Majalah Ilmiah Fisioterapi Indonesia
Indonesian Scientific Journal of Physiotherapy

Case Studies
ISSN (Print): 2303-1921
ISSN (Online): 2722-0443
Volume 14, Number 1, Pages 163-168 (2026)
DOI: https://doi.org/10.24843/mifi.000001238

Effectiveness of DNS and SI Sensorimotor Exercises in a Child with Down Syndrome: A Case Study

Nova Ayu Aisyah[1], Dimas Arya Nugraha[2], Diah Rosyida Maulidina[3]

[1-3]Diploma in Physiotherapy Program, Faculty of Health Sciences, Universitas Muhammadiyah Lamongan, Lamongan, East Java, Indonesia

Corresponding author:
Name: Dimas Arya Nugraha
E-mail: faishalahmadarrozaq428@gmail.com
Phone: +62 857-1938-9607

Received 25 December 2025; Revised 15 January 2026; Accepted 17 January 2026; Published 19 Jnauary 2026

Abstract
Introduction: Sitting and crawling are essential milestones in gross motor development. Children with Down syndrome frequently experience delays due to hypotonia and impaired sensory integration, leading to difficulties in coordination and postural control. Dynamic Neuromuscular Stabilization (DNS) and Sensory Integration (SI) approaches aim to stimulate neuromuscular and sensory systems to enhance motor development.
Objective: This study aimed to describe the effects of a combined Dynamic Neuromuscular Stabilization and Sensory Integration intervention on gross motor function, primitive reflex maturation, and sensory responses in a child with Down syndrome.
Methods: This descriptive case study involved a 2-year-old male with delayed sitting and crawling abilities. The intervention consisted of four sessions over one month, including gym ball activities, quadruped and squat positions (DNS), and structured sensory activities (SI). Assessments included the Gross Motor Function Measure (GMFM) for Dimensions A and B, primitive reflex testing, and sensory response observation.
Results: GMFM Dimension A scores improved from 68.8% to 91.2%, and Dimension B from 43.3% to 76.7%. Primitive reflexes, including the Asymmetrical Tonic Neck Reflex (ATNR) and palmar grasp reflex, decreased from positive to negative. Sensory responses showed notable improvement, particularly in vestibular, tactile, and auditory systems.
Conclusion: Combining DNS and SI approaches demonstrated positive effects on gross motor function, reflex maturation, and sensory integration in a child with Down syndrome. These findings highlight the potential of integrated sensorimotor interventions in addressing developmental delays associated with Down syndrome.

Keywords
Sensorimotor stimulation, Dynamic Neuromuscular Stabilization, Sensory Integration, Gross motor skills, Down syndrome

Introduction

Gross motor development, such as the ability to sit and crawl, represents a crucial phase in a child's growth, serving as the foundation for subsequent functional skills such as standing and walking. These milestones reflect the maturation of the neuromotor system, play a pivotal role in postural control, and support the child's capacity to explore the environment. In children with Down syndrome (DS), attainment of these stages is often delayed due to hypotonia, core muscle weakness, and sensory integration disorders.[1]

DS is a genetic condition caused by the presence of an extra copy of chromosome 21 (trisomy 21), which affects neuromuscular and sensory development. Children with DS often retain primitive reflexes beyond the expected age, present with poor postural control, and have difficulties responding to visual, auditory, and tactile stimuli.[2,3] These factors hinder the acquisition of basic functions such as sitting and crawling, consequently impacting independence and daily participation. Genetic factors, such as meiotic errors, also contribute to the condition, and recent genetic studies have further demonstrated associations between chromosomal abnormalities and gross motor developmental delays.[4,5,6]

Dynamic Neuromuscular Stabilization (DNS) is employed to activate core muscles and improve postural control by replicating normal infant motor development patterns, including crawling (quadruped), squatting, and balance training using a gym ball.[7] In contrast, Sensory Integration (SI) aims to stimulate the sensory systems, enabling children to recognize, process, and respond adaptively to stimuli through activities involving touch, movement, sound, and visual input.[8,9]

Several studies have reported that combining DNS and SI can enhance gross motor skills and sensory processing abilities in children with DS.[10] This case report is unique in that it evaluates the combination of DNS and SI delivered over only four therapy sessions within one month in a 2-year-old child with DS, an approach rarely documented in the literature.

Nevertheless, research on the effectiveness of short-term combined DNS and SI interventions remains limited, particularly in the context of improving sitting and crawling abilities. This gap is noteworthy given that limited therapy duration is a common challenge in clinical physiotherapy practice. Therefore, the present study aims to evaluate the effectiveness of sensorimotor stimulation exercises based on DNS and SI in improving sitting and crawling abilities in a child with DS. The findings are expected to contribute to the development of physiotherapy interventions that are efficient, measurable, and capable of producing positive outcomes even within a short intervention period.

Methods

This study employed a descriptive case study design and was conducted at the Medical Rehabilitation Clinic, Muhammadiyah Lamongan Hospital (RSML), in January 2025. The subject was a 2-year-old male diagnosed with Down syndrome (DS) at birth through chromosomal analysis, presenting with gross motor delays, particularly in sitting and crawling. The subject was purposively selected based on an initial assessment indicating the absence of age-appropriate basic motor skills. He was born at term with a birth weight of 2800 g, with no family history of similar conditions. The parents were actively involved in the therapy process.

At baseline assessment, the child was unable to sit independently for more than 5 seconds, had not developed a crawling pattern, and demonstrated positive bilateral asymmetric tonic neck reflex (ATNR) as well as a persistent palmar grasp reflex upon stimulation. Responses to auditory stimuli were delayed, and discomfort was noted upon tactile contact. The primary challenges encountered during therapy included low core muscle tone, unintegrated primitive reflexes, and reduced attention span during sensory activities.

The intervention was delivered by a certified physiotherapist in four sessions conducted over a four-week period, with each session lasting approximately 45–60 minutes. The intervention combined Dynamic Neuromuscular Stabilization (DNS) and Sensory Integration (SI). DNS interventions included quadruped positioning, squatting, and sitting transition exercises using a gym ball to enhance core muscle activation and postural stability. Meanwhile, SI interventions involved structured play activities, including texture exploration, visual interaction, eye contact, and sound processing, aimed at stimulating the tactile, visual, and auditory sensory systems.

The DNS protocol was based on the principles of the Prague School, whereas the SI protocol followed Ayres' theoretical framework. Exercise intensity and activities were adapted in each session according to the child's responses. For example, in the second session, gym ball balance exercises were increased due to good adaptation to vestibular stimulation, while visual and auditory activities were modified to maintain focus.

The intervention was structured into a four-week program comprising one initial assessment session, three intervention sessions, and one final evaluation session. Each session incorporated a combination of Dynamic Neuromuscular Stabilization (DNS) and Sensory Integration (SI) techniques, with progressive modifications tailored to the child's responsiveness and adaptation. DNS activities primarily targeted postural stability and core muscle activation through age-appropriate developmental positions, while SI activities aimed to enhance sensory processing across visual, auditory, tactile, and vestibular domains. A detailed overview of the intervention timeline and main activities is presented in Table 1.

Table 1. Intervention Timeline and Core Activities Implemented During the Study Period

Week / Session	Main Activities
Week 1 – Assessment	GMFM, primitive reflex examination, sensory observation
Session 1	DNS: quadruped & squat sitting; SI: visual-auditory stimulation
Session 2	DNS: gym ball with increased intensity; SI: tactile integration
Session 3	DNS: sitting balance; SI: vestibular focus
Session 4 – Evaluation	GMFM, reflex examination, sensory observation

Assessment instruments included the Gross Motor Function Measure (GMFM) dimensions A (sitting) and B (crawling), a primitive reflex examination assessing the asymmetrical tonic neck reflex (ATNR) and palmar grasp in accordance with standardized developmental protocols, as well as observational assessment of sensory responses to visual, auditory, and tactile stimuli.

Primary data were obtained from clinical observations, evaluation forms, and therapy documentation. Descriptive analysis was conducted by comparing pre- and post-intervention GMFM scores quantitatively, while qualitative analysis was performed on changes in primitive reflexes and sensory responses based on the physiotherapist's notes. The long-term prognosis was considered favourable, provided that therapy was continued with active family involvement.

Results

This study presents the outcomes of four physiotherapy intervention sessions combining Dynamic Neuromuscular Stabilization (DNS) and Sensory Integration (SI) for a 2-year-old male child diagnosed with Down syndrome (DS). Assessments were conducted before and after therapy using the Gross Motor Function Measure (GMFM), primitive reflex examination, and observation of the child's sensory responses.

Table 2 presents the detailed timeline of the intervention sessions along with observed progress for each stage of therapy. It outlines the sequence of therapeutic activities, the duration of each phase, and notable milestones achieved by the child. This table serves as an overview of how the intervention was structured and how the participant's functional abilities evolved over the course of treatment.

Table 2. Intervention Timeline and Progress

Week/Session	Main Activities	Developmental Findings
Week 1 – Assessment	GMFM, primitive reflex examination, sensory observation	Unable to sit independently; unable to crawl; ATNR positive bilaterally; palmar grasp positive; slow auditory response; negative tactile response
Session 1	DNS: quadruped, squatting, gym ball; SI: eye contact, sound toys	Brief supported sitting; increased eye contact; slight auditory response
Session 2	DNS: gym ball (increased intensity); SI: texture exploration	Stable sitting for 10 seconds; initiated forward movement using knees; adaptive tactile response
Session 3	DNS: seated balance & transition to quadruped; SI: vestibular swing	Independent sitting for 20 seconds; quadruped with minimal assistance; improved auditory response
Session 4 – Evaluation	GMFM, primitive reflexes, sensory evaluation	GMFM A: 68.8% → 91.2%; GMFM B: 43.3% → 76.7%; reflexes negative; improved sensory responses

Table 3 summarizes the results of the Gross Motor Function Measure (GMFM) assessment conducted before and after the intervention. The scores in each dimension demonstrate measurable improvements in gross motor skills, indicating the effectiveness of the therapy in enhancing motor control, coordination, and mobility.

Table 3. GMFM Evaluation Results

Dimension	Calculation	T1	T2	T3	T4
A (Lying & Rolling)	—	68.8%	78.0%	85.0%	91.2%
B (Sitting)	—	43.3%	55.0%	66.7%	76.7%

Both GMFM dimensions demonstrated marked improvement, indicating enhanced postural control and motor function following intervention. The GMFM-88 is a standardized and widely used assessment tool in pediatric physiotherapy for objectively and validly evaluating gross motor development.

Table 4 displays the findings from the primitive reflex examination, highlighting changes in reflex responses following the intervention. The reduction or integration of certain primitive reflexes reflects positive neurological adaptation, which is essential for achieving higher-level motor patterns.

Table 4. Primitive Reflex Examination Results

Reflex	T1	T2	T3	T4
Palmar grasp	+	+	+/-	–
Spinal galant	+	+	+/-	–

These findings indicate a reduction in primitive reflex responses, with both palmar grasp and spinal galant reflexes transitioning from positive at T1 to negative at T4, reflecting improved neural maturation and reflex integration.

Table 5 provides an overview of the participant's sensory response profile, as measured through various tactile, proprioceptive, and vestibular stimuli. Improvements in sensory processing abilities suggest that the intervention not only addressed motor skills but also contributed to better sensory integration.

Table 5. Sensory Response Evaluation Results

Sensory Component	Response Criteria	T1	T2	T3	T4
Vision (Visual)	Focus on objects, track with eyes, recognize faces/people	2	2	2	2
Hearing (Auditory)	Turn toward name being called, respond to environmental sounds, enjoy music	2	2	2	2
Smell (Olfactory)	Reaction to odors	2	2	2	2
Taste (Gustatory)	Sensitivity to food taste/texture	2	2	2	2
Touch (Tactile)	Appropriate reaction to touch	2	2	2	2
Balance (Vestibular)	Maintain stability while moving	0	1	1	2

Most sensory responses remained stable at a score of 2, indicating good functional ability. Notable improvement was observed in vestibular function, increasing from 0 at T1 to 2 at T4, suggesting enhanced postural stability. Scoring**:** 0 = Not responsive; 1 = Moderately responsive; 2 = Highly responsive.

Table 6 presents the results of the Dynamic Neuromuscular Stabilization (DNS) balance assessment performed on a gym ball. This evaluation captures the participant's ability to maintain postural stability in a dynamic environment, reflecting enhanced core control and balance capacity.

Table 6. DNS Gym Ball Balance Evaluation

Time Point	Observations
T1	Unable to maintain sitting on gym ball without assistance; poor balance when ball moved; insufficient postural muscle activation
T2	Able to sit with minimal assistance; maintained balance for 10 seconds during slow ball movement
T3	Sat independently on gym ball with improved stability; maintained position for 30 seconds during gentle movement
T4	Demonstrated good postural control; maintained dynamic balance for 1 minute with ball movement in multiple directions

Note: Improvement was evident from inability to sit at T1 to maintaining stable posture for 1 minute at T4.

Figure 1. DNS balance training using a gym ball (Author's documentation, 2025).

Table 7 outlines the participant's performance in maintaining the quadruped position according to DNS principles. The ability to sustain this position for longer durations with improved alignment indicates readiness for more complex motor activities such as crawling.

Table 7. DNS Quadruped Position Evaluation

Time Point	Observations
T1	Unable to maintain quadruped; instability in arms and legs; frequent lateral falls
T2	Held quadruped for 10 seconds with supervision; emerging trunk activation
T3	Maintained quadruped for 30 seconds; began attempting contralateral limb lifts
T4	Held quadruped for 1 minute; spontaneously demonstrated cross-lateral coordination

Note: These findings indicate improved postural control and body stability.

Figure 2. DNS quadruped position training (Author's documentation, 2025).

Table 8 details the participant's ability to maintain the squat position, a crucial transitional posture for functional mobility. The findings suggest better lower-limb strength, pelvic control, and postural endurance as a result of the intervention.

Table 8. DNS Squat Position Evaluation

Time Point	Observations
T1	Unable to maintain squat; frequent backward falls or use of hand support
T2	Squatted with hand support for 5–10 seconds
T3	Squatted independently for 20 seconds, slight wobbling
T4	Squatted stably for >30 seconds; performed stand-to-squat transition with minimal assistance

Note: These results suggest improved balance and postural control.

Figure 3. DNS squat position training (Author's documentation, 2025).

Table 9 reports the participant's responses to toy-based activities during Sensory Integration (SI) sessions. The level of engagement, exploration, and interaction with toys provides insight into improvements in attention, motivation, and sensory-motor coordination.

Table 9. SI Toy Response Evaluation

Time Point	Observations
T1	No interest in toys; glanced briefly before looking away; no hand exploration
T2	Passively held toys placed in hand; increased visual focus (~5 seconds)
T3	Actively reached for and shook toys; maintained attention for ~15 seconds
T4	Actively explored toys visually and manually; showed preference for certain shapes/colors; maintained attention >30 seconds

Figure 4. SI toy recognition training (Author's documentation, 2025).

Table 10 describes the participant's performance in maintaining eye contact and engaging in hand-holding during SI activities. Positive changes in these behaviors point toward enhanced social interaction, emotional connection, and communicative intent.

Table 9. SI Eye Contact & Hand-Holding Evaluation

Time Point	Observations
T1	Inconsistent eye contact; weak, brief hand grasp
T2	Brief eye contact (2–3 seconds) when called; slightly stronger hand grasp
T3	Maintained eye contact for 5–10 seconds; smiled during interaction; active hand grasp following simple movements
T4	Maintained eye contact for >10 seconds; displayed emotional expressions; strong grasp, responsive to movement

Figure 5. SI eye contact and hand-holding training (Author's documentation, 2025).

Table 11 presents the participant's responsiveness to auditory and visual stimuli during SI sessions. Enhanced tracking, orientation, and reaction to sensory cues suggest improvements in sensory processing and attentional focus.

Table 11. SI Auditory and Visual Response Evaluation

Time Point	Observations
T1	No response to toy sounds or name; no reaction to images or music
T2	Turned toward loud sounds, especially mother's voice; minimal reaction to images
T3	Quickly oriented to sound source; showed interest in bright/animated images
T4	Recognized specific sounds; indicated preference for certain images

Figure 6. SI auditory and visual response training (Author's documentation, 2025).

The patient demonstrated high adherence to the therapy schedule. Parents actively participated in each session and continued home-based stimulation as instructed by the physiotherapist. No adverse effects such as excessive fatigue or sensory overstimulation were observed. Follow-up evaluation is scheduled one-month post-intervention to monitor sustainability of outcomes.

Discussion

The findings of this study demonstrate notable improvements in the child's ability to sit and crawl following sensory–motor stimulation training. The GMFM scores increased substantially in dimension A (68.8% → 91.2%) and dimension B (43.3% → 76.7%), indicating enhanced postural control and stability. The combination of DNS and SI proved effective in supporting gross motor development, consistent with previous reports showing that DNS facilitates activation of core musculature and promotes movement patterns aligned with developmental stages.[10] DNS exercises employ natural infant positions, such as crawling and squatting, to encourage greater engagement of the core muscles, while SI enhances alertness and attention, enabling movements to become more purposeful and stable.

The DNS approach, particularly through crawling and squatting positions, stimulates whole-body coordination and strengthens postural support muscles. This is in line with evidence suggesting that DNS promotes motor control through neuromuscular activation. [7,11] Automatic activation of the back and abdominal muscles occurs as the child maintains postural positions, improving coordination between upper and lower body segments. This synergy contributes to both dynamic stability and functional mobility.

Primitive reflexes such as the asymmetric tonic neck reflex (ATNR) and the palmar grasp reflex diminished from positive to negative during the intervention, indicating neuromotor maturation. This aligns with prior literature stating that suppression of primitive reflexes reflects more advanced central nervous system development.[12] In clinical practice, such changes are critical markers for readiness to acquire more complex voluntary motor skills.

The SI approach facilitated improved responses to environmental stimuli, including increased eye contact, active toy exploration, and enhanced reactions to auditory and visual cues. These observations are consistent with reports demonstrating that SI interventions improve sensory processing and attention in children.[3,8] Repeated and structured sensory stimulation may enhance neural plasticity, thereby improving efficiency of sensory–motor integration pathways in the brain.

This study extends the findings of previous work that investigated DNS alone by demonstrating that combining DNS with SI produces synergistic benefits for postural control and sensory responsiveness.[7] To date, reports exploring the combined use of these two methods in children with Down syndrome remain limited, making the present study an early contribution to the literature and a potential foundation for more extensive clinical research.

Several limitations should be noted. First, the single-case study design restricts the generalizability of the findings. Second, the relatively short intervention period prevents confirmation of long-term effects. Third, the absence of a control group limits the ability to differentiate between intervention effects and natural developmental progression. Finally, some progress assessments relied partly on clinical observation, which may introduce subjective bias. Future studies should employ larger sample sizes, longer intervention durations, and more rigorous experimental designs to confirm these results.

The results suggest that integrating DNS and SI techniques can be an effective component of physiotherapy programs for children with Down syndrome, particularly for improving sitting and crawling abilities, reducing primitive reflexes, and enhancing sensory responsiveness. Clinicians are encouraged to incorporate these methods into structured therapy plans with regular evaluations, actively involve families in home-based exercises, and implement long-term follow-up to monitor the sustainability of treatment outcomes.

Conclusion

The application of Dynamic Neuromuscular Stabilization (DNS) combined with Sensory Integration (SI) yielded positive outcomes in improving sitting and crawling abilities in a child with Down syndrome. This intervention enhanced postural stability, reduced primitive reflexes, and improved sensory responsiveness. The key insight from this case is that the DNS–SI combination can serve as a practical short-term intervention strategy for children with developmental disorders. Given the single-subject design and brief intervention period, further studies with larger sample sizes and long-term follow-up are required to strengthen these findings.

A combined DNS and SI approach is recommended as a short-term physiotherapy intervention for children with Down syndrome, supported by active parental involvement to ensure continuity of home-based exercises. Consistent improvements were observed in GMFM scores; however, external factors such as additional home stimulation may also influence outcomes. Clinicians are advised to integrate these methods into structured therapy programs and to include periodic evaluations to monitor progress and treatment effectiveness.

Author Contribution

Nova Ayu Aisyah: Conceptualization, Data Curation, Investigation, Intervention Implementation, Writing – Original Draft.
Dimas Arya Nugraha: Supervision, Methodology, Validation, Formal Analysis, Writing – Review & Editing.
Diah Rosyida Maulidina: Methodology, Data Interpretation, Visualization, Writing – Review & Editing.
All authors have read and approved the final manuscript.

Acknowledgments

The authors would like to express their sincere gratitude to Muhammadiyah Lamongan Hospital for granting permission to conduct this study. Appreciation is also extended to the physiotherapy team for their assistance during the intervention and evaluation process. Special thanks are given to the patient and the patient's parents for their cooperation and for providing informed consent for participation and publication of this case study.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this article.

Funding Sources

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics Statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from the child's parents prior to participation in the study and for the publication of this case report, including the use of clinical data and documentation. Ethical approval was not required for this single-case study, as the intervention was part of routine clinical physiotherapy practice and did not involve experimental procedures.

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