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Innovation in cryotherapy after thirty years research in Poland

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Abstract:
Year (2019) is the thirtieth of the opening of the first low-temperature chamber in Poland, is celebrated. This anniversary is a great occasion to recapitulation and evaluate our experince regarding cryogenic temperatures anhibition and present how this method of treatment has developed over the last 30 years. Cryotherapy became one of the most basic and modern therapeutic methods not only in physical medicine. Cryostimulation in new areas of life and as a form of thermal stimulation and assessment of its impact on the human body, taking into account the differences between individual human areas.
Key words: history of cryotherapy in Poland, cryotherapy, cryogenic chamber, mechanism of cryotherapy, impact of cryoherapy on the body, innovation in cryotherapy, innovation in the construction of cryotherapy,

1. Introduction

Thirtieth aniversary of the opening of the first low-temperature chamber in Poland, is celebrated. This anniversary is a great occasion to recapitulation and evaluate our experince regarding cryogenic temperatures anhibition. During these years cryotherapy became one of the most basic and modern therapeutic methods not only in physical medicine. The innovation of this work is the showing the possibility of using cryostimulation in new areas of life and as a form of thermal stimulation and assessment of its impact on the human body, taking into

account the differences between individual human areas. The task of this artice is also to present how this method of treatment has developed over the last 30 years.

2. History of cryotherapy.

The name cryotherapy was first used in 1906 by A.W. Pusey. You can talk about modern cryogenics from the time physicists acquire the ability to liquefy gases and store them, that is from the end of the 19th century. The 20th century brought further development of many medical and cryogenics techniques, which allowed to explore knowledge about the effects of low temperatures. Whole body cryotherapy in comparison to local cooling has a relatively short history. The first whole-body cryotherapy procedure was performed in 1978 in Japan [1, 2] and then all over the world. It became especially popular in Germany, Poland, Canada, Latvia and in Scandinavian countries. The introduction of cryotherapy for therapeutic practice is attributed to the Japanese prof. Toshiro Yamauchi and his team, working at the Reiken Rheumatism Village Institute in Oita. At the European Rheumatology Congress in 1981, Yamauchi devoted his speech to systemic cryotherapy and its effects not only on lesions but also on the whole organism [3, 4]. The first cryogenic chamber in Europe were introduced in Germany in 1982. Team of prof. Reinhard Friecke - head of the Rheumatology Clinic of St. Jozef in Senehorst (Germany) - he began to deal with cryotherapy in all its forms. The second low-temperature chamber in the world was founded in Germany, and prof. Friecke developed the first standards for the use of cryotherapy in medicine [5].

Second cryogenic chamber in Europe and first in Poland was constructed in 1989. A very important figure in Polish cryotherapy is MSc. Zbigniew Raczkowski, inventor and constructor of the first cryogenic device, and then the entire generation of this type of devices, including a cryogenic chamber, called "Wroclaw", inclusive. He is a co-author of many scientific and technical devices and patents, including the cryosurgical apparatus Krioter GN (1980), the so-called cryocombustioner (1982), cryoapplicators (1983), the first Polish cryochamber (1989), flow cryostats, cryosurgical instrument tips and many more. At first, cryogenic chambers were used only for therapeutic purposes, mainly to treat patients with rheumatic disorders [6].

2. Mechanism of cryotherapy.

The impact of a very low temperature on the body reason a decrease in body temperature. Human body is a homoeothermic organism, and one should take into regard the internal and external skin temperature. The external body layer temperature is under the effect of environmental temperature[7].

Cryostimulation, usually referred to as cryotherapy, is a short-lasting up to three minutes stimulation of the body below -160°C, affecting the entire body surface, its main goal is to induce physiological, systemic and organ reflexes, beneficial to recover homeostasis in the body. These treatments take place in chambers adapted specially for this purpose. The temperature gradient between the body and the environment determines the rapid reception of a significant amount of thermal energy from the body, in the cryogenic chamber this occurs mainly on the principle of convection and evaporation. Over whole-body cryotherapy, the skin temperature follows the low environmental temperature and, at the same time, the defence mechanisms are activated [8, 9, 10, 11]. Homeothermy engages an automatically regulated balance between heat production and heat loss from the surface [11].

During exposure to cold for 3 min whole body in a cryogenic chamber at –100°C to 160°C is a very strong stimulus, over which adaptive changes occur in two phases. Is

maintained by a complex regulatory system, mainly related to the intensified production and protection of body heat.

The main desired response to the systemic action of cryogenic temperatures (below -100°C) is the induction of a stimulus-stimulus congestion. Exposure to a low temperature from 1 to 3 minutes. does not lead to a decrease in skin temperature. The contraction of the subcutaneous blood vessels reaches a maximum at a skin temperature of 31°C, this results in a redistribution of blood to deeper vessels. While the skin temperature reaches 18°C, the relaxation phase of the subcutaneous blood vessels follows [12]. This alternating contraction and relaxation of the blood vessels is called the "hunting reaction". When choosing treatments and parameters of cryostimulation, one should remember about two-phase vascular reaction to extremely low temperatures, have knowledge of the purpose and the intended effect [13].

The use of a lower temperature of the cooling medium (vapor of liquid nitrogen) causes that the first phase, manifested by vasoconstriction, causing tissue ischemia, will appear earlier and will be stronger. In this way, you can reduce the effects of injury, reduce the speed of metabolic processes (very helpful in the process of physical therapy of arthritis), and thanks to hypoxia tissue will reduce the sensation of pain. In the diastolic phase of the procedure, associated with active hyperemia, metabolic processes increase and muscle tone decreases [13].

To safely subject your body to extremely low temperatures, it is very important to follow strictly defined procedures. Keep in mind the effect of chilled air on the body, after getting into the lungs, it increases its volume, which may cause dyspnea. The model and simulation of heat exchange between man and the environment in the cryochamber showed that the organs of a small volume and the high coefficient of convective heat transfer, that is mainly feet, hands, legs, forearms and thumbs, cooled down the most. Treatments in the cryochamber indicate a significant decrease in skin temperature after surgery, which results from the rapid contraction of the skin vessels that the body defends against cooling. Thanks to this, there is no excessive inflow of cooled blood to the lower body layers and at the same time reduces the heat dissipation process. These data were taken from the Pennes equation, it is a differential equation describing the heat in the tissue.

3. The impact of cryotherapy on the body.

Literature circumscribes a lot of changes occurring in the body after exposure to cold [14]. Changes concern ussualy in the endocrine system [15, 16], the immunological system [15-18], lipid profile [17], and hematological values [18-20]. Influence of cryostimulation on the level of physical fitness remains considerably unexplored. In both relation to the components of aerobic and anaerobic capacity. Last reports [21] imply a significant increase in anaerobic power and volume in men.

For 3 to 6 hours after the session lasts the hypoperfusion of the tissues [22], which simplify removal metabolite, rise the capillary perfusion and improves the viability of lymphatic vessels. Drop of sedimentation and another inflammatory markers such ass seromucoid, immunoglobulins G and A and C reactive protein [23, 24], and changes in some hormones, ussuale increased level of ACTH, adrenaline, noradrenaline, cortisol, testosterone in men and β-endorphins [25, 26]. Cold influence the action of myocardium, particularly the sinoatrial node, reducing heart rate, and could leading to arrhythmia [27].

4. Innovation in Cryotherapy.

The question should be asked can cryotherapy be considered the most developmental and a great prognosis not only in medicine or sports but in various areas of life? The past 30

years are hundreds of scientific papers on the physiological responses of the body and the use of cryotherapy. Cryotherapy causes analgesic, anti-inflammatory, anti-oedematous effect, decreases increased muscle tone and improves the mental state of patients. The available literature contains many works on the effectiveness of general cryotherapy in diseases of the musculoskeletal system, such as: rheumatoid arthritis [28-31], ankylosing spondylitis [32, 33], psoriatic arthritis, fibromyalgia [34], post-traumatic or overload changes [29, 35-39] discopathy, osteoporosis [39, 41, 42] and multiple sclerosis [43-45, 46], and root syndromes [37, 39, 47], spastic paresis [30]. In addition, cryotherapy prevents negative effects of training overload, supports the treatment of sports injuries and prepares the body to bear greater loads. It promotes achieving better sports results, enabling the implementation of full training cycles [48-51].

Modern cryotherapy has gained many supporters in the fight against civilization disease of the twentieth century, namely obesity. To confirm the effectiveness of cryotherapy in new fields and to determine its best use, the researchers came up with the idea of using Thermovision.

Thanks to the use of thermovision, scientists in the study of modern cryotherapy in obesity have proved that it is very important in cryotherapy what areas of our body are subjected to criostimulation and what tissue dominates in these places. The largest changes were recorded in the lower limbs, and the smallest in the trunk [52-57].

They also proved that the time of the procedure is very important. Dębiec-Bąk and colleagues confront treatments at four different temperatures from –60°C to –140°C at the same time. After the examination they observed statistically significant differences between temperature changes depending on the time of cold exposure [54]. They also took into account the refrigerant used. Costello and colleagues presented by comparing the results of many authors, similar differences between temperature changes depending on the refrigerant used, among others: cryotherapy such as whole body cryotherapy, cold spray, cryotherapy cuffs, frozen peas, cold water immersion, ice and cold packs. After the test researches showed the importance of the cooling factor and its physicochemical properties, but mainly its thermal conductivity [58].

5. Innovation in the construction of cryotherapy devices.

Promoting the use of cryotherapy, especially systemic, in various branches of medicine, conducting methodological training and publishing the results of scientific studies demonstrating its effectiveness caused a huge increase in interest in this form of therapy.

Poland is one of the leading countries when it comes to the development of the field of cryotherapy. Many companies were produced and supplying cryogenic chambers. These devices have been installed in many Polish and foreign centers [6].

In many centers, cryogenic chambers were installed - designed by Ing. Raczkowski [6]. It consists of several rooms - one or two atria and a treatment chamber. In the atria higher temperatures are maintained, around -10°C and -60°C, while the temperature in the treatment chamber is from about -120°C to even -160°C. In the vestibule, the patient spends about 30 seconds and then goes to the treatment room, where he spends up to three minutes. The aim is to gradually adapt the body to cold and minimize the effects of thermal stress. Both rooms have external doors, which allows patients to leave the cryochamber if necessary. In addition, the vestibule and the actual chamber are connected by internal doors insulation parameters. The glazed door openings, visual and voice contact with external service generally affect the safety of use. The refrigerant is liquid nitrogen, and the control system is fully automated [59].

A typical volume of rooms in a cryochamber is about 15 m3. The cooling of this space requires even about 90 kg of cryogen. Due to the technology used in cooling, cryochambers cooled by liquid nitrogen, a mixture of liquid nitrogen and oxygen (so-called synthetic air) and using cascaded compressor coolers are distinguished. Heat exchangers used in cryochamber use 90-100 kg of liquid nitrogen or synthetic air, respectively, for one hour of operation. The bandwidth of the device is up to 30 people per hour [60].

Due to the high consumption of coolant in cryochamber (usually liquid nitrogen), cryochamber producers focused on producing single-person cryocabin. The functionalities used in it lead to obtaining the most favorable consumption of nitrogen in relation to the achieved temperatures, which results in very large savings in the costs of use. An example is one of the leading Polish CryoSpace JBG-2 companies that manufactures CryoSpace-Hybrid one-room cryocabin. It has used a dual cooling, electric and liquid nitrogen system in its products. Thanks to the electric aggregate, it is possible to pre-cool the device, which does not use liquid nitrogen at all, which results in very large savings in operation.

In conclusion, in the last 30 years, cryotherapy has become one from basic therapeutic methods of physical medicine, very appreciated and popular. Beneficial effects of its application encourage further deepening of knowledge, searching for new possibilities of using, developing therapeutic methodologies and improving cryogenic techniques. Among other things, cryotherapy can be used to fight with stress, increase concentration, to treat infertility and sex problems. Cryotherapy thanks to the effectiveness, simplicity of treatments, but above all due to the joint efforts of many specialists from various scientific fields has a well-deserved and important place in Poland.

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