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Trans-spinal Direct Current Stimulation for Pain Reduction in Non-Specific Chronic Low Back Pain

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A B S T R A C T

Background: Non-specific chronic low back pain (NSCLBP) is prevalent and often challenging to treat effectively. Trans-spinal direct current stimulation (tsDCS) is a non-invasive technique proposed to modulate spinal pain pathways. Evidence for its efficacy in reducing pain intensity in NSCLBP is limited. **Objective**: To investigate the effect of adding active anodal tsDCS to a standard exercise program on self-reported pain intensity (Numeric Pain Rating Scale - NPRS) compared to sham tsDCS plus exercise in individuals with NSCLBP. **Methods**: A double-blind, sham-controlled, randomized trial was conducted. Thirty-seven participants (18-60 years) with NSCLBP (>12 weeks) were randomized into two groups. Group A (n=19) received active anodal tsDCS (2mA, 20 min, T8-L2 anode/cathode) plus standardized exercises. Group B (n=18) received sham tsDCS plus the same exercises. Interventions were delivered 3 times weekly for 4 weeks (12 sessions). The primary outcome was the NPRS score measured at baseline and post-intervention. Paired and independent t-tests were used for analysis ($p<0.05$). **Results**: Groups were comparable at baseline ($p>0.05$). Post-intervention, the active tsDCS group showed a significant reduction in mean NPRS scores (5.8 ± 1.6 to 4.2 ± 1.7; mean difference 1.6; $p=0.0002$). The sham group showed no significant change (5.9 ± 1.3 to 5.4 ± 1.6; mean difference 0.5; $p=0.240$). Post-treatment NPRS scores were significantly lower in the active group compared to the sham group (4.2 ± 1.7 vs 5.4 ± 1.6; mean difference -1.23; $p=0.031$). **Conclusion**: Adding active tsDCS to a conventional exercise program resulted in a statistically significant greater reduction in pain intensity compared to sham tsDCS plus exercise over four weeks in participants with NSCLBP. While statistically significant, the clinical meaningfulness requires further consideration.

Keywords: Low back pain, Musculoskeletal disorders, Electrotherapy, TsDCS, Chronic Pain

1. Introduction

Non-specific chronic low back pain (NSCLBP) is an incredibly common problem worldwide, causing significant personal suffering and disability. It's a major reason people miss work and visit doctors, creating a substantial burden on healthcare resources and society in general (Hartvigsen et al., 2018). Unfortunately, finding consistently effective treatments for the chronic form of this condition is often difficult. Many common therapies, such as exercise, manual treatments, or pain medications, frequently offer only modest or temporary pain relief, leaving many patients still struggling (Chou et al., 2017). This situation really pushes researchers and clinicians to look for new and potentially more effective approaches.

There's growing evidence that NSCLBP isn't just a simple tissue injury but involves complex changes within the nervous system, including how pain signals are processed in the spinal cord and brain (Nijs et al., 2010). These central changes might help explain why pain can persist long after any initial injury should have healed. Because the nervous system seems to play such a key role, therapies that can directly target and modulate neural activity are gaining interest.

One such technique is trans-spinal direct current stimulation (tsDCS). This is a non-invasive method that involves applying a weak, constant electrical current to the skin over the spine using electrodes (Cogiamanian et al., 2008). The idea behind tsDCS is that this current can influence the excitability of nerve pathways within the spinal cord (Zaghi et al., 2010). Importantly, these spinal pathways include those involved in transmitting and processing pain signals. By potentially altering the activity in these sensory circuits, tsDCS might be able to reduce the perception of pain (Bocci et al., 2021). Some preliminary studies in different pain conditions have suggested tsDCS could have pain-relieving effects.

Given its potential to modulate spinal cord sensory processing, tsDCS seems like a logical approach to investigate for NSCLBP, where altered central pain mechanisms are often implicated. However, despite the theoretical rationale, high-quality evidence specifically demonstrating that tsDCS can reduce pain intensity, as measured by tools like the Numeric Pain Rating Scale (NPRS), in people with NSCLBP is still limited. While our broader study also investigated the physiological effects of tsDCS using electromyography (EMG) to understand potential mechanisms (to be reported separately), establishing whether tsDCS actually provides immediate pain relief is a critical first step.

Therefore, the primary aim of this specific study was to investigate the immediate effect of a single session of anodal tsDCS on self-reported pain intensity, measured using the NPRS, in individuals with NSCLBP compared to a sham stimulation condition. We hypothesized that active anodal tsDCS would lead to a significantly greater reduction in NPRS scores immediately following the intervention compared to sham tsDCS.

2. Methods

Study Design

This investigation employed a pretest-posttest, randomized controlled trial methodology with double blinding (assessor and participant) and a sham control group to assess the impact of trans-spinal direct current stimulation (tsDCS) on chronic low back pain.

Participants

Forty individuals meeting criteria for non-specific chronic low back pain (NSCLBP) were initially enrolled via convenience sampling from local university clinics, orthopedic referrals, and university staff/student populations. Thirty-seven participants ultimately completed the study protocol.

Eligibility

Included patients aged 18-60 years old from both sexes, with NSCLBP persisting for over 12 weeks, lacking specific pathology, radicular signs, or major neurological deficits, consistent with established guidelines (Qaseem et al., 2017). Exclusions comprised prior spinal surgery/fracture, radiating neuropathic leg pain, electronic implants (pacemakers), pregnancy, malignancy, systemic conditions, epilepsy, significant psychiatric history, diabetes, and obesity.

Ethical Procedures

The study protocol received approval from the Cairo University Faculty of Physical Therapy Institutional Review Board (Ref: P.T.REC/012/005480). Participants provided written informed consent before any study procedures commenced.

Randomization and Blinding

Upon enrollment, participants were allocated to either the active tsDCS group (Group A) or the sham tsDCS group (Group B). Allocation concealment was maintained using a systematic sequence (e.g., based on enrollment order parity) managed by an independent third party. This ensured neither participants nor the outcome assessor were aware of group assignments throughout the intervention and assessment periods.

Intervention: Trans-spinal Direct Current Stimulation (tsDCS)

- Stimulation was delivered using a commercially available stimulator (Primo Multidyne 970, EMS Physio Ltd, UK).
- Setup: Two 7 cm × 8 cm carbon electrodes embedded in saline-soaked sponges were utilized. Following skin cleaning, the anode was placed over the T8 spinous process, and the cathode over the L2 spinous process, secured with straps.
- Active Stimulation (Group A): A constant direct current of 2 mA was administered for 20 minutes per session. The current intensity was gradually increased over 30 seconds at the beginning and decreased over 30 seconds at the end (Guidetti et al., 2021). This resulted in a current density (0.035 mA/cm²) considered safe based on established guidelines (Nitsche et al., 2003).
- Sham Stimulation (Group B): To maintain blinding, the sham protocol involved the same initial 30-second ramp-up to 2 mA, but the current was only active for 5 seconds before being ramped down over 30 seconds. The device remained inactive for the remainder of the 20-minute session, mimicking the initial sensation of active stimulation (Gandiga et al., 2006).

Outcome Measure: Pain Intensity

The primary outcome for this report was self-reported pain intensity, measured via the 11-point Numeric Pain Rating Scale (NPRS), anchored from 0 ("no pain") to 10 ("worst possible pain"). The Arabic version (ANPRS) was used for administration (Alghadir et al., 2016). Participants completed the scale on paper before the first intervention session (baseline) and after the final session (post-intervention). Note: Additional neurophysiological and quality-of-life outcomes were collected but are not the focus of this report.

Measurement Protocol

After baseline assessments, eligible participants were randomized. They attended treatment sessions three times weekly for four consecutive weeks (12 sessions total). During each session, participants received their assigned stimulation (active or sham) while lying prone, followed immediately by a standardized routine of conventional low back exercises (including stabilization and mobility components) (Inani & Selkar, 2013). Post-intervention assessments, including the NPRS, were conducted after the 12th session.

Statistical Analysis

Data analysis was conducted using SPSS (Version 26.0). Baseline characteristics and NPRS scores were summarized using means and standard deviations. Paired t-tests assessed within-group changes in NPRS scores from pre- to post-intervention. An independent samples t-test compared post-intervention NPRS scores between Group A and Group B. Statistical significance was defined as $p < 0.05$

3. Results

Participant Flow and Baseline Data

Thirty-eight participants (Group A: n=19; Group B: n=19) with non-specific chronic low back pain completed the study. The groups were well-matched at baseline regarding age, weight, height, Body Mass Index (BMI), and gender distribution, with no statistically significant differences observed between Group A (active tsDCS) and Group B (sham tsDCS) ($p > 0.05$ for all comparisons). Baseline characteristics are detailed in Table 1 and gender distribution in Table 2.

Numeric Pain Rating Scale (NPRS)

At baseline, there was no significant difference in mean NPRS scores between Group A (5.8 ± 1.6) and Group B (5.9 ± 1.3) ($p = 0.748$). Following the 4-week intervention period:

- **Group A (Active tsDCS):** Showed a statistically significant decrease in mean NPRS score from 5.8 ± 1.6 to 4.2 ± 1.7 (Mean Difference = 1.6; $p = 0.0002$).
- **Group B (Sham tsDCS):** Showed a small, non-significant decrease in mean NPRS score from 5.9 ± 1.3 to 5.4 ± 1.6 (Mean Difference = 0.5; $p = 0.240$).

The post-intervention comparison revealed a statistically significant difference between the groups, with Group A reporting lower mean NPRS scores than Group B (4.2 ± 1.7 vs. 5.4 ± 1.6; Mean Difference = -1.23; $p = 0.031$). Detailed NPRS results are presented in Table 3.

Table 1. Comparison of Baseline Demographics and Anthropometrics

Variable	Group A (Active tsDCS) (n=19)	Group B (Sham tsDCS) (n=18)	p-value	Interpretation
Age (years)	33.1 ± 11.9	35.8 ± 13.5	.510	NS
Weight (kg)	70.5 ± 9.7	72.0 ± 12.7	.683	NS
Height (cm)	169.1 ± 6.7	169.2 ± 7.9	.944	NS
BMI (kg/m²)	24.5 ± 1.7	24.9 ± 2.2	.542	NS

Values are Mean ± Standard Deviation. BMI: Body Mass Index. NS: Non-significant difference ($p > 0.05$) via independent t-tests.

Table 2. Baseline Gender Composition by Group

Group	Male	Female	p-value	Interpretation
Group A (n=19)	13 (68.4%)	6 (31.6%)	0.714	NS
Group B (n=18)	14 (77.8%)	4 (22.2%)		

Values count (percentage). NS: Non-significant difference Test.

Table 3: Numeric Pain Rating Scale (NPRS) Scores (Mean ± SD)

Comparison	Group A (n=19)	Group B (n=18)	Mean Difference	p-value	Significance
Baseline (Pre-Treatment)	5.8 ± 1.6	5.9 ± 1.3	-0.15	0.748	NS
Post-Treatment	4.2 ± 1.7	5.4 ± 1.6	-1.23	0.031	S
Within-Group Change					
Group A (Post - Pre)			1.6	0.0002	S

Comparison	Group A (n=19)	Group B (n=18)	Mean Difference	p-value	Significance
Group B (Post - Pre)			0.5	0.240	NS

Data presented as Mean ± Standard Deviation (SD). Mean Difference refers to Group A - Group B for between-group comparisons, and Post - Pre absolute change for within-group comparisons. S: Significant ($p < 0.05$); NS: Non-significant ($p > 0.05$).

4. Discussion

The primary aim of this specific analysis was to determine if trans-spinal direct current stimulation (tsDCS), when added to a standard exercise regimen, could significantly reduce pain intensity compared to sham stimulation plus exercise in individuals with non-specific chronic low back pain (NSCLBP). The findings indicate that the group receiving active tsDCS experienced a statistically significant reduction in pain, as measured by the Numeric Pain Rating Scale (NPRS), over the four-week intervention period, whereas the sham group did not show a significant change.

At the study's conclusion, the active tsDCS group reported significantly lower mean NPRS scores compared to the sham group. This between-group difference suggests that the active stimulation provided a benefit for pain reduction beyond that attributable to the exercise program or potential placebo effects associated with the sham procedure. The observed mean reduction of 1.6 points on the NPRS within the active group is statistically robust ($p=0.0002$). While any pain reduction is positive, the clinical significance of this magnitude warrants consideration, as minimal clinically important difference (MCID) thresholds for NPRS in LBP are often cited around 2 points (Childs et al., 2005a). The average effect size observed here approaches, but does not clearly exceed, this threshold.

The lack of significant pain reduction in the sham group ($p=0.240$) is also noteworthy. It suggests that the conventional exercise program, while potentially beneficial in other ways not assessed in this specific report, did not independently lead to statistically significant pain relief within the four-week timeframe for this cohort. This reinforces the interpretation that the active tsDCS component was the primary driver of the superior pain outcome observed in Group A.

These results align generally with the growing body of literature exploring the use of non-invasive brain and spinal stimulation techniques for chronic pain management. While direct comparisons are complex due to variations in stimulation parameters and target populations, the finding that active tsDCS can modulate pain perception is consistent with proposed mechanisms involving altered neuronal excitability within spinal pain pathways (Cogiamanian et al., 2008; Truini et al., 2011). However, this study did not directly measure such mechanisms.

Limitations

Several limitations pertinent to this focused analysis should be acknowledged. Firstly, this report deliberately concentrates only on the NPRS outcome. The full study included measures of function, quality of life, and neurophysiological changes (NFR), which provide a broader context but are outside the scope of this specific paper. Therefore, conclusions drawn here relate strictly to pain intensity. Secondly, the follow-up period was limited to immediately post-intervention; the long-term persistence of the observed pain reduction is unknown. Thirdly, while the between-group difference in pain was statistically significant ($p=0.031$), the mean difference of 1.23 points falls below the commonly accepted 2-point MCID threshold, raising questions about the definitive clinical impact for the average patient, even if statistical significance was achieved. Finally, the study utilized a convenience sample from specific settings, potentially limiting the generalizability of the findings to the broader NSCLBP population.

Clinical Implications

Based solely on these pain findings, tsDCS shows potential as an adjunct to exercise for enhancing short-term pain relief in NSCLBP. If the observed statistically significant difference translates to a noticeable benefit for some patients, it could offer a non-pharmacological option. However, clinicians should weigh the statistical significance against the magnitude of the average effect and the lack of long-term data when considering its application.

Conclusion

Within the limitations of this focused analysis, the addition of active tsDCS to a conventional exercise program resulted in a statistically significant greater reduction in self-reported pain intensity (NPRS) compared to sham tsDCS plus exercise over four weeks in participants with NSCLBP. While promising for pain management, the clinical meaningfulness requires careful consideration, and further research is essential to confirm these findings, evaluate longer-term effects, and understand the impact on broader functional outcomes.

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