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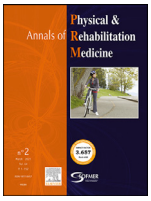

Original article

Anodal tDCS over the motor cortex improves pain but not physical function in chronic chikungunya arthritis: Randomized controlled trial

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ABSTRACT

Background: Chikungunya virus (CHIKV) is a globally prevalent pathogen, with outbreaks occurring in tropical regions. Chronic pain is the main symptom reported and is associated with decreased mobility and disability. Transcranial direct current stimulation (tDCS) is emerging as a new therapeutic tool for chronic arthralgia.
Objective: To evaluate the effectiveness of 10 consecutive sessions of anodal tDCS on pain (primary outcome) in participants with chronic CHIKV arthralgia. Secondary outcomes included functional status, quality of life, and mood.
Methods: In this randomized, double-blind, placebo-controlled trial, 30 participants with chronic CHIKV arthralgia were randomly assigned to receive either active (n = 15) or sham (n = 15) tDCS. The active group received 10 consecutive sessions of tDCS over M1 using the C3/Fp2 montage (2 mA for 20 min). Visual analog scale of pain (VAS), health assessment questionnaire (HAQ), short-form 36 health survey (SF-36), pain catastrophizing scale, Hamilton anxiety scale (HAS), timed up and go (TUG) test, lumbar dynamometry, 30-s arm curl and 2-min step test were assessed at baseline, day 10 and at 2 follow-up visits.
Results: There was a significant interaction between group and time on pain (p = 0.03; effect size 95 % CI 0.9 (-1.67 to -0.16), with a significant time interaction (p = 0.0001). There was no interaction between time and group for the 2-minute step test (p = 0.18), but the groups differed significantly at day 10 (p = 0.01), first follow-up (p = 0.01) and second follow-up (p = 0.03). HAQ and SF-36 improved but not significantly. There was no significant improvement in mental health, and physical tests.
Conclusion: tDCS appears to be a promising intervention for reducing pain in participants with chronic CHIKV arthralgia, although further research is needed to confirm these findings and explore potential long-term benefits.
Trial Registration: Brazilian Registry of Clinical Trials (ReBEC): RBR-245rh7.

Introduction

Chikungunya virus (CHIKV) is a globally prevalent pathogen with outbreaks occurring in numerous tropical regions worldwide, including countries in the Americas, Africa, and Asia [1]. The incidence of CHIKV cases is subject to regional and temporal fluctuations, with outbreaks appearing periodically [1]. The reporting of chikungunya cases is contingent upon a number of factors, such as access to healthcare services, the availability of diagnostic tests, and the efficiency of local surveillance systems [2]. On a global scale, over 100 countries and territories are affected by periodic epidemics, with an estimated annual incidence of one million infections worldwide [1].

Chikungunya fever is a debilitating illness caused by the CHIKV. The acute phase of the infection presents with symptoms such as fever, joint pain and swelling, muscle pain, headache, rash, fatigue,

Abbreviations: Active-G, active group; CHIKV, Chikungunya virus; HAQ, Health Assessment Questionnaire; HAS, Hamilton Anxiety Scale; M1, motor cortex; PCS, Pain Catastrophizing Scale; SF-36, Short-Form 36 Health Survey; Sham-G, sham group; tDCS, Transcranial direct current stimulation; TUG, timed up and go; VAS, Visual Analog Scale

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nausea, and vomiting [3,4]. However, for some individuals, the infection can evolve into chronic arthritis, which can persist for an indefinite period of time [3]. The course of chikungunya fever can be divided into 3 distinct phases: acute, post-acute, and chronic. The acute phase lasts up to 21 days, followed by the post-acute phase, which lasts from 21 to 3 months [3]. The chronic phase begins after 3 months and can last for more than 6 years [5].

Since 2013, outbreaks of the CHIKV have occurred in various tropical regions of the world, causing increased demand on health systems and secondary impairments to affected individuals [4]. Between 14 % to 87 % of cases become chronic, with musculoskeletal disorders, chronic chikungunya arthritis, enthesitis or tenosynovitis, affecting individuals' functional capacity, work ability, and quality of life [6]. Chronic pain is an important long-term manifestation of chikungunya fever and is associated with anxiety, pain catastrophizing, and decreased physical capacity and quality of life. This clinical characteristic decrease mobility and can lead to disability [7].

Chronic pain related to CHIKV infection is the main symptom reported and can have a neuropathic nature [3]. Chronic neuropathic pain can cause functional changes in the brain, including alterations in brain structure, activity, and connectivity [8,9]. These changes may result from prolonged exposure to pain and can impact cognitive, emotional, and behavioral processes [9]. In this process, the motor cortex (M1) plays an important role in modulating pain activity through its functional connection with deep brain structures associated with pain volume control [8,9]. Transcranial direct current stimulation (tDCS) involves the application of a low-level electrical current across the scalp, which is understood to modulate the activity of neurons in the brain and alter pain perception [10]. tDCS is considered safe with minor and transitory side-effects [11]. For treatment of chronic pain syndromes, tDCS is often applied with the anode electrode placed over M1 [12,13]. By increasing the excitability of neurons in the M1, tDCS may reduce the perception of pain [8]. The M1 appears to be co-activated with other brain regions related to pain, such as the primary and secondary somatosensory cortices, which are involved in sensory discrimination of pain, and the dorsolateral prefrontal cortex, involved in the cognitive aspects of pain [14]. Furthermore, deep structures such as the anterior cingulate cortex and insula (involved in the affective-motivation processing of pain), have important connections with M1 [15]. This strong functional connection appears to be modulated by anodal tDCS over M1, which may lead to a decrease in pain in diseases that present with chronic pain [15].

Previous studies of 5 and 6 sessions of tDCS showed that the anode M1/Sp2 montage improves pain in individuals with chronic chikungunya arthritis [16,17]. Chronic chikungunya arthralgia can last for 6 years or more, and rehabilitation options should focus on interventions that produce long-term effects. Evidence suggests that short-term therapy of 10 or more sessions of tDCS may help to sustain the effect of the treatment on pain over time [18]. The tDCS parameters, such as the number of sessions targeting the M1, hold the potential to enhance the therapeutic efficacy of tDCS in clinical neuropathic pain management [18]. It is conceivable that a regimen of 10 or more sessions of tDCS may represent a viable clinical approach to pain management and enhancement of overall physical function for chronic chikungunya arthritis.

Given the limited options for treatment and physical rehabilitation models for individuals with chronic chikungunya arthritis, the application of tDCS seems promising. However, questions regarding medium-term effects and overall level of therapy evidence limit routine clinical application and inclusion in rehabilitation guidelines. Thus, this study aimed to evaluate the medium-term effects of 10 consecutive sessions of anodal tDCS over the M1 (C3/Fp2 montage) on pain (primary outcome) in individuals with chronic chikungunya arthritis. The secondary outcomes were functional status, quality of life, pain catastrophization, anxiety, mobility, balance, muscle strength and cardiovascular endurance.

Methods

Study design

A single-center, double-blind, randomized controlled trial with 2 arms was conducted at the Onofre Lopes University Hospital of the Federal University of Rio Grande do Norte, Brazil from September 2019 to October 2022. Because of the COVID-19 pandemic and Brazilian health regulations, the study was interrupted from March 2020 to March 2021. The study was conducted in accordance with the declaration of Helsinki and the Resolution 466/12 of the National Health Council. The trial was approved by the local ethics committee (number 2.932.953) and all participants provided written informed consent prior to inclusion. The trial was registered on the Brazilian Registry of Clinical Trials (ReBEC) with the identifier RBR-245rh7. The study is reported according to the CONSORT 2010 guidelines.

Recruitment and eligibility criteria

Participants were recruited from physical therapy clinics, health clinics, and hospitals affiliated with the Federal University of Rio Grande do Norte. Potential participants were invited to participate through formal invitation and presentation of the study's objectives. Inclusion criteria required confirmed CHIKV infection, as determined by detection of IgG and IgM antibodies using a direct enzyme-linked immunosorbent assay/IgM/Euroimmun test at the Central Laboratory (LACEN, Brazil), a clinical diagnosis of chronic chikungunya (at least 3 months post-initial infection), pain ≥4 on a Visual Analog Scale (VAS), sufficient functional capacity to perform physical tests, absence of regular physical therapy or exercise, and no signs of respiratory infection or COVID-19. Exclusion criteria included a history of epilepsy or convulsive episode, a history of stroke, the presence of metallic devices implanted in the head, a pacemaker, signs of increasing severity and/or indications for hospitalization, and undergoing physical rehabilitation.

Randomization

Participants was randomly allocated (1:1) to receive active tDCS or sham tDCS (Fig. 1). The stratified randomization method was used, with the order of entry into the study as the stratifying factor. Randomization was performed using appropriate software (www.random.org) to assign each participant to either the active tDCS group (Active-G) or the sham group (Sham-G). The allocation sequence was generated by an external research assistant and was executed using opaque envelopes. Participants were blinded to their group allocation throughout the trial. At the end of the study, participants were informed of their group and all participants in the control group were invited to undergo active tDCS.

Sample size

The sample size was based on the VAS rating, calculated in accordance with statistical considerations for a parallel trial using data from previous study by Silva-Filho et al. [16]. G-Power 3.1.9.2 was used to determine the sample size according to F tests (repeated measures, within-between interaction), assuming a significance level of 0.05, a power of 90 %, a 0.3 effect size, and 2 groups. The calculation estimated a requirement for 22 participants. However, considering a possible 20 % loss, 8 additional participants were included, bringing the total number of recruited participants to 30, with 15 participants in each group.

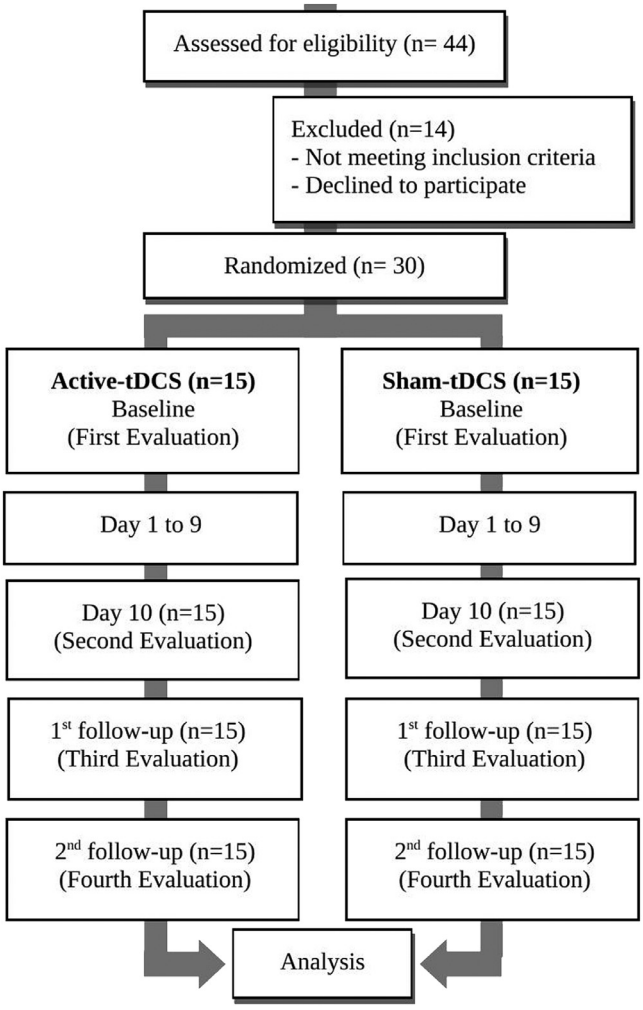

Fig. 1. Flowchart of inclusions and study schedule.

Intervention

The mini-CT (Soterix Medical, Woodbridge, NJ, USA) was used to deliver a continuous monophasic current with an intensity of 2 mA for 20 min. All sessions were performed in a controlled temperature environment free of noise or visual distractions, such as television or smartphone use. The tDCS was applied with the anodal electrode over the M1 cortex (C3) and the cathodal electrode over the contralateral supraorbital cortex (Fp2) according to the international 10–20 electroencephalography system standard. The 1 SNAPstrap (Soterix Medical) was used to position the electrodes and EASYpads (Soterix Medical) sponges (5 × 7) with a 35 cm^2 area were used. In case of feedback from the MINI-CT device sensor, supplementing saline was used during stimulation. A 30 s ramp-up was used to reach the desired intensity of 2 mA at the start of stimulation and a 30 s ramp-down was used at the end of the session. For the Sham-G, the same parameters were used as in the Active-G, but the stimulator delivered a 30-second ramp-up to 2 mA immediately followed by a 30-second ramp-down.

Outcomes

The sociodemographic data of all study participants were evaluated at baseline to characterize the sample. For all clinical outcomes, 4 evaluations were performed: (1) baseline, (2) at session 10, (3) first follow-up 15 days after the last tDCS session, and (4) second follow-up 30 days after the last tDCS session (Fig. 1). All evaluations were performed in the morning (8:00 am – 11 am) by a trained physical therapist who was blinded to group allocation.

The primary outcome was pain assessed using the VAS for pain [19]. The VAS is a unidimensional measure of pain intensity consisting of a continuous scale comprised of a 10-centimeter (100 mm) horizontal line anchored by 2 verbal descriptors, one for each extreme symptom [19]. The scale is anchored by "no pain" (score of 0) and "worst imaginable pain" (score of 100 [100 mm scale]). The VAS was self-administered by the respondent, who was asked to place a dash at the point that represented the intensity of their pain at the time of evaluation. The VAS is commonly used to measure pain in clinical investigations because of its convenience and reliability [19]. The participant was asked rate the amount of pain they were feeling on the day of the evaluation.

For the secondary outcomes, questionnaires and physical tests were used.

The Health Assessment Questionnaire (HAQ) assesses functional status and monitors the progression of the disease over time [20]. The HAQ is a self-administered questionnaire that measures the impact of disease on a person's daily activities, including household tasks, personal care, work, recreational activities, and mobility [21]. The questionnaire contains 20 questions about a person's daily activities, including household tasks, personal care, work, recreational activities, and mobility. Each question has a response scale that ranges from 0 (no difficulty) to 3 (total inability) [21]. The total HAQ score is obtained by summing the responses of each question and dividing by 20. The final HAQ score ranges from 0 to 3 points, with higher scores indicating greater functional limitations [21].

Quality of life was assessed by the Short-Form 36 Health Survey (SF-36) [22]. The SF-36 measures 8 dimensions of quality of life, including functional ability, emotional aspects, pain, mental health, physical health, vitality, work, and social aspects. Scores range from 0 to 100, with higher scores indicating a better quality of life [22].

Pain catastrophizing was assessed using the Pain Catastrophizing Scale (PCS) [23]. Pain catastrophizing is defined as a set of negative thoughts, emotions, and behaviors related to pain, such as fear, pessimism, and a sense of loss of control. The PCS consists of 13 questions that assess 3 aspects of pain catastrophizing: rumination, hopelessness, and magnification. Each question has a response scale ranging from 0 (never) to 4 (always) [23]. The total PCS score is obtained by summing the responses to each question and can range from 0 to 52.

The Hamilton Anxiety Scale (HAS) was used to measure the severity of anxiety symptoms [24]. The scale has 14 items, each rated from 0 to 4, with a total score of 56. The higher the score, the higher the degree of anxiety.

A functional test battery was performed using the timed up and go (TUG) test, lumbar dynamometry, 30-s arm curl and 2-min step test.

The TUG measures mobility and balance [25]. To perform the test, individuals were instructed to stand up from a seated position on the examiner's signal, walk 3 m at their own, comfortable pace, turn around a cone, walk back to the chair, and sit down again. The time (in seconds) for this action was recorded to assess performance [25].

The lumbar dynamometry test was performed with the participants standing, using a dynamometer (Crown-200hgf) and recorded in kgf. Three tests were performed, and the average was used for statistical evaluation [26].

The 30-s arm curl (elbow flexion test) was used to assess elbow flexion muscle power. The number of curls completed in 30 s was measured [27]. A 2 kg dumbbell was used to perform the test. The participant performed the test in the sitting position, with the dumbbell in the hand of the evaluated limb and performed the elbow flexion movement as fast as possible in 30 s [27]. The number of completed moves was recorded.

The 2-minute step test is a physical fitness test used to evaluate an individual's cardiovascular endurance and overall physical fitness

[27]. The examiner quantified the number of knee elevations executed by the participant within a 2-minute interval [27]. Prior to initiating the examination, a marker was placed on the wall to demarcate the midpoint between the patella and the anterosuperior iliac spine. The examiner counted the number of knee elevations [27].

Statistical analysis

Statistical analyses were performed using SPSS version 19.0 software (IBM Corp., Armonk, NY, USA). Clinical and sociodemographic characteristics were described by means, medians, and standard deviations for continuous numerical parameters and by frequency tables with 95 % confidence intervals for qualitative parameters. A chi-square or Fisher's exact test was used to compare the distributions of qualitative variables. A paired *t*-test or Mann-Whitney test was used to compare baseline data between groups. The Shapiro-Wilk and Levene tests were applied to evaluate the normality of the data distribution and homogeneity of variance, respectively. The Mauchly's sphericity test was used to validate correlations between repeated measures. The effects of stimulation on primary and secondary variables were calculated using a mixed-model analysis of variance (ANOVA). The dependent variable was the score of each outcome, and the independent fixed variables were treatment time (baseline and re-evaluations), stimulation group (active and sham), and time versus group interaction. When appropriate, post-hoc comparisons were performed using the Bonferroni correction for multiple comparisons. Missing data were treated by intention-to-treat analysis. Significance level was set at $p < 0.05$.

Results

A total of 44 individuals were screened for inclusion in the study. Thirty individuals participated in the study and 14 were excluded for not meeting the inclusion criteria or they withdrew from participating. No differences were found in sociodemographic characteristics between groups (Table 1). Participants tolerated the tDCS well and reported sensations of itching and tickling during the sessions.

Pain improved significantly in the Active-G across the time points, as shown by a significant group x time interaction, F(3.84) = 2.983, $p = 0.03$; effect size 0.9 (95 % CI −1.67 to −0.16). Furthermore, a significant time effect on pain was found F(3.84) = 6.973, $p = 0.0001$. Pain ratings differed between the Active-G and Sham-G at the first (95 % CI 4.7 to 46.5; $p = 0.01$) and second follow-ups (95 % CI 0.05 to 41.1; $p = 0.04$). Pain reduced in the Active-G between baseline and first follow-up (95 % CI 3.62 to 45.44; $p = 0.01$) and baseline and second follow-up (95 % CI 6.4 to 46.39; $p = 0.005$), but it did not change in the Sham-G (Fig. 2A).

HAQ improved in both groups, but not significantly, and there was no time x group interaction (F(3.84) = 2.470, $p = 0.06$); effect size 0.5 (95 % CI −1.23 to 0.22). HAQ improved significantly only in the Active-G group from baseline to day 10 (95 % CI 0.14 to 0.77, $p = 0.002$), as well as baseline to the first (95 % CI 0.3 to 0.84, $p = 0.0001$) and second follow-ups (95 % CI 0.14 to 0.87, $p = 0.003$) (Fig. 2B). There was no time x group interaction for the 2-minute step test F(3.84) = 1.633, $p = 0.18$), but the groups differed significantly at day 10 (95 % CI 9.57 to 70.29, $p = 0.01$), first follow-up (95 % CI 9.60 to 76.52; $p = 0.01$) and second follow-up (95 % CI 2.5 to 72.96, $p = 0.03$). Significant improvements were only found in the Active-G from baseline to day 10 (95 % CI 8.77 to 44.68, $p = 0.001$), and baseline to first (95 % CI 11.42 to 56.97, $p = 0.001$) and second follow-ups (95 % CI 11.14 to 56.59, $p = 0.001$) (Fig. 2C).

Table 2 shows the result of the ANOVA performed for SF-36, PCS, HAS, TUG, 30-s arm curl, 2-min step test and dynamometry. No time x group interactions occurred, but significant between-group differences were found for TUG ($p = 0.02$) and 2-min step test ($p = 0.01$).

Table 1
Sociodemographic and baseline clinical characteristics of active and sham groups.

Variables	Active-tDCS ($n = 15$)	Sham-tDCS ($n = 15$)	p-value
Age (years)	44 (10.3)	49.3 (6.2)	0.10
BMI (kg/m^2)	27 (4.5)	30. (4.3)	0.07
Time since CHIKV onset (years)	2.7 (2.2)	4.06 (2.9)	0.16
Ethnicity n (%)			0.81
White	6 (40 %)	8 (53 %)	
Black	2 (13 %)	1 (7 %)	
Mixed-race	5 (33 %)	5 (33 %)	
Not provided	2 (13 %)	1 (7 %)	
Education n (%)			0.49
Elementary school	2 (13 %)	2 (13 %)	
Secondary school	4 (26 %)	7 (46 %)	
College	9 (60 %)	6 (40 %)	
VAS baseline	51.2 (25.3)	54.1 (25.8)	0.76
HAQ baseline	1.2 (0.5)	1.1 (0.5)	0.61
SF-36	45 (7.9)	44.2 (11.5)	0.81
PCS	31.7 (11.2)	30.3 (10.1)	0.72
HAS	23.2 (12.6)	23 (9.4)	0.96
TUG (s)	8.4 (3.4)	11.4 (5.5)	0.08
Dynamometry (kgf)	50.7 (19.7)	35.1 (17.9)	0.03
30-s arm curl (elbow flexion)	16.8 (5.5)	11.8 (7)	0.03
2-min step test (knee elevations)	94.6 (26)	72.3 (33.4)	0.051

Data are mean (SD).
BMI: Body Mass Index; CHIKV: Chikungunya Virus; HAS: Hamilton Anxiety Scale; HAQ: Health Assessment Questionnaire; PCS: Pain Catastrophizing Scale; SF-36: Short-Form 36 Health Survey; SD: Standard Deviation; TUG: Timed up and go; tDCS: Transcranial direct current stimulation; VAS: Visual Analogic Scale.

Discussion

This study found that 10 sessions of anodal tDCS over the M1 cortex reduced pain in people with chronic chikungunya arthritis. The study participants reported moderate levels of pain at baseline (Table 1). It is reasonable to expect that demonstrating a substantial post-treatment difference would be quite challenging for these pain intensities. When comparing the baseline to the second follow-up, the active group exhibited a 26.4-point difference on the VAS scale, representing a 51 % improvement. These results suggest that tDCS reduced pain in a sample of people with chronic chikungunya arthralgia. A tendency for improvement in functional capacity in the Active-G was observed. Although there was an improvement in the quality of life of both the Active-G and Sham-G, this was not significant. There was no significant improvement in mental health, or the physical tests.

The high number of chikungunya cases in previous years and the chronicity of a large proportion of those infected has led to a population that requires physical rehabilitation care [2]. Chronic chikungunya arthritis is a common condition in the clinical practice of rehabilitation professionals [7]. However, the guidelines published by health entities and ministries of different countries present simple rehabilitation treatment protocols with no robust scientific evidence to support their use [28–31]. The lack of studies on chronic chikungunya arthritis has led to the use of therapies used for rheumatoid arthritis and osteoarthritis [28–31]. In the chronic phase, resisted, proprioceptive, aerobic exercises, stretching, manual therapy, and aquatic physical therapy are recommended [31]. However, all these therapies have very low quality of evidence, which means that the treatment is not optimized and not tailored to the specific symptoms chronic chikungunya arthritis [31].

Pain is the main symptom observed in these individuals [30]. Studies suggest that chronic pain can persist for up to 6 years in these individuals, leading to reduced function, quality of life and work performance [5]. The chronicity of pain can lead to modifications in the signal transmission pathways and brain areas related to the perceived pain volume [8,9]. This model has already been observed in

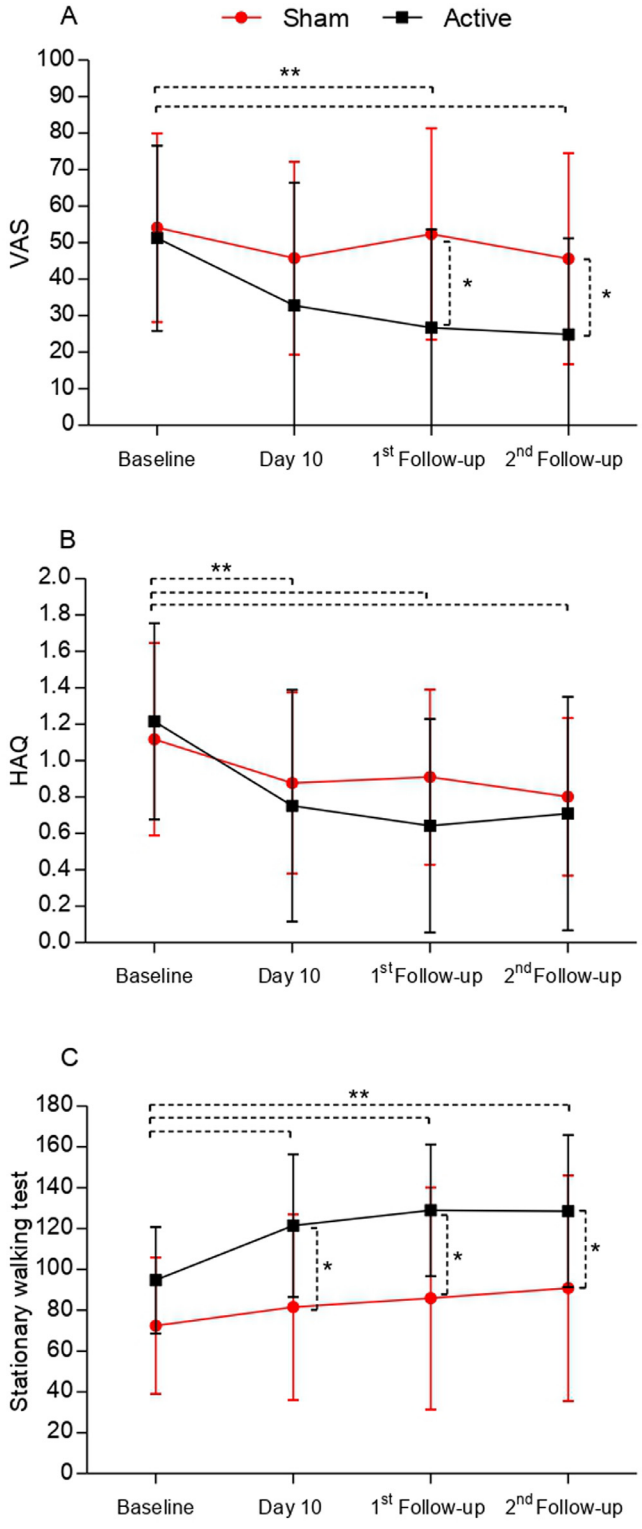

Fig. 2. Change in visual analog scale (VAS) pain rating (A), health assessment questionnaire (HAQ) (B) and 2-minute step test (C) over time in both groups. The 1st follow-up was 15 days and the 2nd follow-up was 30 days after the last day of intervention.
Data are mean (SD).
* significant between-group difference.
** significant intragroup difference for active group.

other diseases that lead to chronic pain and is likely to occur in individuals with chronic chikungunya arthritis [8,9]. Studies using functional magnetic resonance imaging could expand knowledge about pain modulation in these individuals.

Table 2
Result of the ANOVAs performed for each outcome measure.

Variable	Df	F	P	Power	Effect size (95 % CI)
SF-36					0.42 (−0.29 to 1.15)
Time x Group	3	1.161	0.255	0.3	
Time	3	12.194	0.0001*	1	
Group	1	0.26	0.6	0.07	
PCS					0.04 (−0.75 to 0.67)
Time x Group	3	0.69	0.55	0.19	
Time	3	8.061	0.0001*	0.98	
Group	1	1.405	0.24	0.2	
HAS					0.25 (−0.97 to 0.46)
Time x Group	3	0.66	0.57	0.184	
Time	3	24.090	0.0001*	1	
Group	1	0.119	0.73	0.06	
TUG					0.85 (−1.59 to −0.10)
Time x Group	3	2.698	0.66	0.152	
Time	3	1.909	0.13	0.477	
Group	1	5.304	0.02*	0.604	
30-s arm curl					0.79 (−0.05 to 1.54)
Time x Group	3	0.544	0.65	0.157	
Time	3	9.743	0.0001*	0.997	
Group	1	4.043	0.05	0.493	
2-min step test					0.96 (0.20 to 1.71)
Time x Group	3	1.633	0.18	0.414	
Time	3	10.774	0.0001*	0.999	
Group	1	6.858	0.01*	0.715	
Dynamometry					0.57 (−0.15 to 1.30)
Time x Group	3	0.111	0.95	0.069	
Time	3	2.725	0.04	0.642	
Group	1	2.955	0.09	0.38	

* Statistically significant result. HAS: Hamilton Anxiety Scale; PCS: Pain Catastrophizing Scale; SF-36: Short-Form 36 Health Survey; TUG: Timed Up and Go test.

Non-invasive neuromodulation, particularly tDCS, has been applied to individuals with chronic pain with good levels of evidence [12,13]. Recently, some clinical trials focusing on pain reduction are being published, but few address non-pharmacological therapies. The study by Silva-Filho et al. was the first to apply tDCS to individuals with chronic chikungunya arthritis. The authors found a significant improvement in several aspects of pain after 5 consecutive sessions of anodic tDCS over the M1 (C3/Fp2 montage). Another study, using the same electrode montage and 6, non-consecutive sessions, also found a significant improvement in pain in these individuals [17]. However, no improvements were found in functional tests related to aerobic capacity, muscle strength, or flexibility [16]. Similar results were found in the present trial. Anodal tDCS over M1 seems to be the standard montage for the treatment of chronic pain (C3/Fp2) [8]. The M1 area is involved in the regulation of pain perception through connections with deeper areas such as the accumbens, cingulate and prefrontal areas [8]. Increased excitability of the M1 leads to decreased activation of these areas, resulting in temporary pain relief [8].

It is noteworthy that in a previous study of tDCS and chronic chikungunya arthritis no improvement in functional parameters such as aerobic capacity, muscle strength and flexibility were observed [16]. Two hypotheses can be proposed to explain this finding. Firstly, none of these tests have been validated for individuals with chronic chikungunya arthritis, only for disorders with similar symptomatology such as rheumatoid arthritis, fibromyalgia and ankylosing spondylitis [21,32]. The lack of validation may compromise the specificity of the tests for this group. Secondly, all participants had experienced at least 3 months of pain, fatigue and decreased function, and some participants had chronic chikungunya arthritis for years. This chronic condition leads to low levels of functional capacity, decreased mobility and quality of life [7]. Five to 10 sessions of tDCS would be insufficient to improve aerobic capacity, muscle strength and flexibility, which suggests that research into to the combination of tDCS and physical therapy is required [33].

The study has several limitations. The clinical trial was conducted during the post-pandemic period, and isolation may have altered

functional parameters. It was not possible to identify this possibility. A second limitation is the absence of validated functional tests for chronic chikungunya arthritis. Therefore, we used tests already validated for fibromyalgia and arthritis. The results of this study provide stronger evidence for the clinical plausibility of tDCS for the physical rehabilitation of individuals with chronic chikungunya arthritis. Therefore, tDCS can be considered as an adjuvant resource to the therapies already recommended. Future studies should address optimal tDCS dosing for this population, as well as protocols associated with physical therapy.

Conclusions

tDCS appears to be a promising intervention for reducing pain in individuals with chronic CHIKV arthralgia, although further research is needed to confirm these findings and explore the long-term benefits. tDCS is a relatively easy-to-use, portable and low-cost intervention, which makes it a feasible treatment option for use in areas with limited healthcare resources, including those where CHIKV is endemic.

Data availability

Data will be made available on request.

Declaration of competing interest

The City University of New York has a patent on brain stimulation with MB as the inventor. MB has equity in Soterix Medical Inc. No conflict of interest was declared by the other authors.

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