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Long Wave Diathermy Therapy for Pain Relief

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ABSTRACT
Heat has been used as a therapeutic modality for a number of years and is described by two categories: superficial and deep heating agents. Deep heating modalities include therapeutic longwave and shortwave diathermy, ultrasound, other electrical simulations. Long Wave Diathermy is generally described to decrease pain, increase metabolic functions, increase deep tissue temperature, and increase range of motion. While the depth of tissue heating varies with each thermotherapy modality, the primary physiological effects and benefits of using heat remain relatively constant and include the following: increased circulation and blood flow increased metabolism, increased muscle temperature, increased tissue temperature, decreased pain, decreased tissue stiffness and muscle spasm relaxation. Long Wave Diathermy uses an electric current to produce heat deep inside a targeted tissue. It can reach areas as deep as two inches from the skin's surface. This project proposes a simpler version of the existing Long Wave Diathermy modalities.

Keywords— Long Wave Diathermy, Deep heating, Pain Relief, capacitive electrodes, Visual Analog Scale

I. INTRODUCTION

Oscillating electric and magnetic fields produce heat in biological tissues by inducing a rapidly alternating movement of ions, rotation of dipolar molecules and the distortion of non-polar molecules. A movement of ions represents a real flow of current and occurs readily in tissues rich in electrolytes such as blood vessels and muscle. The activity of the LWD field at molecular level in fatty tissues, causes blood vessels and muscle to heat strongly and adipose tissue to heat vigorously because it is permeated by small blood vessels that contain a solution of electrolytes. The heat generated is then retained due to the insulating properties of fat allowing a high temperature to develop. Fibrous tissue is not particularly rich in either blood vessels or fat and usually shows a moderate elevation of temperature. In general, the tissue response to LWD compares closely with that from other methods of heating, and the common indications and contraindications are similar to those for superficial heating. Diathermy heats both the deep and superficial layers of tissue whilst the effect of superficial heating is most marked in the skin and subcutaneous tissues. Longwave diathermy involves generation of oscillating electromagnetic fields (EMF) that are comprised of both electrical and magnetic fields. Variations in strength of these fields are dependent upon several factors including the frequency of the unit and characteristics of the applicator like capacitive electrodes. Diathermy is generally described to decrease pain, increase metabolic functions, increase deep tissue temperature, and increase range of motion. LWD can be used with patients having metal implants and pacemakers since its frequency is not high enough to heat any metal. In addition to that it does not cause any irritation to boney parts.

II. PAIN MANAGEMENT APPLICATIONS

Empirical evidence justifies the use of heat to reduce pain although the physiological basis for this observation is poorly understood. Longwave diathermy operates at a frequency range of 0.3-1MHz.

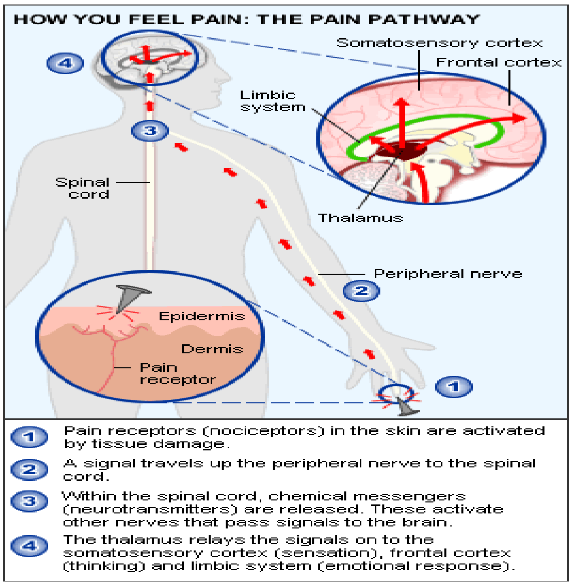

Fig. 1. Pain Pathway

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The high frequency current produces heat deep into the tissues which lasts for around 30 minutes. The heat stimulates the cutaneous thermoreceptors sufficiently to block the transmission of pain as it enters the spinal cord via the 'pain-gate' mechanism. Heat has a therapeutic effect on muscle spasm by acting directly upon the muscle spindles. The increase in conduction velocity observed when peripheral nerves are heated by LWD would facilitate the pain relief mechanism. Heating also eases pain by promoting vasodilation and efflux from the affected tissue of chemicals implicated as mediators of pain e.g. bradykinin, serotonin and the prostaglandin. These deep structures will be most effectively heated by LWD which has a penetration depth of 4mm. As the temperature of the muscle spindle rises the activity of the mechanisms conveying information about static stretch to the spinal cord decreases. At the same time, Golgi tendon organ output increases, helping to prevent muscle over-stretch. The sum of these influences on the anterior horn cells in the spinal cord is inhibitory and results in the relaxation of the affected muscle. Furthermore, the output of muscle spindles is reduced and relaxation facilitated by a reduction in gamma efferent activity caused by a reflex response to skin warming. LWD is often used successfully in conditions in which pain and muscle spasm are prominent including bursitis, low back pain, arthrosis and ligament injuries.

III. Methodology and Implementation

The block diagram in Fig. 2. illustrates the stages of the project.

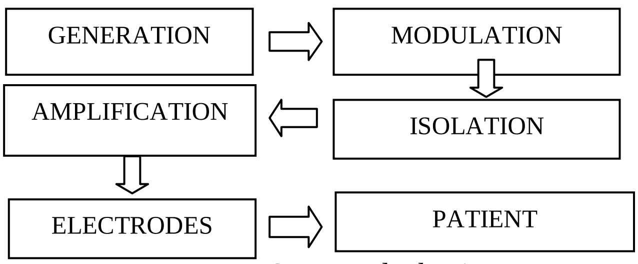

Fig. 2. System Block Diagram

A) Generation:

In this stage a pulse signal with a frequency in the range of 0.3MHz to 1MHz is generated. This can be achieved either by using a microcontroller like Arduino, 8051, Raspberry Pi, etc. or using any integrated circuit having its operating frequency lying in the range. To generate the signal using an analog circuit which consists of an integrated circuit, in this project TS555 is used which has a maximum astable frequency of 2.7MHz.

B) Amplification:

For RF frequency, a power amplifier is needed to boost the intensity and power of the pulse signal as the signal when generated using a microcontroller will have its maximum amplitude only 5 Volts. Thus, an amplifier is a must for the pulse signal to reach deep into the body tissues to produce heat for alleviating pain.

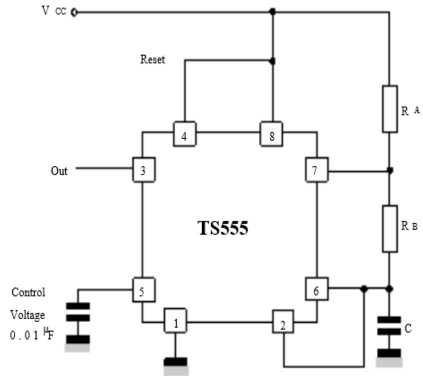

Fig. 3. TS555 circuit in Astable mode

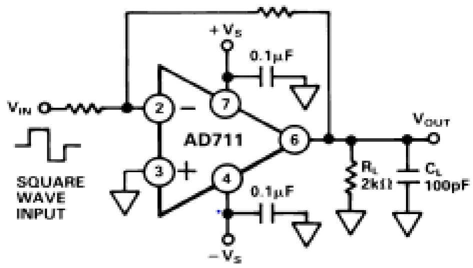

Fig. 4. Pre amplification using AD711

C) Modulation:

After amplification, the signal will be modulated in terms of amplitude using a microcontroller to generate various types of waveforms like burst, ramp, triangular etc. This can be achieved by using microcontrollers like 8051 or Arduino.

D) Isolation:

For every biomedical application, an isolation transformer is a necessity for the protection of the patient from high frequency current shocks. As LWD uses a signal having a frequency in the RF range we need to use a ferrite core transformer which supports RF frequencies. The resultant signal will be passed through an isolation transformer as a safety measure for the patients. An isolation transformer is a transformer that transfers electrical power from a source generating

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an alternating current (AC) power to an equipment or device while isolating the powered device from the power source, usually for safety reasons. Isolation transformers provide galvanic isolation and protect against electric shock. The secondary winding of an isolation transformer is not earthed and hence is floating or isolated.

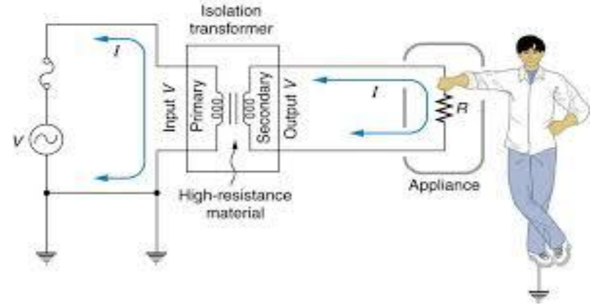

Fig. 5. Isolation Tranformer

E) Delivery mode: Capacitive Electrodes

An electrode is used to transfer the energy of the signal into the human. The most common type of electrodes used for biomedical applications are capacitive or inductive. Two capacitive electrodes are used to transfer the signal into the patient's body. One acts as the active electrode which passes the signal from the circuit into the human body while the other is the return electrode which collects the signal from the human body and passes it to the circuit back. The generated signal can be modulated in terms of amplitude, frequency or phase to produce various modulated patterns – burst, ramp, triangle, PAM, PPM, PWM etc.

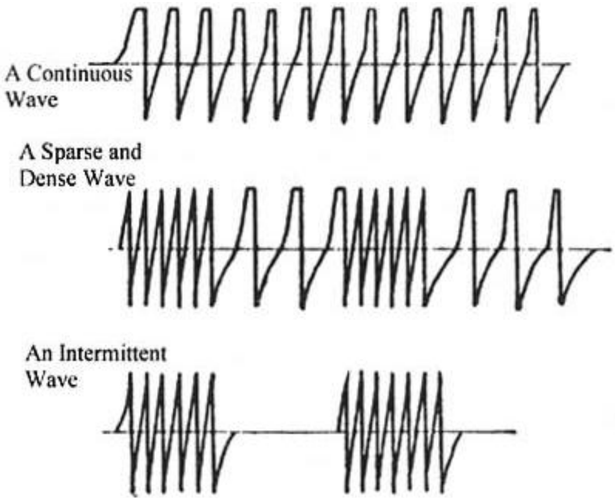

Fig. 6. Modulation Patterns

The capacitive mode permits to treat the tissues characterized by low resistance to current, focusing the action on skin tissue, connective tissue, blood circulatory system and lymphatic system. To obtain the capacitive effect, the current is applied on the bodywith two electrodes: a small insulated electrode (active) and a not-insulated counter electrode placed on the opposite side of the part of the body to treat. In this mode, which uses the condensation system, a movement of electric charges (ionic movement current) is generated inside the treated part.

A

B

Fig. 7. Electrodes: (A) Active Electrode, and (B) Return Electrode

F) Patient:

Using the electrodes, the signal is applied to the patient to relieve pain. While placing the electrodes the electrode placement chart must be consulted as the electrodes cannot be applied at certain body parts like the brain which will have a dangerous side effect on the said body part. LWD benefits patients suffering from chronic conditions causing pain such as rheumatoid arthritis, osteoarthritis, bursitis, tendinitis, capsulitis or other musculoskeletal conditions involving stiff, painful joints. It is also used to treat discomfort due to kidney stones or sinusitis as well as treat pelvic infection, neuralgia, muscle spasms.

IV. Validation and Results

The results of this therapy can be validated using Visual Analogue Scale and Statistical Package for the Social Sciences software or using Microsoft

Excel across a sequence of values that cannot easily be directly measured. A Visual Analogue Scale, VAS is a measurement instrument that tries to measure acharacteristic or attitude that is believed to range across a sequence of values and cannot easily be directly measured.The VAS is a simple robust pain measurement tool. It can be used to measure severity and improvement. The VAS is usually designed as a 10cm line with descriptors at each end.Statistical Package for the Social Sciences, SPSS package is one of the most popular statistical packages which can perform highly complex data manipulation and analysis with simple instructions. Various parameters like the patient's blood pressure, oxygen content in the blood, body temperature, pulse rate, etc. can be measured and recorded before and after the therapy is administered. This data can then be analyzed using the SPSS software. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures. The data obtained can be analyzed using this test. set up before running the experiment, and post hoc tests are run after the experiment has been conducted.There are two types of tests for comparing means: a priori contrasts and post hoc tests. Contrasts are tests set up before running the experiment, and post hoc tests are run after the experiment has been conducted.

TABLE I. TABLE STYLES

PARAMETERS	**GROUP 1 LOW BACK PAIN** n MEAN±SD	**GROUP 2 NECK** n MEAN±SD	**GROUP 3 FROZEN SHOULDER** n MEAN±SD
AGE (years)	63±2.87	56±6.8	58±2.88
SEX FEMALE MALE	 7 3	 8 2	 9 1
BLOOD PRESSURE (BP) (mmHg) PRE-TREATMENT POST-TREATMENT	 141/76±7.76/3/122 134/69±13.93/4.743	 127/77±2.44/2.51 119/75±3.74/4.123	 134/76±7.78/2.645 1 29/72±9.036/4.082
PULSE RATE (PR) (bpm) PRE-TREATMENT POST-TREATMENT	 74±16.347 73±10.677	 71±11.343 70±4.358	 79±11.045 77±9.469
OXYGEN CONTENT (%O_2) PRE-TREATMENT POST-TREATMENT	 98±0.866 98±1.000	 98±0.816 98±0.846	 98±1.154 98±1.290
VISUAL ANALOGUE SCALE (VAS) PRE-TREATMENT POST-TREATMENT	 8±0.707 3±0.866 (75%)	 8±0.577 3±0.683 (70%)	 8±0.816 3±1.290 (80%)

The patients under consideration for the test, belonged to different age groups, were diagnosed with different health problems and had different medication histories. These subjects were divided into three major groups, based on the affected area of pain.Varios vital parameters like the blood pressure, pulse rate, oxygen content in the blood were measured for all the patients. These measurements were taken prior to treating the patients with LWD and also post treatment. Group 1 and Group 3 were applied continuous LWD, at 500Watts, with a current rating of 250milli Amperes and Group 2 was applied continuous LWD at 250Watts, with a current rating of 220 milli Amperes. All the groups were given LWD for a duration of 15 minutes. It was observed that the blood pressure level of all the patients, irrespective of the groups, were stabilized and returned to their normal levels once the subjects were given the therapy. Lack of significant differences in the oxygen content in the blood and the pulse rate can be attributed to the fact that the patients were not exposed to heavy and tiring exercises before, during or after the therapy. It can be concluded from the mean and standard deviation values that there is a certain level of stabilization achieved in the blood pressure levels. It is also found from the VAS reading that patients with a higher degree of pain, on the scale, had some relief after the LWD therapy. In conclusion, thus, by attending regular sittings of the therapy, patients certainly experience a sense of relief for a long period of time. The LWD therapy simply speeds up the recovery process of subjects who have been in extreme pain conditions.

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