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Temperature response as a contralateral effect of physiotherapy

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Abstract

Introduction: In the presented research, we characterized the contralateral effect after applying capacitive and resistive transfer of energy (TECAR) in the treatment of active myofascial trigger point (MTrP). In order to assess the contralateral effect, we used the infrared thermovision method. We hypothesize that by means of thermal imaging studies, we will be able to present and confirm the contralateral effect which can be important in establishing the MTrP treatment protocol with the use of TECAR.

Material and methods: In the study, thermographic imaging was performed on a group of 6 volunteers with an age range [25-45] years (mean age: 32.3 years ± 9.83 years) who were randomly selected for the study from among people practicing recreational sports and showing the clinical presence of active MTrP in the upper trapezius muscle (UT).

Results: On both sides, the reference area (side untreated) and the target area (side treated), there was an increase in the percentage changes of isotherms. These results indicate the presence of a contralateral effect. The use of TECAR therapy ipsilaterally in the treatment of MTrP in UT results in an increase of temperature on the symmetrical body part and it may be connected with the presence of vascular contralateral effect on the untreated side.

Conclusions: These changes were investigated by IR which, as our research shows, can be an effective form of assessing the therapeutic effects of TECAR in MTrP treatment.

Keywords: contralateral effect; TECAR therapy; myofascial trigger point; infrared thermovision.

Introduction

The TECAR therapy (capacitive and resistive transfer of energy) is a non-invasive musculoskeletal method using high-frequency current (300 kHz – 1 MHz). TECAR is classified as deep thermotherapy. Energy is applied to tissues through a capacitive electrode (CET) or resistive (RET) in order to invoke desired changes.

CET electrode is covered by an insulator and impacts on superficial tissue layers, with a selective action on low-impedance (water-rich) soft tissues such as muscles, adipose tissue, cartilage, and lymphatic system.[1] RET electrode is a conducting electrode which generates heat in the deeper more resistant (low water content) tissue layers, for example, bone, muscular fascia, capsules, and tendons. In conclusion, the main effect of therapy is generating heat in superficial and deep tissues.

TECAR affects blood flow, which allows the removal of inflammatory catabolites and has a positive effect on the healing process. Bito et al. reported that TECAR substantially improves blood circulation in the peritendinous region and increases haemoglobin saturation.[2] Moreover, a recent study shows the impact of TECAR therapy on perfusion of the skin microcirculation and intramuscular blood flow enhances blood flow volume in muscle tissue.[3] Resulting of greater vascularization promotes the relaxation of tissues (especially muscular tissue) and drainage of swelling (oedema and hematoma).[4] In addition, TECAR alleviates muscle and joint pain,[5] and increases connective tissue elasticity.[6] TECAR therapy is used in specific pathologies such as low back pain,[6-7] neuralgia, oedema, muscle spasm, tendinopathies,[8] osteoarthritis,[9-10] plantar fasciitis[11]. TECAR therapy outweighs other therapies with the possibility of using manual therapy simultaneously with the use of a physical factor. Furthermore, passive and active therapy are possible at the same time as well.

Authors' contribution: A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article.

Absolut contraindications of TECAR are suppurative processes, vascular diseases, neoplasia, cardiac stimulator, sensitivity to various temperatures and pregnancy. It is not recommended for direct application to the eyes, testicles, and growth plate cartilage as well.[12]

Numerous supporting studies characterized contralateral microvascular response for its effects on the regulation of peripheral and core thermoreceptors.[13-18] No research has previously tested this effect under the influence of TECAR therapy. Furthermore, most studies have focused on assessing the contralateral effect in the limbs.[13-18] In our study, we assessed this effect in the area of the trunk, more specifically in the upper trapezius muscle (UT), the dysfunction of which may be the cause of tension and local pain, tension headaches, neck pain, dizziness, limited range of neck mobility and brachioscapular rhythm disorders.[19] These dysfunctions can be explained by the presence of myofascial trigger point (MTrP) which is defined as hyperirritable areas in taut muscle bands generating pain during palpation or muscle stretching.[20] Myofascial trigger points were categorized by Simons et al.[20] as either active or latent. While active MTrP produce a spontaneous clinical complaint of pain, latent MTrP are clinically silent and are only painful when properly stimulated.[21] It is estimated that 78.8% of healthy individuals have latent MTrP in UT.[22]

There are many theories of the formation of MTrP. The most frequently described in the literature is the theory of energy crisis proposed by Simons and Travell., which assumes that MTrP is caused by ischemia and hypoxia of muscle tissue.[17] Consider this, TECAR therapy and its contralateral effect may have an impact on the treatment of MTrP. Therefore, the presence of the above effect should be taken into consideration when developing a methodology for performing TECAR therapy in the UT area with MTrP present in this place.

Nowadays thermal imaging is used in medicine due to its non-invasive and quite simple and fast possible use. Moreover, the distribution of body surface temperature may bring very important information about the functioning of the tissues. The information is indirectly correlated with blood flow, and part of the body activity – so the tissue metabolism. That is why thermal imaging can be treated as a functional imaging and diagnostic method. It should be also underlined that the temperature of the skin and superficial tissue is strictly connected with the thermal balance between tissue activity, vasodilation, the rate of sweat evaporation and the external physical factors i.e., therapy as TECAR.[23-27] Thus, thermovision can be easily used as a method of evaluation of local as well as systemic cutaneous blood flow changes as a function of organism response to different physical factors so the therapy too.

Consequently, the main aim was to prove and show the contralateral effect of the blood system induced by TECAR therapy using thermal imaging.

Material and Methods

A Winback 1s device was used for the TECAR therapy. The patient laid down in a prone position. Directly in the area of the upper part of the trapezius was applied conductive electrode. A passive electrode (made of medical stainless steel) closing the electricity circuit was placed directly on the skin of the abdomen. The therapist worked out the entire muscle from the occipital region to the acromion generating light pressure above the muscle belly.

The Low pulse program was used for therapy which includes 0.5 seconds of work and 0.5 seconds of break. Power used for the therapy was expressed in % and it was 40% for each. Therapy lasted 10 minutes. Balm with electrolytes was used to better conduct the current. The intervention was performed by a physiotherapist with 5 years of experience in this technique.

The research group consisted of 6 volunteers with an age range [25-45] years (mean age: 32.3 years ± 9.83 years) who were randomly selected for the study from among people practicing recreational sports. Each volunteer was clinically tested. Only patients with active myofascial trigger points (MTrP) located in the trapezius muscle (upper part, UT) were included in the group. Diagnostic criteria for active MTrP are based on the consensus of the Delphi panel.[28] It was assumed that active MTrP is a palpable, tender, taut band of muscle fibres, the compression of which causes a violent pain reaction possible to be identified by the patient (reproduction of the patient symptoms) and a local twitch response (LTR). The following exclusion criteria were set: musculoskeletal pain syndrome, MTrP therapy in the UT region during the last year; history of neck trauma, cervical spine and humeral joint surgeries; cervical radiculopathy, chronic and acute diseases of the cardiovascular, respiratory, and nervous systems; endocrine disturbances; skin lesions; acute inflammation; cancer; and BMI > 30 kg/m^2.

Thermal imaging was performed by using the FLIR T540 camera with a sensitivity of < 0.03 [K]. The examination room temperature was 23 ± 1 [°C], and the humidity was about 50%. The camera has been always set perpendicular to the upper back according to the standards at a distance of 1±0.1 m.[27] For every volunteer thermal imaging has been performed before TECAR therapy which relied on 10 minutes application of CET electrode in place of pain and trigger point presence. Then the next thermovision examination was performed immediately after the procedure (1 minute) and after 15, 30 and 45 minutes of the end of therapy.

The whole back was always monitored, and the isotherm threshold was set as the average temperature of it.

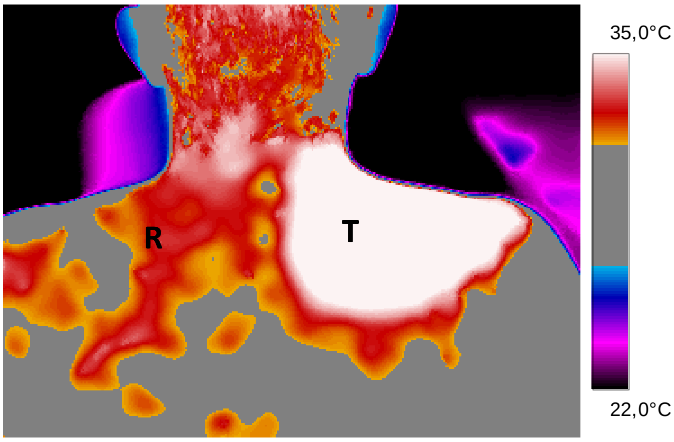

Figure 1. The scheme of TECAR therapy thermal effect analysis. R – reference area (untreated part), T – target area (treated part)

For the thermal image analysis performed using the ThermaCAM Researcher Pro 2.10. In detail, an evaluation of therapy's influence on the tissue and the presence of the contralateral effect of the UT area has been chosen and once one side of the muscle was treated (it was marked as T – target) the other one was imaged and the contralateral effect was observed (it was marked as R – reference) – it is presented in **Figure 1**.

The statistical analysis was performed using STATISTICA 10 software. The dependence groups of variables were checked before and in every measured time interval after therapy by using repeated measures. Due to a lack of normality as well as homogeneity of variances the Anova Friedmans with Kendall compatibility factor test was performed. Differences were considered statistically significant for p-value <0.05.

Results

All measured area parameters for both sides of the upper back at every time interval are collected in **Table 1**. The Isotherm area was set as an area characterized by a higher temperature than the mean of the back – it was the isotherm threshold.

Both in the case of the reference area and the target area, there was an increase in the percentage changes of isotherms.

Immediately after treatment (1 minute after), the percentage change of isotherms in the TECAR application area is slightly lower than the temperature of the reference area. Perhaps already during the therapy, there is a distribution of excess heat from the area subjected to TECAR therapy to the reference area.

Interestingly, 45 minutes after the therapy, the percentage change of isotherms is slightly higher in the group without TECAR application.

One can observe that the isotherm area on symmetrical to the therapy part of UT is quite similar to those that was treated. It can be even seen a little trend to increase the effect after 1 and 45 minutes since therapy. However, it should be noted that the parameters collected in the table are average, and the studied group was quite small, so we can only state about some trends not the significant differences.

The above results indicate the presence of a contralateral effect. Describing changes can be explained also as the phenomenon known as “cross-education”. Earlier research showed the presence of the cross-education phenomenon after using acupuncture,[29] neuromuscular electrostimulation (NMES),[30] external pneumatic compression therapy,[31] percutaneous electrolysis[32] and blood flow restriction training[33]. In the literature, you can find studies confirming the occurrence of a contralateral effect under the influence of thermotherapy. The therapies used in their case were superficial heat therapies such as hot packs or warm baths.[13,15-16] To the best of our knowledge, no previous study has shown this phenomenon after using TECAR therapy and using it in the presence of active MTrP.

Table 1. Percentage changes of Isotherm areas (T – target and R – reference area) counted as (Area $_i$/Area $_{\text{before treatment}}$) * 100%, where i = 1, 15, 30 and 45; and before treatment is 0 = 100%.

Time of measurement in target area (T)	**1**	**2**	**3**	**4**	**5**	**6**	**Average T area ratio**
1	132	101	112	123	192	122	**132**
15	88	68	56	65	152	61	**86**
30	72	32	15	16	136	17	**54**
45	12	16	16	17	65	21	**25**
Time of measurement in reference area (R)							**Average R area ratio**
1	80	108	125	143	236	132	**137**
15	41	70	40	64	168	61	**74**
30	54	26	1	5	147	4	**39**
45	51	13	13	26	72	26	**33**

The phenomenon of cross-education and contralateral effect creates new therapeutic possibilities for patients undergoing conservative treatment with immobilization in a cast, after the surgery and for whom the movement of the joint causes pain in conditions such as osteoarthritis, tendinopathies, and muscle strains. Using TECAR therapy in these cases, we should expect better blood supply to the immobilized side, as a result of which the tissues should heal and regenerate faster. In addition, the loss of muscle mass should be smaller. In the presence of MTrP, by working on both sides, with and without MTrP, it is possible to enhance the therapeutic effect. This hypothesis should be investigated in subsequent research.

To observe the raw data in thermal images as it was obtained for the representative thermal images performed before – 0, one minute after – 1, and 15, 30 and 45 minutes after therapy of the patient's back with marked isotherm areas are presented in **Figure 2**.

Moreover, for better look inside into the problem there are thermal images also performed before – 0, one minute after – 1, and 15, 30 and 45 minutes after therapy of the patient's back in another – medical temperature scale.

Figure 3 clearly shows the area of increased temperature appearing on the reference side, on which the treatment was not performed. This area changes over time, suggesting the presence of a contralateral effect.[29-33]

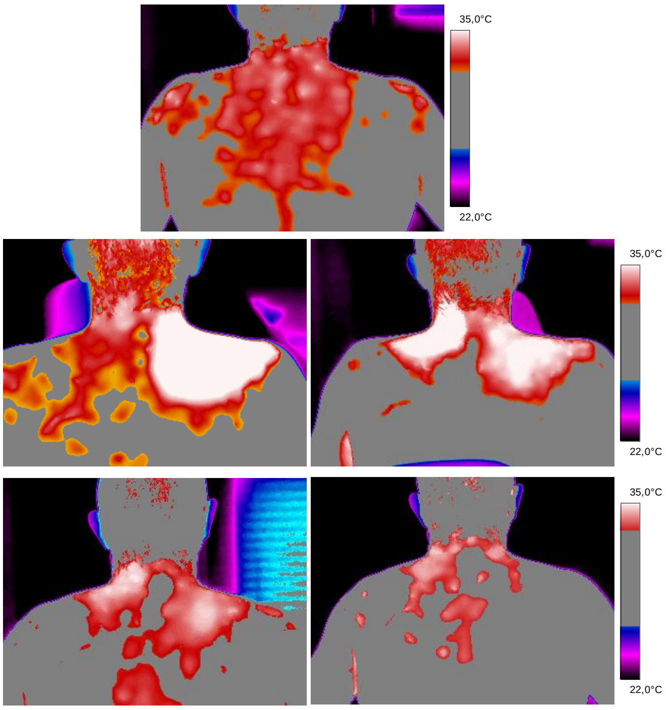

Figure 2. The thermal images as it was obtained for the representative patient performed before – 0, one minute after – 1, and 15, 30 and 45 minutes after therapy of the patient's back with marked isotherm areas.

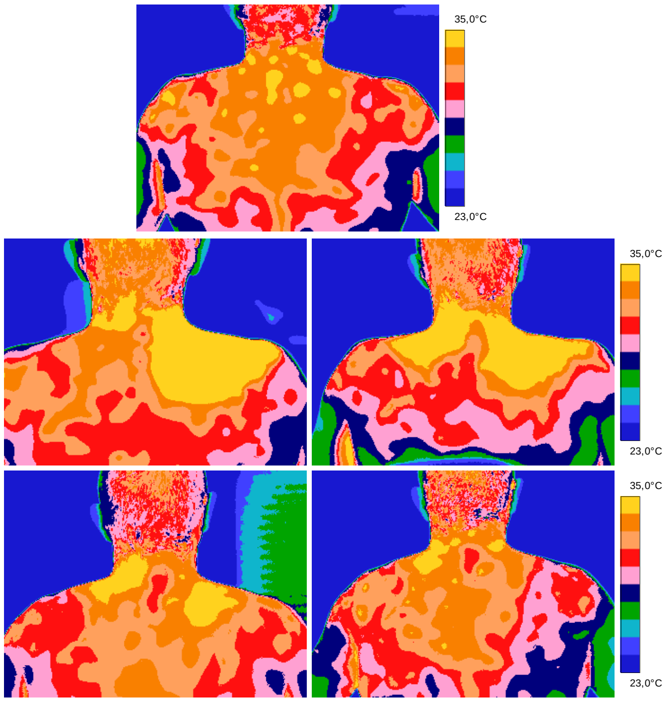

Figure 3. The thermal images of the representative patient performed before – 0, one minute after – 1, and 15, 30 and 34 minutes after therapy of the patient's back in the medical color scale.

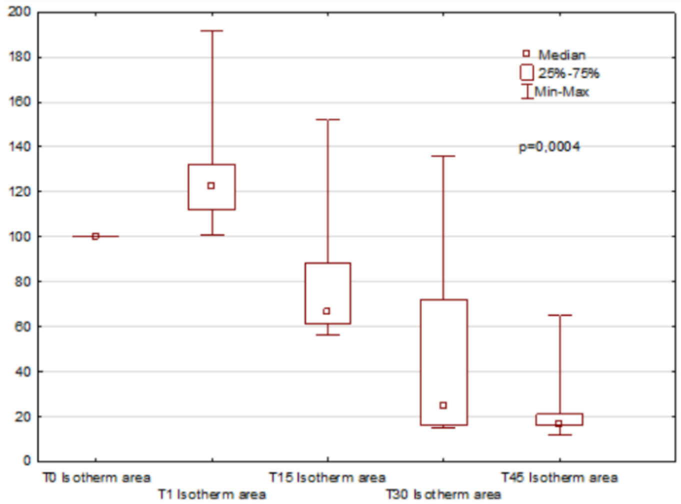

Figure 4. Box graph of median isotherm area changes for studied volunteers target counted as $(Area_i/Area_{before\ treatment}) \times 100\%$, obtained before (T0), and 1 (T1), 15 (T15), 30 (T30) and 45 (T45) minutes after treatment.

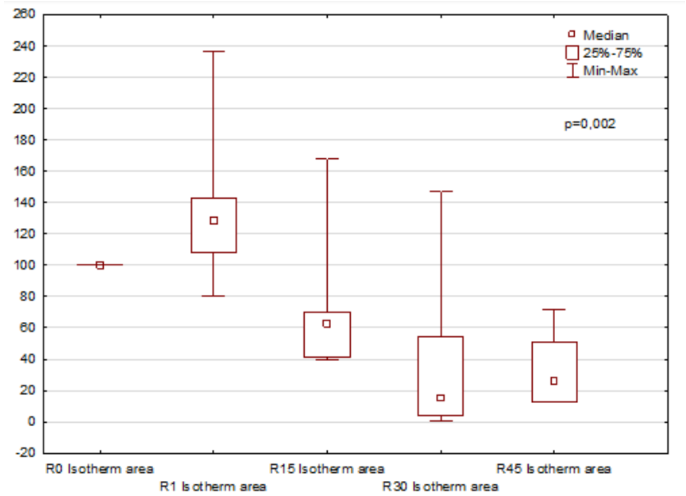

Figure 5. Box graph of median isotherm area changes for studied volunteers reference area counted as $(Area_i/Area_{before\ treatment}) \times 100\%$, obtained before (R0), and 1 (R1), 15 (R15), 30 (R30) and 45 (R45) minutes after treatment.

Moreover, the statistical analysis as well as box graphs were performed and presented in **Figures 4-6**.

Figure 5 clearly shows the response on the reference side - and this supports the appearance of the contralateral effect. The results may confirm the occurrence of the contralateral effect both in the median parameter (**Figures 4** and **5** for T and R, respectively) and the average in **Figure 6**.

In the case of the mean, an upward trend in isotherm changes for the R area is clearly visible in the 1st and 45th minutes after the therapy.

Discussion

There are many studies examining the effect of TECAR therapy with IR.[1, 34-36] To the authors' knowledge, no previous study has examined the TECAR effect in the case of active MTrP therapy and shown the presence of a contralateral effect. In the study by K. Kubo et al., after using the heating treatment (hot pack), a contralateral effect was obtained by healing the Achilles tendon.[13] Astrup et al. reported that contralateral heating can increase the subcutaneous blood flow of the unheated forearm and affect the metabolism of the unheated hand.[15] Gorodkin et al. Found that the vasodilator responses to heating stimulus were similar in the affected and unaffected areas of the calf in people with complex regional pain syndrome.[16]

Physiologically, the contralateral effect can be explained as follows: elevated arterial blood flow temperature activates central thermal receptors, resulting in bilateral skin vasodilatation and an increase in peripheral blood flow and cardiac output. Thus, a thermal stimulus applied to one side can elicit opposite skin temperature and blood flow responses by innervating peripheral and central thermal receptors.[14]

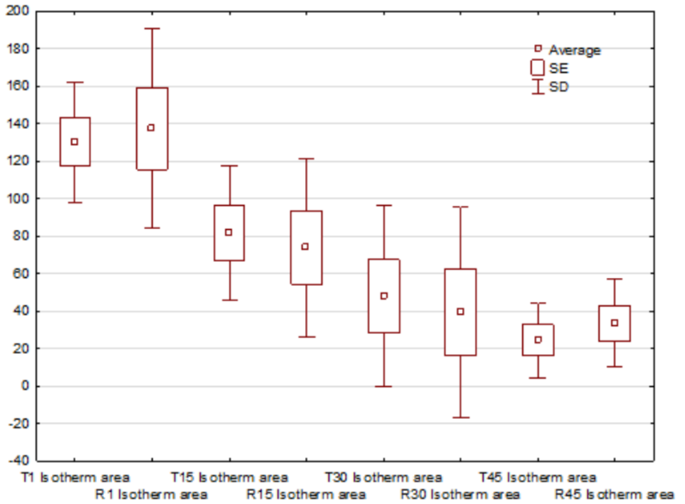

Figure 6. Box graph of average isotherm areas changes for studied volunteers' reference and target areas counted as $(Area_i/Area_{before\ treatment}) \times 100\%$, obtained before, and 1, 15, 30 and 45 minutes after treatment.

In terms of the methodology of performing the TECAR procedure, the described phenomenon may turn out to be extremely important, especially in the presence of MTrP, which is described as an ischemic disorder. The above effect creates new possibilities for the use of TECAR therapy for instance: a patient unsuitable to apply a thermal stimulus directly to the affected area, suffering from peripheral vascular diseases, skin lesions or wearing an external fixator.

Considering the small research group, further research confirming the presence of the contralateral effect should be conducted.

Conclusion

The use of TECAR therapy ipsilaterally in the treatment of MTrP in UT results in an increase of temperature on the symmetrical body part and it may be connected with the presence of vascular contralateral effect on the untreated side.

Moreover, it seems that on the untreated side, the isotherm area seems to be similar to the treated one, which may have great therapeutic importance. It may be also seen that the observed contralateral effect by average calculated area may be even bigger 45 minutes after therapy (**Table 1** and **Figure 6**). These changes were investigated by IR which, as our research shows, can be an effective form of assessing the therapeutic effects of TECAR in MTrP treatment.

However, due to the small research group and development of an effective MTrP treatment protocol, further research into the presence of a contralateral effect should be conducted to prove observed trends and relations.

References

1. Clijsen R, Leoni D, Schneebeli A, et al. Does the Application of Tecar Therapy Affect Temperature and Perfusion of Skin and Muscle Microcirculation? A Pilot Feasibility Study on Healthy Subjects. The Journal of Alternative and Complementary Medicine. 2020;26(2):147-153. https://doi.org/10.1089/acm.2019.0165
2. Bito T, Tashiro Y, Suzuki Y, et al. Acute effects of capacitive and resistive electric transfer (CRet) on the Achilles tendon. Electromagnetic Biology and Medicine. 2019;38(1):48-54. https://doi.org/10.1080/15368378.2019.1567525
3. Kumaran B, Watson T. Thermal build-up, decay and retention responses to local therapeutic application of 448 kHz capacitive resistive monopolar radiofrequency: A prospective randomised crossover study in healthy adults. Int J Hyperthermia. 2015;31:883-895. https://doi.org/10.3109/02656736.2015.1092172
4. Paolucci T, Pezzi L, Centra M A, et al. Effects of capacitive and resistive electric transfer therapy in patients with painful shoulder impingement syndrome: a comparative study. Journal of International Medical Research. 2019;48:2. https://doi.org/10.1177/0300060519883090
5. Aishwarya B, Nelson N, Joseph N, Chandurkar Y. Long wave diathermy therapy for pain relief. International Journal of Engineering Technology Science and Research. 2017;4(4).
6. Notarnicola A, Maccagnano G, Gallone MF, Covelli I, Tafuri S, Moretti B. Short term efficacy of capacitive-resistive diathermy therapy in patients with low back pain: a prospective randomized controlled trial. J Biol Regul Homeost Agents. 2017;31(2):509-515.
7. Osti R, Pari C, Salvatori G, Massari L. Tri-length laser therapy associated to tecar therapy in the treatment of low- back pain in adults: A preliminary report of a prospective case series. Lasers Med Sci. 2015;30:407-412. https://doi.org/10.1007/s10103-014-1684-3
8. Wiegerinck JI, Kerkhoffs GM, van Sterkenburg MN, et al. Treatment for insertional Achilles tendinopathy: A systematic review. Knee Surg Sports Traumatol Arthrosc. 2013;21:1345-1355. https://doi.org/10.1007/s00167-012-2219-8
9. Rabini A, Piazzini DB, Tancredi G, et al. Deep heating therapy via microwave diathermy relieves pain and improves physical function in patients with knee osteoarthritis: A double-blind randomized clinical trial. Eur J Phys Rehabil Med. 2012; 48:549-559.
10. Coccetta CA, Sale P, Ferrara PE, et al. Effects of capacitive and resistive electric transfer therapy in patients with knee osteoarthritis: a randomized controlled trial. Int J Rehabil Res. 2019;42:106-111. https://doi.org/10.1097/MRR.0000000000000324
11. Costantino C, Vulpiani MC, Romiti D, et al. Cryoultrasound therapy in the treatment of chronic plantar fasciitis with heel spurs. A randomized controlled clinical study. Eur J Phys Rehabil Med. 2014;50:39-47.
12. Dragone, L. La termoterapia. In Fisioterapia Riabilitativa del Cane e del Gatto; Elsevier: Milano, Italy, 2010; Volume 2, pp. 21-27.
13. Kubo K, Yajima H, Takayama M, Ikebukuro T, Mizoguchi H, Takakura N. Changes in blood circulation of the contralateral Achilles tendon during and after acupuncture and heating. Int J Sports Med. 2011;32(10):807-813. https://doi.org/ 10.1055/s-0031-1277213.
14. Ren W, Xu L, Zheng X, Pu F, Li D, Fan Y. Effect of different thermal stimuli on improving microcirculation in the contralateral foot. BioMed Eng OnLine. 2021;20(1). https://doi.org/10.1186/s12938-021-00849-9
15. Astrup A, Simonsen L, Bulow J, Christensen NJ. Measurement of forearm oxygen consumption: role of heating the contralateral hand. American Journal of Physiology-Endocrinology and Metabolism. 1988;255(4):E572-E578. https://doi.org/10.1152/ajpendo.1988.255.4.e572
16. Gorodkin R, Herrick AL, Murray AK. Microvascular Response in Patients with Complex Regional Pain Syndrome as Measured by Laser Doppler Imaging. Microcirculation. 2016;23(5):379-383. https://doi.org/10.1111/micc.12286
17. Kim Y-M, Park S-Y, Choi H-S, Kwon O-Y. Contralateral heating efects of contrast bath and warm bath. Physical Ther Korea. 1996;32:49–54.

18. Rutkowski R, Straburzyńska-Lupa A, Korman P, Romanowski W, Photochemistry M. Thermal efectiveness of diferent IR radiators employed in rheumatoid hand therapy as assessed by thermovisual examination. Photochem Photobiol. 2011;876:1442-1446. https://doi.org/10.1111/j.1751-1097.2011.00975.x

19. Ziaeifar M, Massoud A, Mosallanezhad Z et all. Dry needling versus trigger point compression of the upper trapezius: a randomized clinical trial with two-week and three-month follow-up. J Man Manip Ther. 2019;27(3):152-161. https://doi.org/10.1080/10669817.2018.1530421

20. Simons DG, Travell J, Simons LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. Vol 1: Upper Body. Bal timore, MD: Lippincott Williams & Wilkins; 1999

21. Cerezo-Téllez E, Lacomba MT, Fuentes-Gallardo I, Mayoral del Moral O, Rodrigo-Medina B, Gutiérrez Ortega C. Dry needling of the trapezius muscle in office workers with neck pain: a randomized clinical trial. Journal of Manual & Manipulative Therapy. 2016;24(4):223-232. https://doi.org/10.1179/2042618615y.0000000004

22. Lucas KR, Rich PA, Polus BI. Muscle activation patterns in the scapular positioning muscles during loaded scapular plane elevation: the effects of Latent Myofascial Trigger Points. Clinical Biomechanics. 2010;25(8):765-770.

23. Modrzejewska M, Parafiniuk M. Application of thermography in medicine - literature review.; Pomeranian Journal of Life Sciences. 2018;64(3). https://doi.org/ 10.21164/pomjlifesci.441

24. Gorczewska I, Szurko A, Kiełboń A, Stanek A, Cholewka A. Determination of Internal Temperature by Measuring the Temperature of the Body Surface Due to Environmental Physical Factors—First Study of Fever Screening in the COVID Pandemic. IJERPH. 2022;19(24):16511. https://doi.org/10.3390/ijerph192416511

25. Cholewka A, Stanek A, Kwiatek S, Sieroń A, Drzazga Z. Does the temperature gradient correlate with the photodynamic diagnosis parameter numerical colour value (NCV)? Photodiagnosis and Photodynamic Therapy. 2013;10(1):33-38. https://doi.org/10.1016/j.pdpdt.2012.07.001

26. Baic A, Kasprzyk T, Rżany M, et al. Can we use thermal imaging to evaluate the effects of carpal tunnel syndrome surgical decompression? Medicine. 2017;96(39):e7982. https://doi.org/10.1097/md.0000000000007982

27. Ammer, K. The Glamorgan Protocol for recording and evaluation of thermal images of the human body Thermology International. 2008;18(4):125-129.

28. Fernández-de-las-Peñas C, Dommerholt J. International Consensus on Diagnostic Criteria and Clinical Considerations of Myofascial Trigger Points: A Delphi Study. Pain Medicine. 2017;19(1):142-150. https://doi.org/10.1093/pm/pnx207

29. Guangjun W, Yuying T, Shuyong J, Tao H, Weibo Z. Change of Blood Perfusion in Hegu Acupoint After Contralateral Hegu Acupoint Was Stimulated. The Journal of Alternative and Complementary Medicine. 2012;18(8):784-788. https://doi.org/10.1089/acm.2011.0440

30. Benito-Martínez E, Senovilla-Herguedas D, de la Torre-Montero JC, Martínez-Beltrán MJ, Reguera-García MM, Alonso-Cortés B. Local and Contralateral Effects after the Application of Neuromuscular Electrostimulation in Lower Limbs. IJERPH. 2020;17(23):9028. https://doi.org/10.3390/ijerph17239028

31. Martin JS, Martin AM, Mumford PW, Salom LP, Moore AN, Pascoe DD. Unilateral application of an external pneumatic compression therapy improves skin blood flow and vascular reactivity bilaterally. PeerJ. 2018;6:e4878. https://doi.org/10.7717/peerj.4878

32. Carvajal-Fernández O, Álvarez Prats D, Medina i Mirapeix F, Minaya-Muñoz F. Efectos de la electrolisis percutánea en el tendón rotuliano sobre la temperatura local y contralateral medida con termografía infrarroja. Rev Fisioter Invasiva. 2016;1:18–25.

33. Bowman EN, Elshaar R, Milligan H, et al. Proximal, Distal, and Contralateral Effects of Blood Flow Restriction Training on the Lower Extremities: A Randomized Controlled Trial. Sports Health. 2019;11(2):149-156. https://doi.org/10.1177/1941738118821929

34. Valentini S, Bruno E, Nanni C, Musella V, Antonucci M, Spinella G. Superficial Heating Evaluation by Thermographic Imaging before and after Tecar Therapy in Six Dogs Submitted to a Rehabilitation Protocol: A Pilot Study. Animals. 2021;11(2):249. https://doi.org/10.3390/ani11020249

35. Rodríguez-Sanz J, Pérez-Bellmunt A, López-de-Celis C, et al. Thermal and non-thermal effects of capacitive–resistive electric transfer application on different structures of the knee: a cadaveric study. Sci Rep. 2020;10(1). https://doi.org/10.1038/s41598-020-78612-8

36. Yeste-Fabregat M, Baraja-Vegas L, Vicente-Mampel J, Pérez-Bermejo M, Bautista González IJ, Barrios C. Acute Effects of Tecar Therapy on Skin Temperature, Ankle Mobility and Hyperalgesia in Myofascial Pain Syndrome in Professional Basketball Players: A Pilot Study. IJERPH. 2021;18(16):8756. https://doi.org/10.3390/ijerph18168756