL also captures emotional, social, and school functioning alongside physical functioning, so differences in motor performance need not correspond directly to differences in the overall score. Although motor and social abilities may be related in ASD, such an association does not establish that short-term motor gains necessarily produce broader psychosocial benefits (19). Caregiver awareness of treatment allocation and concurrent speech or behavioural therapy also complicate interpretation of this parent-reported outcome.

The distinction between the adjusted and unadjusted analyses is important. ANCOVA favored TOMT for the motor outcomes at the original threshold, whereas supplementary change-score comparisons did not. These approaches use baseline information differently and can yield different precision; their differing p-values do not, by themselves, constitute contradictory findings. However, the weak baseline coefficients and small sample support cautious interpretation of the estimates. The post hoc multiplicity assessment adds useful information about sensitivity but does not substitute for a prospectively documented primary-outcome decision rule. Within-group changes likewise cannot isolate treatment effects from maturation, repeated assessment, concurrent care, or nonspecific therapeutic attention.

Clinically, the findings support considering task-specific practice when the immediate rehabilitation goal is gait performance, while retaining uncertainty about clinical importance and transfer to daily participation. They do not establish that TOMT is preferable for every child with ASD or that sensory-focused approaches lack value. The diversity of interventions represented in the exercise and sensory rehabilitation literature underscores the importance of interpreting results in relation to the programme actually delivered and the outcome being targeted (20). Public-health implications remain preliminary because the trial did not assess cost, service accessibility, caregiver burden, or sustained participation.

Strengths include randomized allocation, reported allocation concealment, comparable planned treatment exposure, blinded motor assessment, complete outcome follow-up, and high attendance. Important limitations include the small convenience sample from one centre, the short assessment period, and restricted applicability to children able to follow simple instructions and walk with no more than minimal assistance. Participants and therapists could not be blinded, and caregiver-reported quality of life remained susceptible to expectation effects (21).The use of OGS without established ASD-specific measurement performance limits interpretation of the gait result. Concurrent therapy, heterogeneous clinical characteristics, and possible therapist-related effects also require consideration. The small number of transient adverse events supports tolerability during this supervised programme but cannot establish safety across broader populations. Larger studies with prospectively specified analyses, longer follow-up, and complementary objective and participation measures are needed to determine the durability and practical importance of the observed differences (22).

Conclusion

Among children with ASD aged 5–12 years, eight weeks of TOMT yielded higher baseline-adjusted balance and gait scores than the structured SIT programme at the original significance threshold, but only the gait finding remained statistically significant under the post hoc multiplicity assessment. No statistically significant between-group difference was found in parent-proxy health-related quality of life. The findings suggest a short-term comparative advantage of TOMT for observed gait performance, while its clinical importance and broader functional benefit remain uncertain.

DECLARATIONS

Author Contributions:	Concept: AI, MNB; Design: AI, MNB, SR; Data Collection: AI; Analysis: AI, SR; Drafting: AI, MNB, SR.
Ethical Approval:	Ethical approval was obtained from the Institutional Review Board of Superior University, Lahore, Pakistan (reference: IRB/FAHS/REHAB/04/26/MS/RS-4011).
Informed Consent:	Written informed consent was obtained from parents or legal guardians before participant enrolment. Child assent was sought according to age, communication ability, and cognitive capacity. Trial Registration: Registration status and identifier require author confirmation.
Conflict of Interest:	Requires confirmation from all authors.
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Data Availability:	The availability of deidentified data and conditions for access require confirmation from the corresponding author.
Acknowledgments:	Require author confirmation.
AI Declaration:	Generative AI tools assisted with manuscript review, structural and language revision, table preparation, reference checking, and verification of selected summary-statistic calculations.

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