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Transcranial direct current stimulation for nonspecific low back pain: double-blind randomized sham-controlled trial

Przezczaszkowa stymulacja prądem stałym przy nieswoistym bólu dolnego odcinka kręgosłupa – randomizowane badanie z podwójnie ślepą próbą, z grupą kontrolną otrzymującą placebo

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Key words
Transcranial, current stimulation, low back pain, disability, Oswestry

Abstract
Introduction: Low back pain is recognized as a major cause of morbidity worldwide. Between 70 and 80% of adults experience at least one occasion of low back pain with duration of 3 months or longer in their lifetime. Aside from the classic treatment methods, there are other new techniques yet to be clinically investigated. Transcranial direct current stimulation (tDCS) has been reported to alleviate pain by affecting the central nervous system. To date only a small number of studies have been published on the effects of tDCS on chronic low back pain. Some of these were pilot studies and others were low-powered in terms of their inference. Therefore the clinical application of tDCS requires further careful evaluation.
Objective: To assess the efficacy of transcranial direct current stimulation for treatment of chronic nonspecific low back pain.
Materials and methods: We carried out a double-blind randomized sham-controlled trial in a University Hospital. In total 70 people (15 women) with low back pain were randomized to either active or sham stimulation. The primary outcome was intensity of low back pain on the Visual Analog Scale. We also used the Oswestry Disability Questionnaire to evaluate the effects of back pain on daily activities. For the active stimulation group we administered 2 mA tDCS, 20 minutes for each session, once daily, 5 days per week for 2 weeks, totaling 10 sessions. For the sham stimulation group a similar program was followed with no stimulation. Both groups used analgesic medication.
Results: Within-group analysis showed that an initial decrease in pain intensity was significant in both groups (both $p < 0.001$). However, pain reduction became stable only in the active treatment group. There was a significant difference in the pattern of change in mean pain scores in favor of tDCS ($p < 0.001$). Active treatment also significantly reduced disability scores (all p values < 0.001), whereas participants in the sham treatment group did not experience functional recovery. Mixed ANOVA indicated that the pattern of change in mean scores of disability differed between the two groups throughout the study course, in favor of active stimulation ($p < 0.001$).
Conclusion: Transcranial direct current stimulation is an effective and safe initial treatment for chronic nonspecific low back pain, and the benefits remain for at least several months.

Słowa kluczowe
przezczaszkowy, prąd stały, ból dolnego odcinka kręgosłupa, niepełnosprawność, Oswestry

Streszczenie
Wstęp: Na całym swiecie ból dolnego odcinka kręgosłupa jest uznawany za poważną przyczynę zachorowalności. Pomiędzy 70 a 80% dorosłych osób doświadcza co najmniej raz w życiu bólu dolnego odcinka kręgosłupa, utrzymujacego się 3 miesiące lub dłużej. Oprócz klasycznych metod leczenia, istnieją inne nowe techniki, które jeszcze należy sprawdzić klinicznie. Dowiedziono, że przezczaszkowa stymulacja prądem stałym (ang. transcranial direct current stimulation, tDCS) łagodzi ból poprzez

The individual division of this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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oddziaływanie na centralny system nerwowy. Do tej pory, opublikowano tylko niewielką ilość badań na temat wpływu tDCS na przewlekły ból dolnego odcinka kręgosłupa. Niektóre z nich były badaniami pilotażowymi, a inne były słabe pod względem swoich wniosków. Dlatego też kliniczne zastosowanie tDCS, wymaga dalszej, starannej oceny.

Cel: Określenie skuteczności przezczaszkowej stymulacji prądem w leczeniu przewlekłego niespecyficznego bólu dolnego odcinka kręgosłupa.

Materiały i metody: Przeprowadziliśmy randomizowane badanie z podwójnie ślepą próbą, z grupą kontrolną otrzymującą placebo w Szpitalu Uniwersyteckim. W sumie 70 osób (15 kobiet) z bólem dolnego odcinka kręgosłupa, przydzielono losowo do grupy z aktywną stymulacją lub grupy z pozorowaną stymulacją. Głównym ocenianym parametrem była intensywność bólu dolnego odcinka kręgosłupa na Wizualnej Skali Analogowej (ang.the Visual Analog Scale). Zastosowaliśmy również kwestionariusz Oswestry (ang. the Oswestry Disability Questionnaire) do oceny wpływu bólu pleców na codzienne czynności. U grupy z aktywną stymulacją, zastosowaliśmy 2 mA tDCS, 20 minut na każdą sesję, raz dziennie, 5 dni w tygodniu, przez okres 2 tygodni, w sumie 10 sesji. U grupy z pozorną stymulacją, zastosowano podobny program, ale bez stymulacji. Obie grupy stosowały leki przeciwbólowe.

Wyniki: Analiza wewnątrzgrupowa wykazała, że początkowy spadek intensywności bólu był znaczący w obu grupach (obie wartości $p < 0.001$). Jednak zmniejszony ból utrzymał się tylko w grupie z rzeczywistym leczeniem. Wystąpiła znacząca różnica we wzorze zmian w średnich wynikach na korzyść tDCS ($p < 0.001$). Aktywne leczenie również znacznie obniżyło wyniki niepełnosprawności (wszystkie wartości $p < 0.001$), podczas gdy uczestnicy z grupy z pozorowanym leczeniem, nie doświadczyli funkcjonalnego powrotu do zdrowia. Mieszana ANOVA wykazała, że wzór zmiany w średnich wynikach niepełnosprawności różnił się pomiędzy dwoma grupami podczas całego toku badania, na korzyść aktywnej stymulacji ($p < 0.001$).

Wniosek: Przezczaszkowa stymulacja prądem stałym jest efektywnym i bezpiecznym początkowym leczeniem dla przewlekłego niespecyficznego bólu dolnego odcinka kręgosłupa, a jej efekty utrzymują się przez co najmniej kilka miesięcy.

INTRODUCTION

Low back pain is recognized as a major cause of morbidity worldwide[1,2]. Between 70-80% of adults experience at least one occasion of low back pain, with a duration of three months or longer, in their lifetime[3]. However, only 15% of the diagnostic workups reveal a specific cause[1]. Chronic nonspecific low back pain (CNLBP) is the most common debilitating condition of the musculoskeletal system, particularly in elderly people. The condition affects physical, psychological, and social dimensions of life[4-6].

Researchers have assessed the effects of different therapeutic modalities on the manifestations of low back pain. They reported a variety of medications, non-medical interventions, and surgical procedures that are effective in controlling pain, restoring function, and improving quality of life[3]. People are commonly instructed to avoid a sedentary lifestyle and prolonged sitting[7]. Patients with CNLBP benefit from manual therapy through an increased pain threshold and sympathetic excitation[1,8]. Progressive aerobic or resistance training, core stabilizing workouts, routine or balance physical training, stretching, and combinations of exercise programs with electrical stimulation are reported to decrease pain intensity in patients[2,9-13]. Moreover, exercise appears to improve psychological well-being and quality of life[9].

Nevertheless, there is no established optimal technique for the treatment of CNLBP. Some studies have indicated that high-quality randomized controlled trials are still required to compare the efficacy of different exercise programs[9,14,15]. Debate as to the benefits of exercise programs reflects the lack of consensus regarding the best treatment strategy[16]. Furthermore, adherence to treatment is still a concern in prescribing long-term exercise programs[17]. Other studies suggest that conservative strategies such as absolute rest are ineffective, and that medications commonly provide short-term benefits[1]. Adverse reactions also restrain the long-term prescription of analgesics[18]. There is much controversy surrounding the application of thermotherapy and electrotherapy[1].

Among the published works on the efficacy of treatment modalities are studies with poor methodological quality[17,19]. Descriptions of the interventions, the assessment tools, sample sizes and gender composition of the participants, and duration of follow-ups vary among studies leading to limited external validity[20-22]. Further research is required to investigate the efficacy of different strategies, especially those therapeutic interventions that have been suggested more recently[1,3].

Aside from classic treatment methods there are other new techniques yet to be clinically investigated. Transcranial direct current stimulation (tDCS) has been reported to alleviate pain through its effects upon the central nervous system[23]. Recent studies suggested that patients with chronic low back pain may benefit from tDCS more significantly compared to an exercise program[24]. Researchers also believe that tDCS would diminish the affective component of pain and thereby relieve pain-related symptoms in patients with chronic low back pain[25]. However, other studies have failed to replicate the favorable outcomes[26,27]. Overall only a small number of studies have been published on the effects of tDCS on chronic low back pain. Some of these were pilot studies[23-25] whilst others were low-powered in their inferences[27-29]. As such, the clinical application of tDCS still requires careful evaluation.

We conducted a trial to compare the outcomes of active versus sham-controlled tDCS in two groups of participants with CNLAB. Our alternative hypothesis was that tDCS would affect the intensity of pain and disability in patients with CNLBP.

STUDY AIM

To assess the efficacy of transcranial direct current stimulation for treatment of chronic nonspecific low back pain.

MATERIALS AND METHODS

Design and setting

From September 2017 for one year we performed a sham-controlled randomized clinical trial with two parallel groups. The study was conducted in an outpatient clinic of the department of Physical Medicine and Rehabilitation at a University hospital. The hospital is a large referral and subspecialty center.

Recruitment

Patients who came to the hospital because of low back pain or were referred by primary care physicians for a diagnostic workup were invited to attend an assessment of their symptoms. At the first visit a resident of physical medicine and rehabilitation interviewed the patients and performed general physical examinations. Potential participants filled in a questionnaire on their medical history and on risk factors for low back pain. Eligible patients were visited by two of the authors in order to diagnose the causes of their low back pain. Patients without any specific cause of low back pain were enrolled. Then they filled in a questionnaire for the Oswestry Disability Index.

Any gradual deterioration of the symptoms was recorded and the severity, pattern of distribution and time relations were investigated. Plain radiography and magnetic resonance image were taken for participants with uncertain diagnosis. If the diagnosis remained equivocal an advisory committee including the authors and other consulting physicians determined the opinion. Finally, participants who gave written consent were included in the study and were randomly assigned to two groups. They were then immediately instructed to begin one of the treatments.

Eligibility criteria

We recruited patients aged from 18 to 55 years with CNLBP. Chronic low back pain was defined as the presence of pain between the lower edge of the last rib and the iliac crest lasting for more than 12 weeks. We resolved to exclude patients with contraindications to tDCS such as active skin lesions under the site of the electrodes or if they had episodes of headache and vertigo during treatment sessions. We also excluded individuals if they had low back pain of a non-mechanical nature, radiculopathy, a history of fracture or severe trauma to the low back region, back surgery within the last year, specific spinal pathology including malignancies and neurological diseases, incontinency, severe weight loss, manifestations of infection such as fever and night sweat, progressive muscular weakness, immunodeficiency, a positive history of rheumatologic diseases in first degree relatives, significant psychiatric conditions, were taking systemic corticosteroids within the last month or were pregnant. Further, patients who had sought prior treatment for peripheral joint disease, and those unwilling to follow the study program were also excluded.

Outcome measures

The primary outcome measure was intensity of pain in the low back region. A 10 cm Visual Analog Scale was used to measure subjective pain rated from 0 (no pain) to 10 (most severe pain). We also used the Oswestry Disability Questionnaire for evaluating and monitoring the effects of back pain on daily activities. The questionnaire is self-report and includes the following groups of questions: pain intensity and its effect on personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and travelling. Each subscale contains 6 questions and to each question a score from zero to four is assigned. The levels of disability are determined according to the total score as: no disability (0 to 4), mild disability (5 to 14), moderate disability (15 to 24), severe disability (25 to 34), and complete disability (35 to 50). For no disability only advice on lifting, sitting, and exercise is given, and for mild disability conservative treatment is indicated. Patients with moderate disability need detailed investigation while individuals with severe disability require intervention. Completely disabled people are either bed-bound or are exaggerating their symptoms.

As such, the questionnaire encompasses a wide range of levels for physical activity. It takes the patient approximately 10 minutes to answer all the questions. We performed the measurements before intervention and again five days, four weeks, and 12 weeks after completion of the treatment program. Anthropometric features including age and body mass index were also recorded for all participants.

Study intervention

A trained resident of physical medicine and rehabilitation administered tDCS with an Endomed (ENRAF Company, Netherlands). Patients were instructed to sit on a chair and were not allowed to fall asleep. The instrument was placed out of the patients' sight. The anode and cathode electrodes were inserted in a 20 cm^2 sponge, soaked in a 1% saline solution, and were placed with Velcro over the motor cortex area, and over the contralateral supraorbital cortex respectively. For patients with one sided back pain the contralateral hemisphere was stimulated; otherwise the dominant hemisphere was selected for stimulation. The international 10/20 system EEG was used for positioning the electrodes. The anode was fixed over the motor cortex for paraspinal muscles, 1 cm anterior and 4 cm lateral to the vertex. For the active stimulation group we administered 2 mA tDCS of duration 20 minutes for each session, with 30 s ramp up from zero and 30s ramp down period. For the sham treatment group we administered 30 s ramp up of the current from zero to 2 mA, 10 s stimulation, 30 s ramp down to zero, and 20 minutes without current. We informed all participants that people in both groups would experience an initial tingling or itching at the electrode sites. The program repeated once daily, five consecu-

tive days for two weeks totaling 10 sessions. We allowed at most three missed visits, which were replaced at the end of the study to complete the 10 session program. All participants were instructed to take the non-steroidal anti-inflammatory drug Celecoxib 100 mg daily for the duration of the trial.

Ethical considerations

The trial was conducted in full compliance with the Helsinki Declaration. The institutional review boards approved the protocol, and all participants gave signed written consent for inclusion and follow-up. A trained nurse explained the study to eligible participants and obtained the consents. Patients were informed that they were free to withdraw from the study at any time. All authors had full access to the data.

Randomization and blinding

Referring to a previous study we calculated our sample size using the difference in mean VAS for pain between the intervention and sham group[30]. Based on a power of 80% and a two tailed p value of less than 0.05 as statistically significant, we required 29 participants in each group. We added a further six people to each group as contingency against a loss of up to 20% at follow-up. Therefore, 70 participants were randomized using blocked randomization with block size 4, to provide two samples with equal size. Random numbers were generated by a computer.

The study was sham-controlled and all participants were unaware of their allocation status. We informed all participants regarding possible side-effects of tDCS such as itching and pain at the site of stimulation. Whilst some patients from both groups reported occasional itching, skin irritation was seen only in the group receiving active tDCS. Moreover, all follow-up evaluations were performed by assessors blinded to group assignment and to the study question.

Statistical analyses

Data are presented as mean and standard deviation (SD) for continuous variables and as numbers and proportions for categorical variables. The normality of the outcome variables at baseline and post intervention follow-ups were examined with the Kolmogorov-Smirnov test. Differences in continuous variables at the baseline and at the end of the follow-up period were compared using paired t-test. Differences between categorical variables were evaluated using the Chi-squared test. Non-parametric tests (Mann-Whitney, Kruskal-Wallis and Friedman) were used when the data was not normally distributed. Mixed design ANOVA was carried out to compare the two groups in repeated measures. Mauchly's test was used to assess sphericity of data. Where the data was not normally distributed we performed a robust non-parametric counterpart of mixed ANOVA (R package WRS – Wilcox' Robust Statistics). The level of significance was set at 0.05. Data analyses were performed with R version 3.5.0.

RESULTS

A total of 70 people with CNLBP were randomized to either active or sham-tDCS. Figure 1 shows the flow of patients during the study. We did not have any case of loss to follow-up or withdrawal from the study. Except for 5 instances of mild skin irritation no important side-effects were reported by our participants. Of the 70 participants, 63 (90%) were right-handed and 35 (50%) had bilateral low back pain. We had 15 (21%) women in our sample; eight in the active tDCS group and seven in the sham tDCS group [χ^2 (2) = 0.08, p = 0.7]. Baseline characteristics were similar between the two groups (Table 1).

Data for pain measurements were not normally distributed throughout the study (Figure 2). Accordingly, we were unable to carry out parametric tests in analyzing pain data. Table 2 shows that mean rank for pain scores decreased in the active tDCS group, while the mean rank increased in the sham group. Between group non-parametric tests indicated that the differences were significant at each step after the intervention, in favor of tDCS.

Within-group analysis with Friedman ANOVA showed that the decrease in pain intensity was significant in the active tDCS group [χ^2 (3) = 87.70, $p < 0.001$] and also in the sham group [χ^2 (3) = 21.58, $p < 0.001$]. Which is to say, participants from both groups experienced pain alleviation. Figure 2 shows that the initial pain reduction was stable in the active tDCS group until the end of study, while the pattern of reduction in the sham group disappeared at the end of the follow-up period.

Robust analysis for mixed designs showed that there was a significant interaction of group effect x time for pain scores, Ψ = 19.94, $p < 0.001$. Hence, there was a significant difference in patterns of change in pain scores between the two groups, in favor of tDCS.

One-way ANOVA showed that between-group differences in mean disability scores were statistically significant at each step after the intervention (all p-values < 0.001). The results indicated that tDCS was clearly effective in reducing disability, whereas participants in the sham group did not experience functional recovery (Figure 3).

We compared the patterns of change in disability scores by considering within and between group factors using mixed ANOVA. As Mauchly's Test for sphericity was significant for time × group (w = 0.25, $p < 0.001$) we used the Greenhouse-Geisser correction to adjust the results. There was a significant interaction effect of group assignment and time of measurements (group × time), F (1.7, 136.8) = 129.54, p Greenhouse-Geisser corrected <0.001, η^2=0.19. Thus, the patterns of change in mean scores of disability differed in favor of active tDCS throughout the study.

DISCUSSION

We aimed to compare the outcomes of tDCS with a control in order to see whether tDCS affects the inten-

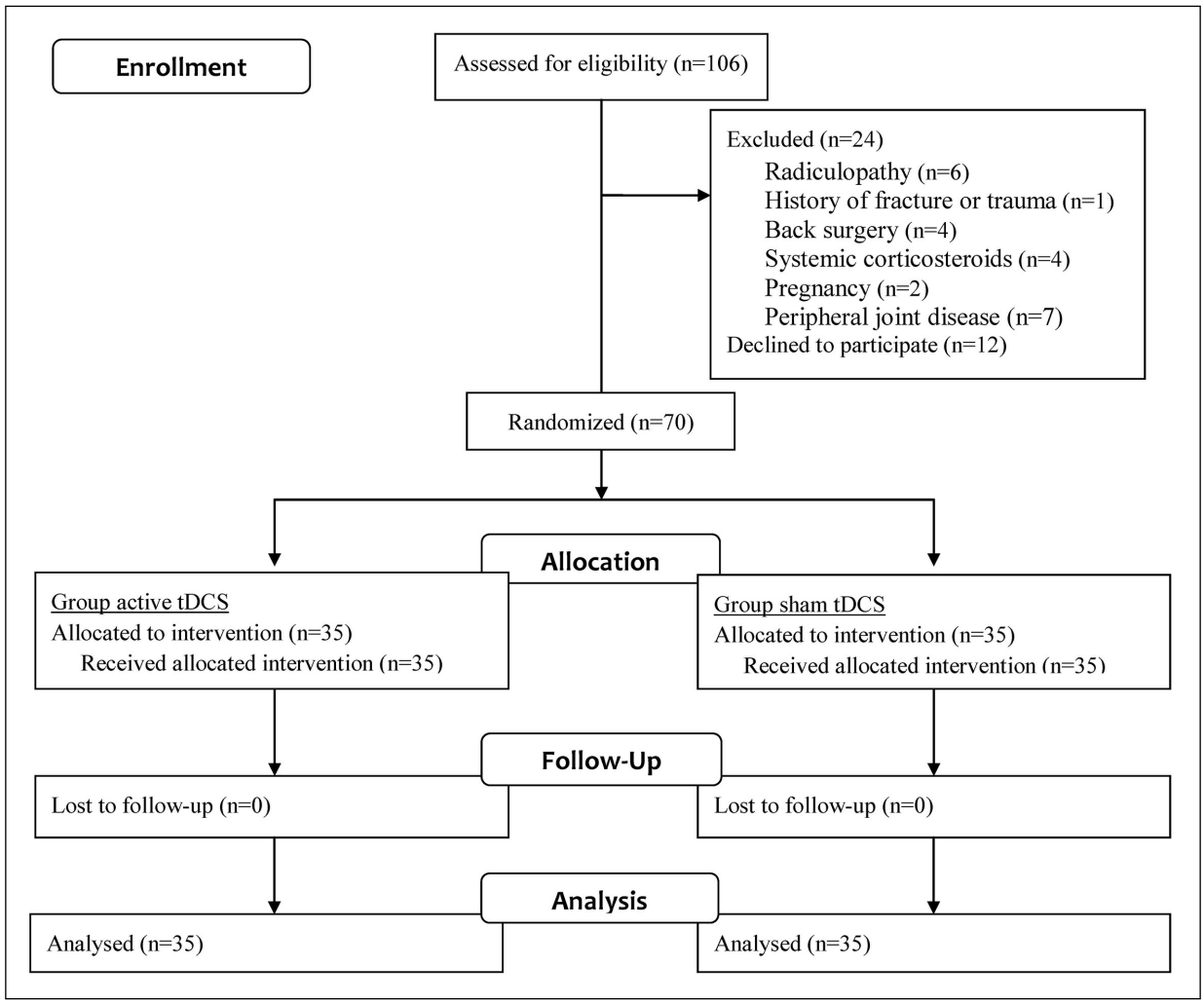

Figure 1
Patient's flow diagram

Table 1

Participants' baseline characteristics

Variable	Group		
	tDCS mean (SD) (n=35)	Sham mean (SD) (n=35)	*p*-value*
Age (year)	35.6 (34.9)	33.5 (10.9)	0.73
Height (cm)	173.2 (7.8)	174.2 (7.4)	0.58
Weight (kg)	74.3 (9.5)	72.1 (7.4)	0.28
BMI (kg/m^2)	24.8 (3.2)	23.7 (1.7)	0.07
Niepełnosprawność (wynik)	41.4 (9.7)	39.8 (8.6)	0.47

* Unpaired *t*-test

sity of pain and index of disability in patients with CNLBP. Our results showed that tDCS reduces pain after treatment and the beneficial effects remain for at least three months. We also observed some pain alleviation in the sham group. However, this could be attributed to the placebo effect or the effect of Celecoxib given to both groups. Between-group analyses showed an obvious dominancy of active tDCS compared to sham in pain reduction at each step after the intervention. We also found that disability score reduced in the active tDCS group immediately after the intervention with functional improvement lasting for 3 months. There was no comparable effect upon patients' disability in the sham group. Our clinical experience informed a sense that the differences between the two groups were practically significant, too. We recognized that patients in the active tDCS group were clearly more satisfied than those in the sham group. We did not observe important adverse effect with the treatment.

Changing neuronal excitability is the mechanism of action for the clinical effects of tDCS. Anode stimulation causes membrane depolarization and increases excitability of the neurons in the cortex. Cathode stimulation hyperpolarizes the neurons and decreases their excitability. It has been suggested that inhibition of thalamic sensory, and disinhibition of the periaqueductal gray matter neurons is a possible reason for pain reduction[28].

Overall, our results were plausible and also consistent with several previously published works on tDCS. In a recent pilot trial 35 pa-

Table 2

Changes in mean rank for pain scores (VAS) during the study

Time	Group		
	tDCS (n = 35)	Sham (n = 35)	*p*-value*
Before intervention	38.6	32.4	0.18
After intervention			
5 days	30.2	40.5	0.03
4 weeks	25.4	45.0	< 0.001
12 weeks	23.3	46.8	< 0.001

* Kruskal Wallis test

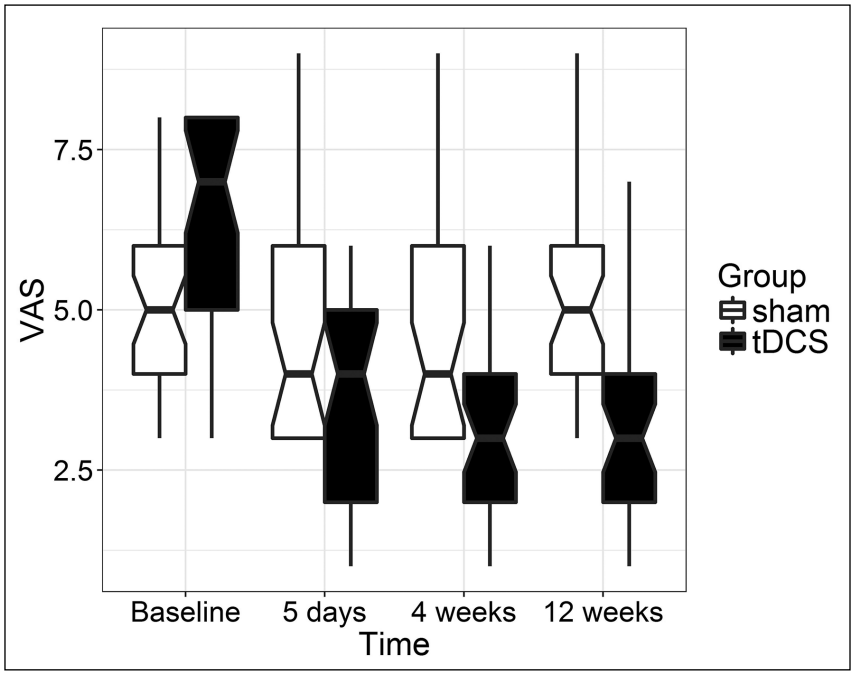

Figure 2

Changes in pain scores (VAS) throughout the study

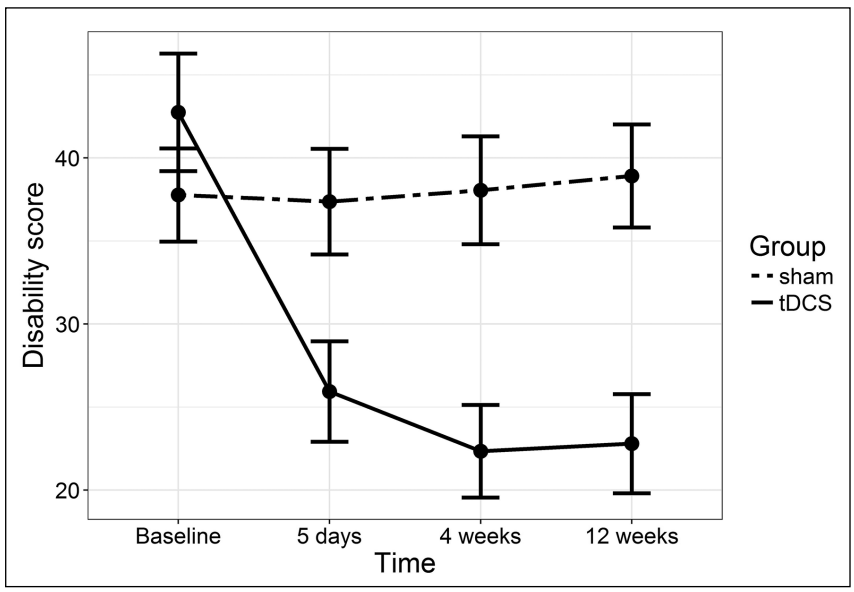

Figure 3

Changes in disability scores throughout the study measured with Oswestry Disability Questionnaire (error bars represent 95% CI)

tients (nine men and 26 women) with CNLBP were randomly allocated to two groups of real- (n=18), and sham-tDCS (n=17)[24]. Both arms followed an exercise program after the intervention. Patients received five consecutive daily stimulations with dosage similar to that of our trial. All participants were followed until one month after the treatment. It was concluded that tDCS has significantly larger effects on pain sensation and also on psychological well-being, compared to sham treatment. However, the effects were more observable in the follow-ups. It was reported that immediately after tDCS there was no significant reduction in pain intensity. This could be attributed to lack of inferential power owing to the small sample size. Our research included 35 participants in each group, prescribed 10 sessions of tDCS for all patients, provided a control group taking only an analgesic drug and followed our patients for three months. At follow up five days after the end of the intervention program we identified a significant difference in pain intensity between the groups of our study. We believe that it would be beneficial to evaluate combined therapy in a factorial design. However, our results were similar in that tDCS has beneficial effects on pain intensity and disability level.

In another pilot trial study, researchers evaluated the effects of 10 daily sessions of tDCS on the affective component of chronic low back pain[25]. In total, 21 participants were randomly allocated to tDCS group (4 taking opioid and 6 non-opioid) and sham group (5 opioid and 6 non-opioid) and were followed for six weeks after the intervention. The cathode electrode was fixed over FC1and the anode was placed over the contralateral mastoid. The outcomes also included affective symptoms. They found significantly less pain (p = 0.002), disability (p = 0.001), and depression (p = 0.003) in the active tDCS group upon completion of the treatment. Of course, as an under-powered pilot study the results could not be a basis for comparison. We did not evaluate mood symptoms in our participants; however, patients

in the active tDCS group were more satisfied and more willing to continue the study. The effects of tDCS on the affective component of pain should be addressed in future research.

Researchers have evaluated the effects of combined tDCS and peripheral electrical stimulation on pain intensity, cortical organization, sensitization and sensory function in patients with chronic low back pain[28]. They carried out a placebo-controlled crossover trial with 16 participants receiving four possible combinations of the active or sham treatments. Participants were evaluated regarding the outcomes at several intervals. The results showed that an active combined therapy is the best choice. However, single treatment was also found to be beneficial in pain reduction. In addition to the complicated design the researchers did not report how they calculated sample size or how they analyzed the power of their study.

In an interrupted time series study, researchers compared active versus sham tDCS for pain reduction[27]. Eight patients with CNLBP underwent three days of baseline measurements. Individuals then began 15 days experimental treatment over a three week period in which each participant had sham stimulation until a randomly allocated day when active tDCS was prescribed and thereafter. Pain intensity and unpleasantness in VAS were the main outcome measures, with disability, affective symptoms and cognitive evaluations as secondary outcomes. The study found there was no significant difference in pain ($p = 0.821$) and unpleasantness ($p = 0.937$) between sham and active tDCS. Secondary outcomes also showed no benefit in using active tDCS compared with sham. However, the authors of that study were uncertain of the quality of patients' masking. Additionally, they reported that the small and non-randomized sample restricted the generalizability of the conclusions.

We did not find recent high-powered trials of the efficacy of tDCS for the treatment of low back pain. Our research team was expert, the participants were compliant, the design and analyses were straightforward, and the sample was sufficiently large to detect important differences. However, we did not investigate the clinical efficacy of tDCS for more than 3 months. Therefore, further long-term longitudinal research is indicated to find the final place of tDCS in treating patients with CNLBP. A large dose-response trial or factorial design for combined therapies would be good choice for the next step in evaluating clinical applications of tDCS. Finally, it is recommended that any further assessment of tDCS for pain control should include an affective component.

CONCLUSION

In conclusion, our study showed that tDCS is beneficial for treating CNLBP and the positive effects remain for several months at least. The findings indicated that the treatment is effective, safe, and satisfactory to patients. Satisfaction may derive from the effect of tDCS on the affective components of chronic pain. Furthermore, the treatment can increase patients' compliance to attend other therapeutic programs such as exercise or manual therapy. Our results suggested that tDCS could serve as an initial treatment for pain reduction. Finally, tDCS is neither an expensive therapeutic procedure nor does it require expensive setup. We prefer to use tDCS alone or combined with other therapeutic modalities in the treatment of CNLBP.

Highlights

- tDCS is effective for treatment of CNLBP.
- tDCS is a safe therapeutic procedure.
- tDCS could be used as an initial treatment for controlling pain.
- tDCS reduces disability in patients with CNLBP.
- The benefits of tDCS remain for at least several months.

Conflict of interest
The authors declare that they have no competing interests.

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Authors' contributions
ZR contributed to the study conception and literature review. SA and SN participated in the planning of the study and assessing patients' eligibility. SS helped in the literature review, data analysis, and interviews. MEM participated in the recruitment of patients, physical examinations and programming the intervention. AD designed the study and helped in the development of the protocols. All the authors critically reviewed, and approved the final version of this manuscript.

References

1. Cuenca-Martínez F., Cortés-Amador S., Espí-López G.V. Effectiveness of classic physical therapy proposals for chronic non-specific low back pain: a literature review. Phys Ther Res 2018; 21(1): 16-22.
2. Waseem M., Karimi H., Gilani S.A., Hassan D. Treatment of disability associated with chronic non-specific low back pain using core stabilization exercises in pakistani population. J Back Musculoskelet Rehabil 2019; 32(1): 149-154.
3. Paolucci T., Attanasi C., Cecchini W., Marazzi A., Capobianco S.V., Santilli V. Chronic low back pain and postural rehabilitation exercise: a literature review. J Pain Res 2019; 12: 95-107.
4. Wong A.Y.L., Forss K.S., Jakobsson J., Schoeb V., Kumlien C., Borglin G. Older adult's experience of chronic low back pain and its implications on their daily life: Study protocol of a systematic review of qualitative research. Syst Rev 2018; 7(1): 81.
5. Ng S.K., Urquhart D.M., Fitzgerald P.B., Cicuttini F.M., Hussain S.M., Fitzgibbon B.M. The Relationship Between Structural and Functional Brain Changes and Altered Emotion and Cognition in Chronic Low Back Pain Brain Changes: A Systematic Review of MRI and fMRI Studies. Clin J Pain 2018; 34(3): 237-261.
6. Alhowimel A., AlOtaibi M., Radford K., Coulson N. Psychosocial factors associated with change in pain and disability outcomes in chronic low back pain patients treated by physiotherapist: A systematic review. SAGE Open Med 2018; 6: 2050312118757387.
7. Barone Gibbs B., Hergenroeder A.L., Perdomo S.J., Kowalsky R.J., Delitto A., Jakicic J.M. Reducing sedentary behaviour to decrease chronic low back pain: the stand back randomised trial. Occup Environ Med 2018; 75(5): 321-327.
8. Coulter I.D., Crawford C., Hurwitz E.L., Vernon H., Khorsan R., Suttorp Booth M., et al. Manipulation and mobilization for treating chronic low back pain: a systematic review and meta-analysis. Spine J 2018; 18(5): 866-879.
9. Wewege M.A., Booth J., Parmenter B.J. Aerobic vs. resistance exercise for chronic non-specific low back pain: A systematic review and meta-analysis. J Back Musculoskelet Rehabil 2018; 31(5): 889-899.
10. Pugliese J.M., Sions J.M., Velasco T.O., Hicks G.E. Use of trunk muscle training and neuromuscular electrical stimulation to reduce pain and disability in an older adult with chronic low back pain: A case report. Physiother Theory Pract 2019; 35(8): 797-804.
11. Hosseinifar M., Akbari A., Mahdavi M., Rahmati M. Comparison of balance and stabilizing trainings on balance indices in patients suffering from nonspecific chronic low back

pain. J Adv Pharm Technol Res 2018; 9(2): 44-50.
12. Deckers K., De Smedt K., Mitchell B., Vivian D., Russo M., Georgius P., et al. New Therapy for Refractory Chronic Mechanical Low Back Pain-Restorative Neurostimulation to Activate the Lumbar Multifidus: One Year Results of a Prospective Multicenter Clinical Trial. Neuromodulation 2018; 21(1): 48-55.
13. Cortell-Tormo J.M., Sanchez P.T., Chulvi-Medrano I., Tortosa-Martínez J., Manchado -López C., Llana-Belloch S., et al. Effects of functional resistance training on fitness and quality of life in females with chronic nonspecific low-back pain. J Back Musculoskelet Rehabil. 2018; 31(1): 95-105.
14. McCaskey M.A., Wirth B., Schuster-Amft C., de Bruin E.D. Postural sensorimotor training versus sham exercise in physiotherapy of patients with chronic non-specific low back pain: An exploratory randomised controlled trial. PloS One 2018; 13(3): e0193358.
15. Ibrahim A.A., Akindele M.O., Ganiyu S.O. Motor control exercise and patient education program for low resource rural community dwelling adults with chronic low back pain: a pilot randomized clinical trial. J Exerc Rehabil. 2018; 14(5): 851-863.
16. Bellido-Fernandez L., Jimenez-Rejano J., Chillon-Martinez R., Gomez-Benitez M.A., De-La-Casa-Almeida M., Rebollo-Salas M. Effectiveness of Massage Therapy and Abdominal Hypopressive Gymnastics in Nonspecific Chronic Low Back Pain: A Randomized Controlled Pilot Study. Evid Based Complement Alternat Med 2018; 2018: 3684194.
17. Uzawa H., Davis S. Outcome measures for adherence to home exercises among patients with chronic low back pain: a systematic review. J Phys Ther Sci 2018; 30(4): 649-653.
18. Park T.S.W., Kuo A., Smith M.T. Chronic low back pain: a mini-review on pharmacological management and pathophysiological insights from clinical and pre-clinical data. Inflammopharmacology 2018; 26(4): 881-898.
19. van Erp R.M.A., Huijnen I.P.J., Jakobs M.L.G., Kleijnen J., Smeets R. Effectiveness of Primary Care Interventions Using a Biopsychosocial Approach in Chronic Low Back Pain: A Systematic Review. Pain Pract 2018; 19(2): 224-241.
20. Ungureanu G., Chitu A., Iancu I., Kakucs C., Maior T., Florian I.S. Gender Differences in the Self-assessment of Quality of Life and Disability After Spinal Fusion for Chronic Low Back Pain at a Neurosurgical Center in Eastern Europe. Neurospine 2018; 15(3): 261-268.
21. Pauli J., Starkweather A., Robins J.L. Screening Tools to Predict the Development of Chronic Low Back Pain: An Integrative Review of the Literature. Pain Med 2018; 20(9): 1651-1677.
22. Mendonca L., Monteiro-Soares M., Azevedo L.F. Prediction of clinical outcomes in individuals with chronic low back pain: a protocol for a systematic review with meta-analysis. Syst Rev 2018; 7(1): 149.
23. Ouellette A.L., Liston M.B., Chang W.J., Walton D.M., Wand B.M., Schabrun S.M. Safety and feasibility of transcranial direct current stimulation (tDCS) combined with sensorimotor retraining in chronic low back pain: a protocol for a pilot randomised controlled trial. BMJ Open 2017; 7(8): e013080.
24. Straudi S., Buja S., Baroni A., Pavarelli C., Pranovi G., Fregni F., et al. The effects of transcranial direct current stimulation (tDCS) combined with group exercise treatment in subjects with chronic low back pain: a pilot randomized control trial. Clin Rehabil 2018; 32(10): 1348-1356.
25. Mariano T.Y., Burgess F.W., Bowker M., Kirschner J., Van't Wout-Frank M., Jones R.N., et al. Transcranial Direct Current Stimulation for Affective Symptoms and Functioning in Chronic Low Back Pain: A Pilot Double-Blinded, Randomized, Placebo-Controlled Trial. Pain Med 2018; 20(6): 1166-1177.
26. Luedtke K., Rushton A., Wright C., Jürgens T., Polzer A, Mueller G., et al. Effectiveness of transcranial direct current stimulation preceding cognitive behavioural management for chronic low back pain: sham controlled double blinded randomised controlled trial. BMJ 2015; 350: 1640.
27. O'Connell N.E., Cossar J., Marston L., Wand B.M., Bunce D., De Souza L.H., et al. Transcranial direct current stimulation of the motor cortex in the treatment of chronic nonspecific low back pain: a randomized, double-blind exploratory study. Clin J Pain 2013;29(1): 26-34.
28. Schabrun S.M., Jones E., Elgueta Cancino E.L., Hodges P.W. Targeting chronic recurrent low back pain from the top-down and the bottom-up: a combined transcranial direct current stimulation and peripheral electrical stimulation intervention. Brain Stimul 2014; 7(3): 451-459.
29. Luedtke K., May A., Jurgens T.P. No effect of a single session of transcranial direct current stimulation on experimentally induced pain in patients with chronic low back pain - an exploratory study. PloS One 2012; 7(11): e48857.
30. Luedtke K., Rushton A., Wright C., Juergens T.P., Mueller G., May A. Effectiveness of anodal transcranial direct current stimulation in patients with chronic low back pain: design, method and protocol for a randomised controlled trial. BMC Musculoskelet Disord 2011;12: 290.

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