

A Review of Treatment Methods Using Electrical Stimulation

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Abstract: This article deals with a theoretical study of methods of electrical stimulation therapy which is one of the physical therapy used to treat pain and increase the strength of the weak muscle where the treatment is done by connecting electrodes to the patient which in turn deliver electrical impulses through nerve paths at specific intervals. Also, the relationship between methods of electrical stimulation and types of electric current has been shown in this review, Stimulation methods were divided according to the type of current used where continuous current is used in the case of galvanic with high frequency and low current. Methods (Trabert, Leduc, Faradic, H-wave, Micro-current) use the pulse current with a frequency not exceeding 1000 Hz, while methods like Transcutaneous Electrical Nerve Stimulation (TENS), Four-pole interfering, Two-pole interfering, Isoplaner interfering, Neuromuscular, dipole interfering, diadynamic use alternating current with a frequency between (3600 Hz - 10000 Hz) and the value of the current is between (50 mA - 140 mA). The most important effect or use of electrical stimulation is to reduce pain (Analgesic effect), as well as, 2-pole and 4-pole interference effect on myorelaxation and spasmolytic. Finally, there are many studies that show that there are no long-term side effects of electrical stimulation, only some temporary effects resulting from the misuse of electrodes for the stimulation device or resulting from the use of high currents.

Keywords: Physiotherapy, Stimulation, Faradic, Electric current, diadynamic.

دراسة نظرية حول طرق العلاج باستخدام التحفيز الكهربائي

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المستخلص: تتناول هذه المقالة دراسة نظرية لطرق العلاج التحفيزي الكهربائي وهي من العلاجات الفيزيائية المستخدمة لعلاج الألم وزيادة قوة العضلات الضعيفة حيث يتم العلاج عن طريق توصيل الأقطاب الكهربائية بالمريض والتي بدورها توصل نبضات كهربائية من

خلال مسارات الأعصاب على فترات زمنية محددة. كما تم توضيح العلاقة بين طرق التحفيز الكهربائي وأنواع التيار الكهربائي في هذه المراجعة ، حيث تم تقسيم طرق التحفيز حسب نوع التيار المستخدم حيث يتم استخدام التيار المستمر في حالة الجلفانية ذات التردد العالي والتيار المنخفض. تستخدم الطرق (Trabert ، Leduc ، Faradic ، H-wave ، Micro-current) تيار النبض بتردد لا يتجاوز 1000 هرتز ، طرق مثل التحفيز الكهربائي للأعصاب عبر الجلد (TENS) ، التداخل رباعي الأقطاب ، التداخل ثنائي القطب ، التداخل المتساوي ، عصبي عضلي ، ثنائي القطب متداخل ، استخدام ديايناميكي للتيار المتردد بتردد بين (3600 هرتز - 10000 هرتز) وتكون قيمة التيار بين (50 مللي أمبير - 140 مللي أمبير). أهم تأثير أو استخدام للتحفيز الكهربائي هو تقليل الألم (تأثير مسكن) ، وكذلك تأثير التداخل ثنائي القطب و 4 أقطاب على توسع العضل ومزيل التشنج. أخيرًا ، هناك العديد من الدراسات التي تُظهر أنه لا توجد آثار جانبية طويلة المدى للتحفيز الكهربائي ، فقط بعض الآثار المؤقتة الناتجة عن سوء استخدام الأقطاب الكهربائية لجهاز التحفيز أو الناتجة عن استخدام التيارات العالية.

الكلمات المفتاحية: العلاج الطبيعي، التحفيز، تيار كهربائي، الأقطاب.

1- Introduction.

Electrical stimulation is one of the types of electrical therapy, which is a method of physical therapy, which is done by using electric current, which helps to strengthen muscles, reduce pain and improve blood circulation. (Laura & Mohamad, 2022)

When performing any movement, the mind is the one who issues commands (nervous signals) to the main muscles to do the movement and at the same time it gives instructions to other muscles to do the work of assistance and stabilization and on the contrary, some muscles work against the main muscles to protect the individual from the force of contraction of the main muscles and thus the occurrence of injury Which has spread recently in a striking way, especially back injuries due to lack of movement and lethargy. (Johnson, 2017)

As a result of technological progress and scientific development, many means and devices have been introduced in order to speed up the rehabilitation and treatment of injuries, and electrical stimulation had a great role in the rehabilitation of some injuries. What we notice clearly when an individual is exposed to an electrical short, the muscles work involuntarily and the use of stimulation maintains the functional efficiency of the muscle and nerve. (Nussbaum & et. al., 2017)

In addition to that it works to disrupt the pain signals emanating from the brain by finding an alternative sensory mechanism in the field of sports injuries, research has confirmed the important role that electrical stimulation plays in that it works to avoid the lack of muscle strength and muscular atrophy, and its contribution to reducing the treatment period. (Adams, 2018)

Electric therapy has been found since ancient times, so the sources refer to the use of the torpedo fish, also known as the electric ray to treat head pain and gout diseases, as this fish issues electric shocks (these creatures are capable of producing between 8 and 220 volts of electricity), and this case is the first use of electricity in treatment. As a result of the tremendous technological progress, specialized and advanced electrical devices have been manufactured that help speed rehabilitation to reach the deep

tissues, and among these devices, electrical stimulation that stimulates blood and lymph circulation as a result of the secretion of histamine in the tissues. (Chalovich & Joseph, 2012).

Objectives of the article:

The research aims to study the types of electric current that are used in electrical stimulation, where the methods are classified according to the type and frequency of the current.

The importance of the article:

The importance of the article lies in two aspects: the theoretical, which studies the electrical current from a physical point of view, and the coefficients of this current, such as frequency, resistance, and others. The article is also concerned with the practical aspect, which is how to use this current in the physical therapy of several disease states.

2- Previous studies.

- Medical electrotherapy was used in London in 1767 at Middlesex Hospital using a special apparatus. Several years later, another device appeared at St. Bartholomew's Hospital. Then Guy's Hospital published many cases that were treated with electricity. (Steavenson & William, 2017), (Hung, 2012).
- In 1959, the journal Science published a research showing the use of direct current in the treatment of cancer, as it completely destroyed the tumor in 60% of patients (Humphrey & Seal, 1952).
- In a study presented by (Cancer Research magazine in 1985), it was mentioned that 98% of the animals shrunk the tumor by using continuous current for five days and an average of five hours per day.
- Recently, many studies have been presented that demonstrate the importance of electrostimulation therapy, (Lynne, Sheffler & John, in 2007) they presented a study on the use of neuromuscular electrical stimulation in neurological rehabilitation.
- (Bronfort & et. al., 2009), studied the use of non-surgical physical therapy in the treatment of types of chronic recurrent headaches. The study indicates that there are several methods used in the treatment of migraine headaches, including: Pulsating Electromagnetic Fields, Transcutaneous Electrical Nerve Stimulation (TENS), Therapeutic Touch, Cranial Electrotherapy, and a combination of self-massage/TENS/stretching are used. The study also found that these methods have few side effects.
- (Aziz, Flemming, Cullum & Olyae, 2010) Electromagnetic therapy for treating pressure ulcers was study by, Sores on the skin known as pressure ulcers are brought on by rubbing or pressure. They typically afflict people with limited mobility on their bony body parts, such as the elbows, heels, and hips, and they are slow to heal. Since the goal of Electromagnetic Therapy (ET) is to promote healing, it does not involve radiation or heating. Instead, it employs an electromagnetic field. The evaluation of

studies found no conclusive evidence, nevertheless, to support either the benefit or harm of electromagnetic therapy for pressure ulcer healing.

- (Aziz, Cullum, Flemming, 2013), studied electromagnetic therapy for treating venous leg ulcers.
- (Castillo, 2015) showed effectiveness of neuromuscular electrical stimulation in the functional knee rehabilitation in soldiers.
- (Jheng, & et. al. 2019), presented a systematic study on the effectiveness of electrical stimulation in improving arm function after the brain attack.
- (Shiyu & et.al., 2020) demonstrate the use of Functional Electrical Stimulation to cause muscular contractions during rehabilitation exercises following spinal cord damage.
- (Cesar & Milos, 2020) published a review on the use of functional electrical stimulation therapy for restoration of motor function after spinal cord injury and stroke.
- (Alberto, Jose & David, 2021) study mirror therapy simultaneously combined with electrical stimulation for upper limb motor function recovery after stroke was as a systematic review. Insomnia, Anxiety, and Depression are just a few of the clinical illnesses that can be treated using Cranial Electrotherapy Stimulation (CES), a neuro-modulation technique.
- (Brunyé & et.al., 2021) introduces study about the effects of CES on mood, physiology, and behavior in healthy, non-clinical sample has only lately been the subject of a small number of investigations.
- (Saranya, Rajendran & et. al, 2021) The use of electrical stimulation as a therapeutic method for wound healing has been researched by researchers., the study showed that electrical stimulation speeds up wound healing.
- (Akhlasur & et. al., 2022), A study on the application of electrical stimulation for spinal rehabilitation following spinal cord damage was presented by a team of experts.

3- Types of current used in electrotherapy

Continuous Current or (galvanic current):

This current represents a continual flow of energy with a given direction, and it is symbolized by *DC* this meaning (Direct Current). It used in case of iontophoresis and trophic stimulation (hyperemia) effect. One of the harms of using DC current is tissue damage under the electrodes, which results from the chemical reaction of hydrochloric acid that forms beneath the soda or anode solution which arises down the negative pole (cathode). (Bhargava & Kulshreshtha, 1983)

Pulsed direct current (PDC):

An electric-current with change power but of constant polarity and direction. There are many examples of (PDC) current, such as diadynamics (It is a mixture of direct pulse current and Galvanic

Current), Rectangular (e.g. Trabert's Current), Triangular and one-polarity exponentially pulse. This current has a stimulating, nourishing and analgesic effect depends upon intensity and frequency the user. One of the dangers of direct current with variable intensity is the abrasion of the skin surface and therefore the patient must be carefully monitored when using this type of current treatment. (Jeszenszky & Sándor, 2012)

Alternating Current (AC):

Depending on the electrical system being used, the electrical current occasionally reverses and oscillate round-trip 50 or 60 times per second. Only an alternating ac generator is capable of producing this current in accordance with faraday's law. The Alternating Current (AC) is safer and more tolerated by the patient, it can also be used for a long time in the case of patients who have devices implanted in their bodies such as pacemakers. The use of alternating current in electrotherapy causes very little damage to the tissue under the electrode compared to direct current. (Zipernowsky & Bláthy. 2009). Figure (1) show the different types of electric current that use in electrotherapy.

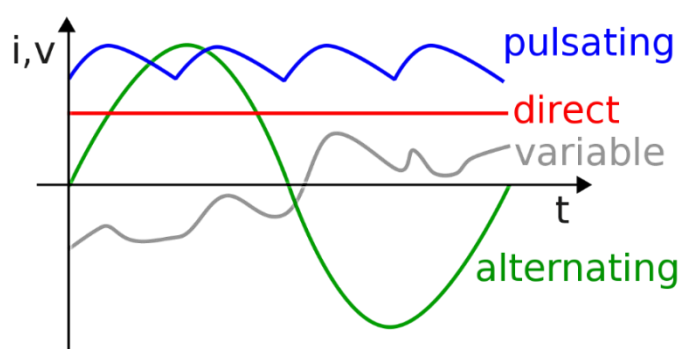


Figure (1): types of electric current.

In this type of current, the capacitive component of the skin resistance, which determines the patient's tolerance to the current, must be taken into account. There are several methods of treatment that use alternating current, including (Mohammed, 2017):

1. Electrical Nerve Stimulation Transcutaneous (TENS)

It is a treatment method to relieve pain that uses low voltage electric currents based on alternating current, so there is no chemical reaction with the tissues. These current used to stimulate of nerve fibers and stimulation of not boneless muscles. A battery-powered device that transmits electrical impulses through electrodes positioned on the skin's surface is what makes up an Transcutaneous Electrical Nerve Stimulation (TENS) device (Gibson and el. at.,2021).

The electrodes are positioned at trigger points or in or close to the nerves where there is pain, as shown in figure (2)

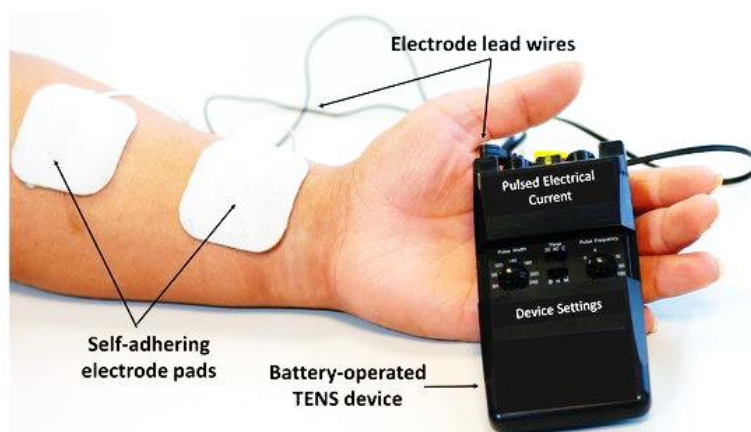


Figure (2): Transcutaneous Electrical Nerve Stimulation (TENS) apparatus.

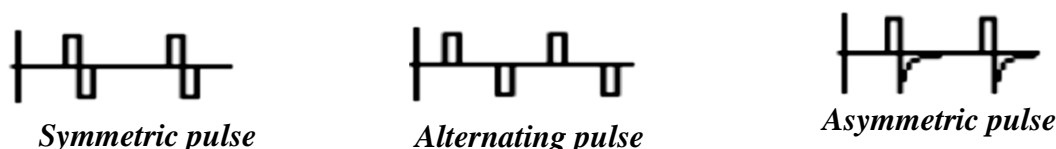
According to a study presented by (Banerjee & Johnson, 2013), regarding how transcutaneous electrical nerve stimulation might operate, there are two competing theories. The electric current is thought to stimulate nerve cells that prevent the passage of pain signals, altering how painful stimuli are perceived. According to a different notion, nerve stimulation increases the body's natural painkiller endorphin levels. Then endorphins block the perception of pain. Table [1] shows the pathological cases in which we can use transcutaneous electrical nerve stimulation and the cases in which the use of electrical stimulation is not allowed. (Johnson MI, 2014)

Table [1]: cases that use and not use Transcutaneous Electrical Nerve Stimulation (TENS)

Cases used TENS	Cases not used TENS
Osteoarthritis	An implantable device
Fibromyalgia	In case of pregnancy
Tendinitis	Cancer
Bursitis	Epilepsy
Low back pain	Deep vein thrombosis
Chronic pelvic pain	A bleeding (hemorrhagic) disorder
Diabetes related neuropathy	heart disease, arrhythmias
Peripheral artery disease	IN infected tissues

There are three types of transcutaneous electrical nerve stimulation, depending on the waveform of the current (den Adel & Luykx, 2005):

- ✓ Symmetrical: the negative pulse comes right after the positive one.
- ✓ Alternate: The negative and positive pulse exchange regularly.
- ✓ Asymmetrical: An exponential pulse with a negative polarity follows a positive rectangular pulse.



The basic parameters of the current pulse used for TENS therapy can be determined, such as frequency, pulse length and pause between TENS frequency as in the figure (3).

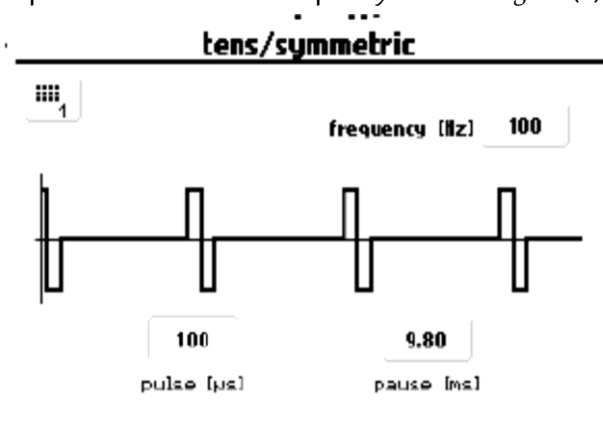


Figure (3): the parameters of TENS pulse.

These parameters are related to each other by the following mathematical relationships:

Types of TENS	The equation	Units
Symmetrical TENS	$Frequency = 1000000 / [2 * pulsation + 1000 * Pause]$	{Hz, µs, ms}
Alternate TENS	$Frequency = 1000000 / [2 * pulsation + 2000 * Pause]$	{Hz, µs, ms}
Asymmetrical TENS	$Frequency = 1000000 / [7 * pulsation + 1000 * Pause]$	{Hz, µs, ms}

Table [2] shows the frequency and time duration required for TENS treatment with a pulse width of between (175- 200 µs)

Table [2]: The frequency and time duration required for TENS treatment

Cases	Frequency (Hz)	Time Duration (min)
acute pain	80 to 120	20 to 60
muscle stimulation	35 to 50	30-60
chronic pain	2 to 10	20 to 30

2. Classic (four – pole) interference (Interferential Therapy)

It is one of the methods of Interferential Therapy (IFT) is a method of electrotherapy using low-frequency currents without harm, this is done by using four electrodes and two channels. Two electrical circuits of different frequency are used, where an interference occurs between a sinusoidal current circuit with a frequency of F_1 with another circuit of frequency F_2 , as the frequency of the first circuit is less than the second circuit to produce a low-frequency pulse current of about 50 Hz. (Ozcan, Ward & Roberson, 2004)

The pulses previously modified in terms of amplitude and frequency are overlapped inside the patient's skin [figure (4)]

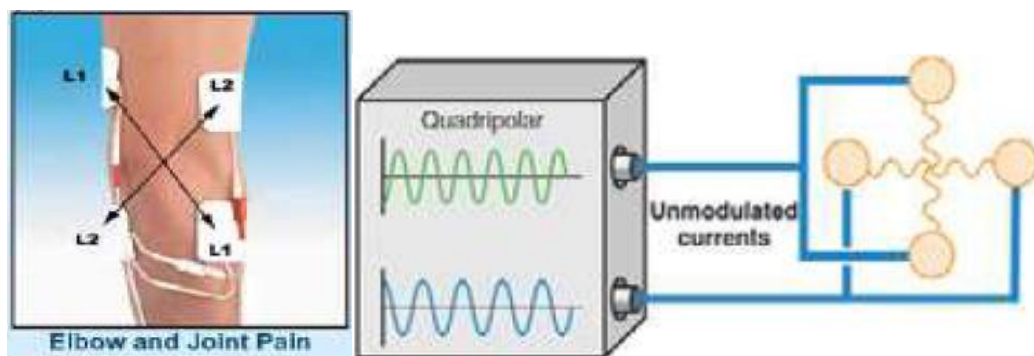


Figure (4): Quadripolar Method

There are two types of modulated IFC:

- ✓ Static Quadripolar: (Filed: static, Shape: Four-leaf clover). This type use for acute conditions because of its mildness effect.
- ✓ Quadripolar Vector Scan: (Filed: dynamic, Shape: circular), Uses: best suited for large area and diffuse pain as shoulder, back, and thigh. (Jeszenszky & Sándor, 2012).

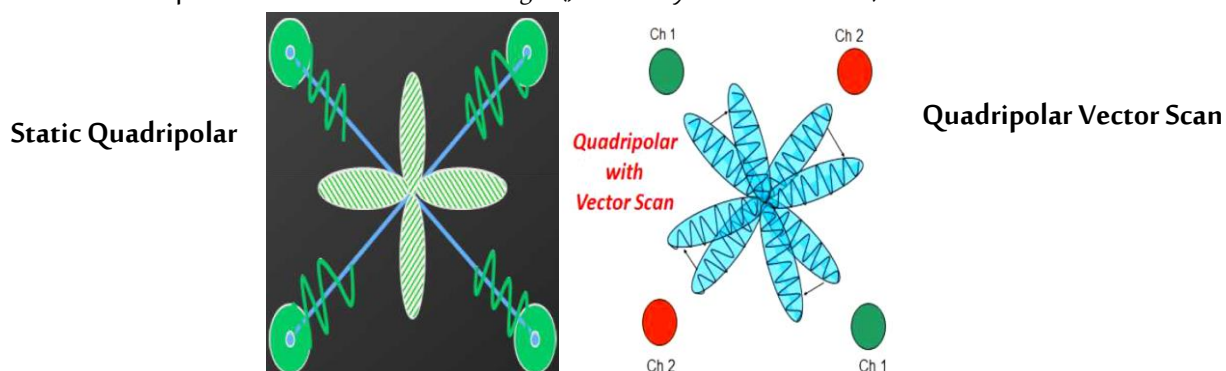


Figure (5): types of quadripolar modulated IFC

3. Two- pole interference (Interferential Therapy)

In this type of treatment, two electrodes and one channel are used where the two waves overlap and produce a low frequency. The amplitude and frequency are adjusted in the device before it is delivered to the patient. The absolute intensity values obtained from the application of this current are less than the resulting intensity from the quadrupole current. The effect of this current on the skin is less than the effect of the quad current. The most important advantage of dual current it has the ability to be used with dot electrodes on the surface of the skin and thus can be used with therapeutic ultrasound (Nussbaum & et. al., 2017).

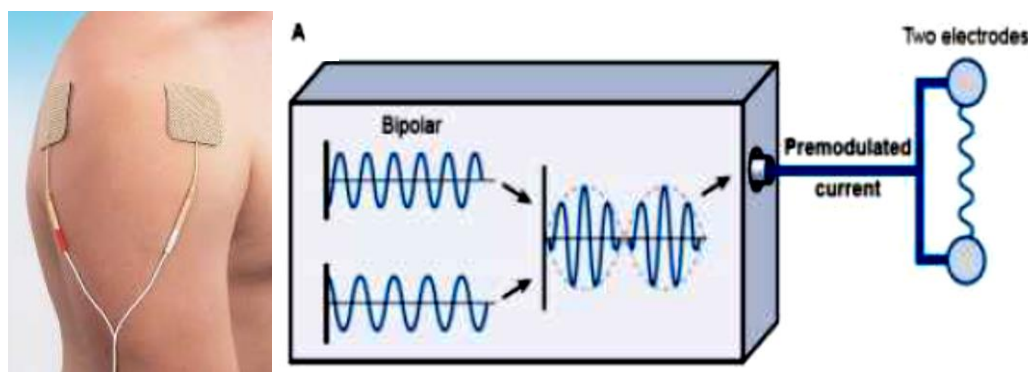


Figure (6): Bipolar Method

The waveform in bipolar interventional therapy is elliptical and the resulting amplitude is high intensity but comfortable for muscle contraction. This type of treatment is suitable for small areas such as the ankle and elbow.

4. Iso-planar Interference "Field Rotation"

It is a form of quadrupole interventional therapy where the additional modification of the two channels allows the distribution of the current or the resulting waves over the entire area of the treated area. The regular changes of amplitude result in the rotation of the current. The intensity value is better if it is equal to the total duration of treatment. (Ozcan, Ward & Roberson, 2004)

5. Dipole vector field

It is also a special case of quadrupole interference, in which the amplitude and phase are modified so that we obtain a field in one direction, i.e. a dipole inside the tissues, where the field modification in the direction of this dipole is complete up to 100% and in other directions equal to zero. This electrode can be rotated manually so that the desired effect of the treatment on tissues can be determined or left to rotate automatically. There are two types of dipole vector: automatic, manual rotation. (Lambert & el. al., 2000)

Table (3) reviews the methods of electrotherapy with an indication of the type and value of the current and frequency used for each method.

Table [3]: Types and parameters of electric stimulation therapy

Method of electric therapy	Types of current	Values of current	Frequency
Galvanic	Continuous	65 mA	8000Hz
Trabert	Pulse	92 mA	143 Hz
Leduc	Pulse	140 mA	100 Hz
Faradic	Pulse	140 mA	45.5 Hz
H-wave	Pulse	140-86 mA	0.1-87.7 Hz
TENS	Alternating	50- 140 mA	0.2-1000 Hz
4-Pole interference	Alternating	100 mA	3600-10000 Hz
2-Pole interference	Alternating	140 mA	3600-10000 Hz
Isoplaner interference	Alternating	100 mA	3600-10000 Hz

Method of electric therapy	Types of current	Values of current	Frequency
Neuromuscular	Alternating	140 mA	2500-10000 Hz
Dipole interference	Alternating	100 mA	3600-10000 Hz
Diadynamics	Alternating	70-100 mA	50-60 Hz

4- Impacts to Electrostimulation Therapy

Painkilling Impact:

Being in pain is an unpleasant sensory and emotional feeling that leads to actual or potential tissue damage. There are two types of pain (Laura, 2020):

1. Sharp ache: low-term (extending over a few weeks or days) and resulting from mechanical damage to tissues or disease. This type of pain comes following an agonizing stimulation and subsiding with the disappearance of this stimulus, and the acuity of the pain depends on the severity of the factor causing the pain.
2. Enduring ache: prolonged-term (in excess of 90 days) and its severity does not depend on the severity of the pain stimulus.

According to the idea of pain perception, there is a sensor system that uses neural pathways to transmit data through sensory nerves towards the central nervous. Electrotherapy acts as a pain reliever by increasing the producing internal endorphins. Also, the painkilling impact of electrostimulation therapy appears from the trophic effects of the flow current. Electrotherapy helps to relieve the pain caused by muscle hypertonia and calm the muscles as well as the pain of the muscle fascia.

Low-frequency currents, in the range of 50-100 Hz, are used to relieve acute and cross-sectional pain, such as stimulating thick beta and delta nerve fibers. As for chronic painful syndrome, it is preferable to use currents with low frequencies of 2-8 Hz, that is, to stimulate type C thin fibers. The currents used to relieve pain are: Galvanic current, Diadynamics currents, trarbet current, ENST, two-pole interfere, four-pole interfere, Isoplaner interference and Dipole vector fields.

Spasmolytic and myorelaxant impact:

Use two-pole interfere current with frequency 100-200 Hz as well as 4-pole interference current with ultrasonic and high voltage therapy. Paraffin is utilized as a therapeutic tool for tiny superficial muscles, particularly on the hands. (Rampazo & Liebano, 2022)

Trophic impact:

The use of physiotherapy methods leads to hyperemia, so caution should be exercised when using electrical stimulation therapy. In general, it is recommended to use galvanization, which is a treatment method use direct current with low-voltage up to 80 V, and a low current value of 50 mA.

Anti-edematous impact:

This type of influence is also related to increased capillary permeability, eutonisation of the vessels, and hyperemia, Therefore, the use of galvanizing is also appropriate in this case.

fantasy medication impact:

A person experiences the fantasy medication impact when their physical or mental health seems to get better after receiving a placebo or "delusive" treatment. A treatment that seems to be real but is intended to have no therapeutic benefit is known as a placebo, which is derived from the Latin phrase "I shall accept."

Delaying impact:

At a troublesome patient has normally received 10 treatments, they are frequently only invite for the examination after this point, when they "hopefully will be well." Unfortunately, the majority of physical therapy prescriptions currently in use fit into this category, despite the fact that it is unethical and defamatory to a professional. In some procedures, patients are even informed that the recommended physical therapy won't start to work for them for several months, indicating that the doctor is completely reliant on the body's capacity for self-healing. Therefore, When the prognosis is uncertain, as in cases of periarthritis humeroscapularis, etc., the recommendation for physiotherapy shouldn't be entirely based on the diagnosis.

It is necessary for the specialist in electrical stimulation therapy to be familiar with the information about the injury, that is, to know the type of pain, functional or organic dysfunction, the affected area, as well as the type of treatment that is appropriate for the pathological condition and that there is no danger to the patient's life. The kind, setting, level, regularity, actual number, also in relation to them of treatments, the date of the patient's assessment, should be decided by the doctor using these responses. (Melzack & Wall, 1965)

5- Contraindications to Electrostimulation Therapy

Electrical stimulation therapy is not used in the following cases ((Alberto, Jose & David, 2021)

- ✓ Patients with tuberculosis.
- ✓ If the patient is sensitive to the liquids used to wet the spongy pads which cover the electrodes.
- ✓ Avoid applying electrostimulation therapy near heart or eyes.
- ✓ Pacemakers.
- ✓ Cardiovascular Diseases.
- ✓ Implantation Cochlear.
- ✓ The presence of a metal implant or malignant tumors in the area to which the current is to be applied.

- ✓ Inflammation and skin flaws.
- ✓ Bleeding, Menses and Pregnancy
- ✓ Carcinoma.
- ✓ Allergy problems that appear in the places where the electrodes are placed.
- ✓ Organic psychoses and psychopathological syndrome.
- ✓ Multiple Sclerosis.
- ✓ Vein and Lymphatic path inflammation.

6- Disadvantages of Electrostimulation Therapy

Therapeutic electrical stimulation does not currently have any documented long-term, harmful side effects. A few adverse effects are temporary. Spasticity may actually increase if electrodes are positioned improperly. Muscle pain can be caused by stimulation that is applied too vigorously. Immediately after the treatments are stopped, these side effects will go away. Occasionally, instances of skin discomfort brought on by the electrodes have been made. If someone has a skin lesion or sunburn, skin irritation is more likely to happen (such as chicken pox). While such lesions heal, it is advised that treatment be discontinued. (Pelaez1 & Taniguchi, 2015)

7- Discussion

According to Table (3), electrical stimulation methods have been divided into several types depending on the type of current. The galvanic method uses a constant current of (65 mA) and a high frequency (8000 Hz). This method is used to stimulate muscles with damaged nerves. We also notice a rise in the current values in the methods that use the pulsed current, where the current values range between (86-140 mA), while the frequency is low (0.1-143 Hz) compared to the direct and alternating current. One of the methods that use the faradic pulse current that is used to stimulate the muscles with healthy nerves. Alternating current values range between (50-140 Ma) and frequencies (0.2- 10000 Hz), one of the ways that uses alternating current TENS Which is used to stimulate the muscles superficially, that is, used for back, knee and neck pain.

8- Recommendations about Electrostimulation Therapy

Use sponge covers with water that have been moistened for plate electrodes (or, in the case of iontophoresis, by therapeutic solution). The covers must initial be rinsed in lukewarm water before being used. Patients are kept from burning by moistening blankets or sponges. Put the first side of the sponge-covered electrodes to the patient's body to generate low-energy currents transcutaneous electrical nerve stimulation [see figure (7)]. The electrode will be in close proximity to the patient's skin, separated by one ply of the sponge cover. Applied the second side of the sponge-covered electrodes to the patient's body to provide powerful current (recommend for all currents other than TENS).

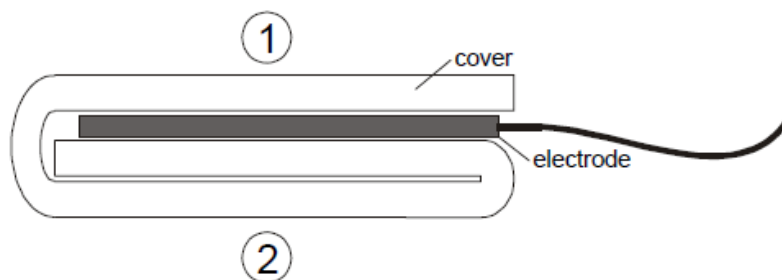


Figure (7): Electrode electrostimulation device

9- Conclusion

Electrical stimulation therapy is one of the physiotherapy methods used in the treatment of many diseases such as Parkinson's and muscle spasms through deep brain stimulation, improving motor coordination, reducing pain and arthritis, and also used in the case of facial nerve paralysis. There are three main types of current used in electrical stimulation, they are direct current, pulsed current, and alternating current. Each method of stimulation uses a specific type of current, but most methods use alternating current, so it can be considered the best for stimulation. One of the ways that uses alternating current electrical nerve stimulation transcutaneous (TENS), 4-Pole interference, 2-Pole interference, Diadynamics.

There are several effects of treatment using electrical stimulation, such as analgesic effect, myorelaxation and spasmolytic effect, trophic effect, anti-edematous effect, placebo effect and delaying effect. The use of electrical stimulation is prohibited in several cases, including: tuberculosis, pacemakers, cardiovascular diseases, implantation cochlear, inflammation and skin flaws, bleeding, menses and pregnancy. The most important recommendations that must be followed when using electrical stimulation for treatment is to moisten the electrodes by immersing the surrounding sponge with water or a special solution to prevent skin irritation as well as to improve the quality of treatment.

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