Efficacy of capacitive and resistive electric transfer at muscle level. Literature review

Jesús Sánchez Lozano[1], Sandra Martínez Pizarro[2]

[1]Centro de fisioterapia policlínica Baza. Granada. [2]Servicio Andaluz de Salud. Distrito Sanitario Granada. Granada.

doi: 10.18176/archmeddeporte.00177

Received: 14/08/2023
Accepted: 10/06/2024

Summary

Introduction: Between 25% to 30% of high-performance athletes suffer muscle injuries. The main causes are due to overload, muscle fatigue, insufficient warm-up, muscle imbalance, and eccentric work with greater vulnerability of the biarticular muscles. In the most innovative and updated studies of recent years, the use of capacitive and resistive electrical transfer therapy in these patients has been proposed.
Objectives: The objective of this work is to conduct a review of the available scientific literature on the effectiveness of capacitive and resistive electrical transfer at the muscular level. The secondary objectives are to determine the treatment protocol, establish the frequency and necessary sessions and analyze its safety.
Material and method: A review of the literature was carried out following the PRISMA 2021 regulations. The databases of PubMed, Cinahl, PsycINFO, SPORTDiscus, Academic Search Complete, Lilacs, IBECS, CENTRAL, SciELO, and WOS were consulted. The Cochrane Manual tool was used to assess the risk of bias of the studies and the quality of the evidence was evaluated using the GRADE tool.
Results: Capacitive and resistive electrical transfer is effective and safe in patients at the muscular level. The total sample was 192 athletic patients from five studies. The duration of each session ranged between 15 and 30 minutes, and the total number of sessions was five to six spread over one or two weeks. In all studies the technique was tolerated by patients and there were no important adverse effects.
Conclusions: Capacitive and resistive electrical transfer improves muscle strength, physical function, muscle pain, mobility, facilitates muscle activity and reduces disability.

Key words:
Capacitive and resistive electrical transfer. Muscle. Treatment. Revision.

Eficacia de la transferencia eléctrica capacitiva y resistiva a nivel muscular. Revisión de la literatura

Resumen

Introducción: Entre un 25% a 30% de los deportistas de alto rendimiento sufren lesiones musculares. Las principales causas se deben a sobrecarga, fatiga muscular, calentamiento insuficiente, desequilibrio muscular, y trabajo excéntrico con mayor vulnerabilidad de los músculos biarticulares. En los estudios más novedosos y actualizados de los últimos años se ha propuesto el uso de la terapia de transferencia eléctrica capacitiva y resistiva en estos pacientes.
Objetivos: El objetivo de este trabajo es realizar una revisión de la literatura científica disponible sobre la eficacia de la transferencia eléctrica capacitiva y resistiva a nivel muscular. Los objetivos secundarios son determinar el protocolo del tratamiento, establecer la frecuencia y sesiones necesarias y analizar su seguridad.
Material y método: Se realizó una revisión de la literatura siguiendo la normativa PRISMA 2021. Se consultaron las bases de datos de PubMed, Cinahl, PsycINFO, SPORTDiscus, Academic Search Complete, Lilacs, IBECS, CENTRAL, SciELO, y WOS. Se utilizó la herramienta Manual Cochrane para valorar el riesgo de sesgo de los estudios y la calidad de la evidencia se evaluó mediante la herramienta GRADE.
Resultados: La transferencia eléctrica capacitiva y resistiva es eficaz y segura en los pacientes a nivel muscular. La muestra total fue de 192 pacientes deportistas de cinco estudios. La duración de cada sesión osciló entre 15 y 30 minutos, y el número total de sesiones fue de cinco a seis repartidas en una o dos semanas. En todos los estudios la técnica fue tolerada por los pacientes y no hubo efectos adversos importantes.
Conclusiones: La transferencia eléctrica capacitiva y resistiva mejora la fuerza muscular, la función física, el dolor muscular, la movilidad, facilita la actividad de los músculos y reduce la discapacidad.

Palabras clave:
Transferencia eléctrica capacitivay resistiva. Músculo. Tratamiento. Revisión.

Correspondence: Jesús Sánchez Lozano
E-mail: jesus-dbz@hotmail.com

Introduction

Muscles are structures or tissues which have the ability to generate movement by contracting and relaxing. Muscle tissue is made up of specialised cells called myocytes which increase or decrease in length when stimulated by electrical impulses from the nervous system. Muscles help human beings move, give them stability and balance, provide strength and energy to perform activities, and support and protect the whole body. The muscles can be affected by many problems. In sport, muscle injuries are one of the most frequent pathologies[1].

Between 25% and 30% of high-performance athletes suffer muscle injuries (it should be borne in mind that, in elite athletes, between 30-40% of their body weight is muscle)[2].

The main causes of muscle injuries in athletes are overload, muscle fatigue, insufficient warming up, muscle imbalance and eccentric work involving greater vulnerability of the biarticular muscles[3].

The latest and most up-to-date studies in recent years have proposed the use of a new therapy called capacitive and resistive electric transfer (CRET) to treat muscle pathologies in these patients[4].

Capacitive and resistive electric transfer therapy uses radiant energy to generate endogenous heat. It normally uses a long-wave radio frequency of ~0.5 MHz. The system consists of a neutral plate and two different electrodes which can transfer energy in two modes: capacitive and resistive. While the capacitive mode is supposed to interact with soft tissues, the resistive mode interacts more with hard tissues[5,6].

In this treatment, high-frequency electromagnetic waves are used to increase heat in deep tissues. The principle of radio frequency heating is based on the movement of electric charges within an electric field with switching polarity. When said electric field is applied to the tissues, the water molecules present (dipoles) are deformed because the charges are attracted by the electrode of opposite polarity. When the electron current reaches the patient's tissues, these electronic currents become ionic. It is this flow of ions and charged molecules colliding with the immobile tissue particles that induces an increase in the temperature of the area being treated. The temperature reached depends on the intensity of the current and the electrical and anatomical characteristics of the tissues under treatment. The higher the frequency, the more intense the friction between molecules and the greater the heat[7].

This technique arrived in the field of physiotherapy only very recently and because there is little information, this review is proposed to explore the evidence available on the application of capacitive and resistive electric transfer at muscle level in the clinical practice of physiotherapy.

Objectives

The objective of this paper is to review the scientific literature available on the efficacy of capacitive and resistive electric transfer at muscle level.

Secondary objectives:

- To determine a treatment protocol.
- To establish the frequency and sessions needed.
- To analyse its safety.

Material and method

To write this paper, a literature review was conducted following the recommendations of the PRISMA Statement (Preferred reporting items for systematic review and meta-analysis). The review used the PRISMA 2020 statement and a checklist with 27 items[8].

The studies in the review were identified by means of electronic searches in different databases. The main database used was PubMed through the National Library of Medicine platform. The following were also consulted: Lilacs and IBECS through the Biblioteca Virtual en Salud platform; CENTRAL through the Cochrane Library platform; Academic Search Complete, PsycINFO, Cinahl and SPORTDiscus through the EBSCO Host platform; WOS Core and SciELO through the Web of Science and PEDROS to identify a greater number of references.

The search strategy was based on the following PICOS strategy (*Patient, Intervention, Comparison, Outcome, Study*)[9]:

- P (patient): Muscle pathologies.
- I (Intervention): Capacitive and resistive electric transfer.
- C (Comparison intervention): Not applicable.
- O (Outcome): Efficacy.
- S (Studies): Randomised controlled clinical trials (RCTs).

The search strategy in the different databases was carried out using a combination of terms included in the English thesaurus, MeSH headings and free terms (TWs). The truncated term "Random*" was also used to try to locate studies that were randomised clinical trials. All the terms were combined with the Boolean operators "AND" and "OR".

Only randomised clinical trials published in national and international peer-reviewed journals in which the efficacy of capacitive and resistive electric transfer at muscle level was evaluated were included.

Risk of bias assessment was performed on an individual basis using the tool suggested by the Cochrane Handbook for Systematic Reviews of Interventions. This tool consists of 6 specific domains, which can be rated as high, medium or low risk of bias. The domains assessed by this tool are: selection bias, performance bias, detection bias, attrition bias, reporting bias and other biases[10].

The quality of the evidence was assessed through the *Grading of Recommendations, Assessment, Development and Evaluation* (GRADE) system. The GRADE system evaluates the quality of evidence based on the extent to which users can be confident that the reported effect reflects what is being evaluated. Assessment of the quality of evidence includes the risk of study bias, inconsistency, imprecision, publication bias, indirect results and other factors which may affect the quality of evidence. To summarise this information, summary of findings tables[11] have been created.

Results

All the databases consulted gave a total of 79 studies. After removing duplicates with the Rayyan QCRI program[12], the titles and abstracts

of 37 studies were read, a total of 19 trials meeting the inclusion criteria. After reading the full texts of these studies, 14 were excluded because they did not meet the specific selection criteria. Finally, a total of 5 trials were included in this systematic review (Figure 1).

A total of five articles were reviewed. All studies included in the review were randomised controlled clinical trials (100%). The publication period spanned from 2019 to 2023.

20% were conducted in Italy, 20% in Austria, 20% in Japan, 20% in Korea and 20% in Greece. They were published in a diverse range of journals which included: *"Int J Rehabil Res", "Int J Environ Res Public Health", "Electromagn Biol Med", "Technol Health Care",* and *"Medicina (Kaunas)"* (Table 1).

Capacitive and resistive electrical transfer was used in the experimental group in the interventions carried out in all the clinical trials. It should be noted that in the case of the study by Nakamura M *et al.*[14], CRET was combined with eccentric exercises and in that of Kasimis K *et al.*[17], with manual therapy. The control group received sham therapy. The pathology of the patients in three studies was chronic low back pain (Wachi M *et al.*[15], Park C *et al.*[16] and Kasimis K *et al.*[17]), in the trial by Coccetta CA[13], the patients had knee osteoarthritis and in that by Nakamura M *et al.*[14], eccentric muscle damage.

The total sample was 192 patients. The group with the largest sample number was that of Kasimis K *et al.*[17] with 60 participants and the smallest sample was that of Park C *et al*[16] with only 21.

Figure 1. Study selection process flow diagram.

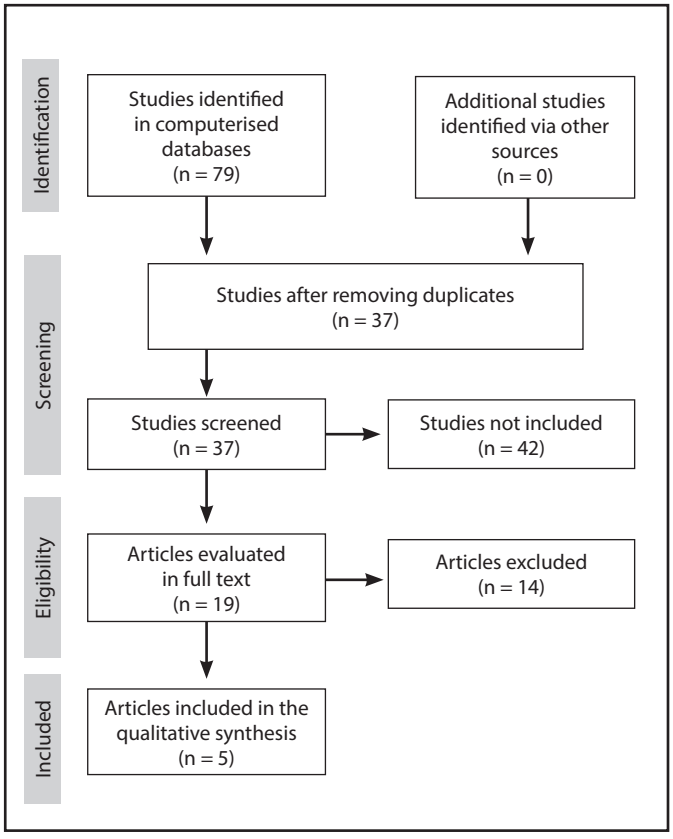

Table 1. General characteristics of the study.

Author	Year	Journal	Country	Design
Coccetta CA[13]	2019	*Int J Rehabil Res*	Italy	RCT
Nakamura M[14]	2022	*Int J Environ Res Public Health*	Austria	RCT
Wachi M[15]	2022	*Electromagn Biol Med*	Japan	RCT
Park C[16]	2023	*Technol Health Care*	Korea	RCT
Kasimis K[17]	2023	*Medicine (Kaunas)*	Greece	RCT

RCT: randomised controlled clinical trial.

The application of capacitive and resistive electrical transfer was safe in all the studies. The duration of each session ranged from 15 to 30 minutes and the number of sessions was five to six over one or two weeks (Table 2).

The main results obtained were.

The Coccetta CA *et al.*[13] clinical trial conducted in 2019 in Italy evaluated whether a two-week CRET programme can reduce pain, stiffness and functional limitations in knee osteoarthritis compared with a sham treatment. Patients were randomly assigned to a study group (n = 31) or a control group (n = 22). The study group underwent six intermittent applications of CRET, while the control group was subjected to a sham protocol which did not involve the application of energy. The outcome measures were the *Western Ontario and McMaster University Osteoarthritis Index* (WOMAC) (primary outcome) and the *Visual Analogue Scale* (VAS) for pain, and the Medical Research Council Scale (secondary outcomes). All the patients were evaluated before treatment (T0), at the end of treatment (T1), and at one month (T2) and 3 months after treatment (T3). The results showed that CRET significantly improved strength, physical function and pain reduction in the patients. Considering the small number of sessions, low cost and long-term benefits, CRET might be a useful therapeutic option for conservative management to reduce pain, stiffness and functional limitation.

The study by Nakamura M *et al.*[14] conducted in 2022 in Austria investigated the acute effect of capacitive and resistive electric transfer (CRET) intervention on eccentrically damaged muscle. A total of 28 male participants were randomly assigned to the CRET intervention or control groups. The participants performed a bout of eccentric exercise of the knee extensors with the dominant leg and received 30 minutes of CRET intervention of the quadriceps 48 hours afterwards. The dependent variables for the analysis were knee flexion range of motion (ROM), muscle soreness and maximum voluntary isometric (MVC-ISO) and concentric contraction (MVC-CON) torque of the knee extensors. These were measured before exercise (baseline) and before and after CRET intervention (48 hours post-exercise). The results of the study showed that CRET intervention significantly improved knee flexion ROM, muscle strength (MVC-ISO and MVC-CON) and muscle soreness. CRET intervention may improve muscle soreness and loss of muscle function in an eccentrically damaged muscle.

The Wachi M *et al.*[15] clinical trial conducted in 2022 in Japan examined the immediate effect on the onset time of muscle pain after irradiating CRET therapy for non-specific chronic low back pain (NSCL-

Table 2. Characteristics of intervention.

Autor	Intervention	Sample	Safety	Duration	Results
Coccetta CA[13]	CRET *versus* sham therapy	53	Yes	6 sessions 15 minutes	CRET improves muscle strength, physical function and pain.
Nakamura M[14]	Eccentric exercise of knee extensors and CRET on quadriceps *versus* sham therapy	28	Yes	30 minutes	CRET intervention improves muscle soreness and loss of muscle function in an eccentrically damaged muscle.
Wachi M[15]	CRET *versus* sham therapy	30	Yes	15 minutes	CRET reduced pain and facilitated activity of the trunk muscles.
Park C[16]	CRET with Pulley Master machine *versus* sham therapy	21	Yes	5 sessions 1 week 20 minutes	CRET improves pain control and mobility in low back pain.
Kasimis K[17]	Manual therapy *versus* manual therapy with CRET *versus* sham therapy	60	Yes	6 sessions 2 weeks	CRET with manual therapy is more efficacious than manual therapy and the control group in reducing pain and disability and improving pressure pain.

CRET: Capacitive and resistive electric transfer.

BP). Thirty patients were randomly divided into an intervention group (n = 15) and a sham group (n = 15). The participants and statisticians were blinded to participant allocation. The intervention group received one 15-minute session of CRET therapy on their lower back; the sham group similarly received one 15-minute session of sham therapy. Before and immediately after the intervention, the onset time of the trunk and lower limb muscles was measured during prone hip extension, and pain intensity was recorded using a visual analogue scale. The intervention group showed a significant reduction in pain and a significantly earlier onset time of the thoracic part of the iliocostalis lumborum, lumbar part of the iliocostalis lumborum, lumbar multifidus and gluteus maximus. These results showed that CRET therapy not only reduced pain but also facilitated trunk muscle activity. Improvement in muscle activity patterns may improve daily-life activities.

Park C *et al.*[16]'s 2023 research in Korea studied the effects of capacitive and resistive electric transfer therapy and the Pulley Master machine, which is designed to offer active movement evaluation and monitoring as well as repetitive and task-specific training, on the lumbar pain scale and thoracic and pelvic mobility in amateur golfers with low back pain. Twenty-one amateur golfers with low back pain (six females, mean age = 23.43 ± 2.36 years) were randomly assigned to either intervention or control groups for five days per week over one week. Clinical outcome measurements included pelvic and thoracic mobility and a pain rating scale. The results provided novel and encouraging clinical evidence that these therapies improve pain control and mobility in amateur golfers with low back pain.

The Kasimis K *et al.*[17] study conducted in 2023 in Greece investigated the efficacy of a manual therapy (MT) programme combined with CRET therapy in people with chronic low back pain. Sixty adults were randomly divided into three groups. The first group followed a manual therapy protocol in the lumbar region, the second group followed the same manual therapy protocol combined with CRET therapy using a conventional capacitive electrode and a special resistive electrode bracelet, and the third group (control group) received no treatment. Both intervention programmes included six treatments over two weeks. Pain in the last 24 h with the *Numeric Pain Rating Scale* (NPRS), functional ability with the *Roland–Morris Disability Questionnaire* (RMDQ), pressure pain threshold (PPT) in the lumbar region with pressure algometry, and mobility of the lumbo-pelvic region through the fingertip-to-floor distance (FFD) test were evaluated before and after the intervention period with a one-month follow-up. In the NPRS score, both intervention groups showed statistically significant differences compared to the control group both during the second week and the one-month follow-up (P <0.001). Between-group differences were also noticed between the two intervention groups in the second week (P <0.05). Differences in the RMDQ score were detected between the intervention groups and the control group in the second week, and at the one-month follow-up (P <0.001), while differences between the two intervention groups were only detected at the one-month follow-up (P <0.001). Regarding the PPT values, differences were found mainly between the MT + CRET group and the control group, and between the MT + CRET group and the MT group (P <0.05), with the MT + CRET group in most cases showing the greatest improvement compared to the other two groups, which remained statistically significant at the one-month follow-up (P <0.05). Finally, both intervention groups improved the mobility of the lumbo-pelvic region at both time points compared to the control group without statistically significant differences between them (P >0.05). Therefore, the application of an MT protocol with CRET therapy appeared more efficacious than conventional MT as well as compared to the control group in reducing pain and disability, and improving pressure pain threshold in individuals with low back pain.

Discussion

The limitations of this literature review were the result of the search strategies chosen for it, such as the language (Spanish and English); we can suppose that articles relevant to the objective of the study have been missed. However, the appropriate thesauri were used in the search of the databases. In most of the clinical trials, the exact way in which capacitive and resistive electric transfer therapy was applied was not specified, which could lead to uncontrolled differences in the studies. This, together with the lack of data in some of the articles in this review, limits the scope of analysis of the studies.

The studies included in this review were generally at low risk of bias. The domains with the lowest risk of bias are those of proper sequence generation (selection bias), sequence concealment (selection bias) and blinding of outcome assessors (detection bias). The greatest risk of bias was committed in blinding the participants because interventions of this kind cannot be completely blinded. However, all the studies blinded the outcome assessors, which is important when analysing the results.

Therefore, it is necessary to continue research to establish a unified protocol in terms of the frequency, duration of the session, duration of the programme and number of sessions, with long-term follow-up of patients. It would also be necessary to carry out randomised controlled clinical studies in more types of athletes, analysing the possible synergistic effect with other therapies or treatments. In this way, healthcare professionals will be able to offer patients the best care based on the latest scientific evidence.

Conclusions

Capacitive and resistive electric transfer is efficacious and safe in patients at muscle level. This therapy improves muscle strength, physical function, muscle pain and mobility, facilitates muscle activity and reduces disability.

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

Bibliography

1. Suchomel TJ, Nimphius S, Bellon CR, Hornsby WG, Stone MH. Training for muscular strength: methods for monitoring and adjusting training intensity. *Sports Med.* 2021;51:2051-66.
2. Gardiner B, Devereux G, Beato M. Injury risk and injury incidence rates in crossFit. *J Sports Med Phys Fitness.* 2020;60:1005-13.
3. Rudisill SS, Kucharik MP, Varady NH, Martin SD. Evidence-based management and factors associated with return to play after acute hamstring injury in athletes: a systematic review. *Orthop J Sports Med.* 2021;9:11.
4. Gehl J. Electroporation: theory and methods, perspectives for drug delivery, gene therapy and research. *Acta Physiol Scand.* 2023;177:437-47.
5. Beltrame R, Ronconi G, Ferrara PE, Salgovic L, Vercelli S, Solaro C, Ferriero G. Capacitive and resistive electric transfer therapy in rehabilitation: a systematic review. *Int J Rehabil Res.* 2020;43:291-8.
6. Yokota Y, Sonoda T, Tashiro Y, Suzuki Y, Kajiwara Y, Zeidan H, *et al.* Effect of capacitive and resistive electric transfer on changes in muscle flexibility and lumbopelvic alignment after fatiguing exercise. *J Phys Ther Sci.* 2018;30:719-25.
7. De Sousa-De Sousa L, Tebar Sanchez C, Maté-Muñoz JL, Hernández-Lougedo J, Barba M, Lozano-Estevan MDC, *et al.* Application of capacitive-resistive electric transfer in physiotherapeutic clinical practice and sports. *Int J Environ Res Public Health*. 2021;18:12446.
8. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *J Clin Epidemiol.* 2021;19:26.
9. Mamédio C, Andrucioli M, Cuce M. The PICO strategy for the research question construction and evidence research. *Rev Latino-Am Enfermagem.* 2007;15:508-11.
10. Higgins JPT, Thomas J. *Cochrane handbook for systematic reviews of interventions.* 2.aed. WILEY Blackwell; 2019.
11. Aguayo-Aledo JL, Flores-Pastor B, Soria-Aledo V. Sistema GRADE: Clasificación de la calidad de la evidencia y graduación de la fuerza de la recomendación. *Cirugía Española.* 2014;92:82-8.
12. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev*. 2016;5:210.
13. Coccetta CA, Sale P, Ferrara PE, Specchia A, Maccauro G, Ferriero G, *et al.* Effects of capacitive and resistive electric transfer therapy in patients with knee osteoarthritis: a randomized controlled trial. *Int J Rehabil Res.* 2019;42:106-11.
14. Nakamura M, Sato S, Kiyono R, Yahata K, Yoshida R, Kasahara K, *et al.* The effect of capacitive and resistive electric transfer intervention on delayed-onset muscle soreness induced by eccentric exercise. *Int J Environ Res Public Health*. 2022;19:5723.
15. Wachi M, Jiroumaru T, Satonaka A, Ikeya M, Oka Y, Fujikawa T. Effect of electromyographic activity using capacitive and resistive electric transfer on non-specific chronic low back pain: a double-blind randomized clinical trial. *Electromagn Biol Med*. 2022;41:222-9.
16. Park C, Kim K, Yoon S, Park I, Cha Y. Physiotherapeutic effects of an innovative golf swing-assist device on discomfort and mobility in amateur golfers with low back pain: A randomized controlled trial. *Technol Health Care*. 2023;31:137-44.
17. Kasimis K, Iakovidis P, Lytras D, Koutras G, Chatziprodromidou IP, Fetlis A, *et al.* Short-Term Effects of Manual Therapy plus capacitive and resistive electric therapy in individuals with chronic non-specific low back pain: a randomized clinical trial study. *Medicina (Kaunas).* 2023;59:1275.