

DEVELOPMENT OF A MECHATRONIC SYSTEM MODEL USED IN MEDICAL RECOVERY

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Abstract - The paper presents a mechatronic system that will use two types of techniques: cold technique and ultrasound.

The system will use the technique of cold (cryogenics) and will allow the treatment of the different pathologies of the locomotor device, eg.

- Severe inflammatory pathologies;
- Intensification of pain at the chronic degenerative level;
- Severe phases in traumatology (pain-spasm-immobilization treatment, improvement in the recovery process and faster recovery).

The system supports the healing process, causes a faster recovery due to the interruption of the pain cycle, because, there is a strong analgesic and anti-inflammatory effect on the treated tissues.

Using cryogenic therapy, in the affected area, body temperature decreases, the main effects being capillary and arterial vasoconstriction and the reduction of tissue hypoxia. In other words, pain disappears and inflammation is reduced in the affected area.

Ultrasound or ultrasound therapy is a very large therapeutic method within the measures of physiotherapy. This measure requires the use of waves (ultrasound) at a frequency of 1 MHz or 3 MHz, which means an emission of these ultrasounds in two types: continuous emission or pulsed (so interrupted) emission. These ultrasounds also have a component that most types of energy is not just a radiation energy but has a thermal component, ie the released thermal energy will contribute to the temperature increase in the target tissue and thus can produce a double benefit.

Keywords: Medical Recovery, Cryogenics, Ultrasound, Physiotherapy, Mechatronics.

1. Introduction

Recovery is a clinical-therapeutic specialty that involves an interdisciplinary approach, with specialties such as orthopedics-traumatology, neurology, neurosurgery, rheumatology, geriatric gerontology, cardiology and cardiovascular surgery, pneumology, dental medicine, occupational medicine and occupational health, urology, cardiothoracic surgery, plastic and reparative surgery, with special attention given to the recovery of the surgical hand, etc.

The medical recovery is based on analyzing, interpreting and objectifying its results, on the values of functional balances, data of measurements such as podometry, gait analysis, assessment and recording of spine movements, limb joints.

Recent clinico-experimental researches of physiology, neurophysiology, adaptive physiology, confirm the mechanisms of action of the techniques and methods of medical recovery applied, support the observed effects and objectify them based on the performed clinical balance sheets, whose data are

recorded in order to compare the results and allow the development of standardized functional recovery programs. The medical recovery aims to maintain or maintain (prophylactic purpose) the current functional level, to regain the lost or installed functional capacity as a result of the disease or a trauma, dysfunction that can go from incapacity, infirmity, to disability, decrease of the degree of dependence or increasing the degree of personal and environmental functional independence, combating aggravating factors, creating complex medical recovery programs, adapted to the different types of pathology, individualized, adapted to the functional residency and the level of expectation of the loan (therapeutic / curative and medical recovery / functional and socio-professional and family reintegration).

Medical recovery, through all its therapeutic methods (methodologies) and modalities (means or techniques), ensures the physical or functional rehabilitation of a person, the psychological one, also ensuring the socio-economic, vocational-professional, educational, recreational and

reintegration reintegration, family of the respective person.

The main objective is to increase the independence of a person in carrying out self-care activities, in his daily activities, professional-vocational, domestic / domestic, family, social, leisure and recreational or recreational activities. Secondary but not least, it is followed by the complex reintegration and the quality of life expected by a person. [1]

The most important methods of recovery: physiotherapy and kinetotherapy. Physiotherapy is a method of medical treatment with the help of physical agents (air, light, water, electricity, etc.) [2]

Physiotherapy is a science that studies the mechanisms of action of physical factors (massage, regular exercise, water, light, heat, electricity) on the human body, with the help of which muscles, joints and upper and lower limbs regain their mobility.

Physiotherapy includes several types of treatments, such as:

- **Massage:** this technique is adapted to the person's problems and has the effect of increasing his mobility and flexibility;

- **Physical therapy:** this involves a variety of physical exercises to improve the flexibility and to reduce the muscular rigidity of the patient;

- **Electrotherapy:** it is used to reduce muscle pain and to help regenerate muscle tissue;

- **Hydrotherapy:** this procedure takes place in the water, and the patient is encouraged to move as much as possible to increase the mobility of the joints.

Through these methods of physiotherapy we obtain the recovery, the improvement and the maintenance of the mobility lost as a result of diseases and the reintegration in the normal daily activity, but also the reduction until the disappearance of the muscular and joint pains. [3]

Physiotherapy comprises a wide range of maneuvers and medical procedures designed to treat degenerative disorders of the musculoskeletal system (spondylosis, discopathy, osteoarthritis, tendonitis, bursitis, etc.), post-traumatic (sprains, dislocations, bruises or muscular, ligamentous ruptures), neurological disorders (stroke). peripheral neuropathies etc).

Medical recovery involves the application of certain therapeutic modalities that have their own techniques, methods, treatment maneuvers:

The conditions that physiotherapy ameliorate or treat:

Muscle pain - the most common muscle pain is that of the back area, affecting more and more people due to the sedentary lifestyle.

Physiotherapy reduces pain, stimulates blood circulation and reduces back strain. The therapeutic massage, combined with physiotherapy procedures, has effective results in the treatment of back pain.

Physical injuries - the pains caused by the physical injuries during the effort or of some sporting activities can also be reduced with the help of physiotherapy. Specific procedures help to heal after injury.

Rheumatic diseases - chronic inflammatory diseases such as gonarthrosis, rheumatoid arthritis, lupus erythematosus or fibromyalgia are some of the conditions that can be ameliorated or treated by physiotherapy procedures.

Diseases of the locomotor system - from spinal disorders such as disc herniation, scoliosis or kyphosis, and to knee deviations or foot mounts, all disorders of the locomotor system can be ameliorated by physiotherapy. Specific procedures may delay, ameliorate or treat the condition, depending on its severity, but also on the strictness with which the patient respects the indications offered by the doctor.

Post-operative recovery - if surgery could not be avoided, physiotherapy can be used for rapid recovery after the intervention. Whether it is fractures or hernias, specific procedures accelerate the healing process.

Neurological disorders - and disorders such as paresis, neuropathy or nerve trauma can be treated with the help of physiotherapy procedures.

High blood pressure - galvanic (continuous) current is effective in treating high blood pressure. [4].

Types of therapeutic techniques specific to physiotherapy:

1.1 Cryotherapy and thermotherapy

1.1.1 Cryotherapy

Cryotherapy represents the therapeutic application of cold (cold thermal agent). The name comes from the Greek Kryos which means cold.

The cold acts on the tissues, organs, devices and systems as well as on the whole organism by the rapid cooling (taking heat from them) that it causes.

There are four ways in which the exchange of thermal energy takes place: evaporation, convection, radiation, conduction.

The thermal energy transfer is performed faster or slower, depending on the skin temperature, that of the applicator, the specific thermal conductivity of the thermoconductive agent, the surface of the area to be treated, the level of blood irrigation of the area.

Both local and general cryotherapy applications have both local and systemic effects, with the final result changing the health of the whole organism: on the circulatory system; the nervous system; metabolism; breathing; endocrine system; muscle; joints.

Therapeutic effects of local cryotherapy applications: analgesic effect, the miorelaxative effect-antispastic, anti-inflammatory effect, the antiedematous effect, hemostatic effect, the regenerative effect.

1.1.2 Thermotherapy

Thermotherapy is that segment of physiotherapy that uses for therapeutic purposes the physiological changes induced by causing caloric exchanges between the body as a whole or certain segments of it and the environment element of the environment towards the patient's body) and about cryotherapy - which uses cold applications (thermal energy transfers from the body to an element of the environment). Some authors include in thermotherapy and procedures with cold applications up to temperatures down to +10 degrees Celsius.

Thermophysical characteristics of the physical environments used as thermal vectors in hydrothermal therapy

1.2. Ultrasound or ultrasound therapy

Definition: ultrasound is the mechanical vibration pendulum with a frequency between 500 KHz - 3000 KHz. The devices used in physiotherapy provide ultrasound with a frequency between 800 KHz-1000 KHz.

The importance of knowing the physical principles of ultrasonography derives from the less "intuitive" character of this procedure than the radiological ones. Indeed, ultrasonography, as the diagnostic method, is based on sound wave reflections at some interfaces.

The range of frequencies used in ultrasonography is quite wide and their selection for the purpose of making a correct diagnosis depends on the knowledge of certain principles of crossing of biological environments. Last but not least, false echoes and distortions that occur during exploration can be a source of false diagnosis

Ultrasounds were initially discovered for submarine detection and mapping and initial use was made for this purpose for military use.

It was later established that this use of ultrasound can also be performed in medicine where the use initially was an imaging for use in ultrasound, so that this military use was transposed into a medical one.

From the medical diagnostic use, ultrasound imaging was subsequently observed in the transposition of certain waves on a certain frequency that these ultrasounds can be used and therapeutic not only diagnostic.

1.3. Electrotherapy

Electrotherapy is a form of therapy that uses electrical stimulation to help the body heal and recover after being injured. Electrotherapy is a form of physical therapy that uses different forms of electric current: Galvanic current; Low frequency currents (dyadic current, trarbert current, TENS, interferential currents); Medium frequency currents; High frequency currents;

Low frequency magnetic fields. Radiant light energy (phototherapy); Magnetic field therapy;

1.4. Laser therapy

LASER - is an acronym: Light Amplification by the Stimulated Emission of Radiation.

The laser is an optical device that generates a coherent beam of light. There are different types of lasers. Some of them can be cut or burned; others can be used in communication systems, printers, CD players. Lasers can also be used in medicine. Generally in this case, two different principles apply:

The principle of incandescent glass - a strong light can create a high temperature when absorbed into the tissue. It is used in laser surgery to cut, evaporate and clot the tissue. For this reason, these lasers are called surgical lasers or aesthetic lasers.

Laser characteristics are: atraumatic, aseptic, painless. Depending on the intensity of the laser radiation on a tissue, a number of biological processes occur.

1.5. Vibration therapy

1. Vibration therapy aims to prevent bone loss by transmitting vibrations directly through the body.
2. Vibration causes the muscles to contract and relax and can stimulate the production of osteoblasts, which are bone-producing cells.
3. There are two main types of vibration therapy: whole body and localized.

2. Mechatronic equipment used in medical recovery

The apparatus that is the subject of the paper is based on the synergy between the two therapeutic techniques known as cryotherapy and ultrasound therapy. These two techniques stimulate each other, avoiding any complications due to the heat effect of the ultrasound in acute and subacute trauma. The use of the device facilitates the healing process with a faster recovery due to the interruption of the cycle of inactivity of the painful spasm.

This device is indicated in the treatment of people who have suffered a recent trauma or in the presence of an acute or subacute inflammatory condition.

The simultaneous use of cold and ultrasound has two main effects, as a natural response of the body's immune system to cold: the initial dermal vasoconstriction in the injured area, followed by a

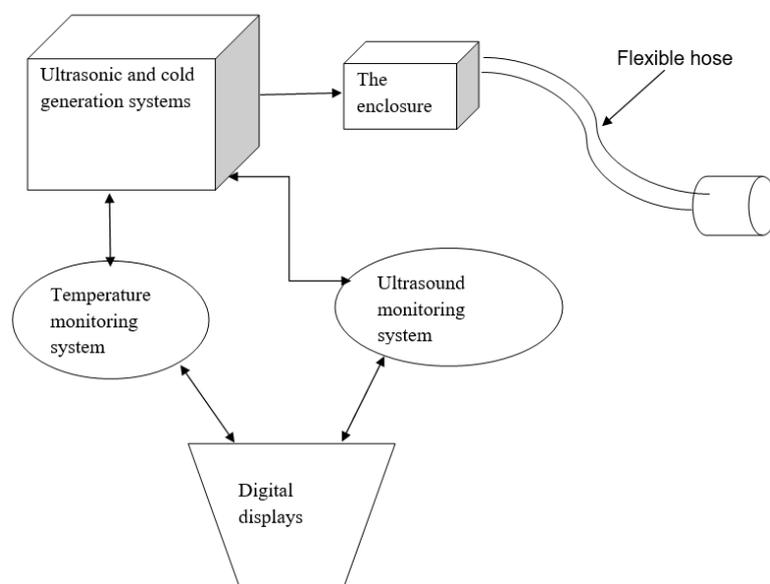
strong vasodilation, and the diminution of blood circulation in depth, at the muscular level.

It is still being used successfully and in the treatment of osteoarthritis of the small joints and in the knee or spine, of the ligamentous wounds and inflammation, acute inflammation (arthritis, synovitis, tendonitis, bursitis), muscle hematomas, periarticular calcifications, diseases of the hip or shoulders, Sindingson and Larsen syndromes - Johan - Larsen Osgood - Schlatter, trauma and muscle injury, etc.

Lowering the temperature in the deep tissue increases the density of the tissue, thus enhancing the mechanical effect induced by ultrasound of 1-3 MHz. The simultaneous use of cryogenics and ultrasound allows the treatment of patients with pathologies in acute phases, with traumas and inflammatory conditions, accelerating the recovery time.

The equipment will be equipped with a cold generation system, a system for obtaining ultrasound and an IT interface for control, control and regulation. At the same time as cold therapy up to -10 C, an ultrasonic wave from 1 MHz and one at 3 MHz is performed. The working interface with 300 mm touch screen will allow the monitoring of the delivery parameters of both therapies and the management of the treatment throughout its duration.

2.1 Block diagram



2.2 Operation

There are two main systems:

2.2.1 The cryogenic system

The cooling system comprises a generator of cold-compressor which produces from -30°C to $+10^{\circ}\text{C}$, with power supply 85-240 V AC 50/60 Hz.

A Danfoss tablet should be used:

BD35F / 50F Multivoltage

R134a, -30°C , $+10^{\circ}\text{C}$ evap. temp.

85-240 V AC 50/60 Hz, 12-24 V DC, automatic AC power selection when available,

15-152 / 20-191 W cooling capacity*.

The enclosure is a parallelepiped box, made of metal. The fluid generated by the cooling system passes through the enclosure, towards the hose, to the metal head.

The hose connects the enclosure with the patient and has a length of 1500 mm, is flexible and has thermal insulation.

The hose has a metal head that will come in contact with the patient's skin. The temperature of the cooled fluid and the regulated temperature will be displayed on the monitor.

2.2.2 The ultrasonic system

The ultrasonic system consists of a power supply unit and an ultrasound transducer.

Ultrasonic transducers ensure the reciprocal and successive conversion of electricity into mechanical energy. Their active element is the piezoelectric crystal. It is shaped like a disc and is covered on both sides with two metal layers, good conductors of electricity, on which two electrodes are applied, one on each surface.

The application of an electrical voltage between the electrodes will cause the crystal to deform and consequently the emission of mechanical energy to both surfaces.

The metallic layers have the role to transfer the electrical voltage to the crystal, as well as to take the electrical impulse created on its surface after the action of the ultrasound reflected in the tissues. This created electrical impulse is then directed to the amplification system of the device.

The thickness of the piezoelectric disk determines the nominal frequency. An acoustic lens, with a thickness equal to a quarter of the wavelength of the electrical excitation frequency, is sometimes arranged on the inner surface from which it is operated.

The lens is also called an adaptive quarter-wavelength layer, its role being that of focusing and making each electrical impulse strengthen the other, thus increasing the translator's output. An insulating layer with impedance similar to that of the body is placed in front of the lens.

Behind the piezoelectric disk is a layer of material that absorbs US then emitted and to dampen vibrations that do not have the desired frequency. All this assembly is surrounded by an acoustic insulating layer and is inserted in a plastic bag with which the operator comes in contact during the examination. The rear face of the piezoelectric material is lined with an attenuating material, having the role of reducing the sound resonance capability.

Ultrasonic wave characteristics: 1 MHz and 3 MHz. The ultrasonic wave values are displayed on the monitor.

3. Conclusions

Good health is an important concern of European citizens. The European Union (EU) pursues a higher level of health protection through its policies and activities, in accordance with Article 168 of the Treaty on the Functioning of the European Union. The EU's actions in the field of health aim to improve public health, prevent diseases and threats to health (including lifestyle), and promote research. The equipment presented is one of the many systems that ensure good health of the people."

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