

## Physical rehabilitation and thermoregulatory processes in athletes with disabilities

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### Abstract:

Both physical and sports methods are applied for rehabilitation of athletes with disabilities. Interrelationship of rehabilitation measures implies common goals, tasks and methods. Twenty qualified athletes 32-45 years of age, candidates for the Paralympic national team of Ukraine in archery were involved in the research. All the sportsmen were with traumatic consequences of musculoskeletal system. Methods of analysis and synthesis of theoretical and methodological publications in physical therapy of athletes with disabilities; method of thermography and method of mathematical statistics were used for the purposes of the study. Physical exercise during training sessions put forward excess requirements to physiological systems functioning of those practicing athletes who have traumas of locomotor apparatus. Administration of rehabilitative modalities such as correctional massage, passive exercises and stretching exercises increase the skin temperature indicators of lower limbs and stimulate blood and lymph flow in the area, which is massaged, enhance circulation in the neighboring areas and more remote veins and arteries. After applying the course of physical rehabilitation (6 months) the cutaneous temperature of the dorsum at rest increased by  $0,21 \pm 0,05^{\circ}\text{C}$  ( $p < 0,05$ ); of lower extremities – by  $1,51 \pm 0,11^{\circ}\text{C}$  ( $p < 0,05$ ); and of upper extremities – by  $1,35 \pm 0,09^{\circ}\text{C}$  ( $p < 0,05$ ). Physical rehabilitation of athletes with disabilities promotes the development of compensatory mechanisms, restores and enhances the ability to manipulative actions, corrects pathological condition related to underlying and associated diseases. Physical rehabilitation means application increases thermoregulatory processes, stimulates the work of peripheral vessels, increases metabolism, and improves regional blood flow.

**Key words:** disabled persons, athletes, thermography, thermoregulation, rehabilitation.

### Introduction

Integration of people with disabilities into the society, their social protection and support is one of the most important political priorities of in every developed country of the world, because human attitude to people with disabilities is largely a measure of a civilized democratic state structure (Shyyan, Slyvka, Turchyk, 2014). The studies of A.I.Kravchenko and V.I. Honcharenko (2008) in particular are devoted to the issues of work rate rehabilitation in football players with disabilities by mean of acupuncture. G.M. Boyko (2005, 2007) and O.M. Maksimova (2005) investigated theoretical and methodological aspect of medical and psychological classification of athletes belonging to all nosological groups. The specificity of autonomic regulation of cardiovascular system in basketball players with lesions of the spinal cord by means of physical rehabilitation was investigated by O.Romanchuk and M. Sorokin (2005). The role of physical training and sports in physical rehabilitation that improve disabled athletes' standards of living is presented in the research of V.V.Khramov (2008, 2010). R.Y. Rudenko (2010 – 2014) has carried out a number of research on the effect of physical therapy measures upon physiological condition of athletes with disabilities. In particular, monitoring of potassium, calcium, phosphorus, creatinine and creatine kinase in blood, 17-KC of urine at rest, after exercise, after a course of physical rehabilitation have been administered; methodology of correctional massage, active and passive exercises with a glance at underlying and accompanied diseases, amount of physical activity in different periods of the training process (Rudenko R., 2014). The issues of physical therapy development in Ukraine, rehabilitation and sport for disabled persons were investigated by J.O. Liannyi (2010, 2013). Problems of diagnostic tests, role of clinical practice in physical rehabilitation experts training are stated in the research of T.V. Boichuk (2008 – 2012). Functional capacities of archers with disabilities according to the indicators of muscle strength and sensitivity as well as sense of time before and after control competitions were analyzed by A. Mahliovanyi (2002). The author substantiated the necessity of specific physical activities in preparing the athletes with disabilities for training and competitions. Joel A. DeLisa, M.D., Professor, the founder of

Foundation Research Center, Head of the Department of Restorative Medicine and Rehabilitation of Medical School in New Jersey in 2010 reissued a manual "Restorative Medicine: principles and practice". One of the chapters is devoted to practical advice on physical rehabilitation in different diseases, the relationship between the rehabilitation and sport is outlined. In 1966 Ludwig Huttman (Stock Mandevil, UK) founded British Association of athletes with disabilities. He fundamentally changed theory and practice of rehabilitation for disabled people, giving preference to doing sports. In conclusion it is indicated that physical rehabilitation of disabled people improves physical abilities of patients. Disabled persons with injuries of musculoskeletal system should be actively involved in sports (Gowin W., 2010). Current research highlight mainly the issues of improvement of sports training, pedagogical and psychological aspects of support for athletes with disabilities, methods of disabled people integration in modern society, physiological changes in the body under the influence of physical activity (Bashkin, Makarova, 2012; Kravchenko, Chkhajlo, 2008; Bozon, Vanlandewijck, 2007). There is a lack of scientific papers that would disclose the mechanism of physical rehabilitation measures, regulation of physical activity with a glance at their main clinical course and comorbidities. Thus the range of problems in our research was caused by objective requirements as well as by the development of sport for athletes with disabilities in general.

### Material & methods

Organization of the research. Educational observations were held at the premises of the shooting range of Lviv National Medical University named after Danylo Halytskiy. Thermography indicators were analyzed at the Lviv Regional Clinical Diagnostic Centre. Twenty qualified athletes (Masters of Sport International Class, Masters of Sport, 1-st category) candidates for the Paralympic national team of Ukraine in archery were involved in the research. Athletes 32-45 years of age with traumas of musculoskeletal system took part, 6 of which were females and 14 males. The studies were conducted in the same room, and at the same time (in the morning). Women have not been studied during ovulation (female body temperature depends on the rate of hormonal activity and menstrual cycle). Their experience of training activity reached from 6 to 10 years. The research lasted 6 months (according to the decision of Ethics Committee of the Lviv National Medical University named after Danylo Halytski, minutes No2 of February 16, 2015).

Methods of research. Analysis and synthesis of information of scientific, methodical and professional literature; analysis of medical statistics; biomedical methods: thermography, methods of mathematical statistics. Analysis of current publications was accomplished within the framework of the problem field of the research topic including the issues of underlying and concomitant diseases, physical rehabilitation, and physical capabilities of athletes with disabilities. Medical statistics data were analyzed according to medical records. General classification allowed to determine diagnosis and degree of impairment, whereas functional diagnostics allowed to define the degree of locomotor skills enabling to participate in appropriate competitions. Locomotor abilities of Paralympic participants are taken into account regardless of their fitness, and athlete's classification or category is subjected to constant revision depending on the possible functional changes of the body.

Thermography is a method of functional diagnostics, which registers infrared radiation of a human body proportional to its temperature (Kotovskij, Mikitenko, 2008; Hildebrandt, Raschner, Ammer, 2010). The distribution and intensity of thermal radiation is determined by nature of physiological processes taking place in a human body. The thermography method allowed to study the effect of physical rehabilitation measures upon the cutaneous temperature of separate parts of the body (Rudenko, 2013; Larin, Zamechnik, 2008). The study was conducted on a colour computer thermograph „Райдуга” ТБЦ-0,1. Statistical analysis of data was carried out using Microsoft Excel for Windows, SPSS 10 for Windows, Statistica 6.0 application packages. Arithmetic mean ( $\bar{X}$ ), error of the arithmetic mean ( $S_x$ ), variance ( $D_x$ ), standard deviation ( $\delta_x$ ), coefficient of variation ( $V$ ), correlation coefficient ( $r$ ) etc. were measured. Conventional statistic methods were applied.

### Results

Modern system of training top-class athletes is characterized by complex structure of training process that is based upon strict periodization, variable loads appliance etc. For this reason a permanent monitoring of athletes' functional condition is of great importance (Briskin, 2006). Optimum balanced control is needed because it is impossible to achieve high results or exercise too vigorously without causing damage to athlete's health. The programme of physical rehabilitation for athletes with disabilities takes into account the impact of physical activity; it is elaborated for individual needs according to the range of disability or lesion, pathological changes or clinical course of underlying and concomitant diseases (Mukhin, 2010). Spinal cord injuries might cause different types of paralysis whose nature depends on localization of lesions (Morozov, Poljakova, Kareva, 2011). In case of lesion focus occurrence in the cervical spine the flaccid paralysis of upper extremities and the spastic paralysis of lower limbs is developing. In case of lesion area in the thoracic spine the spastic paralysis of lower extremities occurs and flaccid paralysis of lower limbs develops when lumbar thickening and *cauda equine* areas are injured. Besides focal symptoms in spinal cord injuries other functional abnormalities are observed, like hearing or vision loss, speech disorders, visceral organs functioning (respiration, circulatory system, urination, defecation etc.). All the above mentioned factors impede rehabilitation (Boghdanovsjka, 2012).

Method of thermography implies diagnostic study of the dynamics of human thermogram spatial structure, which allows to determine quantitative characteristics of the body thermoregulatory processes during various types of physical activity or manipulative procedures (Mjatyga, Mjatyga, 2011). Temperature distribution in different parts of a human body may serve as a diagnostic criterion of certain physiological processes that take place in the organism and are caused by mechanical action or physical exercise etc. Human body temperature is maintained at a relatively constant level irrespective of ambient temperature fluctuations (Chudecka, Lubkowska, 2012). This temperature relative constancy (isothermal temperature) is necessary for body normal functioning and is maintained due to balance of heat production and heat loss throughout the body. Isothermal temperature is achieved by means of physiological (nervous and endocrine) mechanisms of thermoregulation. In flaccid and spastic paralysis motor functions as well as thermoregulation processes are disturbed. Optimal ratio between heat production and heat loss is provided by a set of physiological processes called thermoregulation. Major source of thermogenesis in the body is cellular metabolism. Oxidative processes take place in the cells and organs being accompanied by energy release. The most intense thermogenesis occurs in muscles. In dormancy the skeletal muscles produce 20% of heat. A small motor activity increases thermogenesis to 50 – 80%, whereas heavy muscular work increases this parameter to 400 – 500 % (Bozon, Vanlandewijck, 2007). Skin blood flow plays a significant role in all the above mentioned mechanisms. Heat output increases considerably with skin blood flow growth. Volume of blood circulation increase has the similar effect.

The study of thermography indices are presented in the publication of Sonkin et al. (2011). The authors analyzed thermal condition of the body during extreme tests with application of physical and cold stress. The researchers claim that brown adipose tissue of an adult participates in thermoregulatory responses and generates additional heat in case of acute or chronic cooling. The study was conducted with the prospect of further differentiated diagnostics of the conditions characterized by thermoregulation changes, which might be registered with the help of infrared thermography. Boguscesky, Kovalska, Adamchuk, Bialoshevsky, (2012) studied the application of sports massage and aerobic exercises in training process. The authors emphasized the effectiveness of massage during warming up period for the improvement of psychomotor functions, physical exercises performance and injury prevention. The effect of heat modalities in rehabilitation of swimmers with disabilities is described in the research of Neniana Prystupa (2014). The author remarks that muscle stiffness during trainings has a sinuous pattern. Finnish sauna reduces increased muscle tone at rest and maintains fit body condition. The conclusions confirm the benefit of sauna for the disabled athletes' rehabilitation. Adamchuk, Mastey, Boguscesky, Bialoshevsky (2013) investigated the appliance of thermography in indirect noninvasive evaluation of physical performance. The effect of exercise tests upon skin temperature changes in different parts of the body was studied and correlation between the body temperature and maximal oxygen consumption (VO<sub>2</sub>max) was determined. The results of the research indicate a direct relationship between the body temperature and maximal oxygen consumption. The lower the skin temperature of the trunk is, the higher VO<sub>2</sub>max indices are (Adamchuk, 2013).

The suggested author programme of physical rehabilitation for athletes with disabilities has its own peculiarities. Physical rehabilitation measures have a selective effect since they combine both general and special influence upon systems of the body. Elaboration of health-protective component, improvement of overall condition as well as moral and volitional qualities – all these factors belong to physical rehabilitation measures. Special effect implies improvement of body system functioning caused by primary or accompanying pathology. Relationship between general and special influence of physical rehabilitation is complicated because the differentiation of indirect action upon work rate increase takes place, as well as improvement of body organs and systems associated with clinical course of underlying and concomitant diseases. However identification of this relationship, its appliance for health improvement, overcoming the restrictions of motor functions and malfunction of internal organs – all these factors are within the tasks and goals of physical rehabilitation. Physical rehabilitation of athletes with disabilities has only correctional orientation upon athlete's condition. Thus therapeutic massage was administered three times a week, swimming pool – twice a week, sauna – the last day of training microcycle, stretching exercises, muscle relaxation and special breathing exercises were recommended at the final part of the training session. Remedial massage implies administration of preliminary, training and restorative massage (Rudenko, 2014). Special correction was accomplished by means of segmental-reflex and selective massage of paravertebral areas. Some indicators of physical rehabilitation effect upon the training process were examined both in dynamics and in the current control of physiological body systems condition in athletes with disabilities.

The influence of physical rehabilitation on the skin thermography indicators of certain parts of the qualified disabled athletes body was studied at the beginning and end of the research after physical rehabilitation modalities application during 6 months. Thermography indicators of upper extremities of archers with disabilities were within the physiological norm. The examined athletes with injuries of the spine have impaired or completely absent motor functions of lower limbs, dysfunction of the pelvic organs, atrophy of the muscles of lower extremities, decreased metabolism. The above malfunctions were confirmed by thermography indicators of lower limbs before physical rehabilitation appliance. Due to the capability of the body to maintain constant temperature and thermal radiation of the tissues it was possible to determine on how these figures are reduced as

compared with physiological norm. In flaccid and spastic paralysis the thermoregulatory mechanism is violated, and partial stimulation of this process is due to administration of physical rehabilitation measures. The results of thermoregulatory processes are presented in the Table 1. Mean skin temperature indicators of the lower extremities in athletes with disabilities who suffered from paresis and paralysis were  $25,32^{\circ}\text{C}$  ( $N=28-30^{\circ}\text{C}$ ) at the beginning of the study. The lack of movement in the lower extremities reduces the activity of metabolic processes. Vasoconstriction of skin, opening of arteriovenous anastomoses contributes less heat influx from the core to the shell and the heat retention in the body.

Table 1. Changes of thermo topography indicators of the skin from various parts of the body in qualified athletes with disabilities ( $n=20$ ) under the influence of specific physical activity and physical rehabilitation modalities

No.	Parts of the body	M $\pm$ m	SD	CV
<i>At rest</i>				
1	Dorsum skin temperature	33,71 $\pm$ 0,06	0,27	0,81
2	Temperature of the lower extremities	25,32 $\pm$ 0,07	0,3	0,91
3	Temperature of the upper extremities	31,56 $\pm$ 0,07	0,3	0,44
<i>After specific physical activity</i>				
1	Dorsum skin temperature	34,67 $\pm$ 0,05	0,32	0,91
2	Temperature of the lower extremities	27,23 $\pm$ 0,11	0,53	1,56
3	Temperature of the upper extremities	32,72 $\pm$ 0,09	0,51	1,61
<i>After the course of physical rehabilitation at rest</i>				
1	Dorsum skin temperature	33,92 $\pm$ 0,06	0,24	0,71
2	Temperature of the lower extremities	26,83 $\pm$ 0,11	0,26	0,80
3	Temperature of the upper extremities	32,91 $\pm$ 0,09	0,24	0,82

CV – coefficient of variation M – arithmetic mean; m – error of the arithmetic mean;  
SD – standard deviation.

After the course of physical rehabilitation (6 months) we can observe the increase of skin temperature in various parts of the body. Thus, the dorsum skin temperature at rest increased by  $0,21\pm 0,05^{\circ}\text{C}$  ( $p<0,05$ ); of the lower extremities – by  $1,51\pm 0,11^{\circ}\text{C}$  ( $p<0,05$ ); upper extremities – by  $1,35\pm 0,09^{\circ}\text{C}$  ( $p<0,05$ ). Apparently the rise of temperature had a temporary effect and metabolic processes increased due to physical rehabilitation administration.

## Discussion

In free nerve endings there are receptors sensitive not only to pain but also to mechanical and thermal stimuli (Hildebrandt, Raschner, Ammer, 2010). Massage techniques in particular raise skin temperature, stimulate cutaneous receptors. Excitation of a significant number of cutaneous receptors is accomplished as follows: the mechanical stimulus deforms the receptor membrane, which makes it easily penetrative for Na ions. Ionizing current arises causing the receptor potential and, depending on strength of stimulation, the change of frequency of the impulses that come through the fiber to CNS occurs. Massage enhances the process of discharge in the salivary and sweat glands. Skin thermoreceptors are the most studied. Cutaneous receptors are of two types: cold and heat. Cutaneous receptors transmit various stimuli like mechanical (massage techniques) to nervous impulses. It is possible to affect CNS through the receptors by *через рецептори за допомогою прийомів* means of massage procedures thus managing different body organs and systems. Different massage techniques have different effect on the receptors. Massage effect upon human skin is also different. Thanks to massage the dead cells of the epidermis are peeled and removed from the skin surface, the inflow of the arterial blood to the massaged area increases, blood supply to the tissues increases, enzymatic processes including plastic ones are enhanced and thus a new skin structure appears. Under the influence of massage the outflow of venous blood and lymph increases, this in its turn helps to reduce swelling and congestion not only in the massaged area but also in more remote areas. Massage improves skin breathing, increases the secretion of subcutaneous glands, and helps to remove waste products from the body (Adamczyk, Boguszewski, Siewierski, 2012). Under the influence of massage the release of histamine and acetylcholine increases thus creating favourable conditions for muscles activity. During vigorous stroking acetylcholine is secreted causing the expansion of thermal blood vessels and blood flow intensification. Turning into an active state under the influence of massage acetylcholine provides transmitter function stimulating muscles activity. Under the effect of acetylcholine the transmission of neural excitation from one cell to another and from neurons to muscles is intensifying. It has been stated that massage affects not only structural layers of the skin but also CNS activity through numerous extra- and interoreceptors. Even the slightest changes in the nervous system are reflected in the receptor apparatus of the skin and *visa versa*, the changes occurring in the skin under a temperature stimulus affect the CNS functioning (Akimov, Andreev, Arkov, 2009; Chudecka, Lubkowska, 2010). Massage improves the skin and muscle tone

thus making the skin smooth, dense and elastic (Sukhostat, Stepashko, 2010; Yefymenko, 2012; Rudenko, 2014). Thus according to experts different massage techniques affect the whole body due to its influence upon the skin with the help of neuro-reflex, humoral and mechanical factors. Comparing thermography indicators before physical rehabilitation modalities application after rehabilitation procedures the temperature increase of the skin could be observed that affects metabolic processes, reduces the processes of atrophy in muscles, improves blood flow to pelvic organs.

### Conclusions

Current publications on rehabilitation issues in connection with training process and athletes with disabilities sports results improvements demonstrate the relevance of this topic. The study of thermoregulatory mechanisms enables to investigate the effect of physical rehabilitation measures on metabolic processes and muscles conditioning. Physical education and sports for people with disabilities is a constituent of their recreation, leisure, rehabilitation and social adaptation. Renovations and improvements of the recovery methods are called for the provision of physical work rate increase, better sports results, improved quality of life and social adaptation of people with disabilities.

The results of thermography analysis could be applied to determine the state of thermal conductivity of the body with a glance at underlying and concomitant diseases, physical stress effect, training sessions planning for athletes with disabilities.

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