

Integrated Sensory–Motor–Praxis Gait Training for Persistent Toe Walking in a Preschool Child with Autism Spectrum Disorder and ADHD: A CARE-Compliant Case Report

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ABSTRACT

Aim: To analyse the effectiveness of Integrated Sensory–Motor–Praxis Gait Training for Toe Walking in a Preschool Child with Autism Spectrums Disorder and ADHD. Toe walking is one of the frequently observed signs in children with autism spectrum disorder (ASD) and that may be associated with sensory processing differences that affect gait, participation, and daily activities of that child.

Methods: A five-year-old boy diagnosed with autism spectrum disorder and Attention-Deficit/Hyperactivity Disorder presented with persistent toe walking from last two years also presenting speech delay, hyperactivity, and tactile sensory processing difficulties. The child was independently ambulatory with full active range of motion of all proximal and distal joints, normal muscle tone, and normal muscle strength. Sensory Profile-2 indicated predominant sensory-seeking behaviours. The child attended preschool and communicated verbally with pointing over the required things and tries to express his demands. A **12-week Integrated Sensory–Motor–Praxis Gait Program (ISMP-G)** comprising sensory regulation, motor planning, and task-oriented gait training. Each session included proprioceptive sensory priming, praxis-based motor planning activities, visual heel-strike training with verbal cueing, graded walking on different sensory surfaces, and functional gait tasks to promote participation.

Results: The case highlights successful approach of **ISMP** in autism. This case reinforces the need of Integrated sensory motor approach to deal with toe walking in autism. the child demonstrated marked improvements across gait, balance, and functional participation. Toe-walking frequency decreased from 90.6% at baseline to 45.4% at week 6 and 12.9% at week 12. Heel-strike during gait increased from 15% to 60% and 85%, respectively. Goal Attainment Scaling improved from –2 at baseline to +1 for heel walking, 0 for participation, and +2 for textured surface walking at week 12. Parent-reported participation improved from 3/10 to 6/10 and 8/10, while Timed Up and Go performance improved from 10.8 s to 9.2 s and 7.9 s over the intervention period, indicating enhanced functional mobility and participation.

Conclusion: Following intervention, toe walking reduced from occurring almost continuously to only occasional episodes. Parents reported improvements in eye contact, participation in structured activities, behavioural regulation, and transitions between tasks. The child demonstrated greater engagement during therapy sessions and improved tolerance to tactile sensory input.

Keywords: Autism, ADHD, Toe waking, Sensory Regulation.

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INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by differences in social communication together with restricted or repetitive behaviours and sensory processing differences. Motor impairments, including gait abnormalities, postural instability, and motor planning difficulties, are also frequently reported and may affect participation in daily life^{1,2}.

Toe walking is frequently observed sign in children with autism spectrum disorder (ASD) and that may be associated with sensory processing differences that affect gait, participation, and daily activities of that child³. Evidence regarding physiotherapy management of persistent toe walking in children with ASD still remains limited⁴. Tactile stimulations, sensory inputs, stretching exercises and gait training are some common therapeutic protocols followed by

therapist to eliminate toe walking and related signs among autistic children⁵.

Persistent toe walking is commonly observed in children with ASD. Although the exact mechanisms remain unclear, altered sensory processing, vestibular dysfunction, proprioceptive differences, and motor control deficits have been proposed as contributing factors. Persistent toe walking may reduce stability, alter biomechanics, increase the risk of falls, and interfere with participation in functional activities^{6,7,8}. Current management includes physiotherapy, occupational therapy, serial casting, orthoses, and, in selected cases, surgical intervention⁹. Physiotherapy aims to address sensory regulation, postural control, balance, gait mechanics, stretching and functional mobility through individualized intervention programs¹⁰.

Despite increasing clinical use of sensory-based physiotherapy, published evidence describing comprehensive neurophysiotherapy approaches for persistent toe walking in children with ASD remains limited^{11,12,13}.

This report describes the rehabilitation of a preschool child with ASD and ADHD using a structured **Integrated Sensory–Motor–Praxis Gait Program for toe walking in autism**.

Methods

Case Presentation

A five years old male preschool child was referred for physiotherapy with a primary complaint of persistent toe walking that had been present for approximately

last two years. The child had previously been diagnosed with autism spectrum disorder and Attention-Deficit/Hyperactivity Disorder. He was born following an in vitro fertilization (IVF) pregnancy. There was no significant medical history, no history of neurological disease, and no current medication use. Parents reported persistent toe walking, speech delay, hyperactivity, tactile sensory sensitivities, and difficulties maintaining attention during structured tasks. The child communicated verbally with supplementary pointing gestures and attended preschool.

Clinical Assessment

On examination, the child demonstrated: Independent ambulation without assistive devices, Persistent bilateral toe walking during most walking activities, Full active range of motion in both lower limbs, Normal muscle tone and muscle strength.

- Gross Motor Function Classification System (GMFCS) Level I: Children classified as **GMFCS Level I** can walk independently without assistive devices and perform age-appropriate gross motor activities. They can negotiate stairs, run, and jump, although speed, balance, and coordination may be slightly reduced compared with typically developing peers. Functional limitations are minimal and mainly evident during more advanced motor tasks.

☒			GMFCS Level I Children walk indoors and outdoors and climb stairs without limitation. Children perform gross motor skills including running and jumping, but speed, balance and co-ordination are impaired.
☐			GMFCS Level II Children walk indoors and outdoors and climb stairs holding onto a railing but experience limitations walking on uneven surfaces and inclines and walking in crowds or confined spaces.
☐			GMFCS Level III Children walk indoors or outdoors on a level surface with an assistive mobility device. Children may climb stairs holding onto a railing. Children may propel a wheelchair manually or are transported when traveling for long distances or outdoors on uneven terrain.
☐			GMFCS Level IV Children may continue to walk for short distances on a walker or rely more on wheeled mobility at home and school and in the community.
☐			GMFCS Level V Physical impairment restricts voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Children have no means of independent mobility and are transported.

PICTURE 1: Gross Motor Function Classification System (GMFCS)

- The Paediatric Balance Scale score at baseline (Day 0) was 35/56, suggesting moderate balance impairment.
- The Toe Walking Tool suggested findings consistent with idiopathic toe walking after exclusion of other neurological or orthopaedic causes.
- Toe walking frequency was 90.6%, heel strike observation showed 3/20 gait cycles and 15%, **Goal Attainment Scaling (GAS)** – Heel walking, participation and Textured

surface walking was Baseline (much less than expected), Parent-Reported Participation (VAS, 0–10) reported 3, Timed Up and Go (s) was 10.8.

Physiotherapy intervention:

INTEGRATED SENSORY–MOTOR–PRAXIS GAIT PROGRAM (ISMP-G) 12-WEEK PROTOCOL

1. Sensory Priming (5–7 min) Start every session with a predictable sensory sequence: Deep pressure squeezes, Joint compressions, Weighted push/pull activities (therapy cart, resistance

band), Animal walks (bear, crab, frog). “Heavy-work before walking” principal gait training always followed proprioceptive loading.

2. Motor Planning (Praxis) Circuit (10 min)

Step over coloured spots in a pattern, Jump–turn–walk–stop on cue, follow a visual floor path, copy therapist’s movement sequence.

3. Visual Heel-Strike Training (10 min): Place coloured heel targets on the floor, Child aims to “stamp the heel on the colour.” Use auditory cues: “Heel–toe, heel–toe. “Progress to obstacle walking.

4. Sensory Surface Progression (8 min): Grass

mat → Bubble wrap → Rice/beans → Sand → Firm floor. Asked the child to identify the surface while maintaining heel contact.

5. Regulation-to-Participation Transition (5 min) End with a functional task like: Carry toys while walking (Follow 2-step commands during walking).

Parent education and a structured home exercise program: Parents were instructed to continue selected sensory regulation and gait activities at home to reinforce therapy goals.

Component	Duration	Intervention Activities	Purpose
1. Sensory Priming	5–7 min	Deep pressure squeezes, joint compressions, weighted push/pull activities (therapy cart, resistance band), animal walks (bear, crab, frog). Proprioceptive "heavy-work" activities were completed before gait training.	Enhance sensory regulation, proprioceptive input, and postural readiness for walking.
2. Motor Planning (Praxis) Circuit	10 min	Step over coloured spots in sequence, jump–turn–walk–stop on verbal cue, follow a visual floor pathway, and imitate therapist movement sequences.	Improve motor planning, sequencing, coordination, and dynamic balance.
3. Visual Heel-Strike Training	10 min	Child stepped onto coloured heel targets while following verbal cues ("Heel–toe, heel–toe"). Progressed to obstacle walking with maintained heel contact.	Facilitate heel-strike pattern, improve gait mechanics, and increase motor control during walking.
4. Sensory Surface Progression	8 min	Walking across different textured surfaces: Grass mat → Bubble wrap → Rice/beans → Sand → Firm floor. Child identified each surface while maintaining heel contact.	Improve tactile discrimination, sensory integration, balance, and gait adaptability.

TABLE 1: INTEGRATED SENSORY–MOTOR–PRAXIS GAIT PROGRAM

Integrated Sensory–Motor–Praxis Gait Program (ISMP-G) 12-Week Protocol			
Component	Duration	Intervention Activities	Purpose
1 Sensory Priming	5–7 min	Start every session with a predictable sensory sequence: Deep pressure squeezes, Joint compressions, Weighted push/pull activities (therapy cart, resistance band), Animal walks (bear, crab, frog)	Enhance sensory regulation, proprioceptive input, and postural readiness for walking.
2 Motor Planning (Praxis) Circuit	10 min	Step over colored spots in a pattern, Jump–turn–walk–stop on cue, Follow a visual floor path, Copy therapist's movement sequence	Improve motor planning, sequencing, coordination, and dynamic balance.
3 Visual Heel-Strike Training	10 min	Place colored heel targets on the floor, Child aims to "stamp the heel on the color", Use auditory cues: "Heel-toe, heel-toe.", Progress to obstacle walking	Facilitate heel-strike pattern, improve gait mechanics, and increase motor control during walking.
4 Sensory Surface Progression	8 min	Walk across different textured surfaces: Grass mat, Bubble wrap, Rice / beans, Sand, Firm floor. Child identifies each surface while maintaining heel contact.	Improve tactile discrimination, sensory integration, balance, and gait adaptability.
5 Regulation-to-Participation Transition	5 min	End with functional tasks: Carry toys while walking, 1. Pick up the block 2. Put it in the box, Follow 2-step commands during walking	Promote transfer of therapeutic gains into functional participation and daily activities.

PICTURE 2: INTEGRATED SENSORY–MOTOR–PRAXIS GAIT PROGRAM

Results:

Toe-Walking Frequency was recorded by a **5-minute natural walking observation** using this formula and observations were done at baseline, week 6 and week 12:

Toe-walking frequency (%)

Toe-walking frequency (%)

=

Toe-walking steps

÷

Total steps

×

100

Toe-walking steps:
Number of steps taken on the toes.

Total steps:
Total number of steps taken (toe-walking + heel-toe walking).

× 100
Converted to percentage.

PICTURE 3: FORMULA OF TOE WALKING FREQUENCY

Heel-Strike Observation was done for 20 consecutive gait cycles at baseline, week 6 and week 12.

Goal Attainment Scaling (GAS) was used where three goals were aimed Goal 1 was to Walk with heel contact during indoor walking, Goal 2 was to Participate in circle time for 10 minutes and Goal 3 was to Walk on textured surfaces without distress. 2 Scoring was marked as -2 is Baseline (much less than expected), -1 was Some improvement, 0 was Expected outcome achieved, +1 was Better than expected and

+2 was Much better than expected

Parent-Reported Participation using Visual Analog Scale (VAS): we asked parents "How well does your child participate in daily activities?" e.g. about Dressing, Play, School, Walking outdoors and social interaction. Where 0 means Cannot participate and 10 showed Participates independently. Timed Up and Go, Sensory Profile-2 was done.

The Paediatric Balance Scale score was done for assessment on day 0, week 6 and week 12.

S.no	Item description	Score (0-4)	Day 0	Week 6	Week 12
1	Sitting to standing 	0 1 2 3 4 	4	4	4
2	Standing to sitting 	0 1 2 3 4 	4	4	4
3	Transfers 	0 1 2 3 4 	4	4	4
4	Standing unsupported 	0 1 2 3 4 	4	4	4
5	Sitting unsupported 	0 1 2 3 4 	4	4	4
6	Standing with eyes closed 	0 1 2 3 4 	3	4	4
7	Standing with feet together 	0 1 2 3 4 	3	4	4
8	Standing with one foot in front 	0 1 2 3 4 	2	3	4
9	Standing on one foot 	0 1 2 3 4 	2	3	4
10	Turning 360 degrees 	0 1 2 3 4 	2	3	4
11	Turning to look behind 	0 1 2 3 4 	2	3	4
12	Retrieving object from floor 	0 1 2 3 4 	1	2	4
13	Placing alternate foot on stool 	0 1 2 3 4 	0	1	1
14	Reaching forward with outstretched arm 	0 1 2 3 4 	0	0	1
Total score (56)			35	43	50

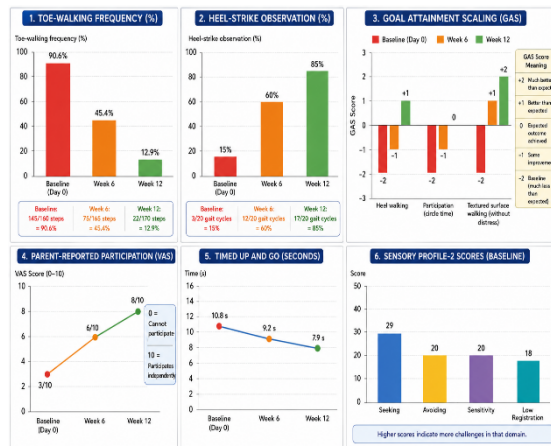
TABLE 2: PAEDIATRIC BALANCE SCALE

Outcome Measure	Baseline (Day 0)	Week 6	Week 12
Toe-walking frequency (%)	90.6% (145/160 steps)	45.4% (75/165)	12.9% (22/170 steps)
Heel-strike observation (%)	15% (3/20 gait cycles)	60% (12/20 gait cycles)	85% (17/20 gait cycles)
Goal Attainment Scaling (GAS) – Heel walking	-2	-1	+1
Goal Attainment Scaling (GAS) – Participation	-2	-1	0
Goal Attainment Scaling (GAS) – Textured surface walking	-2	+1	+2
Parent-Reported Participation (VAS, 0–10)	3/10	6/10	8/10
Timed Up and Go (s)	10.8	9.2	7.9
Paediatric Balance Scale	35	43	50

TABLE 3: RESULT OF ALL OUTCOME MEASURE

Following the 12-week Integrated Sensory–Motor–Praxis Gait Program (ISMP-G), the child demonstrated marked improvements across gait, balance, and functional participation. Toe-walking frequency decreased from 90.6% at baseline to 45.4% at week 6 and 12.9% at week 12. Heel-strike during gait increased from 15% to 60% and 85%, respectively. Goal Attainment Scaling improved from

–2 at baseline to +1 for heel walking, 0 for participation, and +2 for textured surface walking at week 12. Parent-reported participation improved from 3/10 to 6/10 and 8/10, while Timed Up and Go performance improved from 10.8 s to 9.2 s and 7.9 s over the intervention period, indicating enhanced functional mobility and participation.



GRAPH 1: GRAPHICAL PRESENTATION OF RESULTS

Discussion: At the completion of the intervention program, parents reported a marked reduction in toe walking, with heel contact occurring more consistently during daily ambulation. Improvements were also observed in functional participation, sustained attention during therapy activities, transitions between tasks, eye contact, and tolerance of tactile sensory experiences. The home exercise program was completed consistently, and caregivers expressed satisfaction with the child's progress.

This can be concluded that physiotherapy intervention including integrated sensory-motor-praxis gait program including Sensory Priming, Motor Planning (Praxis) Circuit, Visual Heel-Strike Training, Sensory Surface Progression and Regulation-to-Participation Transition can help the child to walk on complete weight bearing on foot, sensory regulation in autism.

Statements and declarations

Conflict of interest: The authors of this paper have no disclosures or conflicts of interest.

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