Nerve root magnetic stimulation improves locomotor function following spinal cord injury with electrophysiological improvements and cortical synaptic reconstruction

**Abstract**

Following a spinal cord injury, there are usually a number of neural pathways that remain intact in the spinal cord. These residual nerve fibers are important, as they could be used to reconstruct the neural circuits that enable motor function. Our group previously designed a novel magnetic stimulation protocol, targeting the motor cortex and the spinal nerve roots, that led to significant improvements in locomotor function in patients with a chronic incomplete spinal cord injury. Here, we investigated how nerve root magnetic stimulation contributes to improved locomotor function using a rat model of spinal cord injury. Rats underwent surgery to clamp the spinal cord at T10; three days later, the rats were treated with repetitive magnetic stimulation (5 Hz, 25 pulses/train, 20 pulse trains) targeting the nerve roots at the L5–L6 vertebrae. The treatment was repeated five times a week over a period of three weeks. We found that the nerve root magnetic stimulation improved the locomotor function and enhanced nerve conduction in the injured spinal cord. In addition, the nerve root magnetic stimulation promoted the recovery of synaptic ultrastructure in the sensorimotor cortex. Overall, the results suggest that nerve root magnetic stimulation may be an effective, noninvasive method for mobilizing the residual spinal cord pathways to promote the recovery of locomotor function.

**Key Words:** evoked potentials; H-reflex; motor activity; nerve conduction; neural plasticity; rehabilitation; sensorimotor cortex; spinal cord injury; synapses; transcranial magnetic stimulation

**Introduction**

Spinal cord injury (SCI) is a serious disorder of the central nervous system (CNS) (Hu et al., 2020; Sugeno et al., 2020; Zhang et al., 2020) caused by damage to the nerves that run through the spinal canal (Yao et al., 2021). Following SCI, output signals from the upper motor neurons terminate at the proximal end of the nerve injury site, thus interrupting the neural conduction that controls movement (O’Shea et al., 2017). SCI can be classified as either complete or incomplete, depending on the severity of the damage (Marino et al., 2003). Approximately 42% of patients with SCI are clinically diagnosed as having a complete SCI; however, an autopsy study showed that the diagnosis could be confirmed in just 14.3% of cases (Kakulas, 2004), thus indicating that the majority of patients have an incomplete SCI with some intact nerve fibers (Weidner et al., 2001; Kaegi et al., 2002; Rosenzweig et al., 2010). It has been suggested that certain

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**Graphical Abstract**

Nerve root magnetic stimulation promotes electrophysiological restoration and cortical synaptic reconstruction following spinal cord injury

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interventions could enhance the neural plasticity of these remaining nerve fibers, and that this could rehabilitate neural conduction and function (Larikov et al., 2007; Serradji et al., 2017; Khorasanizadeh et al., 2019). This is of much clinical importance, because SCI continues to be associated with high rates of disability, despite widespread efforts to treat the disorder (Katoh et al., 2019; Liu et al., 2020).

In recent years, noninvasive magnetic stimulation has become an effective therapeutic intervention in the neuropsychiatric field (Concerto et al., 2015; Lanza et al., 2018; Wessel and Hummel, 2018; Staudt et al., 2019). Recent studies have shown that it can also be used for neural rehabilitation following SCI (Ganzler et al., 2018; Wagner et al., 2018; Elmgreen et al., 2019). The technique involves selecting stimulation targets; when these are located in the cortex, transcranial magnetic stimulation (TMS) is typically used (Barker et al., 2019). A number of studies have demonstrated that patients with SCI have improved motor function following TMS of the motor cortex (Sato et al., 2018; Guo et al., 2020). However, for a more optimal recovery, the sensorimotor neural circuits in the spinal cord would need to be reconstructed. This would require more than the stimulation of the motor cortex, which can only excite the descending corticospinal tract. Our team therefore developed a neural circuit-magnetic stimulation protocol, which involves stimulating both the motor cortex and the nerve root of the target muscle group, to fully activate the residual intact nerve fibers. In our preliminary study, subjects with chronic incomplete SCI underwent four weeks of treatment using intermittent theta-burst stimulation (rTBS) of the motor cortex combined with bilateral nerve root stimulation. The patients showed significant improvements in lower limb motor function as well as nerve conduction in the corticospinal tract.

To further evaluate the efficacy of our novel approach for treating SCI, we used a SCI rat model to explore the effects of nerve root magnetic stimulation (NRMS) on motor function, nerve conduction, and the synaptic ultrastructure of the sensorimotor pathway.

Materials and Methods

Animals

The experiments were approved by the Animal Ethics Committee of Tongji University Affiliated to Tongji University School of Medicine on August 31, 2019 (approval No. 2019-DW-(036)). The experimental procedures followed the United States National Institutes of Health Guide for the Care and Use of Laboratory Animals (NIH Publication No. 85-23, revised 1996) and strictly complied with the guidelines of Animal Research: Reporting of In Vivo Experiments (Periee du Sert et al., 2020).

The study was carried out on 45 adult male Sprague-Dawley (SD) rats (specific-pathogen-free, weighing 200–220 g, 2–3 months old), which were obtained from Shanghai Jiesijie Experimental Animal Farm (license No. SCXK (Hu) 2018-0004). The sample size (n = 45) was determined using *G*Power 3.1 software for a two-way analysis of variance with α = 0.05 and β = 0.95 (Dattalo, 2009; Ko and Lim, 2021).

The 45 rats were divided into three equal-sized groups using a random number table (n = 15 in each group): (1) sham operation + sham stimulation (sham + SS), (2) SCI + sham stimulation (SCI + SS), and (3) SCI + nerve root magnetic stimulation (SCI + NRMS). All of the rats were kept at a constant temperature of 25°C with a 12-hour light-dark cycle. Food and water were well supplied ad libitum. The rats were preadapted for one week prior to SCI surgery.

Rat spinal cord injury model

The 30 rats in the SCI + SS and SCI + NRMS groups underwent clip compression using a method developed by Rivlin and Tator (Rivlin and Tator, 1978) for the rat SCI model. The rats underwent preparative fasting and water deprivation for at least 6 hours. They were then anesthetized by an intraperitoneal injection with 1% pentobarbital sodium (4 ml/kg; Sigma-Aldrich; St. Louis, MO, USA), placed on a bench in the prone position, and shaved. An incision was made, and the muscles were separated; a laminectomy was performed at the T9–T11 level and the spinal cord was exposed at the T10 level. An aneurysm clip (50 g, Fine Science Tools, Heidelberg, Germany) was placed so that the inner blade passed extradurally and completely around the spinal cord and nerve roots at the T10 vertebra. This was then rapidly released from the applicator, producing a bilateral impact force and sustained dorsal-ventral compression. This was maintained for 15 seconds before the clip was removed, resulting in a sudden, violent convolution of the hindlimbs and tail swing, which indicated the success of the SCI model. The rats from the sham + SS group underwent the same laminectomy but without the aneurysm clip compression. For all of the rats, the muscle and skin incisions were closed, they were injected with normal saline solution according to the intraoperative blood loss, and they were placed on a heating pad until fully awake. Postoperative care included keeping the rats singly in cages with enough food and water, a daily intraperitoneal injection of penicillin (200,000 IU/d) for one week to prevent infection, and an abdominal massage to induce micturition twice a day until the recovery of autonomous urination.

Nerve root magnetic stimulation treatment

We started NRMS treatment on day three after the SCI surgery, when the blood-borne monocytes had started to infiltrate the spinal cord to decrease the apoptosis of neurons (Kjell and Olson, 2016). We used a MagPro R30 magnetic stimulator (MagVenture Co., Farum, Denmark) with a 25 mm, figure-of-eight, custom rodent coil. The rats were treated in the prone position, in a holder made of plastic resin. The stimulation sites were the nerve roots at the L5–L6 lumbar segment, which target the gastrocnemius (GAS) muscles, on both paravertebral sides. The correct location for the NRMS was identified using palpation along with the anatomical landmarks (e.g., the anterior superior iliac spine).

To determine the NRMS stimulation intensity, it was first necessary to ensure that motor-evoked potentials (MEPs) were elicited. For this, the coil was held over the motor cortex, and the stimulation intensity was gradually increased from zero; recordings from the right GAS muscle were observed on a real-time digital oscilloscope so that MEPS could be detected. If none were observed at low intensities, the position of the magnetic coil was adjusted by a few millimeters, and the procedure was repeated. When the optimal position had been found, the resting motor threshold (rMT) was determined, which is the lowest stimulation intensity that induces at least three MEPS of similar amplitude (≤ 100 μV) for five consecutive, single TMS pulses (Rossini et al., 1994). For the treatment, the NRMS was delivered as a series of seven pulse trains, each containing 25 pulses at a rate of 5 Hz and with a stimulus intensity of 100% rMT (500 pulses in total). For the SCI + NRMS group, the rats were treated five times a week for 3 weeks; the other two groups received sham stimulation, which involved treatment with the coil placed perpendicular to the spine, thus giving the same level of sound stimulation. The NRMS treatment was always run between 6 p.m. and 8 p.m.

Evaluation of locomotor function

The rats’ locomotor function was assessed at different time points using the Basso-Beattie-Bresnahan (BBB) scale (Basso et al., 1996), the inclined plane test (Duan et al., 2018), the rotarod test (Sauer et al., 2017), and the modified Tarlov score (Jiang et al., 2016). These were run the day before surgery and on days 1, 3, 7, 14, and 21 after surgery (Figure 1). To enable the rats to adapt to the tests, they were run five times before the official tests took place. Each measure was blindly and independently assessed by two observers, and the averaged scores were recorded for each rat. All of the tests were run on all 15 rats in each group.

Figure 1 | Study timeline and model of the root magnetic stimulation (NRMS) treatment.

(A) The timeline shows the overall study schedule. NRMS treatment began on the third day after the SCI operation. Behavioral tests were run to evaluate the recovery of motor function on days 1, 3, 7, 14, and 21 post-surgery. Electrophysiological measures (MEP, SEP, and H-reflex) were obtained to assess nerve conduction on days 3, 7, 14, and 21 following SCI. (B) The diagram displays the stimulation site and the coil used for the NRMS treatment. The rat was placed in the prone position, and the nerve roots were stimulated at the L5–L6 level bilaterally. The paravertebral foramen with a figure-of-eight rodent coil to activate the gastrocnemius muscle. H-reflex: Hoffmann reflex; MEP: motor-evoked potential; NRMS: nerve root magnetic stimulation; SCI: spinal cord injury; SEP: sensory-evoked potential.
Basso-Beattie-Bresnan locomotor rating scale

Two rats were placed in an open field (2 m in diameter) and were free to move around for 5 minutes. The experimenters observed each rat’s hindlimb locomotor function, including the joint movements, coordination, paw placement, and toe clearance. Each hindlimb was given a score ranging from 0 to 21, and the average for both limbs was calculated for each rat. A score of zero indicated hindlimb paralysis without any hindlimb movement, whereas a score of 21 indicated unimpaired locomotion, as observed in normal, uninjured rats.

Inclined plane test

The rats were placed on a smooth slanting board with freely adjustable angles, with their heads facing the upper end of the board. The angle was gradually increased in 5° steps until the rat could no longer remain stable for five seconds. The test was repeated three times and the average inclined angle was recorded.

Rotated test

The rats were placed on a rotating rod in a rotated apparatus (Shanghai Xinruan, Shanghai, China), with a rotation speed of 20 r/min. The experimenters recorded the length of time that the rats were able to remain on the rod. This was repeated four times for each rat, with a 10-minute interval between the tests, and the average on-rood time was calculated.

Modified Tarlov scoring system

The rats were given a modified Tarlov score based on a six-point scale (0–5): 0) complete paralysis of both hindlimbs without any function; 1) the hindlimbs can move slightly without bearing weight; 2) the hindlimbs can move freely without bearing weight; 3) the hindlimbs can support enough weight to walk a few steps; 4) the rat can walk with a slight impairment; 5) the rat walks normally.

Neuroelectrophysiological measurements

Neuroelectrophysiological tests were carried out to assess nerve conduction in the injured spinal cord following NRMS treatment. These were carried out before the SCI surgery, and at 1, 2, and 3 weeks after the surgery. For these tests, the rats underwent inhalation anesthesia with 5% isoflurane followed by a steady level of 2% isoflurane in 97–98% O2, administered via a nose cone. The rats were placed horizontally in the prone position, and needle electrodes in the Keypoint 4-evoked Potential System (Beijing Weidi Kangtai Medical Instrument Co., Ltd., Beijing, China) were used to measure the MEPs, somatosensory-evoked potentials (SEP), and the Hoffmann reflex (H-reflex). These disposable subdermal needle electrodes were inserted into the hindlimbs, cortex, and tail, and acted as the stimulating, recording, reference, and ground electrodes. The interelectrode impedances were kept ≤ 3 kΩ. Each test was performed on both sides of the rat’s body and the average values were calculated.

Motor-evoked potential

The stimulating electrode was inserted under the skull into the motor cortex, 2 mm anterior to the coronal suture and 2 mm lateral to the sagittal suture. Direct square-wave electrical pulses from the electrode stimulated the motor cortex to elicit slight hindlimb tics. The pulse intensity was 32 mA, the width was 0.1 ms, the frequency was 1 Hz, the sensitivity was 2 mV/D, and the scanning speed was 2 ms/D. Muscle compound action potentials were recorded in the GAS muscle in each hindlimb. The reference electrode was inserted into the Achilles tendon, and the grounding electrode placed subcutaneously near the base of the tail. The electrical stimulus intensity was set so that the toes alone were stimulated; the current intensity was 0–0.5 mA, the pulse width was 0.5 ms, the frequency was 0.5 Hz, the sensitivity was 1 mV/D, the scanning speed was 2 mS/D, the filter was 0–1000 Hz, and the waveform was superimposed 50 times. The test was run on five rats from each group, and there were 10–15 recordings for each side. For the data analyses, the latency and amplitude of the H-reflex H-wave and M-wave were determined, and the H/M amplitude ratio was calculated.

Ultrastructure of the sensorimotor cerebral cortex

After three weeks of NRMS treatment, the rats were sacrificed under anesthesia. The brains were collected on an ice plate, the sensorimotor cortex was dissected, and the tissue was cut into 1 mm × 1 mm × 1 mm pieces. The samples were then fixed in 2.5% glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) for 3–4 hours at 4°C, followed by post-fixation in 1% OsO4 in 0.1 M phosphate buffer in the dark for two hours at room temperature. After dehydration in graded ethanol and embedding in EMBed 812 resin, the samples were moved into a 65°C oven for polymerization for more than 48 hours, and then sliced into 60–80 nm thick slices using an ultramicrotome (Leica, Solms, Germany). The slices were double-stained using uranium acetate for eight minutes and then lead citrate for eight minutes; they were then photographed using a H77800 transmission electron microscope (Hitachi Electronic Instruments, Tokyo, Japan). Ten non-overlapping tissue samples were photographed for each rat, and the synaptic ultrastructure was quantified using Image Pro Plus 6.0 software (Media Cybernetics, MD, USA). The synaptic curvature was measured using a method described by Jones (1993); the thickness of the postsynaptic density (PSD) and the length of the synaptic active zones were measured using a method described by Güldner and Ingham (1980); and the width of the synaptic cleft was determined using the multi-point averaging method. Each of these measurements was obtained for four rats from each group, with a total of 40 tissue sample images per group.

Statistical analysis

Statistical analyses were conducted, and figures were generated using GraphPad Prism 7 software (Graphpad Software, San Diego, CA, USA). All of the data were expressed as the mean ± standard error of the mean (SEM) and analyzed using unpaired t-tests, one-way analysis of variance, or two-way analysis of variance, followed by Tukey’s post hoc tests. A level of P < 0.05 was considered to be statistically significant.

Results

NRMS improves locomotor function in SCI rats

All 45 SD rats completed the whole battery of behavioral tests assessing motor function. The scores on the tests prior to surgery did not differ significantly between the three groups (P > 0.05; Figure 2). On the first day post-surgery, all of the measures (the BBB score, the inclined plane angle, the on-rod time, and the modified Tarlov score) were significantly lower in the SCI + SS group and the SCI + NRMS group compared with the sham + SS group (P < 0.001; Figure 2). On the third day following SCI, there were no significant differences between the SCI + SS group and the SCI + NRMS group. However, on the seventh day following SCI, the BBB score, the inclined plane angle, and the on-rod time were all significantly higher in the SCI + NRMS treatment group compared with the SCI + SS group (P = 0.0036, P = 0.0019, and P = 0.0257, respectively; Figure 2). By the end of the second and third weeks, remarkable group differences could be observed for all four tests, with the SCI + NRMS group achieving higher scores than the SCI + SS group (P < 0.001 for all tests; Figure 2). These results imply that NRMS treatment leads to improved recovery of locomotor function following SCI.

H-reflex

For the H-reflex, the hindlimb tibial nerve was stimulated and recordings were obtained in the second dorsal interosseous muscle of the hind paw, with the reference electrode placed in the muscle tendon, and the ground electrode placed subcutaneously near the base of the tail (Zhang et al., 2007). The electrical stimulus intensity was set so that the toes alone were stimulated; the current intensity was 0.5–5 mA, the pulse width was 0.5 ms, the frequency was 0.5 Hz, the sensitivity was 1 mV/D, the scanning speed was 2 mS/D, the filter was 0–1000 Hz, and the waveform was superimposed 50 times. The test was run on five rats from each group, and there were 10–15 recordings for each side. For the data analyses, the latency and amplitude of the H-reflex H-wave and M-wave were determined, and the H/M amplitude ratio was calculated.

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NRMS improves nerve conduction in SCI rats
To investigate whether NRMS can improve nerve conduction, we recorded MEPs, SEPs, and the H-reflex. These can be used to assess neuronal excitability and conduction within the spinal cord nerve tracts.

NRMS enhances nerve conduction in the sensorimotor pathway
Prior to surgery, there were no significant differences between the three groups in terms of both the latency and amplitude of the SEP. On the third day following surgery, the two groups of SCI rats were found to have prolonged SEP latencies compared with the sham + SS group (P < 0.01; Figure 3A, B). However, no significant differences were observed between the SCI + NRMS group and the SCI + SS group (P > 0.05). After the first week, the SEP latencies in the SCI rats gradually decreased, with a greater reduction seen in the NRMS-treated SCI rats (two-way analysis of variance with Tukey’s post hoc test: P = 0.004, P < 0.001, P < 0.001). However, there were no significant differences in the SEP amplitude between the two SCI groups during the study period (P > 0.05).

NRMS increases the excitability of the corticospinal tract
Prior to SCI surgery, there were no significant MEP latency differences between the three groups of rats. On the third day after surgery, the SCI rats had increased MEP amplitudes. The SEP latencies between the two SCI groups were not significantly different in the SEP amplitudes between the three groups (P > 0.05; Figure 3A, C). After the first week, the SEP latencies in the SCI rats gradually decreased, with a greater reduction seen in the NRMS-treated SCI rats (two-way analysis of variance with Tukey’s post hoc test: P = 0.0137, P < 0.001, P < 0.001). However, there were no significant differences in the SEP amplitude between the two SCI groups during the study period (P > 0.05).

NRMS improves spinal presynaptic inhibition
The H-reflex recordings (Figure 5A) revealed that there was a significantly longer H-waveform latency in the SCI + NRMS group (P < 0.01; Figure 5D). For the H-waveform amplitude, although there were noticeable differences between the two groups, this was only significantly different at the end of the first week (P < 0.01; Figure 5C). For the H/M ratio, the percentage of excited alpha motor neurons responding to the electrical stimulation decreased noticeably in the SCI + NRMS group compared with the SCI + SS group on the seventh day after surgery (P < 0.001; Figure 5B), as well as on day 21 after surgery (P < 0.001; Figure 5B).

NRMS promotes recovery of the synaptic ultrastructure in the sensorimotor cortex
The synaptic ultrastructure in the sensorimotor cortex was examined to determine the effect of NRMS on structural plasticity in the sensorimotor neural pathways. In the SCI + SS group, we observed marked damage to the ultrastructure of the synapses, with a flat synaptic morphology. In contrast, the SCI + NRMS group showed no such changes, with a normal synaptic morphology. In the SCI + NRMS group, the synaptic structure was closer to normal compared with the SCI + SS group, thus suggesting that there had been a certain amount of recovery to restore the synaptic damage. The significant changes in synaptic ultrastructure that followed SCI included the thickness of the PSD, the length of the synaptic active zone, and the curvature of the synaptic interface (P < 0.001; Figure 6C–E), but not the width of the synaptic cleft (P > 0.05; Figure 6B). Importantly, the length of the synaptic active zone increased substantially with NRMS treatment (P < 0.001; Figure 6D).

Discussion
Damage to the spinal cord neural pathways following SCI leads to varying degrees of motor paralysis and sensory disturbance (Zijdewind and Thomas, 2003). In patients with incomplete SCI, the intact nerve fibers can enable partial spontaneous recovery of sensorimotor function through neural plasticity (Weidner et al., 2001; Kaegi et al., 2002; Rosenzweig et al., 2010), although this remains limited (Cafferty et al., 2008; Boulenguez and Vinay, 2009; Lovett-Barr et al., 2012). Studies have shown that TMS, a technique that was first introduced to activate the cerebral cortex (Barker et al., 1985), has the potential to increase the excitability of certain electrically conductive tissues and improve neural plasticity following CNS injury (Wagner and Valero-Cabre, 2007).
The present study used NRMS, a novel approach that aims to stimulate the sensory tract to improve motor function. We were able to demonstrate the following: (1) treatment using repetitive magnetic stimulation of the spinal cord nerve root induces functional recovery following SCI; (2) NRMS leads to changes in the excitability of the sensorimotor pathway and improves inhibition in spinal pathways; (3) NRMS promotes the recovery of synaptic ultrastructure in the sensorimotor cortex; and (4) NRMS can activate the ascending sensory pathways leading to an increase in cortical output and motor function improvement, using the lowest level of the high-frequency magnetic stimulation settings (5 Hz). It can therefore be seen that repetitive high-frequency NRMS has considerable potential for the treatment of SCI and could be used in conjunction with TMS and skilled motor training.

It is widely accepted that the primary motor cortex plays a critical role in the flexible control of spinal circuits during sensorimotor learning (Lemon, 2008). However, while cortical activation can potentially excite the descending corticospinal tract, this is not the case for the ascending sensory tract; thus, for functional recovery from SCI, TMS alone cannot activate the sensory tract that can contribute toward improved motor function. Our team therefore designed a novel neural circuit-magnetic stimulation (NC-MS) protocol that includes two stimulation targets: the motor cortex and the spinal nerve roots (Additional file 1). Our NC-MS protocol was inspired by work on paired associative stimulation (PAS), which involves spike-timing-dependent plasticity (Song et al., 2000; Uribe et al., 2017; Bunday et al., 2018) that modifies the synaptic efficiency in accordance with Hebbian theory (Hebb, 1949). Our NC-MS protocol may involve similar neural mechanisms to PAS (Stefan et al., 2000; Stefan et al., 2002), and initial results have shown that it effectively improves the recovery of motor function in the lower extremities of both SCI patients and rats (Mao et al., 2019; Zhao et al., 2020). The present study demonstrated the efficacy of NRMS alone on SCI functional recovery using the lowest level of high-frequency magnetic stimulation (5 Hz).

The behavioral tests showed that the locomotor function of SCI rats improved following NRMS treatment. The motor recovery was first
assessed using the BBB scale (Basso et al., 1996), which has been extensively used to evaluate motor function in SCI rats. Each score (0–21) represents a combination of movements, which accurately reflects the degree of functional motor recovery during rehabilitation, with higher scores reflecting better motor function. The results showed a significant increase in BBB scores in the NRMS-treated rats compared with the sham stimulation group. This was attributed to the increased functional capabilities of the injured limbs due to NRMS treatment. NRMS was noted to be more effective than sham stimulation in improving motor function, particularly in the lower extremities, which is consistent with previous findings (Kato et al., 2019).

The H-reflex, a single synapse reflex of the spinal cord, was also examined to evaluate the effect of NRMS treatment. The H-reflex was measured in the sciatic muscle of the rats, and the results were compared with those of sham-stimulated rats. The NRMS treatment was found to increase the H-reflex amplitude and decrease the latency, indicating an improved excitability of the motor neuron pool. These findings suggest that NRMS treatment may enhance the excitability of the motor cortex, thereby improving motor function in SCI rats.

The SEP (somatosensory evoked potential) was also measured to evaluate the integrity of the sensory pathway. The SEP latency was significantly shorter in the NRMS-treated group compared with the sham-stimulated group. This finding is consistent with previous studies on the efficacy of NRMS in improving sensory function following SCI (Kato et al., 2019).

In conclusion, the results of this study support the use of NRMS as a potential therapeutic modality for SCI, with improvements in motor and sensory function. Further research is needed to elucidate the underlying mechanisms of NRMS and its long-term effects on neurological function in SCI patients.
