EFFECTS OF CAPACITIVE AND RESISTIVE ELECTRONIC TRANSFER THERAPY IN MUSCULOSKELETAL DISEASES – A RESULTS OVERVIEW OF RECENT CLINICAL TRIALS

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ABSTRACT Introduction: Musculoskeletal diseases imply conditions that impact muscles, bones, joints and associated tissues such as tendons and ligaments and, as such, maybe a significantly limiting factor for performing Activities of Daily Living. The therapy with capacitive and resistive electronic transfer has been applied as a type of endogenous thermal treatment for heating the surface and deep tissues, providing tissue reconstruction and pain relief. This paper aims to provide an overview of the efficiency results of capacitive and resistive electronic transfer (CREt) therapy in managing symptoms associated with musculoskeletal disorders found in the available literature. Material and Methods: Articles related to musculoskeletal disorders were searched through electronic databases, such as PubMed, Web of Knowledge, Lilacs, Cochrane, ResearchGate by the following keywords: capacitive and resistive electronic transfer, Tecar therapy, radiofrequency therapy, musculoskeletal diseases, physiotherapy modalities. After excluding records that are not clinical trials and studies and articles which did not deal with musculoskeletal disorders, 21 articles were eligible and included in the overview. Results: By reviewing the selected articles related to CREt therapy effects on various forms of musculoskeletal disorders, it was found that this therapy has favourable effects in pain reduction, improvement of muscles and joints mobility, and oedema reduction. Its positive effects may be attributed to its capability to increase tissue temperature and improve blood circulation. Conclusion: CREt therapy, applied either solely or in combination with conventional physiotherapies, have rapid and immediate effect, both in chronic and acute conditions.

KEYWORDS capacitive and resistive electronic transfer, Tecar, radiofrequency therapy, musculoskeletal diseases, pain

1. Introduction

Musculoskeletal diseases imply conditions that impact muscles, bones, joints and associated tissues such as tendons and ligaments. There is a variety of these conditions, ranging from those that develop suddenly and are short-lived, such as fractures, sprains and strains, to lifelong conditions accompanied by pain and functional disability [1].

Pain and limitations in both mobility and functional ability are dominant characteristics of musculoskeletal conditions. Not only that they reduce people’s functionality and adversely affect the quality of life, but they also present an economic issue worldwide considering that numerous musculoskeletal disorders are chronic and that many affect the working-age population. Therefore, prevention and proper treatment may have a significant role [1].

As per body structures, they affect, most common conditions include the following:
• osteoarthritis, rheumatoid arthritis, psoriatic arthritis, gout, ankylosing spondylitis - affecting joints;
• osteoporosis, osteopenia and associated fragility fractures, traumatic fractures - affecting bones;
• sarcopenia - affecting muscles;
• back and neck pain - affecting the spine;
• Connective tissue diseases - affecting multiple body areas or systems and vasculitis that have musculoskeletal manifestations, for example systemic lupus erythematosus [1].

Considering their various manifestations, from fractures to irreparable and degenerative chronic diseases, musculoskeletal conditions may develop at any age, and there are many risk factors that vary from those related to everyday activities to those related to natural processes of an organism [1].

World Health Organization (WHO) noted that musculoskeletal conditions were the leading cause of disability in two-thirds of the six WHO regions in 2017 [1]. Some conditions require the administration of medicines, but wherever possible, physical treatment should be applied as well, given its proven benefits and the fact that it commonly stimulates natural human processes in the body. Physical rehabilitation and medicine deal with a wide range of conditions. Its physical treatment modalities are widely used to reduce pain and improve mobility and flexibility, and, above all, improve our performance in Activities of Daily Living (ADL) [2]. One of them is capacitive and resistive electronic transfer (CRet) therapy.

1.1. CRet therapy – background and effect mechanism

The capacitive and resistive electronic transfer (also known under the French acronym - TECAR) therapy has been used as an endogenous thermal treatment for heating the surface and deep tissues, providing tissue reconstruction and pain relief. Its origin dates back to 1890 when Jacques Arsene d’Arsonval, a well-known French physician, discovered that plasma membrane permeability increases with increasing the frequency of electromagnetic waves to more than 100 KHz. In 1920's, together with other researchers and physicians, he developed the first capacitive and resistive electrodes. Since then, this non-invasive physical modality has developed and improved, finding its application in treatment for numerous conditions [3].

CRet therapy is considered a special form of energy. Its non-invasive high-frequency energy stimulates the natural ability of a body to regenerate itself. In this way, natural physiological and metabolic tissue processes are stimulated by transferring energy without radiation coming from outside. The general concept of the device used for administration of CRet therapy includes a movable electrode guided by a therapist, treating the affected area and a fixed electrode used as a conductor being in contact with the skin of a patient [4]. One of the major features of this device is the possibility to be used at low energy levels. In this way, it is possible to treat conditions both being acute or subacute without causing worsening of an inflammatory process developed due to the increased tissue temperature [5].

Furthermore, CRet therapy may operate in two manners of transferring electrical charge: capacitive and resistive. Reactions produced by the capacitive system via capacitive electrode focus on tissues having more electrolytes, such as soft tissues and muscles, unlike resistive systems, which focus on greater and more resistant tissues such as tendons, bones, and joints. With these two ways of transferring energy, the therapy enables intensifying vasodilation and oxygenation, improving microcirculation and causing a rise in internal temperature [6]. CRet therapy offers a unique spectrum of treatments for chronic and acute diseases with some contraindications: pacemaker, pregnancy, and sensitivity to high temperatures [7].

2. Methods

Further to the proven benefits and good tolerance to this therapy, we were interested in reviewing papers dealing with it within the scope of musculoskeletal conditions. Therefore, based on available resources and records, we prepared this results overview of recent clinical trials done in a period between 2009 and 2019 that include effects of CRet therapy in some musculoskeletal disorders where pain and limited motion range are dominant.

Articles related to CRet were searched through electronic databases, such as PubMed, Web of Knowledge, Lilacs, Cochrane, Research Gate, by the following keywords: capacitive and resistive electronic transfer, Tecar therapy, pulsed radiofrequency therapy, musculoskeletal diseases, physiotherapy modalities. Within available papers, 44 records were identified and screened. After excluding records that are not clinical trials and studies (review articles, patient information, PhD papers etc.) and articles which did not deal with musculoskeletal disorders (in total n=23), 21 articles were eligible and included in the overview (Table 1).

3. Results

By reviewing the selected articles related to CRet therapy effects on various forms of musculoskeletal disorders, it was found that this therapy has a favourable effect in pain reduction, improvement of muscles and joints mobility, and oedema reduction. Its positive effects may be attributed to its capability to increase tissue temperature, improve blood circulation, and enhance haemoglobin saturation (Graph 1; Note: some indications can be found joined within one paper, and therefore a number of articles in the graph does not match the number of studies given within these results).

3.1. Effects of CRet therapy on pain

The majority of articles report the effects of CRet therapy on pain (n=19). Most articles deal with low back pain (n = 5 +...
<table>
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<th>Citation</th>
<th>Aim</th>
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<tr>
<td>Aim: The value of ultrasound in the treatment of chronic low back pain</td>
<td>To evaluate the efficacy of Tecar therapy in a group of patients with chronic low back pain.</td>
<td>There was an improvement in the pain symptoms in most patients treated with Tecar therapy, while the treatment in the placebo group showed little or no improvement.</td>
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<td>Table 1</td>
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<td>1. Studies of the noninvasive in ophthlaco tecartherapy versus placebo in the treatment of lombalgia (Randomized, double-blind clinical trial versus placebo Tecartherapy in the treatment of low back pain)</td>
<td>To evaluate the efficacy of Tecar therapy in a group of patients with chronic low back pain.</td>
<td>There was an improvement in the pain symptoms in most patients treated with Tecar therapy, while the treatment in the placebo group showed little or no improvement.</td>
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<td>2. Effects of capsaicin and resveratrol extract on pain in patients with</td>
<td>To determine the effects of CReT on painful shoulder.</td>
<td>VAS scores in the CReT group improved from 22.31 ± 11.8 at baseline to 14.07 ± 10.87 at follow-up. The placebo group did not show any improvement. Similarly, functional scale scores improved in the CReT group compared with the placebo group.</td>
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<td>3. Antidepressant effects of a capsaicin-resveratrol monopolar radiofrequency in patients with myofascial chronic neck pain, a pilot randomized controlled trial</td>
<td>To investigate the immediate effects of capsaicin monopolar radiofrequency, in comparison with a placebo, on (1) neck pain intensity reduction at myofascial trigger points (MTP), (2) myofascial neck disability, and (3) improving cervical range of motion (ROM).</td>
<td>The Wilcoxon test done for VAS indicates statistically significant differences between baselines, just following the first session and after eight sessions. No improvement in both groups after eight sessions, but no differences were found between groups.</td>
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<td>4. Eficácia de la terapia tecar en el tratamiento de las tenesmus dolorosos</td>
<td>To evaluate the effect of the Targeted Radiofrequency Therapy (TR-Therapy) at 500 kHz for treatment of pain caused by trigger points and functional muscle spasm compared to the methods of conventional physiotherapy.</td>
<td>The average decrease of the pain perceptions in the treatment group was 47% and 63% in the Control group. The enhancement of the abilities to perform ADL, both in the Treatment group and in the Control group was on average 41% and 21%, respectively. Subject's test showed a significant difference between the post-treatment results in both groups. There was a statistically significant difference between the results from VAS for Pain perception of both groups.</td>
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<td>5. Efficacy Evaluation of Targeted Radiofrequency Therapy in Trigger Points and Functional Muscle Spasms Treatment</td>
<td>To evaluate the effect of Targeted Radiofrequency Therapy (TR-Therapy) at 500 kHz for treatment of pain caused by trigger points and functional muscle spasm compared to the methods of conventional physiotherapy.</td>
<td>The treatment of the study showed significant improvement in both acute and chronic injuries with a quick and immediate reduction of the pain and reduced recovery times, determined by a prompt return to activity. VAS also showed lower in both chronic and acute injuries.</td>
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<td>6. Multicentre study on tecar therapy in sports pathologies</td>
<td>To evaluate pain reduction with VAS and to reduce motor recovery time.</td>
<td>The final results showed considerable improvement in both articular and muscular and tendonious disorders with a fast pain relief, measured with VAS. In addition, no adverse cases were noted during the study.</td>
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<td>7. Tecar therapy in the treatment of acute and chronic pathologies in sports</td>
<td>To demonstrate the efficacy of Tecar therapy in the treatment of acute and chronic musculo-articular pathology in athletes.</td>
<td>Most patients reported pain relief and significant improvement at the end of the treatment. The categories of the modified Steinbroker index and VAS were statistically significant. There were statistically significant changes, both in acute and chronic cases and in the 3 pathology groups observed. The results indicate that Tecar therapy is a useful tool in treating locomotor pathologies in sports.</td>
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<td>8. Novel methods for the treatment of muscle trauma in athletes</td>
<td>To present the results of a two-year study protocol aimed to verify the efficacy of TECAR therapy in muscle lesions of various grades in athletes by using clinical and instrumental evaluations (pain, swelling, functional impotence, ultrasounds of muscles and tendons) prior and following one cycle of standardized treatment.</td>
<td>The results were extremely good regarding the speed of resolution of the clinical-symptomatological and ultrasound situation. Further, the study confirmed the theoretical safety of TECAR therapy, given that there were no side effects detected.</td>
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<td>9. The effect of Human Tecar Synergistic Healthcare methodology to reduce pain and oedema after the grade II ankle’s sprain</td>
<td>To present the results obtained with the treatment of pain syndrome in the cervical region.</td>
<td>After five treatments, on the sixth day following the injury, the pain reduced from 7 to 2 in VAS, and the mass previously present on foot withdrew with an average reduction of oedema at 3cm.</td>
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<td>10. Targeted radiofrequency therapy in combination with post-isometric relaxation in the treatment of pain syndrome in the cervical region</td>
<td>To evaluate the combined effect of TR-Therapy and Post Isometric Relaxation (PIR) in treating pain related to the cervical spine with mobility limiting factors.</td>
<td>The study shows a statistical difference between the results obtained in the treatment group and control group in terms of mobility.</td>
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<td>11. Cervicalgia, lumbago, sciatica: application of the capacitive energy transfer system</td>
<td>To evaluate the clinical efficacy of Tecar therapy (TECARI®) in patients with cervical and lumbar pain, either fixed or radiating towards the limbs, as well as cases of pathology being secondary to surgical treatment with a diagnosis of lumbago and/or cervicalgia of a mechanical type unrelated to inflammatory or post-surgical pathology.</td>
<td>The clinical evaluation of the obtained data concluded that a significant improvement was achieved in 65% of the patients treated with Capacitive Energy Transfer.</td>
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<td>12. Experimental study: therapeutic application of Tecar therapy in cervical pain syndromes</td>
<td>To evaluate the therapeutic efficacy of Tecar therapy “by patients” with chronic cervical pain syndromes, recruited on an ongoing basis.</td>
<td>The value NRS decreased from 6.63 to 2.70, up to 2.55 at the follow-up to two months. The analysis of the results of the Neck Pain Questionnaire (NPQ) showed there was a significant decrease in the NPQ score from 37.95% to 16.67% at the end of treatment, and after two months at follow up, it was 12.54%.</td>
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<td>13. Effectiveness of therapeutic hyperthermia by capacitive-resistive electric transfer for degenerative neck pain</td>
<td>To evaluate the effectsiveness of a non-invasive hyperthermia system by radio frequency based on Capacitive-Resistive Electric Transfer in treating degenerative cervical pain compared to placebo. The second objective was to evaluate the patients’ tolerance to the treatment.</td>
<td>With its faster analgesic effect, the INDIBA’s method of hyperthermia by deep heating device with ultrasound in pain relief and enhancing function in patients with shoulder issues was significantly more effective than the placebo.</td>
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<td>14. Hyperthermia to treat low back pain and gonarthrosis</td>
<td>To present the results obtained with the treatment of low back pain due to slipped disk and moderate gonarthrosis.</td>
<td>The statistical analysis of the results showed a significant pain reduction and reduced intake of NSAID after the treatment in the case of both disorders. There was an optional stabilization of VAS results in patients suffering from gonarthrosis, also at follow-ups 6 and 12 months after treatment. However, in the case of low back pain, the instances in which pain returns after 6 and 12 months are statistically significant.</td>
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<td>15. Efficacy of Tecar Therapy on Delayed Muscle Deterioration in Quadriceps</td>
<td>To evaluate the efficacy of Tecar Therapy in delayed onset muscle soreness on quadriceps.</td>
<td>It was noted that there was significantly less pain in the Tecar group than in the group without Tecar, at the moment MD4 later. There was the difference in the Single Leg Hop and pressure pain threshold variable.</td>
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<td>16. Efficacy of a Novelly Developed Tecar Therapy Deep Heating Device Using High Frequency in Patients with Shoulder Pain and Disability: A Pilot Study</td>
<td>To evaluate and compare the effectiveness of this deep heating device with ultrasound in pain relief and enhancing function in patients with shoulder issues.</td>
<td>Three out of 14 patients assigned into two groups. 14 patients in the HIPER-500 group and 16 in the Sonostim® group. They all showed significant improvements regarding shoulder pain and shoulder function when comparing the results before the treatment and the results immediately after treatment and four weeks following the treatment.</td>
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<tr>
<td>17. Effects of Tecar Therapy in the treatment of low back pain</td>
<td>To evaluate the effectsiveness of this deep heating device with ultrasound in pain relief and enhancing function in patients with shoulder issues.</td>
<td>Three out of 14 patients assigned into two groups. 14 patients in the HIPER-500 group and 16 in the Sonostim® group. They all showed significant improvements regarding shoulder pain and shoulder function when comparing the results before the treatment and the results immediately after treatment and four weeks following the treatment.</td>
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1 common for low back and cervical syndromes) and cervical pain (n = 4 + 1 common for low back and cervical syndromes), four with pain associated with sports injuries, two articles were found with effects on shoulder pain, and one on pain due to tennis elbow, muscle spasm, fracture, quadriceps discomfort, respectively. According to the results from the trials, pain reduction was achieved in every treated group. In 16 articles, the pain assessment was commonly presented by Visual Analogue Scale (VAS), in 2 by Numerical Rating Scale (NRS) and in 1 by Oswestry Low Back Pain Disability Questionnaire. Statistical significance of values obtained in these scales before and after treatment, as well as at follow-ups, varies. However, pain reduction both during and after the treatment is noted in every case. In the randomized, double-blind clinical trial by Stagi P. et al., where effects of CRet therapy on low back pain were investigated versus the placebo, it is reported that application of CRet therapy appears to be useful in the management of low back pain, with rapid and intense effect in the short term [6]. Studies by Morelli et al., and Notarnicola et al., compared the effects of CRet therapy with some other therapy modalities in low back pain: oxygen-ozone therapy and laser therapy, respectively. Both articles reported rapid improvement regarding pain, but in the former case, the results, both during the treatment period and at follow-ups, were better in the group treated with oxygen-ozone therapy. In the latter, CRet therapy was better in comparison to laser [9, 10].

The study by Saggiini R. et al. presented the results achieved by administering CRet therapy in the case of low back pain and goniarthrosis. After being statistically processed, the results show a significant reduction of both pain and intake of NSAID after the treatment in the case of both ailments [11].

As for the articles related to the effects of CRet therapy on cervical pain, the results are quite similar to those of its effects on low back pain. The study by Alguacil-Diego et al. on analgesic effects of capacitive-resistive monopolar radiofrequency on chronic neck pain, where this treatment modality was evaluated in comparison to the placebo, reports based on the obtained results that the monopolar capacitive, resistive radiofrequency could have a potential effect on pain intensity [12]. However, one study where CRet was administered as the only therapy demonstrated very favourable effects on pain reduction [13]. Rapid and immediate analgesic efficacy of CRet was demonstrated in the study by Pastor and Pernía, which deals with the effectiveness of therapeutic hyperthermia in degenerative neck pain by capacitive-resistive electric transfer. In this case, CRet was compared to ultrasound phonophoresis, showing faster action [14]. It appears that the best results in pain management are achieved when CRet is combined with some other therapies, and this is proven in the study by Gonkova et al. where CRet in combination with Post Isometric Relaxation techniques is a beneficial method for treating pain and restoring mobility, enhancing patient’s quality of life [15]. Based on the clinical evaluation of the data obtained from the study by Molina A. et al. on the application of CRet in cervicalgia, lumbago and sciatica, it may be concluded that a considerable advancement was achieved in 65% of the patients subjected to a treatment with Capacitive Energy Transfer [5].

3.2. Effects of CRet therapy on mobility, flexibility and range of motion

CRet therapy also has a favourable effect on mobility, flexibility and range of motion in muscles and joints. The results of the studies (n=5) show that CRet is an efficient method for preventing and treating musculoskeletal injuries and for improving muscle flexibility and that CRet is an effective solution for treating painful conditions, including ADL limiting factor (led by trigger points and functional muscle spasms) in comparison to the conventional physiotherapy procedures [16, 17, 18]. As in pain management, the effects of CRet on mobility could be enhanced in combination with some other therapeutic techniques [19].

3.3. Effects of CRet therapy on oedema

Successful application of CRet therapy in treating oedema/swelling due to sprains, fracture and muscle trauma is also described (n=3). CRet has a very favourable effect on oedema reduction, being efficient and rapid. It should be noted that CRet may be used at a quite early phase of conditions that resulted in oedema [20, 21, 22]. The oedema reduction is noted in some cases even after the first application of CRet, and the latest by the fourth. The difference in the elapsed time for yielding the effect is due to several factors, such as nature of the injury, administration protocol and patient’s organism itself.
3.4. Effects of CRet therapy in sport injuries

Among the articles selected for this overview, four articles on CRet therapy effects in sport musculoskeletal pathologies may form a separate group considering that these develop due to specific activities. These articles report a prompt reduction of the pain and reduced recovery times, both in acute and chronic injuries and prompt return to activity, significant advancement in articular and muscular and tendinous disorders and oedema reduction [20, 22, 23, 24].

4. Discussion

This paper aimed to imply the significance and advantage of CRet therapy in treating musculoskeletal disorders by reviewing recent studies. By observing the therapy effects in the most common musculoskeletal pathologies, it is found that significant effects were achieved immediately after the first therapy cycle. Such results are likely to result from a biological effect on muscles – anti-oedemic, anti-inflammatory and myorelaxant - through a release of endorphins and controlling both pain types – nociceptive and neuropathic [25]. The results of published papers underline the significance of CRet, whether when applied individually or in combination with other physiotherapy procedures. CRet therapy may have a significant analgesic effect, which in comparison to some other procedures, develops faster and lasts longer. A possibility to be applied in every phase of disease also has a great significance because it is possible to act even in an early phase and prevent more significant motor deficit and the development of chronicity. On the other hand, CRet is considered efficient in chronic conditions where most other physiotherapy procedures do not result in significant recovery. Although there is a small number of clinical studies in this field, CRet appears to be an effective treating method in pain relief and better functionality of patients and therefore improved quality of life.

It appears that the background for most CRet effects lies in its influence on tissue temperature and blood circulation. In two studies with healthy participants, done by Yokota et al. and Tashiro et al., the results showed that the extensibility of soft tissues increases with the temperature increase and muscle flexibility improves. It is not completely clear whether muscle flexibility improves due to some changes in soft tissues or due to increased tolerance to pain being the result of analgesic effect caused by thermotherapy. However, in any case, the therapy yields improvement. Enhanced blood circulation may be attributed to the direct reflective activation of vascular smooth muscles, provided via skin temperature receptors, suppression of the sympathetic nerve system achieved by indirect activation of local spinal reflexes, and elevations in the local release of histamine and prostaglandin. The combined effect would result in vasodilation and an increase in blood flow [16, 26].

Considering that most reviewed studies present results of effects of CRet combined with some other physical therapies, it is necessary to have more studies dealing with CRet as a physical therapy modality applied solely in order to determine all its effects mechanisms more precisely. Understanding more possibilities of this therapy would enable those administering physical therapies not only to set a corresponding duration of the therapy but also to make adequate combinations with other physical therapies in order to get fast and effective results.

List of abbreviations

- CRet – Capacitive and resistive electric transfer
- TECAR – Transfer of Energy Capacitive and Resistive
- VAS – Visual Analogue Scale
- NRS – Numerical Rating Scale
- NSAID – nonsteroidal anti-inflammatory drugs

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Conflict of interest

There are no conflicts of interest to declare by any of the authors of this study.

References


