THE THERAPEUTIC EFFICIENCY OF HYPERTHERMIA COMPARED WITH SHORT-WAVE DIATHERMY

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Abstract

Heat has been used for therapeutic causes, over the past decades. A lot of heat methods have been discovered and have been used for medical and physical therapy treatments. As long as new methods and heat devices are discovered, physical therapists have to struggle between which device is the most effective. The aim of this study is to compare two heat therapeutic methods: the shortwave diathermy and the diathermy through Hyperthermia therapy. For this study, 36 patients have been chosen who suffered from muoskeletal pathologies and have been divided in two groups. The first group recruited 20 patients and underwent a treatment through hyperthermia therapy and the second group recruited 16 patients who underwent a treatment through the shortwave diathermy; both treatments have been associated with a standard physiokinesitherapy treatment. All the selected patients have been given the McGill Pain Questionnaire (MPQ) to fill in at the beginning of the treatments and at the end of them. Data collected through the MPQ, have analyzed through the statistic program IBM SPSS Statistics Data Editor and have shown an improvement in pain intensity in both groups. However, in the first group improvement have been shown in the 3rd-4rd day of treatment (mean: 3.85), but in the second group have been shown in the 6th-7th day (mean: 6.44). In conclusion, the study has corroborated the validity of both treatments leading to improvement of symptomatology, but treatment through hyperthermia therapy seem to has rapider heal effect of pain.

Keywords: *hyperthermia, shortwave diathermy, physiotherapy protocols*

Introduction

Physiological histological effects of hyperthermia are multiple, making it an important therapeutic method. First of all, hyperthermia causes an increase in extensibility of the collagenous tissue due to reduction of viscosity and pain due to ant-irritant action or release of endorphins (Lehmann J.F., et al 1986). Furthermore, the physiological effects of this increase in energy includes a reduction of muscular spasms and contractions due to reduced activity of secondary afferents and more rapid and complete dissociation of oxygen from haemoglobin with more availability, accompanied by a reduction in activation energy of important chemical and metabolic reactions. Vasodilatation with increase of local blood flow contributing to the re-supply of oxygen and nutritional substances as well as the removal of catabolytes is also an effect (Hildebrandt B., et al 2002; Tepperman P. et al 1986).

Hyperthermia therapy belongs to the new advanced methods of physical therapy and owns a great position in rehabilitation. It is used for the treatment of acute and chronic pathologies. The device for the Transfert Electrical Capacitive And Resistive, known as Hyperthermia, operates within the long wavelength radio spectrum at 0.5 MHz, and therefore lower than the frequencies used in the shortwave diathermy (27.1 MHz) and higher than the frequencies that can cause muscle contractions (Watson T 2011, Ganzit G.P., et al 2015; Hawamdeh M. et al 2014; Parolo E. et al 2003; Sanguedolce G. et al 2009). Also, hyperthermia therapy promotes the natural physiological processes of tissue metabolism by transferring energy to them without introducing radiation from an external source. This energy transfer into the tissues is achieved using a capacitive electrode or a resistance electrode *(Image 1)*.

Hyperthermia is characterized by energy transfer between tissues using a capacitive electrode, covered by a special isolator and aresistive electrode, operating in the operating logic of a condenser *(Image 2).* The condenser creates an electromagnetic field through two handpieces and produces a biocompatible energy that diffuses focally into the various tissues of the human body in a focused manner. The basic principle of operation of the condenser is the ability to attract or reject the electrical charges within the tissue, unlike the electrode (capacitive displacement current), allowing allowing electrical transit into deeper tissues. This mode of treatment with energy transfers and transfers through the passage of electricity for both the capacitive and the resistance

effects seems to contribute significantly to the body's anti-inflammatory and healing processes.

Capacitive function is used in soft tissue pathologies, for instance tissues with high fluid content (muscles, vascular / lymphatic system, nervous tissue, etc.), as opposed to the resistive function applied to tissues that have higher resistance and lower fluid content such as bones, cartilage, tendons and fasciae.Independently from the chosen type of electrode, Hyperthermia device consists of two electrodes: one that is either the capacitive electrode neither the resistive electrode, and one static electrode. Hyperthermia device operates in the logic of a condenser, which creates an electromagnetic field, through two handpieces and produces a biocompatible energy that diffuses focused on the various tissues of the human body in a focused manner.

Resistive transport of energy allows the use of hyperthermia for the first time without the use of an external heat source. In fact, it uses a low-power radio frequency generator, which causes an increase in endogenous temperature. In this way, the impedance of the human body between the two electrodes is used to generate rise in temperature. A neutral plate with a large surface area and an active electrode with a smaller size, make effects only on the area between the two electrodes. These effects cause an increase in blood flow and oxygen transfer, as well as a significant reduction in tissue acidosis. The effects of the capacitive system is due to the increase in cell membrane potential, due to the kinetic effect of the ions in both intracellular and intermediate fluid and due to the subsequent increase in internal temperature (Galanti G., et al 2014; Hawamdeh M. et al 2014; Parolo E., et al 2003; Sanguedolce G. et al 2009).

The physiotherapist chooses which electrode is the best and continues with the treatment. In the resistive application, the temperature rises rapidly in the first 10 minutes and then increases quite a lot in the next few minutes. After 20 minutes, the increases are very small and in some areas the temperature tends to increase depending on blood flow.

In every application of Hyperthermia device, the physiotherapist should apply the specific cream at the pathological body area, uses cyclical, spirals moves, so the energy transfer are equal to every spot of the pathological area.

Depending on the power used, three phases characterized by well-defined biological effects such as bio-stimulation, cellular regeneration, analgesia, increased blood flow and lymphatic drainage effects can be observed (Hawamdeh M. et al 2014).

According to A. Terranova, G. Vermiglio et al. 2008, the hyperthermia device has the ability to allow the energy transfer to the tissues, and can therefore be used from the very first postoperative day. This opportunity allows to the physiotherapist, due to the increase in the blood and lymphatic flow, to use hyperthermia also in patients who underwent surgery.

In the research bibliography, there are only a few articles about hyperthermia therapy, whose content refers to limited variety of clinical populations and the clinical results have not been adopted globally and remain limited in their particular geographical areas. For example, hyperthermia has been widely adopted in Italy for various forms of clinical populations, but there is no evidence that it is used in other countries (Hawamdeh M. et al 2014).

Although, hyperthermia therapy can been used in multiple muscular, neurological and lymphatic pathologies such as: ligament,tendon and muscular injuries, acute and chronic bone and joint injuries, bruises, tendonitis, tenosynovitis, bursitis, dislocation,acute and chronic pain, scar tissue and cellulite.

Hyperthermia has the same contraindications as other types of diathermy, including: women during pregnancy, pacemaker, Parkinson's patients, cancer-neoplasms, metal implants, sensory and blood coagulation disorders (Lehmann J.F., et al 1986).

Finally during the use of hyperthermia, the integrity of the wires of the device should be checked, ie if there is any damage to avoid energy losses, but also to ensure the safety of the physiotherapist. The use of the device should be continuous and not static, as in the second case there is a risk of causing burns to the patient.

Many significant therapeutic effects of the hyperthermia system appear in physiotherapy, based on the published articles, due to the local increase in blood circulation and synovial fluid flow, by reducing pain, improving connective tissue elasticity and improving lymphatic circulation. (A. Terranova et al 2008 ; F.Oliva et al 2011; C. Tranquilli et al 2009; E. Parolo et al 2003; G. Melegati et al 2009; Colo A.J. et al 1994; Hawamdeh M. et al 2014). The application of hyperthermia therapy is performed with two different modes of treatment, capacitive function and resistance function in all joints, either acute or chronic joint pathologies. It applies to all

musculoskeletal pathologies, excluding patients who experience sensory problems such as hypersensitivity or hypoaesthesia to heat, Raynaud's syndrome, cancer or even pregnancy.However, it should be noted that treatment with hyperthermia, even though is causing an immediate and a rapid reduction of the symptoms, has no long-lasting therapeutic effect in individuals with idiopathic low back pain (L. Morelli, S.C. et al., 2016).Additionally, in patients with achilles tendonitis, more improvement was observed in patients receiving cryotherapy compared to those treated with hyperthermia. Of course, cryotherapy has no significant differences with hyperthermia treatment, although it has a better average range of efficacy (C. Costantino, et al., 2005). According to P. Mondardini et al 2009, the hyperthermia device helps to avoid surgery in patients with second degree muscle rupture, while Aftosmidis D. et al., 2012, reports that hyperthermia therapy contributes to reducing the edema by 3 cm from the 5th physiotherapy session, in patients with second grade ligament tear in ankle.
In conclusion, hyperthermia is an important and useful tool in the hands of physiotherapists for the treatment of pathologies (Kazalakova Kr. et al 2013; Mondardini P. et al 2009), and its effectiveness is increased if it is applied in combination with other physical methods (M. Perez et al 2003, Benitez M.P. et al 2003; Galanti G. et al 2014; Gonkova M. et al 2014) and with therapeutic exercises, contributing to the improvement of quality of life of patients (GP Ganzit, L. Stefanini et al., 2015, Em. Vicent Pastor et al., R. Osti et al., 2014).
Looking at the published research studies, it is noticed that their number is still small and therefore the Hyperthermia device needs further investigation. In this work, effectiveness of the use of hyperthermia compared with shortwave diathermy in a variety of pathologies, is presented.

Materials and Methods

With the rapid development of technology, the technological equipment used in the field of physiotherapy is constantly being renewed and new methods are discovered. It is therefore logical to wonder, which device is most appropriate for restoring a pathological condition.Based on this new reality, the researcher must investigate the effectiveness of these new technologies. Then, the physiotherapist is called to decide

and to use the appropriate means and methods for rehabilitation. In order to be sure which method is the best, he has to be based on the results of the surveys (Watson T 2011). During the period from March to August 2018, McGill-Melzack (MPQ) questionnaires were distributed to evaluate the pain in 36 patients. The questionnaires were distributed in the city of Corinth, in Greece and specifically in patients of "*Physiotherapy Center Athanasios Giannopoulos*".

The McGill-Melzack questionnaire exists in two forms: complete and short. (Fernandez Ep. et al 2001). In this research investigator has used the short form of the questionnaire, translated into Greek (Georgoudis G. et al 2001).

The MPQ questionnaire has been translated into over 20 different languages, creating that way too many norms (Fig.1). This is a very useful tool, as it is completed very easily and quickly by the participants (only 5-10 minutes required). The completed questionnaire includes a list of 78 different words describing three different dimensions of pain, aesthetics, emotional and descriptive dimensions, as well as 6 words describing the intensity of the present pain (Georgoudis G. et al 2001).

The HCR 900 hyperthermia device is used in this survey. The device consists of a 0.5 MHz radio frequency generator and has a maximum power of 300 watts.

Furthermore, all the participants have followed the same therapeutic protocol, including the use of:

- *therapeutic ultrasound with intensity of 1,5 W/cm2 and 5 min duration*
- *electrotherapy, cross-linked currents have been used of square pulse, frequency of 1:100, 15 min duration and with an intensity accordingly to the patient tolerance*
- *therapeutic massage with a mean duration 10-15 min*
- *appropriate therapeutic exercises, accordingly to the pathologies, and*
- *20 patients were treated with hyperthermia and the remaining 16 with short-wave diathermy, randomly chosen according to their reference number in physiotherapy centerhealth records.*

In the present study, patients with musculoskeletal pathologies, acute and chronic, were selected, from age 14 to 73. From the 36 patients' sample, 16 participants were female

and 20 male. All participants were good at mental level and capable of filling all the appropriate standards to be able to follow the therapeutic protocol.

In this study, patients who met some of the contraindications of thermotherapy in general, were excluded; contraindications such as dermatoses, open wounds, hypoaesthesia or hypersensitivity to temperature rise. Also, the medical history of the patients was taken, before their participation, including indicatively, previous injuries, current medication condition and allergies.

Moreover, many muoskeletical pathologies have been examined, including neck pain, acute and chronic low back pain, edema in the knee, knee's chondropathy, 1st degree rupture in the medial collateral knee ligament, cervical syndrome,tennis elbow *(Image 3)*, 2nd degree sprained ankle, calcific tendinitis of shoulder, partial supraspinatus tendon rupture, herniated disc pain (A3-A4, A5-A6,A6-A7, 04-05, O3-O4), spondylolisthesis in O4 vertebrae, herniated disk O4-O5, 1st degree tendonitis of the biceps muscle, sacroiliac joint dysfunction, knee osteoarthritis, medial meniscus tear, whiplash injury, shoulder impingement syndrome, de quervain tenosynovitis, radial neck fracture, plantar fasciitis, hip pointer, rheumatoid arthritis, hip osteoarthritis, dislocation of 5th metacarpophalangeal joint.

The researcher has evaluated those pathologies and the patients had 10 physiotherapy sessions.

Results

At the end of the physiotherapy sessions, the questionnaires were collected and the final scores delivered from them, were analyzed. For the analysis of the survey results, the IBM SPSS Statistics Data Editor was used. Data were analyzed with the use of independent *T-test* and the researcher had recorded whether or not there are statistically significant differences between hyperthermia therapy and short wave diathermy.The researchers had been examined three parameters, in the first physiotherapy session and in the tenth. Those parameters were: the quality of pain, the VAS Analogue Scale and the Present Pain Intensity (PPI).

At the beginning of the sessions, the quality of the pain was recorded in both treatment groups. It can be observed that for the parameter "QUALITY OF PAIN-BEFORE", the sig is 0.230> 0.05, so there is no statistically significant difference and as for the parameter "QUALITY OF PAIN-AFTER", the sig is 0.766> 0.05. Therefore, both in

HYPERTHERMIA treatment and in short-wave diathermy treatment, the quality of pain was significantly improved (Table 1).

Also, in our sample, pain grading was also evaluated using the VAS analogue scale, at the beginning of the physiotherapy sessions and at the end of the 10th treatment. It is noted that the pain in both treatment methods decreased, without significant statistical difference.

Finally, the quality of the present pain (PPI) was evaluated in the two groups of participants, during the first physiotherapy session and at the 10th. In the hyperthermiatreatment group, there is a significant reduction in the average quality of the present pain from 2.65 to 0.35. On the other hand, in the short wave diathermy therapy group, the PPI of 2.81 was reduced to 0.63, which is less than the corresponding mean with HYPERTHERMIA therapy. Therefore, there is a greater reduction in PPI using HYPERTHERMIA than using short wave diathermy.

Based on the results obtained following the use of the Independent T test, there is a statistically significant difference (0.04 <0.05) to the PPI at the end of the 10th treatment, between the two study groups.

The patients who had followed the rehabilitation program with the HYPERTHERMIA device reported a significant sense of improvement from the third to the fourth day of treatment (mean: 3.85) as presented in Table 2.

On the other hand, in the rehabilitation program concluding the short wave diathermy therapy, patient's subjective sense of improvement was observed at sixth to seventh day (mean: 6.44).

Discussion

In this study, the effectiveness of the hyperthermia device in the treatment of patients with musculoskeletal disorders, both theoretically and practically, has been examined in comparison with the well-established shortwave diathermy. The benefits of the hyperthermia device and the dangers of its use were analyzed, while the contribution of hyperthermia, beyond the field of physiotherapy, in the field of medicine and specifically in the fight against cancer was also reported (Bettaieb Ah. et al 2013).

Thermotherapy has an important role in physiotherapy, so new devices are constantly being discovered. Similar benefits with the hyperthermia device also have shown in the short wave diathermy device, as discussed above. With the application of the short wave

diathermy device and the hyperthermia device, we have the same positive effect on the blood circulation which is attributed to a dilation of all vessels and is accompanied with a similar increase in lymphatic circulation. However, it is important to understand and to follow the safety rules before using physiotherapy devices to avoid possible risks for the physiotherapist and for the patient.

In the treatment of cancerous tumors, in recent years the technological equipment of hyperthermia has been developed to control or to destroy the cancerous tumor in combination with other therapeutic techniques. This is because a constant temperature cannot be achieved (Bleehen N. M. et al 1982). The destruction of cancerous tumors occurs at a temperature of about 43^0 C, because cancer cells have low tolerance at high temperatures, while healthy cells retain their normal functions.

Finally, the present study has corroborated the validity of both treatments leading to improvement of symptomatology, but treatment through hyperthermia therapy seem to have rapider heal effect of pain.

Conclusions

The aim of the present study was to compare two heat therapeutic methods that are used in rehabilitation: the shortwave diathermy and the diathermy through Hyperthermia therapy. According to our results both treatments are leading to effective improvement of symptomatology, but treatment through hyperthermia seem to provide rapider positive effect on pain, according to patient's perceptions. The technological equipment of hyperthermia is quite sophisticated but can be further improved, including devices such as short wave and microwave diathermy and radio frequency overheating.

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Image 1: *The different caps, capacitive and resistive, of the hyperthermia (TECAR) device*

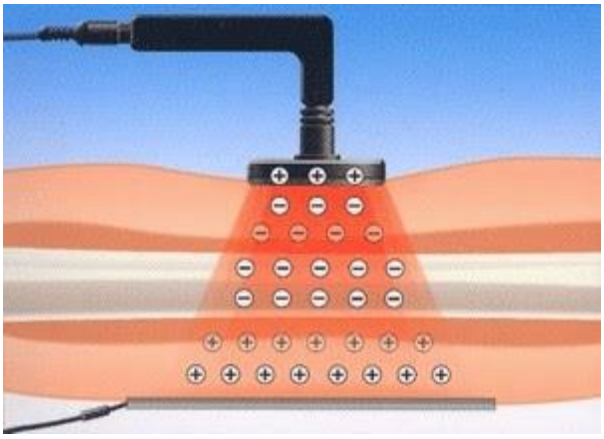

Image 2: *How the device of hyperthermia works. Modified by: https://www.kentavros.com.gr/en/targeted-treatment-with-radiofrequencies-tecar-n-2*

Image 3: *Indicative appliance of hyperthermia in tennis elbow*

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ ΑΞΙΟΛΟΓΗΣΗΣ ΠΟΝΟΥ

	Καθόλου Πόνος	Ήπιος	Μέτριος	Έντονος
παλμικός-ρυθμικός (throbbing)	0)_____	1)_____	2)_____	3)_____
σαν να 'περπατάει' (shooting)	0)_____	1)_____	2)_____	3)_____
σαν 'μαχαιριά' (stabbing)	0)_____	1)_____	2)_____	3)_____
οξύς (sharp)	0)_____	1)_____	2)_____	3)_____
σαν 'κράμπα' (cramping)	0)_____	1)_____	2)_____	3)_____
σαν να 'δαγκώνει' (gnawing)	0)_____	1)_____	2)_____	3)_____
καυστικός – ζεστός (hot-burning)	0)_____	1)_____	2)_____	3)_____
γενικός – διαρκής (aching)	0)_____	1)_____	2)_____	3)_____
αίσθημα βάρους (heavy)	0)_____	1)_____	2)_____	3)_____
ευαίσθητος (tender)	0)_____	1)_____	2)_____	3)_____
διαμελιστικός-σαν να σε 'σκίζει' (splitting)	0)_____	1)_____	2)_____	3)_____
κουραστικός (tiring-exhausting)	0)_____	1)_____	2)_____	3)_____
αηδιαστικός – νοσηρός (sickening)	0)_____	1)_____	2)_____	3)_____
τρομακτικός (fearful)	0)_____	1)_____	2)_____	3)_____
βασανιστικός – σκληρός (punishing-cruel)	0)_____	1)_____	2)_____	3)_____

ΚΑΘΟΛΟΥ ΠΟΝΟΣ (NO PAIN) ——————— Ο ΧΕΙΡΟΤΕΡΟΣ ΠΟΝΟΣ ΠΟΥ ΕΧΕΤΕ ΝΙΩΣΕΙ ΠΟΤΕ (WORST POSSIBLE PAIN)

Ε.Π.Π.	(PPI)	
0. Καθόλου Πόνος	(no pain)	_____
1. Ήπιος	(mild)	_____
2. Ενοχλητικός	(discomforting)	_____
3. Οδυνηρός	(distressing)	_____
4. Φρικτός	(horrible)	_____
5. Αφόρητος	(excruciating)	_____

Figure 1: *The McGill-Melzack questionnaire: the short form translated in Greek*

Table 1: *Treatment results according to patient responses.*

PARAMETERS	**BEFORE**	**AFTER**	**SIGNIFICANT DIFFERENCE (p)**
QUALITY OF PAIN	0,230	0,766	0,863
VAS ANALOGUE SCALE	0,754	0,426	0,526
PRESENT PAIN INTENSITY (PPI)	0,119	0,040	0,700

Table 2: *Patient's subjective sense of improvement*

SUBJECTIVE SENSE OF IMPROVEMENT	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
HYPERTHERMIA THERAPY	20	2	10	3,85	2,059
SHORTWAVE DIATHERMY	16	4	9	6,44	1,548