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The Effect of Transcranial Direct Current Stimulation (tDCS) Modality on Proprioception in Patients with Tendinitis: A Review

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ABSTRACT

Background: Transcranial direct current stimulation (tDCS) triggers brain activity by altering the membrane potential and the synaptic release, thereby aiding in neuroplastic trigger altering. tDCS is widely used to improve motor function in healthy people and neurological patients. This study reviewed the effect of tDCS modality on proprioception in patients with tendinopathy.

Methods: This study mainly evaluated four databases that include PubMed, Scopus, Web of Science, and the first 10 pages of Google Scholar for English clinical articles that studied the effect of tDCS on proprioception. The keywords used in the search included: transcranial direct current stimulation, sense of position, sense of force, sense of effort, tendinitis, tendinopathy, goniometer, electromyography, tendon, muscle force, proprioception, and load cell.

Results: The search yielded nine published articles of the required clinical prospective studies (total participants=199) were obtained. We used the PRISMA checklist for the selected articles.

Conclusion: tDCS can have a positive role in the improvement of proprioception and balance ability. The absolute error of proprioception is predominantly notable in the elbows compared to the other joints.

KEYWORDS:
proprioception; tendinitis; tendinopathy; tennis elbow; transcranial direct current stimulation

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INTRODUCTION

The electrical stimulation of the brain includes several techniques transcranial direct current stimulation (tDCS), transcranial random noise stimulation (tRNS), and transcranial alternating current stimulation (tACS).[1] In all these methods, a small, weak electric current is applied to the conductor electrodes of different shapes and dimensions located on the surface of the head. The most common type of transcranial electrical stimulation is the tDCS, whose usage is increased in clinical studies and applications for the past 15 years.[2]

Recently, tACS has improved the brain mapping studies because of the possibility of adjusting its excitation frequency to the frequency of brain waves.[1] The use of tRNS is also expanding.[3] tDCS has been used to treat disorders such as depression, migraines,

poststroke rehabilitation, addiction, tinnitus, Parkinson's, chronic pain, anxiety disorders, and schizophrenia. Experiments on healthy people have also shown that this method can increase their cognitive function depending on the area being stimulated, such as speech and math abilities, attention span, memory, and so on.[4,5]

Numerous laboratory and clinical studies have confirmed the safety of this technology in children and adults.. So far, this method is not dangerous. Since tDCS is a stimulus method, safety measures like the correct protocol use, proper implementation, and more cautious application in people prone to seizures are recommended. Minor side effects like skin irritation, nausea, headache, dizziness, and itching under the electrode are seen to arise that subsides after 72 hours.[6–10]

The effects of tDCS on motor memory have been transformed into a practical tool for determining hemisphere specialization allocation. For example, brain stimulation used in the study of Schambra et al.[11] showed that the left hemisphere is more specialized in motor learning. Recently, tDCS is more popular as a practical tool in the cognitive, motor, and sensory functions after a stroke, treatment of psychiatric disorders, and neurological diseases.[12] tDCS increases proprioception in mental proprioception. They are also effective adjunct therapy for dysfunctional proprioception in Parkinson's disease and tendinitis.[13–15]. Tendinitis also known as elbow pain or lateral epicondylitis. Mostly occur in tennis players, homemakers, and mechanics. Sometimes the severity of the pain makes it impossible for one to even open a bottle. The most common disease symptoms are uncontrollable pain, sensitivity to low pressure, and a burning sensation on the outer elbow.[16,17] This study reviewed the effect of tDCS modality on proprioception in patients with tendinopathy.

MATERIALS AND METHODS

MATERIALS

The review evaluated international databases like PubMed, Web of Science, Scopus, and Google Scholar (first 10 pages) for English clinical articles that only included patients with proprioception impairment who experienced tDCS.

The review included all articles discussing tDCS modality in humans due to proprioception impairment. Case reports and animal studies were excluded.

Keywords used in the article search included: transcranial direct current stimulation, sense of position, sense of force, sense of effort, tendinitis, tendinopathy, goniometer, electromyography, tendon, muscle force, proprioception, and load cell.

SEARCH STRATEGY

(Transcranial Direct Current Stimulation [Title/Abstract]) OR (tDCS [Title/Abstract]) AND ((Epicondylitis [Title/Abstract]) OR (Tennis elbow[Title/Abstract])) OR (Lateral epicondylalgia [Title/Abstract])) OR (Tennis Elbow [MeSH Terms]) AND (Proprioception[Title/Abstract]) OR (Sense of position [Title/Abstract]) OR (Sense of force [Title/Abstract]) OR (Sense of effort[Title/Abstract]) OR (Goniometer [Title/Abstract]) OR (Electromyography [Title/Abstract]).

The articles of interest were collected and imported to Endnote software for the removal of duplicate titles. Later, studies of unwanted purposes were removed were removed post browsing the titles. Finally, the remaining articles were assessed by two independent investigators t to check if the study were on humans and published in English (Figure 1).

DATA EXTRACTION

The selected articles were cross-checked by two investigators by keeping the inclusion and exclusion criteria in mind. The differences observed in this process were independently rectified by a third investigator.

FINDINGS

There were nine published articles (n = 199) of clinical prospective studies. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist,, an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses.[18,19]

DISCUSSION

The role of proprioception in sensory control is multifactorial. For a proper and correct command performance,, the central nervous system needs a general biomechanical and updated timeline of all body parts. Besides, post performing the movement, it is pivotal to have a sense of correct and efficient proprioception to compare the performed with function with its original functionality.[29] Factors such as pain, effusion, trauma, and fatigue can cause proprioception disorders. All these are evident in tendinopathy.[30–33] Proprioception impairment in a short time affects feedback, feed forward, and muscle stiffness which explains coordination disorders, clumsiness, increased postural displacement, reduced drive with alpha neurons, and visual acuity errors. For a long time, this disorder can also increase a person's risk of injury, recurrence of musculoskeletal diseases, permanent pain, and decreased ability to perform activities.[34,35]

Cole et al.[21] showed that tDCS and high-definition (HD)-tDCS enhance motor learning and are in turn linked by proprioception. These are prospects that improve learning in children and adults. tDCS is also an easy way to improve proprioception in joint disorders and other rehabilitation interventions, which are time-consuming and expensive. Also, tDCS can improve steadiness, in which Achilles tendon vibration resulted in a rapid and immediate recovery response.[22] A study by Muffel et al.[23] assessed the effect of a 15 min tDCS vs. sham on proprioceptive accuracy, which indicated a positive

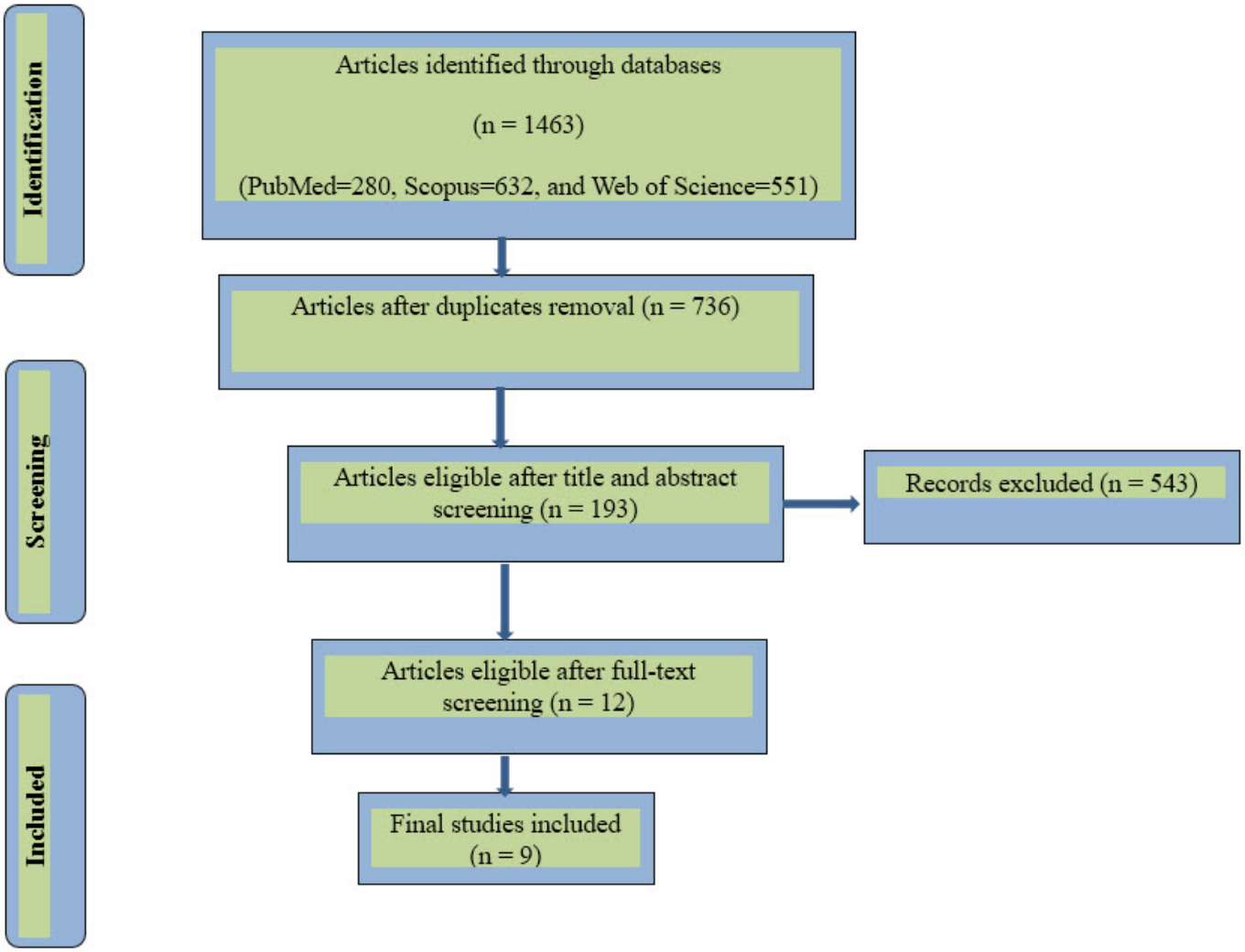

Figure 1 Flow chart of study selection based on PRISMA.

impact on neurological disease recovery. They also showed that tDCS affects proprioceptive accuracy. Juul-Kristensen et al.[20] studied the sense of status in people with tendinitis vs the control group by investigating the proprioception by assessing the position and the threshold of the affected elbow and knee for passive movement and observed that the absolute and relative error rate in the elbow was higher than the knee. The study could not prove the presence of general proprioception disorder because the patient's knees resembled healthy people.[20]

The sensory assessment is one of the most widely used methods of proprioception evaluation,[36] which is performed using simple goniometers, isokinetic dynamometers, electromagnetic path measuring instruments, and researcher-made instruments.[37] Another critical point is to examine the patient's sense of force. Because of the nature of tendinopathy and the absence of inflammatory factors, these patients have difficulty in estimating and producing the required amount of force. To date, no study has researched this aspect of proprioception in these patients. The ability to reproduce a certain amount of maximal isometric contraction is mainly used to assess the sense of force. A previous study by Riemann and Lephart showed that using the opposite limb in tests is a better way than using the same limb.[36]

A study by Sainburg et al. observed that people with proprioception damage when instructed to perform with closed eyes had very nonlinear movement and uncoordinated joint movements. . Healthy people with spatial memory and the use of proprioceptors did not face such problems. These observations made them conclude that proprioception defects could lead to joint disharmony.[25] tDCS improves static and dynamic balance.[38] tDCS of cerebellum improves dynamic balance in older adults. The cerebellum is effective in postural coordination; however, proprioception, visual, and vestibular information is present in the cerebellum.[39,40]

Most purposeful and complex movements are programmed in the central nervous system and adapted by proprioceptive feedback. Motor behaviors such as locomotion, afferent input related to loading, and joint position probably may have a pivotal role in the proprioceptive contribution that aid in the activation of the muscles. There is increasing evidence that movement disorders involve the defective use of afferent input with secondary compensatory processes.[41]

CONCLUSION

tDCS can have a positive role in the improvement of proprioception and balance ability. The absolute error of

Table 1 The detailed list of the reviewed articles in this review study.

Author	Year	Title	Sample	Age (years)	Design	Finding
Juul-Kristensen et al.[20]	2007	Poorer elbow proprioception in patients with lateral epicondylitis than in healthy controls: A cross-sectional study	19	47.8 ± 7.5	Cross-sectional study	Absolute error of joint position sense and proprioception was greater in the elbows than in the knees. It needs an accurate management of lateral epicondylitis.
Cole et al.[21]	2018	Sensorimotor robotic measures of tDCS- and HD-tDCS-enhanced motor learning in children	24	12–18	Double-blind, randomized trial.	tDCS and HD-tDCS enhance motor learning. Exploring mechanisms of neuromodulation may advance therapeutic approaches in pediatric with disabilities.
Poortvliet et al. [22]	2017	Cerebellar transcranial direct current stimulation improves adaptive postural control	28	Sham: 25.14 ± 4.44 Case: 25.64 ± 3.82	Randomized controlled study	ctDCS causes short-term improvement of postural adaptation. Offline cerebellar tDCS can improve postural steadiness.
Muffel et al. [23]	2019	Anodal transcranial direct current stimulation over S1 differentially modulates proprioceptive accuracy in young and old adults	45	Intervention: 27.0 ± 2.4 Control: 69.4±4.9	Double-blind, randomized trial.	tDCS effects on proprioceptive accuracy. There is a possibly relationship between tDCS protocols, brain structure and performance modulation.
Rush[24]	2019	The effects of transcranial direct current stimulation on quadriceps muscle function in individuals with a history of anterior cruciate ligament reconstruction	10	22.9 ± 4.23	Randomized crossover design	One session of active tDCS has no immediate effect on quadriceps activity and muscle function.
Sainburg et al. [25]	1993	Loss of proprioception produces deficits in interjoint coordination	11	10.76 ± 8.1	Cross- sectional study	The roles of proprioceptors in controlling limb interaction torques need further studies.
Goble et al. [26]	2011	Brain activity during ankle proprioceptive stimulation predicts balance performance in young and older adults	40	68.9	Cross- sectional study	Central processing of proprioceptive signals from the foot is critical for balance control.
Roll et al. [27]	1982	Kinaesthetic role of muscle afferents in man, studied by tendon vibration and microneurography	12	24–40	Cross- sectional study	Active isotonic contraction modulated differently the muscle spindle sensory ending discharge, in which it could stop completely, decrease, or sometimes increase during active ankle dorsiflexion.
Park et al. [28]	2019	The effects of sensorimotor training and transcranial direct current stimulation (tDCS) on changes in proprioception and static and dynamic balance in soccer players.	10	24	Randomized controlled study	For soccer players who need to recover quickly after a vigorous soccer match, applying tDCS together with sensorimotor training can have a positive effect on improving proprioception and balance ability.

proprioception is more notable in the elbows compared with the other joints. More research studies are required to get a clearer picture.

ETHICAL CONSIDERATIONS

Ethical subjects such as plagiarism and double publication were observed in this study.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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