THE INFLUENCE OF CRYOGENIC TEMPERATURES ON HEALTHY PEOPLE AND ITS INCREASING POPULARITY IN SPORT AND BIOLOGICAL REGENERATION

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SUMMARY

Currently, cryostimulation and cryotherapy refer to various therapeutic effects of cryogenic temperatures (ranging from -100 ° C to -196 ° C) used to reduce the temperature of the body surface without tissue destruction, the fastest possible heat loss and getting the "rebound effect". This treatment is commonly used to relieve pain symptoms, injuries or overtrain symptoms. To the present day cryostimulation effects were studied in relation to:

1.Motor activities and physical efficiency; 2.Cardiovascular response; 3.Lipid profiles; 4.Hematology; 5.Hormones; 6.Antioxidant Defense System; 7.Immunology and inflammation. According to availably literature date, this paper talk over the lately research in this area.

KEY WORDS

cryostimulation, whole-body cool therapy, cryotherapy

Contemporary cryogenics is based on the liquefaction of gases and has been developing since the end of the 19th century when the liquification of oxygen, nitrogen, carbon dioxide and hydrogen, and also the industrial production and storage of the liquid coolants enabled the development of cryobiology and the use of extremely low temperatures in medicine. Thanks to the team of T. Yamauchi, their portable cryoapplicators and the world's first cryogenic chamber, cryotherapy began to be used in mainstream medicine in Japan [Yamauchi et al 1981]. It is essential to clarify the distinction and clear naming of methods based on using low temperatures and their intended purpose, as the body's response to low temperature depends on the temperature level, method of application, exposure time, method and rate of heat loss, humidity of the cooled air, and the characteristics and age of the subjects. Treatments which use temperatures slightly below 0°C may be called cold-therapy but those that use temperatures below -100°C (cryogenic temperatures) should be called cryostimulation or cryotherapy, depending on whether they are used only as a form of biological regeneration or stimulation of healthy individuals before or after effort, or to support the primary treatment in patients with various ailments and diseases. Depending on the size of the area of the body that has been treated with cryogenic temperatures, we may distinguish the following: local cryotherapy and Whole-body cryotherapy/cryostimulation (WBC): cryosauna, two-stage chambers, and ascending-descending chamber, chambers cooled with liquid nitrogen, a mixture of nitrogen and air, or with a compression cooling system. Initially cryochambers could be found in Japan and Germany, but at present a few dozen cryochambers can be found around the world, including a dozen in Poland. A growing number of centers conduct scientific research on the effects of whole body cryostimulation on the human body, yet knowledge on this subject is still lacking. Whole-body cryostimulation (WBC) is not harmful or detrimental in the healthy subjects. Currently cryostimulation effects

were studied in relation to: motor activities and physical efficiency; cardiovascular response; lipid profiles; hematology; hormones; antioxidant defense system; immunology and inflammation.

MOTOR ACTIVITIES AND PHYSICAL EFFICIENCY

Studies carried out on a large group of athletes (300 people) were in order to find an optimal operating temperature for the improvement of motor skills. The analysis of the results showed no effect of cryostimulation on the level of agility. Balance improved significantly in groups exposed to lower temperatures than -100°C, while no significant effects were observed for

-100°C. Parameters evaluating speed and dynamic strength of abdominal muscles improved most after the application of -100°C [Łuczak et al. 2006]. Subsequent studies showed that a series of 20 stimulations with an average temperature -130°C resulted in an extended duration of exercise and decreased subjective feeling of fatigue at increasing mean speed and angle of treadmill inclination during an exercise according to the Bruce protocol [Hagner et al. 2009]. A recent study on the effects of WBC on aerobic and anaerobic capacities showed that three 10 minute sessions (mean temperature -130°C) lead to an increase in maximal anaerobic power in males but not in females, and additionally did not influence aerobic capacity in either gender [Klimek et al. 2010]. There are also reports of improved exercise tolerance, expressed by a lower level of lactates, heart rate and increased threshold capacity during a rowing ergometer test on Olympic team athletes (rowers) after 23 sessions (3-minutes at a temperature of -150°C, 2 x day) [Chwalbińska-Moneta 2003].

CARDIOVASCULAR RESPONSE

It is known that cold exposure is a risk factor for hypertension. In physiotherapeutic practice, it is standard procedure to test participants before cryostimulation where a blood pressure control is measured, but contraindications to the use of cryotherapy or whole-body cryostimulation do not include unstable blood pressure or hypertension. Literature data on changes in key cardiovascular indicators in humans exposed to cryogenic temperatures are ambiguous. Some of them report a significant but short-term increase in systolic and diastolic blood pressure after WBC both normotensive and midly [Westerlund et al. 2004; Fricke 1989; Taghawinejad et al. 1989]. Similarly, Komulainen et al. [2004] observed a rapid increase in blood pressure in mildly hypertensive subjects exposed to -15°C. Other authors reported that thermal stress (-110°C) does not cause changes in systolic or diastolic blood pressure but only a decrease in heart rate [Zalewski 2009]. In our unpublished experiments in which we used 15 daily cryostimulations (-130°C/3min) the average increase in SBP and DBP on the first day was 20 mmHg and 6 mmHg. All the observed changes in the circulatory system subsided after 10 minutes of resting in a sitting position. Changes in blood pressure were accompanied by a decrease in heart rate.

LIPID PROFILES

There are only a few reports in literature on the influence of whole-body cryostimulation on lipid levels in blood serum. The first information comes from experimental animal models [Skrzep-Poloczek et al. 2002]. Our last report concerned the results of lipid profiles in response to different procedures of whole-body cryostimulation in a cryochamber (-130 °C) for five, ten and twenty sessions. We ascertained that five sessions of whole-body cryostimulation in a cryogenic chamber did not change the lipid profile; in

a group subjected to a series of 10 sessions, the level of TG values statistically significantly decreased, and the changes were more pronounced in the group subjected to 20 sessions: a significant reduction in LDL, reduction in total cholesterol, while a significant increase was observed for HDL fraction. Comparing the ratios of individual lipid fractions, a statistically significant decrease in the TG fraction was observed in relation to total cholesterol, while the HDL fraction increased in comparison with total cholesterol and LDL cholesterol after 20 cryostimulations. No changes in the proportions between lipid fractions were observed after 5 and 10 cryostimulations [Lubkowska et al. 2010]

HEMATOLOGY

Literature on changes in hematological indices induced by crystimulation is often inconsistent and insufficient. Blatteis [1998] reported a decrease in leukocytes and erythrocytes in healthy subjects after a series of cryostimulations. No significant increase in leukocytes was reported by Stanek et al. [2006], although they also observed a significantly increased percentage of monocytes in healthy individuals after a series of 10 two-minute long cryostimulations at -120ºC. Similarly, in our studies the increase concerned the number of lymphocytes and monocytes, and to a lesser extent, neutrophils and eosinophiles [Lubkowska et al. 2009]. With regards to information on the effect of cryotherapy or cryostimulation on the red blood cell system, data is still very scarce and lacking. The only available paper is Banfi et al. [2008] which investigated the effects of 5 session of whole-body cryotherapy treatment on hematological values in athletes.

HORMONES

A single cryostimulation at -130°C causes increased concentration of a proopiomelanocortin-related hormone (ACTH adrenocorticotropic hormone), β-endorphin, adrenaline and noradrenaline in men and women, and a significant increase testosterone in men [Zagrobelny 1993]. Soccer players submitted to ten sessions of cryostimulation followed by 60 minutes of kinesitherapy, had a significant decrease in the concentration of testosterone and estradiol. There were no changes in the level of luteinizing hormone (LH) and dehydroepiandrosterone sulphate [Korzonek-Szlacheta 2007].Reports of changes in the level of cortisol (defined as the stress hormone) are divergent. Smolander et al.[2009] concluded that WBC treatments (-110°C), for 2 min, three times a week for 12 weeks, do not lead to disorder related to secretions of the growth hormone, prolactin, thyrotropin or thyroid hormones in healthy females .

ANTIOXIDANT DEFENSE SYSTEM

Even one session of whole-body cryostimulation causes disturbances in the prooxidant-antioxidant balance [Lubkowska et al. 2008]. Additionally a 36% increase was observed in the activity of superoxide dismutase (SOD), glutathione peroxidase (GPx) and conjugated dienes (CD) in healthy individuals after a single stimulation [Woźniak et al. 2007]. Duge et al. [2005] observed a significant increase in total peroxyl radical trapping antioxidant capacity of plasma (TRAP) in healthy women 2 minutes after the cold stress but only after first 4 weeks of the 12 weekend long study. Additionally those Authors concluded that prolonged, regular cryostimulation or winter swimming for 12 weeks did not appear to be harmful regarding antioxidative capacity. Further studies are needed for the confirmation of potential adaptational advantages occuring in antioxidative response to cryostimulation.

IMMUNOLOGY AND INFLAMMATION

In studies by Jackowska et al. [2006] it was ascertained that IgA, IgG, IgM and C3, C4 complement protein levels increase during cryostimulation, but after cryotreatment the levels of mentioned markers were similar to the initial ones. Leppäluoto et al. [2008] didn't observed changes in plasma level of IL-1β, Il-6 and TNFα during prolonged treatment (12 weeks) with cryostimulation (-110°C; 2min; 3 times a week). In our studies, we observed an increase in the level of white blood cells in response to a series of 10 cryostimulations, and at the same time we showed single a 3 minute long whole-body cryostimulation (-130°C) leads to an increase in the level of interleukin 6, which is maintained for the next 10 stimulations [Lubkowska et al 2010]. This was later confirmed in the next so far unpublished experiment, which additionally showed the more advantageous effect of 20 sessions compared to 10 or 5 cryostimulations. This advantageous effect – an increased level of anti-inflammatory cytokines (IL-6, IL-10, IL-12) - was maintained during the whole series of cryostimulations, and receded as early as after two weeks after the completions of the cryostimulations, regardless of the number of treatments. However, the decreased level of the pro-inflammatory IL-1α was maintained during the sessions of 5 and 10. The similar tendencies in decrease in pro-inflammatory cytokine (IL-2, Il-8) and increase in anti-inflammatory one (IL-10) after cryostimulation observed Banfi et al. [2009].

REFERENCES

1. Banfi G., Krajewska M., Melegati G., Patacchini M.: Effects of whole-body cryotherapy on haematological values in athletes. Br J Sports Med 2008; 42:558-559.
2. Banfi G., Melegati G., Barassi A. et al.: Effects of whole-body Cryotherapy on serum mediators of inflammation and serum muscle enzymes in athletes. Journal of Thermal Biology 2009; 34:55-59.
3. Blatteis CM (1998). Physiology and pathophysiology of temperature regulation. World Scientific Publishing Company, Singapoore-New Jersey-London-Hong Kong.
4. Chwalbińska-Moneta J.: Influence of whole-body cryotherapy of results of selected exercise response. Sport Wycz. 2003; 5-6:461-462.
5. Dugué, B., Smolander, J., Westerlund, T., et al.: Acute and long-term effects of winter swimming and whole-body cryotherapy on plasma antioxidative capacity in healthy women. Scand. J. Clin. Lab. Invest. 2005; 65, 395-402.
6. Fricke R. Ganzkoperkaltetherapie in einer Kaltekammer mit Temperaturen -110°C. Z Phys Med Baln Med Klim 1989;18:1-10.
7. Hagner W., Smolka A., Różańska J.: Influence of whole-body cryotherapy of results of exercise test. Balneol. Pol. 2009; 1(115):35-39.
8. Jackowska E., Pisule A., Drulis-Kawa Z. et al.: Changes of level of immunoglobulins and C3 and C4 proteins in serum during whole-body cryotherapy. Acta bio-optica et Informatica Medica 2006;2:101-103.
9. Klimek A.T., Lubkowska A., Szygula Z., Chudecka M., Frączek M.: The influence of the ten sessions of the whole body cryostimulation on aerobic and anaerobic capacity. IJOMEH 2010; 23(2):181-9.
10. Komulainen S, Oja T, Rintamaki H, Virokannas H, Keinanen – Kiukaanniemi S. Blood pressure and thermal responses to whole body cold exposure in mildly hypertensive subjects. J Thermal Biol 2004;29:851-856.

11. Korzonek-Szlacheta L., Wielkoszyński T., Stanek A. et al.: Influence of whole-body cryotherapy on the levels of some hormones in Professional footballers. Pol J Endocrinol 2007; 58(1):27-32.
12. Leppäluoto J., Westerlund T., Huttunen P., et al.: Effects of long-term whole-body cold exposure on plasma concentration of ACTH, beta-endorfin, cortisol, catecholamines and cytokines in healthy females. Scand J Clin Lab Invest 2008; 68(2):145-153.
13. Lubkowska A., Szyguła Z., Klimek A., Torii M: Do sessions of cryostimulation have influence on white blood cells count, level of IL6 and the total oxidative and antioxidative status in healthy men. EJAP 2009; 109(1):67-72
14. Lubkowska, Banfi G, Dołęgowska B, d'Eril G.M., Łuczak J., Barassi A.: Changes in lipid profile in response to three different protocols of whole-body cryostimulation treatments. Cryobiology 2010; 61:22-26.
15. Lubkowska, M. Chudecka, A. Klimek, Z. Szyguła. B. Frączek: Acute effect of a single whole-body cryostimulation on prooxidant-antioxidant balance in blood of healthy young men. Journal of Thermal Biology 2008; 33: 464-467.
16. Łuczak J., Michalik J.: Influence of extremely low temperatures on selected human motor activities. Fizjoterapia polska 2006; 3(4):206-211.
17. Skrzep-Poloczek B., Romuk E., Birkner E, et al., The effect of whole-body cryotherapy on lipids parameters in experimental rat model, Balneologia Polska 2002; 1-4:7-13.
18. Smolander J., Leppäluoto J., Westerlund T., et al.: Effects of repeated whole-body cold exposures on serum concentrations of growth hormone, thyrotropin, prolactin amd thyroid hormones in healthy women. Cryobiology 2009; 58(3): 275-278.
19. Stanek, Cieslar G., Rosmus-Kuczia I, et al., Influence of whole body cryotherapy on blood morphology parameters in patients with ankylosing spondylitis and in healthy volunteers, Acta Bio-Optica et Informatica Medica 2006; 12 3:207-210.
20. Taghawinejad M, Birwe G, Fricke R, Hartman R. Ganzkoperkaltetherapie Beeinflussung von Kreislauf – un Stoffwechselparametern. Z Phys Med Baln Med Klim 1989;18:23-30.
21. Westerlund T, Smolander J, Uusitalo-Koskinen A, Mikkelsson M. The blood pressure responses to an acute and long-term whole-body cryotherapy (-110°C) in men and women. J Thermal Biol 2004;29:285-290.
22. Woźniak, A., Woźniak, B., Drewa, G., et al.:The effect of whole-body cryostimulation on the prooxidant-antioxidant balance in blood of elite kayakers after training. Eur. J. Appl. Physiol. 2007;101: 533-537.
23. Yamauchi T., Nogami S., Miura K.: Various applications of the extreme cryotherapy and strenuous exercise program focusing on rheumatoid arthritis. Physiother Rehabil. 1981; 26(5): 89-101. 1981.
24. Zagrobelny Z., Halawa B., Niedzielski C. et al. : Concentration of chosen hormones in serum and some hemodynamic parameters in healthy voluntaries in response to single cryostimulation. Pol Tyg Lek 1993; 48:303-305.
25. Zalewski P, Tafil-Klawe M, Klawe J, Buszko K, Lewandowski A, Panowicz I. Influence of the whole-body cryotherapy on the hemodynamic parameters in healthy subjects. Acta Bio-Opt Inform Med 2009; 3:209-214.