Transcutaneous Spinal Cord Stimulation (tSCS / NISE-Stim) Bowel and Bladder Control in Spina Bifida: Current Evidence and Rationale

A research summary for clinical application

Prepared for NISE-Stim | Compiled July 2026 by Andreea Herciu PT

1. Bowel and Bladder Dysfunction in Spina Bifida: Clinical Background

Neurogenic bladder and bowel dysfunction affect the large majority of children with myelomeningocele, because the sacral spinal segments (S2–S4) that coordinate detrusor, sphincter, and anorectal function are frequently involved in the underlying dysraphism — resulting in high rates of urinary incontinence and fecal incontinence in roughly a third to over half of patients. Standard management (clean intermittent catheterization, medication, bowel programs, and in severe cases surgery) is burdensome, carries its own risks, and **does not restore underlying neural function** — which is driving clinical interest in neuromodulation approaches that could reduce reliance on these measures or improve bladder/bowel function directly.

2. What tSCS / NISE-Stim Is, and What It Is Not

tSCS delivers electrical current through surface electrodes placed over the spine (typically T11–L2 and/or S2–S4), aiming to depolarize posterior root afferents and engage spinal interneuronal circuits below the stimulation level. It is **mechanistically and anatomically distinct** from other techniques sometimes grouped with it in the literature: TENS/parasacral TENS and posterior tibial nerve stimulation (both peripheral nerve techniques, not spinal), transcutaneous interferential stimulation (targets the abdomen/pelvic floor, not the spinal cord), and sacral neuromodulation devices such as InterStim (an implanted, invasive technology).

This distinction matters clinically: a family or clinician searching for "electrical stimulation for neurogenic bladder in spina bifida" will find a much larger literature on these peripheral/sacral techniques than on tSCS specifically — the two should not be conflated. Studies of TENS, PTNS, interferential stimulation, or implanted sacral neuromodulation are cited in this document only where explicitly labeled as such.

3. How tSCS May Influence Bowel and Bladder Function: The Underlying Mechanism

The neural circuitry governing continence and voiding is organized across two spinal levels that map directly onto standard tSCS electrode placements:

- **Thoracolumbar level (T11–L2):** houses the sympathetic outflow to the bladder neck and internal urethral sphincter (storage phase) and is a common tSCS stimulation site for lower-limb and postural applications.
- **Lumbosacral level (S2–S4):** contains the parasympathetic preganglionic neurons controlling detrusor contraction, the pudendal motor neurons controlling the external urethral and anal sphincters, and the interneuronal circuits coordinating the anorectal and micturition reflexes.

Preclinical work in intact and spinal-cord-injured animal models (including non-human primates) has shown that transcutaneous stimulation over these levels can activate the detrusor muscle and external urethral sphincter in coordinated, anatomically predictable patterns. In humans, this has translated into several proof-of-concept and pilot studies — reviewed below — showing that lumbosacral tSCS can measurably change bladder capacity, detrusor pressure, detrusor-sphincter coordination, and anorectal resting pressure. The proposed mechanism is neuromodulation of spinal interneuronal networks and afferent-driven reflex circuits, rather than direct muscle stimulation.

A separate line of tSCS research, focused specifically on spasticity rather than pelvic organ function, provides indirect mechanistic support for this framework: Minassian et al. (2024, Cell Reports Medicine) showed that the same posterior-root afferent pathways recruited by lumbar tSCS also drive measurable, transient strengthening of spinal inhibitory circuits (postsynaptic reciprocal Ia inhibition and presynaptic inhibition) in adults with SCI, with improvements that correlated with reduced spasticity. This does not test bladder or bowel function directly, but it reinforces the broader principle that afferent-driven tSCS can engage and temporarily strengthen spinal circuit function broadly, not only in the motor pathways most commonly studied.

4. Current Evidence Base

4.1 Direct tSCS evidence: adults with spinal cord injury and idiopathic overactive bladder

The strongest and most direct evidence that tSCS can modulate bladder and bowel function comes from adult studies — predominantly in traumatic spinal cord injury (SCI) and, in one line of work, idiopathic overactive bladder in adults without SCI. These studies are not conducted in spina bifida populations, but they establish the physiological plausibility and the human dose-response and safety profile of the technique when applied to pelvic organ function, using the same tSCS technology and electrode placement described in Section 3.

- Gad et al. (2018), Frontiers in Neuroscience — TESSLA, a tSCS protocol for lower urinary tract function, restored bladder and urethral sphincter coordination and increased bladder capacity in adults with chronic SCI.

- Niu et al. (2018), Scientific Reports — a related non-invasive magnetic spinal stimulation approach (TMSCS) enabled volitional urination and reduced catheterization frequency in five adults with chronic SCI over sixteen weekly sessions.
- Kreydin et al. (2020), Frontiers in Systems Neuroscience — TESCoN, a tSCS device targeting T11–12 and L1–2, reduced overactive bladder symptoms in adults without SCI, supporting a direct spinal mechanism independent of SCI-related pathology.
- Samejima et al. (2025), Bioelectronic Medicine — a detailed case study in one adult with chronic cervical SCI receiving 30 sessions of lumbosacral tSCS reported improved bladder compliance, lowered anal resting pressure toward normal values, improved rectoanal reflex relaxation, and reduced severity of autonomic dysreflexia during bladder- and bowel-function testing — one of the most direct combined bladder-and-bowel outcome datasets available for tSCS to date.
- León et al. (2024), Frontiers in Medicine — a case report of a 37-year-old woman with a 22-year-old complete spinal cord infarction, treated with tSCS alone for 8 months and then tSCS + physical therapy for 12 more months. Her Neurogenic Bladder Symptom Score (NBSS) improved from 27 at baseline to 17 at 20 months — a clinically meaningful change — alongside self-reported bladder/bowel continence improvements and resolution of recurrent UTIs.
- Gad, Zhong, Edgerton & Kreydin (2021), Neurotrauma Reports — a case study demonstrating that home-based, self-administered SCONE-brand tSCS therapy safely improved neurogenic bladder symptoms in an individual with post-stroke lower urinary tract dysfunction — relevant because it demonstrates feasibility of caregiver/self-administered tSCS outside a clinical/lab setting, directly relevant to a home-based pediatric protocol such as NISE-Stim.
- Samejima et al. (2022), PLOS ONE — a published pilot-trial protocol (not yet reporting final results as of this writing) for a structured trial of lumbosacral tSCS targeting bladder, bowel, and sexual function in forty adults with chronic motor-complete SCI.
- Sachdeva, Law, Nightingale, Gad & Krassioukov (2025), Neuromodulation: Technology at the Neural Interface — a scoping review pooling 47 studies (13 animal, 36 human) on spinal cord stimulation and autonomic function after SCI, including 22 studies reporting bowel-function outcomes. Found consistent positive effects of SCS (epidural and transcutaneous combined) on bowel, bladder, cardiovascular, and sexual function, while noting most studies were observational and higher-quality controlled trials are still needed.
- Laskin, Waheed, Thorogood, Nightingale & Noonan (2022), Archives of Physical Medicine and Rehabilitation — a separate scoping review of SCS research (epidural and transcutaneous) for motor, sensory, and autonomic recovery in SCI, corroborating that autonomic outcomes including bladder/bowel are a growing but still comparatively small share of the literature.
- Charles et al. (2024), Seminars in Spine Surgery (review chapter on central cord syndrome) — describes transcutaneous electrical spinal stimulation as non-invasive with demonstrated effects on spasticity, extremity movement, and bowel function in SCI, consistent with the broader adult literature above.
- Kissane & Ichiyama (2020), in Handbook of Innovations in Central Nervous System Regenerative Medicine — a book chapter noting that some bladder control can be recovered with spinal

stimulation, while cautioning that transcutaneous stimulation requires higher intensities than epidural approaches since the signal must cross multiple tissue layers, which can affect comfort.

Note: *all studies in this subsection were conducted in adults, and SCI-related pathophysiology (particularly injury level/completeness and autonomic dysreflexia risk) differs in important ways from the congenital, typically lower-level, often incomplete lesions seen in spina bifida. These studies establish mechanism and human safety/feasibility; they should not be read as direct evidence of effect size in spina bifida.*

4.2 tSCS evidence specific to spina bifida

As of this review, there is no completed tSCS study that has enrolled children or adults with spina bifida with bowel or bladder function as a primary outcome. The relevant direct evidence consists of the following:

- ClinicalTrials.gov NCT07615686 — an actively recruiting pilot trial (single-center, up to 20 participants ages 4–17 with myelomeningocele) testing lumbosacral tSCS over 4–6 weeks for both lower-limb motor function and bladder control. To our knowledge, the first trial specifically designed to test tSCS for bladder function in a spina bifida population; no results published yet.
- ClinicalTrials.gov NCT06918119 (Mayo Clinic) — a related, currently recruiting study characterizing tSCS-evoked reflex motor responses in children and youth with spina bifida; primary focus is neuromotor characterization rather than bowel/bladder outcomes, but part of the same research program.
- Motavalli, McElroy & Alon (2019), Child Neurology Open — a published case report of a 6-month-old infant with myelomeningocele receiving combined FES and tSCS (the approach NISE-Stim is based on) documented the safe emergence of previously absent sensory and motor responses below the lesion level. Notably, this is one of the few tSCS sources with a bowel-relevant observation: improved anal sphincter closure and reduced fecal smearing over treatment, alongside improved circulation — a secondary clinical observation in a single infant, not a formal continence/urodynamic outcome measure.

Note: *the pediatric spina bifida tSCS literature is early-stage and motor-function-focused; bowel/bladder-specific tSCS trials in this population are only now getting underway. The 2019 case report above (Motavalli, McElroy & Alon) is Gerti Motavalli's own published work — the first documented use of tSCS in an infant with spina bifida — making its bowel-relevant observation a useful anchor point. The rationale is mechanistically strong and supported by adult tSCS data, but formal pediatric spina bifida bowel/bladder outcome data is not yet published.*

4.3 Related pediatric spina bifida neurostimulation evidence (non-tSCS)

A separate and larger body of pediatric evidence exists for non-tSCS electrical stimulation techniques in spina bifida bladder and bowel dysfunction. This is relevant context — it demonstrates that neurostimulation in general is feasible, tolerated, and often beneficial in this population — but should not be cited as tSCS evidence given the different anatomical target described in Section 2.

Study	Modality	Population / Design	Key Finding
Zaidi et al. (2022), J Pediatric Urology (PMC9757791)	TENS (parasacral, ± anticholinergics)	40 children with spina bifida, RCT-style comparison of 3 groups	Improved wet episodes/day, detrusor pressure, bladder compliance and capacity; combined with anticholinergics performed better than either alone.
NCT06025734 (UT Southwestern, recruiting)	Transcutaneous tibial nerve stimulation (TTNS)	12 children with spina bifida and neurogenic bladder	Ongoing pilot evaluating urinary leakage outcomes after 6–12 weeks of home-based TTNS; results not yet published.
Electrostimulation systematic review (2025), PMC12519759	Mixed: invasive and non-invasive electrotherapy (TENS, PTNS, sacral stimulation)	Systematic review/meta-analysis, children 3–21 with spina bifida	Found improvement in bladder compliance across pooled electrotherapy studies, but noted no consensus on optimal technique or protocol.
Bigliardi et al. (2024/2025), JPGN Reports (jpr3.12152)	Transcutaneous parasacral stimulation	Single case, 13-year-old with L4-level myelomeningocele	Resolution of constipation and fecal incontinence after partial response to biofeedback; treated with transcutaneous parasacral neurostimulation.

5. Safety Considerations

Pediatric tSCS safety data comes primarily from spinal cord injury, cerebral palsy, spinal muscular atrophy, and acute flaccid myelitis populations, where sessions numbering in the dozens have been reported without serious adverse events; reported effects are generally mild and transient (skin irritation under electrodes, transient discomfort at higher intensities). No seizure activity has been reported in the published pediatric tSCS literature.

One safety consideration specific to bladder and bowel testing under tSCS in the SCI literature is **autonomic dysreflexia (AD)** — a potentially serious hypertensive reflex response that can be triggered by bladder or bowel distension, most relevant in individuals with spinal cord lesions at or above T6. This is a well-recognized risk in traumatic SCI research protocols, where several tSCS studies (Samejima et al. 2025 among them) specifically monitored for AD during bladder- and bowel-function testing and found that long-term tSCS was actually associated with **reduced AD severity** during these procedures. AD is far less common in spina bifida than in traumatic SCI because most myelomeningocele lesions are at a lower spinal level and are frequently incomplete, but clinicians should be aware of the phenomenon and screen for lesion level and any prior AD history before beginning a stimulation protocol that includes bladder/bowel-focused sessions, particularly in children with higher-level or more complete lesions.

6. Summary

The mechanistic case for tSCS as a tool to influence bowel and bladder function in spina bifida is reasonably strong: the standard tSCS electrode placements sit directly over the spinal segments that govern detrusor, sphincter, and anorectal control, and adult human studies using this exact technology have shown measurable, reproducible changes in bladder capacity, detrusor-sphincter coordination, and anorectal function. However, the direct pediatric spina bifida evidence base for bowel and bladder outcomes specifically is not yet established — the first purpose-built trial (NCT07615686) is currently recruiting and has not yet reported results. Existing pediatric spina bifida neurostimulation evidence with positive bladder/bowel findings largely comes from TENS, TTNS, and interferential stimulation studies, which are related but anatomically distinct techniques. This document should be updated once results from the recruiting tSCS trials become available.

7. References

tSCS — direct mechanistic and adult clinical evidence

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tSCS — spina bifida–specific (pediatric)

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Background / clinical context

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