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Does the Application of Tecar Therapy Affect Temperature and Perfusion of Skin and Muscle Microcirculation? A Pilot Feasibility Study on Healthy Subjects

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Abstract

Background: Tecar therapy (TT) is an endogenous thermotherapy used to generate warming up of superficial and deep tissues. TT capability to affect the blood flow is commonly considered to be the primary mechanism to promote tissue healing processes. Despite some preliminary evidence about its clinical efficacy, knowledge on the physiologic responses induced by TT is lacking.

Objective: The aim of this quantitative randomized pilot study was to determinate if TT, delivered in two modes (resistive and capacitive), affects the perfusion of the skin microcirculation (PSMC) and intramuscular blood flow (IMBF).

Design: A randomized controlled pilot feasibility study.

Subjects: Ten healthy volunteers ($n=4$ females, $n=6$ males; mean age 35.9 ± 10.7 years) from a university population were recruited and completed the study.

Intervention: All subjects received three different TT applications (resistive, capacitive, and placebo) for a period of 8 min.

Outcome measures: PSMC, IMBF, and the skin temperature (ST) were measured pre- and post-TT application using power Doppler sonography, laser speckle contrast imaging (LSCI), and infrared thermography.

Results: Compared with placebo application, statistically significant differences in PSMC resulted after both the resistive ($p=0.0001$) and the capacitive ($p=0.0001$) TT applications, while only the resistive modality compared with the placebo was capable to induce a significant change of IMBF ($p=0.013$) and ST ($p=0.0001$).

Conclusions: The use of power Doppler sonography and LSCI enabled us to evaluate differences in PSMC and IMBF induced by TT application.

Keywords: diathermy, physical therapy modality, perfusion imaging, regional blood flow, laser speckle contrast imaging, skin temperature

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RESEARCH ARTICLE Open Access

Thermal and non-thermal effects off capacitive-resistive electric transfer application on the Achilles tendon and musculotendinous junction of the gastrocnemius muscle: a cadaveric study

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Abstract

Background: Calf muscle strain and Achilles tendon injuries are common in many sports. For the treatment of muscular and tendinous injuries, one of the newer approaches in sports medicine is capacitive-resistive electric transfer therapy. Our objective was to analyze this in vitro, using invasive temperature measurements in cadaveric specimens.

Methods: A cross-sectional study designed with five fresh frozen cadavers (10 legs) were included in this study. Four interventions (capacitive and resistive modes; low- and high-power) was performed for 5 min each by a diathermy "T-Plus" device. Achilles tendon, musculotendinous junction and superficial temperatures were recorded at 1-min intervals and 5 min after treatment.

Results: With the low-power capacitive protocol, at 5 min, there was a 25.21% increase in superficial temperature, a 17.50% increase in Achilles tendon temperature and an 11.27% increase in musculotendinous junction temperature, with a current flow of 0.039 A ± 0.02.
With the low-power resistive protocol, there was a 1.14% increase in superficial temperature, a 28.13% increase in Achilles tendon temperature and an 11.67% increase in musculotendinous junction temperature at 5 min, with a current flow of 0.063 A ± 0.02. With the high-power capacitive protocol there was an 88.52% increase in superficial temperature, a 53.35% increase in Achilles tendon temperature and a 39.30% increase in musculotendinous junction temperature at 5 min, with a current flow of 0.095 A ± 0.03. With the high-power resistive protocol, there was a 21.34% increase in superficial temperature, a 109.70% increase in Achilles tendon temperature and an 81.49% increase in musculotendinous junction temperature at 5 min, with a current flow of 0.120 A ± 0.03.

(Continued on next page)

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Thermal and non-thermal effects of capacitive–resistive electric transfer application on different structures of the knee: a cadaveric study

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Capacitive–resistive electric transfer therapy is used in physical rehabilitation and sports medicine to treat muscle, bone, ligament and tendon injuries. The purpose is to analyze the temperature change and transmission of electric current in superficial and deep knee tissues when applying different protocols of capacitive–resistive electric transfer therapy. Five fresh frozen cadavers (10 legs) were included in this study. Four interventions (high/low power) were performed for 5 min by a physiotherapist with experience. Dynamic movements were performed to the posterior region of the knee. Capsular, intra-articular and superficial temperature were recorded at 1-min intervals and 5 min after the treatment, using thermocouples placed with ultrasound guidance. The low-power protocols had only slight capsular and intra-capsular thermal effects, but electric current flow was observed. The high-power protocols achieved a greater increase in capsular and intra-articular temperature and a greater current flow than the low-power protocols. The information obtained in this in vitro study could serve as basic science data to hypothesize capsular and intra-articular knee recovery in living subjects. The current flow without increasing the temperature in inflammatory processes and increasing the temperature of the tissues in chronic processes with capacitive–resistive electric transfer therapy could be useful for real patients.

Abbreviations

ROM	Range of motion
ACL	Anterior cruciate ligament
CRet	Capacitive–resistive electric transfer
HPC	High-power capacitive
LPC	Low-power capacitive
HPR	High-power resistive
LPR	Low-power resistive

The knee is one of the most frequently injured joints in physically active individuals[1–4]. Injury severity can range from asymptomatic injuries to damaged ligaments or menisci[5,6]. In the USA, anterior cruciate ligament injuries (ACL) are reported to occur in 250,000 individuals per year, with over 127,000 arthroscopic ACL reconstructions

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Article

Thermal and Current Flow Effects of a Capacitive–Resistive Electric Transfer Application Protocol on Chronic Elbow Tendinopathy. A Cadaveric Study

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Abstract: Lateral elbow tendinopathy, or "tennis elbow," is a pathology that affects around 1.3% of the general population. Capacitive–resistive electric transfer therapy aims to provoke temperature and current flow changes in superficial and deep tissues. The aim of this in vitro study was to analyze the thermal behavior and transmission of electric current on the superficial and deep tissues of the elbow during the application of different modalities of a capacitive–resistive electric transfer treatment protocol for chronic elbow tendinopathy. A cross-sectional study was designed; five fresh cryopreserved cadavers (10 elbows) were included in this study. A 30 min intervention was performed based on a protocol commonly used in clinics for the treatment of chronic lateral elbow tendinopathy by diathermy using the "T-Plus." Common extensor tendon, radiohumeral capsule, and superficial temperatures were registered after each application for the duration of the 30 min treatment protocol. During all applications, we observed a current flow of over 0.03 A. The protocol showed a statistically significant increase in superficial temperature by 24% (5.02°) ($p < 0.005$), the common extensor tendon by 19.7% (4.36°) ($p < 0.007$), and the radiohumeral joint capsule by 17.5% (3.41°) ($p < 0.005$) at the end of the 30 min protocol compared with the baseline temperature. The different applications of the protocol showed specific effects on the temperature and current flow in the common extensor tendon and radiohumeral capsule. All applications of the protocol produced a current flow that is associated with the generation of cell proliferation. These results strengthen the hypothesis of cell proliferation and thermal changes in deep and distal structures. More studies are needed to confirm these results.

Keywords: tennis elbow; cadaver; diathermy; physical therapy

1. Introduction

Lateral elbow tendinopathy, or "tennis elbow," is a pathology that affects around 1.3% of the general population, with equal affectation in men and women [1]. People in manual labor, those who use vibration tools, and throwing athletes have a greater risk of suffering this pathology [2]. Lateral elbow tendinopathy is primarily caused by repeated stress in the extensor tendon, in particular the extensor carpi radialis brevis, although it can also be caused by direct traumatism or overstretching [2,3]. Although the pathophysiological mechanism of tendinopathy has not been elucidated, it is believed that chronic tendinopathy is produced by a degenerative mechanism of the extensor tendon. This happens through hypoxia and tendon fibrosis, which could lead to the formation of

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RESEARCH ARTICLE Open Access

Temperature and current flow effects of different electrode placement in shoulder capacitive-resistive electric transfer applications: a cadaveric study

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Abstract

Background: Impingement syndrome is currently estimated to represent 60% of all shoulder pain disorders. Capacitive-Resistive electric transfer therapy is aimed to provoke temperature and current flow changes in superficial and deep tissues. This in vitro study has evaluated the variation of temperature and current flow in the shoulder tissues during two different areas of application of the movable capacitive-resistive electric transfer electrode.

Methods: A cross-sectional study designed, five fresh cryopreserved cadavers (10 shoulders) were included in this study. Four interventions (capacitive and resistive modes; low- and high-power) were performed for 5 min each by a diathermy "T-Plus" device in two shoulder regions: postero-superior and antero-lateral. Supraspinatus tendon, glenohumeral capsule and superficial temperatures were recorded at 1-min intervals and 5 min after treatment.

Results: A statistically significant difference was found only for the superficial area and time interaction, with high power-resistive application at the postero-superior shoulder area ($P < 0.035$). All the applications showed a 5 min after treatment temperature increase compared with the basal data, in all the application points. Superficial temperature in the high power-resistive application showed the greatest percent increase (42.93% ± 22.58), followed by the temperature in the tendon area with the same high power-resistive application (22.97% ± 14.70). The high power-resistive application showed the greatest percent of temperature increase in the applications, reaching 65.9% ± 22.96 at 5-min at the superficial level, and 32% ± 24.25 at 4-min at the level of the supraspinatus tendon. At the capsule level, high power-resistive was also the application that showed the greatest percent of increase, with 21.52% ± 16.16. The application with the lowest percent of temperature increase was the low power-capacitive, with a mean value of 4.86% at supraspinatus tendon level and 7.47% at capsular level.

Conclusion: The shoulder postero-superior or antero-lateral areas of application of capacitive-resistive electric
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RESEARCH ARTICLE

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Human Kinetics
ORIGINAL RESEARCH REPORT

Is Tecar Therapy Effective on Biceps Femoris and Quadriceps Rehabilitation? A Cadaveric Study

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Background: Capacitive-resistive electric transfer therapy is an interesting rehabilitation treatment to use in musculoskeletal injuries. The purpose is to analyze the temperature change and current flow in superficial and deep biceps femoris and quadriceps tissues when applying different protocols of capacitive-resistive electric transfer therapy. ***Methods:*** Five cryopreserved cadavers (10 legs) were included in this study. Four interventions (high/low power) were performed for 5 minutes. Dynamic movements were performed to the biceps femoris and quadriceps. Superficial, middle, and deep temperature were recorded at 1-minute intervals and 5 minutes after the treatment using invasive temperature meters placed with ultrasound guidance. ***Results:*** Low-power applications have generated a very low thermal effect and an important current flow. The high-power capacitive application achieves a greater increase in superficial temperature compared with low power ($P < .001$). The high-power resistive application recorded a greater increase in superficial, middle, and deep temperatures with a greater current flow compared with the other applications ($P < .001$). ***Conclusion:*** This study could serve as basic science data to justify the acceleration of the processes of muscle recovery, improving cell proliferation without increasing the temperature in acute muscle injuries and increasing the temperature and viscoelasticity of the tissues in chronic processes with this therapy.

Keywords: cadaver, CRet, physical therapy

Anatomic studies have provided evidence that many muscles, especially the biceps femoris[1] and the rectus femoris[2,3] include a tendon in their muscular belly,[4,5] and the lesions in the muscular belly occur at the musculotendinous union. This type of injury amounts to 72% in the biceps femoris[6] and 60% in the rectus femoris,[2,3] both clinically and radiologically.[7–10]

Acute lesions usually occur with edema and blood products that extend along the torn muscle fibers.[8,11] It has been seen that the differentiation of satellite cells starts from the third-day postinjury and reaches its peak at 2 weeks.[12] This differentiation is stimulated by somatomedin (insulin growth factor I), basic fibroblast growth factor and, to a lesser extent, nerve growth factor.[12–14] These factors are of great importance for proper muscle regeneration instead of scarring with fibrous tissue.[13,14] It has been shown that cell proliferation is responsible for stimulating this type of growth factors,[12] and inhibiting others responsible for generating fibrous tissue, such as the growth factor of acidic fibroblasts.[12] The most advisable option would be to stimulate cell proliferation from the early stages of the lesion to avoid the generation of fibrous tissue and promote the differentiation of muscle tissue. The initial phases are accompanied by inflammatory processes; therefore, it is important to apply therapies that do not have a harmful thermal effect.[15,16]

Another possible situation generated by poor muscle regeneration is muscle repair through fibrous tissue.[14] In these situations, the therapeutic objective should be to generate a viscoelastic change of the less flexible fibrous tissue. The temperature increase in this type of tissue has been shown to have beneficial effects on the decrease of fibrous tissue and the improvement in muscle regeneration.[17] A temperature rise of 1 °C can have various effects on the human body, such as changes in nerve conduction velocity, enzymatic activity, and improved blood perfusion.[18–21] Insufficient tissue oxygenation leads to hypoxic conditions in the tissues, the production and release of algesic substance and tissue fibrosis, causing pain, muscle spasms, and capsular dysfunctions.[22,23]

Capacitive-resistive electrical transfer therapy (CRet) is a non-invasive electrothermal therapy classified as deep thermotherapy based on the application of electric currents[24–27] within the radio frequency range of 300 kHz to 1.2 MHz.[28] Due to the properties of the tissues, currents in CRet therapy can generate heating of deep muscle tissues, causing improvements in hemoglobin saturation and increasing the temperature,[23] vasodilation, elimination of excess fluids, and improved cell proliferation.[23,29] Some of these reactions, such as the increase in blood perfusion, are related to the increase in temperature, but others such as the increase in cell proliferation seem to be related mainly to the passage of current flow.[29] CRet therapy provides 2 different treatment modes: capacitive and resistive. Capacitive mode is provided with an insulating ceramic layer and the energetic transmission generates heat in superficial tissue layers, with a selective action in tissues with low impedance (water rich). Resistive mode has no insulating ceramic layer, the radiofrequency

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Comparison of resistive capacitive energy transfer therapy on cadaveric molars and incisors with and without implants

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Capacitive–resistive energy transfer therapy (CRet) is used to improve the rehabilitation of different injuries. This study aimed to evaluate and compare the changes in temperature and current flow during different CRet applications on upper and lower molars and incisors, with and without implants, on ten cryopreserved corpses. Temperatures were taken on molars and incisors with invasive devices and skin temperature was taken with a digital thermometer at the beginning and after treatments. Four interventions: 15 VA capacitive hypothermic (CAPH), 8 watts resistive (RES8), 20 watts resistive (RES20) and 75 VA capacitive (CAP75) were performed for 5 min each. All treatments in this study generated current flow (more than 0.00005 A/m^2) and did not generate a significant temperature increase ($p > 0.05$). However, RES20 application slightly increased surface temperature on incisors without implants ($p = 0.010$), and molar with ($p = 0.001$) and without implant ($p = 0.008$). Also, CAP75 application increased surface temperature on molars with implant ($p = 0.002$) and upper incisor with implant ($p = 0.001$). In conclusion, RES8 and CAPH applications seem to be the best options to achieve current flow without an increase in temperature on molars and incisors with and without implants.

Abbreviations

CRet	Capacitive–resistive electric transfer
CAPH	15 VA capacitive hypothermic electrode
RES8	8 Watts resistive
RES20	20 Watts resistive
CAP75	75 VA capacitive

Dental implants are the most commonly used procedure to replace missing teeth[1]. A Dental implant consists of a piece of metal, usually titanium or titanium alloys, inserted and integrated into the bone, giving solid support for the final dental prosthesis. It is estimated that 12–18 million implants are inserted worldwide every year[2]. Furthermore, it is supposed to be one of the most common surgeries in the health field. Successfully integrated implants have a survival rate of more than 96.7% after 8 years[3]. Nowadays, the insertion of a dental implant requires a low-invasive surgical technique[4]. However, inflammation during the healing phase may be present, and the use of anti-inflammatory drugs (ibuprofen, indomethacin, diclofenac or celecoxib) are usually prescribed[5].

Inflammation is a naturally occurring event following the early stages of tissue healing after an injury, or in this case, after a dental implant procedure. Ensuring a rapid and short inflammatory phase guarantees an early

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