# BASIC CONDITION OF THE HEAT- PHYSICAL THEORY OF CRYOGENIC THERAPY

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By humans are not located the sensory organs, capable of estimating the temperature of the cooling medium. The estimation of external temperature conditions is built on the information that coming from the skin cold receptors, which control the temperature of skin surface.

Cold receptors lie nearer to the surface (0,17 mm), than thermal (0,3 mm) one. Total number of thermoreceptors is approximately 280 thousand, including 250 thousand of cold ones. The predominance of cold receptors allows to assume that action by low temperatures capably of rendering the larger stimulating action. The method of positioning the receptors ensures precise observation of a change in the temperature of the epithelium surface, which is determined the intensity of the heat outlet to the cooling medium.

It is known that the layer of body they easily transfer supercooling, and cloths during the cooling to 10 −12 ºC cease normal operation. For the wide application of cryogenic physiotherapy, the propagation of the supercooling zone should be limited by the volume of nucleus.

Cold receptors code information about the skin temperature it is converted into the universal for the brain signals - nerve impulses. An increase in the intensity of stimulus is connected with an increase in the frequency of pulse activity.

The quantitative connection between the intensity of stimulus and the signal frequency is determined by Stevenson's law who asserts, that between the sensation and the intensity of physical stimulus, there is a power dependency. As the factor of that thermostatic control irritating system is proposed to examine threshold signal, i.e., the signal, connected with the approximation of the temperature, recorded by receptors, to the corresponding terminal threshold value $t_{term}$ = - 2,5 ˚C.

Taking into account the inertness of thermoregulatory processes correct to propose the reaction of analyzer for the approximation of the skin temperature to a terminal threshold it has hyperbolic nature, i.e., the intensity of signals from the skin receptors grows repeatedly in proportion to the approximation of the skin temperature to a threshold value.

To estimate the intensity of the hypothermal irritation $I_{ir}$ at any moment of time allows the expression:

$$I_{ir} = \frac{a}{(t_e - t_{term})^n} \qquad (1)$$

where $t_e$ - current temperature of the epithelium surface,
$t_{term}$ = -2,5 ˚C - the temperature of the beginning of cold defeat,
and: a = 2, n = 2.

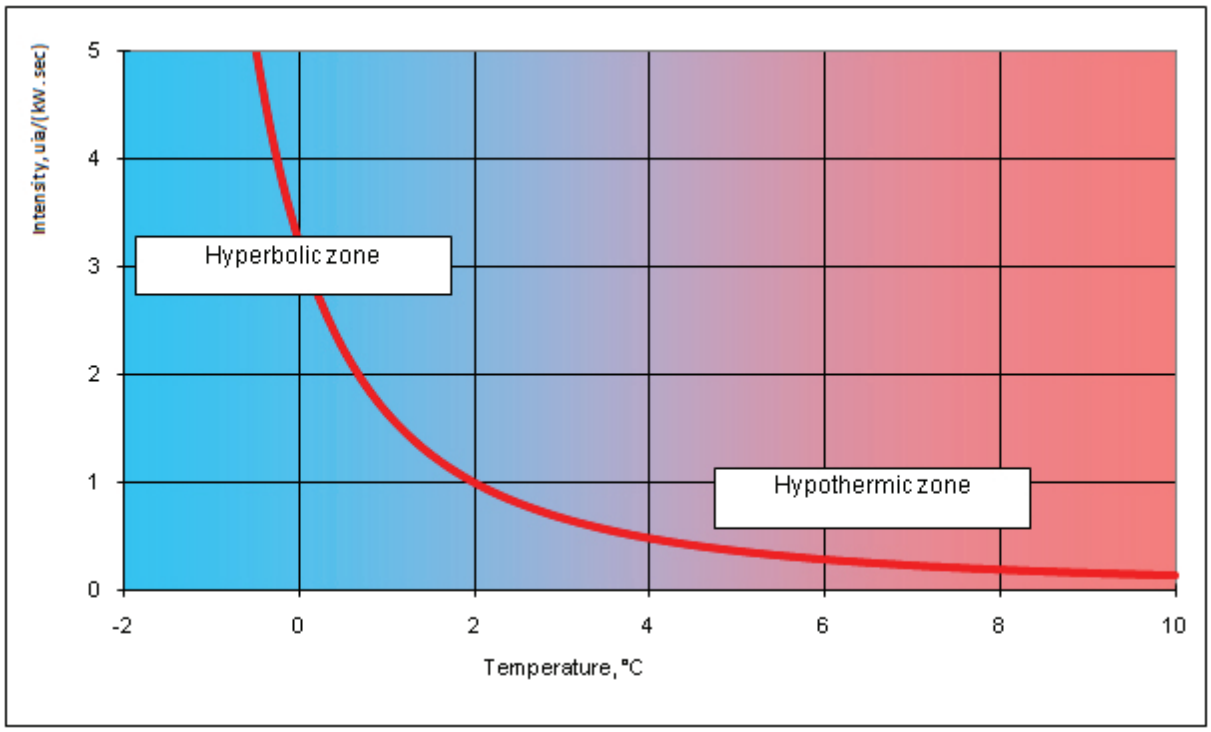


*Fig. 1 Intensity of hypothermal irritation with the different temperature values of the epithelium surface.*

Expression (1) makes it possible to quantitatively describe the intensity of the skin signal with the different values of its temperature entering from the surface unit. The graph of a change in the intensity of hypothermal irritation in proportion to reduction in the epithelium surface temperature is given to Fig.1. It is evident according to graph that at a temperature of the epithelium it is more than 2 ˚C, the intensity of signals from the cold receptors is small. But, in proportion to approximation to a threshold value of -2 ˚C the intensity of alarm signal grows hyperbolic.

The basis of the thermostatic control system reaction for the approximation of the epithelium temperature to a terminal threshold ensures the information, which enters through the extralemniscal sensory system (*in more detail into "Conducting ways of the realized sensitivity"*). This system evolutionarily most ancient, its basis compose primarily − the sensitivity, in particular cold receptors. The threshold of primarily

response − the sensitivity of receptors is high, they are activated only with the strong irritations, which create the threat of the irreversible injury of cloths. The extralemniscal system has the following distinctive characteristics. It will badly recognize localization of irritation. Its receptors react only to the action of terminal level. The conducting rate signals is low: 0,4−1,5 m/s. The system signals are distributed on entire division of thermostatic control; therefore strong, but localized, signal does not cause powerful response reaction and vice versa. With the transfer the information loses discretion, the considerable proportion of the information about the localization is lost. For activating the extralemnisal system are necessary rough, on the face of destruction, actions on the cloth.

***Extralemniscal sensory system*** integrates the scrambled signals, which come from all sections of skin; therefore the total volume of information about the danger, which threatens organism, is determined not only by intensity, but by area and duration of irritation.

When the intensity of the irritation of cold receptors for all points of body is identical, the total irritating action of cryogenic physiotherapy is determined from the expression:

$$S_{ti} = f \cdot \int_{\tau=0}^{\tau \le \tau_{max}} I_{ir}\, \partial \tau, \qquad (2)$$

where f - contact surface of heat-transfer agent and epithelium,
$\tau_{max}$ - the maximum safe duration of procedure.

For simplification in the records is introduced the unit of the measurement of the irritating action uia: $uia = (\mathrm{m}^2 \cdot \mathrm{s}) / \mathrm{K}$, $S_{ti} = [uia]$, $I_{ir} = [\, uia/(\mathrm{m}^2 \cdot \mathrm{s})\,]$.

The subjective perception of contact with the cryogenic medium is distorted by the fact that a change in the temperature of the skin irritates the receptors, which react to the rate of change in the controlled parameter. These receptors belong to other to sensory channel - lemniscal sensory system.

***Lemniscal sensory system*** evolutionarily appeared considerably later, it is most is well developed in primates and homo sapiens. The rate of conducting signals is high: 15 m/s. System carries out precise information about the localization and intensities of irritation; therefore it is the conducting way ″of the rapid ″ temperature sensitivity. This conducting way does not answer for the interpretation of irritation, but only it distinguishes and localizes it.

Subject more sharply accepts the signals, which enter through the second channel of cold sensitivity. Relying on subjective sensations many doctors and patients relate the therapeutic effect of procedure precisely with these sensations and they attempt to strengthen the hypothermal discomfort of procedure. In this case the powerful signals of lemniscal system can cause severe complications up to the sharp heart attacks. Strengthening the discomfort of patient in the course of procedure is useless

from a therapeutic point of view; therefore it follows the aim is reduction in the discomfort.
For the quantitative assessment of the sensations of subject in the course of cryotherapy the concept of the hypothermal discomfort index is introduced:

$$k_{hd} = \frac{\partial T_e}{\partial \tau}, \quad \left[\frac{K}{s}\right] \qquad (3)$$

The system of quantitative criteria proposed makes it possible to analyze the effectiveness of the work of hypothermal systems, to improve hypothermal technologies without the use of procedures dangerous for the patient.

The wide application of basic condition of thermophysical theory in combination with the mathematical simulation processes methods of cooling cover of cloths made it possible within the short time to carry out the large volume of studies and to obtain much new information. The results of studies repeatedly reported at the International conferences and were obtained acknowledgement and support.