INNOVATIVE TECHNOLOGIES IN RUSSIAN SPORT

Innovative Technologies in Russian Sport

Results of applications of innovative technologies in sport, developed in Saint Petersburg Research Institute of Physical Culture are presented. All technologies are accepted by the Russian Ministry of Sport for application in the training process of Olympic and Paralympic teams of Russia. Examples of complex research studies are discussed in details.

Shelkov O.M., Korotkov K.G., Churganov O.M. (editors)

Ministry of Sport of Russian Federation

Saint Petersburg Research Institute of Physical Culture

On the first cover photo of the Institute leading scientists (from left to right):

Standing: Kleshnev I.M., PhD, Golub J.V., PhD, Shelkov O.M., PhD, Professor, Mitin E.A., PhD, Professor, Zlidnev A.A., PhD, Churganov O.A., PhD, Professor, Korotkov K.G., PhD, Professor.

Sitting: Gavrilov D.N., PhD, Korotkova A.K., PhD, Barjaev A.A., PhD.

On the back cover photos of the Institute researchers.

Contents

INTRODUCTION

In 2014 a significant sporting event in the history of modern Russia - Olympic and Paralympic Winter Games in Sochi was held. Paralympic Games are the second largest after the Olympic Games. Attention to the Paralympic Games from the public around the world is increasing every year. Paralympic Games in Sochi have collected a record number of participants - 555 athletes from 45 countries of the World. According to the results of the games, Russian athletes set a new record in the unofficial medal count for the number of medals won. With the result of 30 gold (41.7% of the total number of gold medals played out) and a total of 80 awards of merit (37% of total medals) medals, Russians surpassed Austrian athletes who won 34 gold (31.8% of the total number of gold medals) and 70 total (22.2% of the total medal count) at the Paralympic Winter games in Innsbruck in 1984.

Large contribution to the preparation of the national teams of Russia was made by members of the complex scientific groups of St. Petersburg Research Institute of Physical Culture, who was doing systematic analysis of the preparedness of athletes in the entire four-year cycle of training, which allowed to help coaches with specific recommendations.

I am confident that the positive experience and the knowledge collected by specialists of the complex scientific groups will be helpful both to the Russian Paralympic movement and to the development of international sport.

Director of the St. Petersburg Research Institute of Physical Culture
Professor O.M. Shelkov

DEVELOPMENT OF INNOVATIVE TECHNOLOGIES FOR THE TOP LEVEL SPORT

In St. Petersburg Research Institute of Physical Culture for many years a system for assessing, monitoring and correction of competition readiness of the qualified athletes is being developed. Diagnostic approaches and methods have been tested in the course of scientific and methodological support of athletes from Russian Olympic and Paralympic teams during training and competition periods. Depending on the purpose of the study, the examination of one person takes 15-45 min.

Integrated control methods allow an objective assessment of motor performance and psychophysiological provision of motor activity in the parameters of time, space and effort, as well as indicators of the conscious, motor, autonomic functions and components of mental state.

Reviews of coaches, athletes, leaders of the sport Federations showed high practical importance of various monitoring systems for athletes and high probability of competitive success forecast.

High performance sport is characterized by a number of factors that distinguish it from ordinary physical training:

- The need to maximize the psychophysiological resources at the time of the competition;
- Suitable spending of the bioenergy resources in accordance with the calendar of competitions;
- Efficient use of relaxation - recovery periods in between competitions to resume the lost resources.

However, in the first place should be taken into account the need to maintain athletes' health, preventing it from overtraining and surge leading to breakdowns and psychophysiological injury.

Implementation of the developed systems in the Russian sports allowed to increase the effectiveness of the process of selection of top level athletes in the course of many years of training through the introduction of innovative technologies and systematic monitoring of mental and physical capacity in relation to the effectiveness of competitive activity to enhance the effect of healthy training activity. This manual describes the main developed methods and approaches.

METHOD OF FORECAST OF NATURAL HUMAN PSYCHOLOGICAL FEATURES OF A PERSON

Technique is implemented through software and hardware diagnostic complex "Forecast" (certificate number 2002611802 from 18.10.02, issued by Rospatent, authors Drozdovskii AK and Nosach AR).

Diagnostic complex "Forecast" allows to diagnose personality characteristics, properties of the nervous system of a person, identify typological features and based on them predict natural psychological characteristics in the following areas:

- Psychomotor (motor memory, machinery movement, balance, coordination, speed, complex (differentiating) reaction - the ability to play activity, the rate of muscle tension (sprint makings), the rate of muscle relaxation (stayer makings), speed recovery processes load speed simple motor response - the response to the start signal);

- Intellectual activity (speed of formation of the visual image - perception of reality, memory arbitrary (for character information) - the ability to remember a predetermined text information, involuntary memory - the ability to remember life situations, concentration, switching of attention, speed and associative thinking processes, type thinking, critical thinking);

- The individual style of learning, sports and professional activities (start-up duration, the rate of learning, the dominant aspect of the activity, the predominance of orienting or executive style, adaptability to dynamic situations, the tendency to competition, leadership);

- Resistance to adversity and volitional characteristics (emotional and mental stability, adaptability to adverse environmental factors, speed of decision-making in important situations (determination), courage in stressful situations, perseverance (resistance to static postures), patience, tenacity (work on background fatigue) resistance of monotony, endurance (work until exhaustion).

Forecast of psychological features of a person opens up opportunities for the development of practical recommendations aimed at optimizing the methods of psychological correction of adverse conditions, the construction of individual training and educational programs, the selection of types of sports and professional activities, the compatibility in communication, increase the efficiency of interaction in teams to achieve high results.

Typological features are closely connected with the mental, physiological, biochemical levels. Main advantages of the system: speed (10-15 minutes for each person), reliability, wide age range, and informative.

UNIFIED SYSTEM OF ATHLETES' ANALYSIS

The complex allows quickly evaluate motor activity on the parameters of time, space and effort, as well as indicators of conscious, motor and autonomic components of the mental status and functions. Since 2003, the complex is widely used in scientific and practical support of the Olympic and Paralympic teams of Russia. The procedure is based on the concept of genetic predisposition of a person to certain movements and actions that can be most effectively developed and implemented in the training process. Technique meets the requirements of standardization for the assessment of motor and mental activity, regardless of its type, gender and age of a person. Depending on the purpose of the study a minimum time of inspection per person is 15-45 min. According to the results of monitoring "Profile of an athlete" is formed.

Upon completion of the survey, the following features are evaluated:

- Stability of performing of the main competitive exercise;

- Provision of motor sports activity, which depends on the condition of a person, his self-evaluations and psychology features.

- Psychological status, which consists of the evaluation of the following main components - motivation, activity and originality of propulsion, psychological comfort - discomfort and the level of emotional arousal, situational anxiety.

The system allows analyzing the following parameters:

BIOELEKTROPOTENTSIOMETRIYA	
at the beginning of the survey	at the end of the survey
SELF-EVALUATION	
Wellbeing	confidence in achieving the goal
Mood	Satisfaction in the training process
Desire to train	clarity of purpose
MENTAL STATE	
Situational anxiety	Vegetative factor
Mental comfort-discomfort	Sport Motivation
The sense of time	
MOTOR ACTIVITY (SPEED, POWER)	
Simple reaction	The total time of motion
Reaction of motion	Maximum frequency
The speed of movement	Maximum Power
Spatial accuracy	
ACCURACY OF MOVEMENTS	
Visual-motor reaction	Sense of effort
Sense of space	Power asymmetry
Tempo asymmetry	Asymmetry of space
MOTOR ACTIVITY	
Activity in tempo	Activity in strength

EVALUATION OF THE FUNCTIONAL STATE OF ATHLETES

Basic research opportunities

The main direction of the NIIPC in the field of sport physiology is a comprehensive assessment of the functional state of the athletes in order to select and predict the success of competitive activity and stability of the results. In this vein, in-depth study of the cardiovascular system and bio-energetic characteristics of athletes is carried out.

The main practical conclusions:

1. definition of physical development;
2. determination of the structural and functional reserves of an athlete, exercise capacity, depending on the stages of the annual and long-term training;
3. evaluation of physical qualities of the athlete;
4. forecast of competitive efficiency and reliability;
5. evaluation the level of fitness and overtraining.

Diagnostic techniques:

1. Determination of the morphological status

Anthropologic and morphologic features have an impact on the manifestation of the basic motor qualities - strength, speed, endurance, flexibility; provide adaptation to different environments, which define recovery period after training and competition loads.

The specificity of the particular sport leaves its mark on the athlete's body, resulting in its complexity, the proportions of the body, especially the development of major systems (cardiovascular, respiratory, musculoskeletal system). IN the process of sport activity not only the formation of individual morphological traits and body as a whole is happening, but also the selection of individuals with the most favorable for the particular sport specialization of morphological characteristics and physical properties.

The study of the relationship between anthropometric indices and athletic performance is important for the development of recommendations on optimization of different periods of the training process. It is also possible to adjust the individual components of body weight (fat and muscle) to increase athletic performance.

2. Electrocardiography at rest, during exercise, during the recovery period.

This method allows evaluate the state of the cardiovascular system, its dynamics under the influence of physical activity of varying intensity.

3. Methods of testing using different physical activities, on the basis of the International Biological Program. During exercise is carried out:

- Spirometric tests (determination of pulmonary ventilation);

- Gas analysis of consumption and exhaled (the definition of aerobic and anaerobic power, capacity and efficiency of physical work); by this such important physiological parameters, as maximum oxygen consumption (MIC), the oxygen debt (lactate and alaktatnye its fractions), the threshold of anaerobic metabolism (ANSP), oxygen pulse, the utilization rate of oxygen consumption and the percentage of oxygen evolution, the excess carbon dioxide emissions (ExcCO2) is determined;

- electrocardiography.

All this allows estimate the physical performance of athletes, the level of fitness and overtraining.

4. Analysis of heart rate variability at rest, during exercise and during functional tests. Evaluation of the status and reserves of the neurohumoral regulation of the body.

5. The method of correcting the body functioning and physical performance using electro-mio-stimulation techniques and manual techniques.

6 Electromyography. Evaluation of the space-time interaction of muscle (intramuscular coordination).

7. Miotonometry. Evaluation of the function of the neuro-muscular apparatus.

8, Polidinamometriya of different muscle groups.
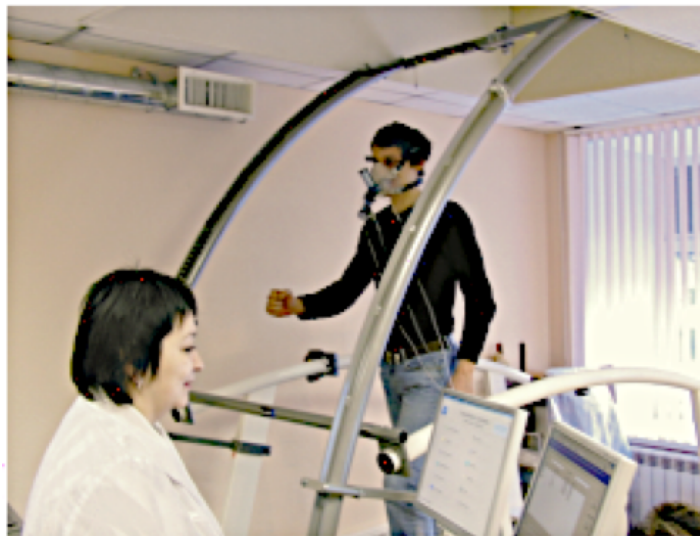
STABILOMETRY TECHNIQUE

Computer stabilometry technique is a complex technical and methodological tools and software that enable the acquisition, processing and analysis of the trajectory of the center of pressure (CSD) of a person on the support base in the process of maintaining their upright posture.

Stabilometry analysis allows assessing the degree of participation of the different sensory systems of the body to set up the body, and provides the possibility of mathematical processing stato-kinezio-gramms for the various functional tests. Methods is used in sports medicine, neurology, orthopedics and prosthetics. Dynamic assessment is carried out on the universal stabilometry indicators.

The following conclusions was developed by PhD Emelyanov VD:

- Statokinetic violations are not revealed;
- Statokinetic violations of the mild preclinical level;
- Moderate statokinetic violations;
- Expressed statokinetic violations.

The values of   stabilometric indicators provided by the survey are compared with the values of apparently healthy people. The resulting data can be used to correct the training process of athletes depending on gender, age and nosology (for Paralympic sport) characteristics of the groups.

HARDWARE-SOFTWARE COMPLEX FOR PSYCHOPHYSIOLOGICAL TESTING "SIGVET"

Complex offers test for the analysis of the psycho-physiological state of motor skills: critical frequency of light flashes, simple and complex sensorimotor reaction, mobility of nervous processes, balance of the nervous processes, response to a moving object, tapping tests, red and black tables, the quality of visual perception, proof-tests, etc..

BIOFEEDBACK DEVICE MINDSKIN

The instrument measures the electrical resistance of the skin.
Biofeedback shows the degree of physiological processes changes in different situations. Consciously tracking these changes, one can learn to use techniques of breathing, visualize the impact and remove the influence of stress. Biofeedback of galvanic skin response is used:
 - To increase stress resilience;
- For the rapid assessment of psycho-physiological state of an athlete;
- To focus and mobilize the will and resources of the body;
- To accelerate the development and implementation of autogenic training.

GDV BIO-WELL SYSTEM

Bio-Well is a revolutionary, non-intrusive way to measure human energy field using a specialized camera and software system.

Bio-Well has been developed by the team of Professor Dr. Konstantin Korotkov and brings the powerful technology known as Gas Discharge Visualization (GDV) technique (www.ktispb.ru) to market in a more accessible way than ever before. The product consists of a desktop camera and accompanying software, which allows a user to quickly and easily conduct human
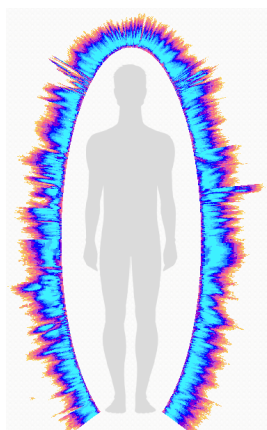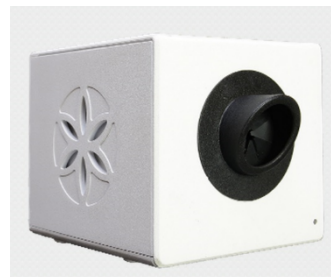
energy scans. When a scan is conducted, a weak electrical current is applied to the fingertips for less than a millisecond. The object's response to this stimulus is the formation of a variation of an "electron cloud" composed of light energy photons. The electronic "glow" of this discharge, which is invisible to the human eye, is captured by the camera system and then translated and transmitted back in graphical representations to show energy, stress and vitality evaluations. Each scan returns a wealth of meaningful information to provide you with a truly holistic view of the state of your wellbeing.

The image, which we create in Bio-Well instrument, is based on ideas of Traditional Chinese Medicine and verified by 18 years of clinical experience by hundreds of medical doctors with many thousands of patients. The scanning process is quick, easy and non-intrusive… do it daily for best results! Get real time feedback on what factors - positive and negative - affect your energy state. View each scan in a variety of interesting ways with up to seven result display options. With the BioWell accessory pack add-on, measure environment and object energies too!

Bio-Well is not a medical instrument. It gives you an impression of your Energy Field and allows to see its day-to-day transformation and the influence of different situations and stimulus to your HEF and hence, to your condition. Friendly

software makes data processing simple and convenient for non-experienced users. With Bio-Well you do not need to be a scientist to make full-scale scientific research!

In order to use your Bio-Well device, you also need an accompanying subscription. While the Bio-Well device captures the scan images, the subscription is the bread and butter of the system. It allows access to our complex algorithm that transforms your scan images into truly meaningful results. You may take images being off-line, and being on-line, you will get all the information. You can choose from three levels of subscription depending on your needs.

Download free software from www.bio-well.eu and view demo accounts.

WHAT CAN YOU DO WITH YOUR BIO-WELL INSTRUMENT
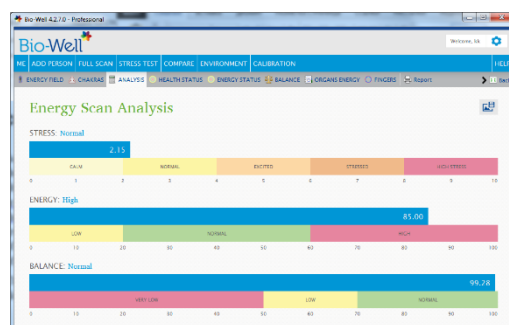
Measuring Human Energy Field
Human Energy Field (HEF) – is the most sensitive reflection of physical, emotional and, in some cases, spiritual condition of a person.

Stress Level evaluation

Through the utilization of special software, it is possible to make a quantitative assessment of the anxiety and health index on a 10-point scale.

0-2 - very calm, relaxed people.

2-4 - normal quiescent state.

4-6 - the excited state characteristic of active work, excitement, intense activity.

6-8 – high level of stress

8-10 - a very high level of stress, the peak of excitement.

Chakra Measurement

According to Eastern metaphysical theories and principles of Ayurvedic Indian medicine, there are seven "Chakras" or integrated energy centers that are considered to affect physical, mental, emotional, and spiritual well-being.

Health Status and Energy Status

Present analysis of the functional state of the human body, by calculating the integral parameters of energy distribution in the body and in organs.

Balance

Shows energy balance for different organs and systems for both right and left side of the body.

Screening

Allows to see particular sectors of different fingers related to body systems as well as to different organs. Numbers indicate the level of energy (in Joules). Colors have the following indication:

| Optimal condition | Energy deficiency | Energy blockage | Hyper Energy

Fingers

See Bio-grams of all 10 fingers divided to sectors. Click with left mouse button on the particular finger allows seeing informational screen.
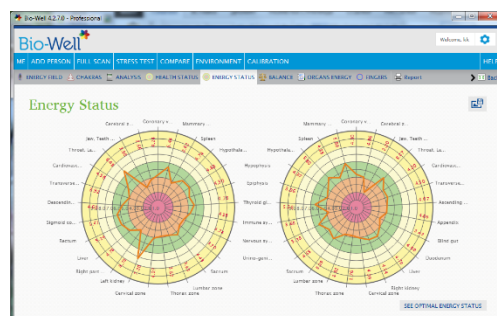
Report

Preparation of printout for the customer. All information may be corrected.

Pressing **Save** button allows to save document as PDF file.

Export to CSV

Save all parameters for the processing in Excell, MathLab or any other program.

Monitoring Energy Reactions

With Bio-Well instrument you may follow up transformation of Energy Field in the process of treatment, exercise, meditation or any other activity. You may test different substances – food, medications, etc.

Environment Scan

Bio-Well instrument with "Sputnik" antenna allows you to monitor time dynamics of the Energy of the Environment. This may be interesting for several aims:

1. Testing different places looking for places with calm and turbulent energy.
2. Testing Energy situation in different places depending on the position of sun, moon, time of the year, etc.
3. Measuring energy in the Places of Power – both natural and man-made – temples, sacred places, ancient cities, etc.
4. Testing Geoactive Zones, in particular, Geopathic Stress Zones.
5. Detecting the influence of emotions and focused attention to the environment.

BioCor accessory

BioCor is a unique device that aids in shifting and correcting your energy state and balance through the use of high frequencies. This device should be used in conjunction with the Chakra audio setting in the BioWell software. Based on your frequencies Bio-Well program creates individual music file, which are send to BioCor device and applied to special earphones together with high frequency modulated by your own frequency.
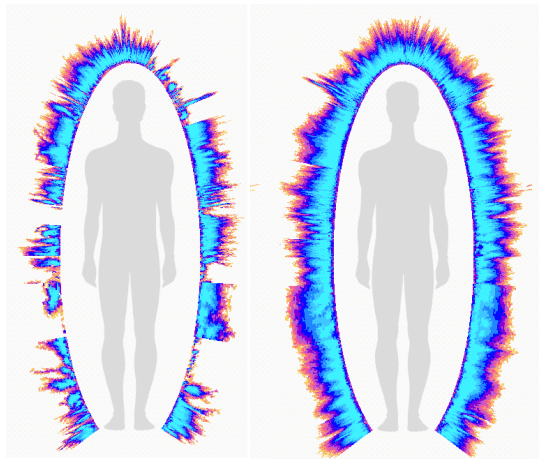
Change of Energy Field after using BioCor

Getting Started

1. Order Bio-Well instrument from your local distributor or from www.bio-well.eu.

2. Download free software for Mac or Windows.

3. Connect your Bio-Well to the computer via USB port.

4. Open Bio-Well software and test free demo accounts.

5. Create your subscription at www.bio-well.com.

6. Start using Bio-Well with your login and password.

All information and programs operate at different languages
For more information visit www.bio-well.eu

HEART RATE MONITOR WITH DIAGNOSTIC STAND «POLAR TEAM^2»

Designed to work with your coaching needs, the POLAR TEAM² system allows you to gain a unique insight into the fitness capabilities of your team. Easy to implement, TEAM² means you can get the most out of your training sessions. Polar heart monitoring technology integrates into the program allowing to achieve the optimum level of fitness for athletes, help eliminate major injuries and prevent overtraining. Polar TEAM² Pro set includes base station, transmitter charger, 10 rechargeable transmitters, USB port and software for PCs.

Since the first Polar heart rate monitor was developed in 1982, Polar Electro has been committed to conducting innovative physiological and sports medical research. In fact, all of the features in Polar products are based upon scientific work and are in accordance with recommendations from the world's leading sports medicine authorities. In addition to its own in-house research and development, Polar Electro is also involved in co-operation with a number of research institutions worldwide, the results of which have been presented in many scientific congresses and published in international scientific papers. Besides individuals interested in their personal well-being, Polar heart rate monitoring and

analyzing technology has been used by numerous researchers in the fields of sports, exercise and health. In the following sections you'll find numerous articles about the research we, and other organisations have carried out in relation to Polar products and exercise training.

VIDEO AND PHOTO RECORDING IN THE FIELD

Photo and video recording of the training and competitive process of Russian national teams for winter and summer sports (Nordic combined, ski jumping and Paralympic teams for cross-country skiing, biathlon, athletics, swimming, rowing) is important part of athletes' preparation process. Computer processing of data allows to make biomechanical analysis of athletes technique. This is essential for preparation of ski jumpers where high-speed recording is used.
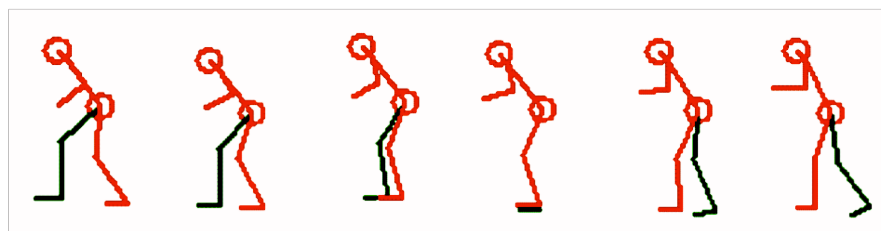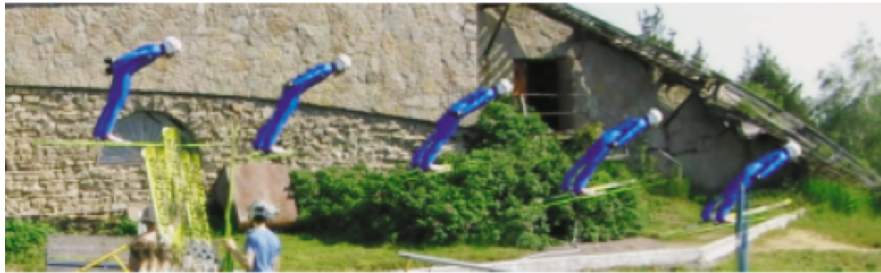
VIDEO AND PHOTOGRAPHY IN THE LABORATORY

Concurrent use of video analysis during simulation exercises on a treadmill and tenzo platform in laboratories of the Institute provides high accuracy of technique correction for skiers and ski jumpers. Analysis of the video performance of cyclic loading on the treadmill with the control of heart rate (heart rate monitor POLAR RS800CX) allows to work out the best recommendations for functional training and technique of running.
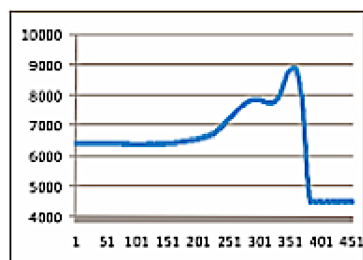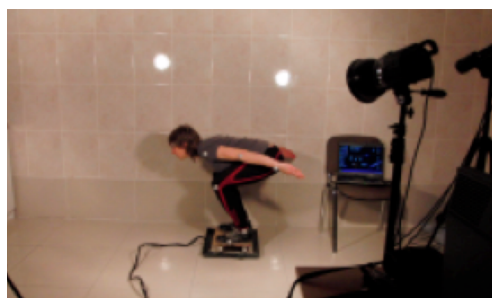
Investigation of dynamic characteristics of repulsion and tenzo-gramm of repulsion.

Video analysis of running and skiing.

LIGHT-ACOUSTIC STIMULATION "LINGVOSTIM"

Using the TMM MIRAGE system allows the athlete to get into a state of relaxation by acting on the deep subcortical structures, which allows to remove the competitive stress, anxiety and more appropriately transform to the state of competitive readiness. This technique was developed by PhD Golub Y. Device models natural light and sound effects (flashing fire, sea, noise of the waterfall, surf, etc...). Light and sound stimulation normalizes a wide range of psycho-physiological processes:

Reduces the impact of stress:

• Reduces muscle tension;

• Normalization of autonomic responses;

• Reduces emotional response;

Enhances mental and physical performance:

• In accordance with the Yerkes-Dodson law "performance increases with physiological or mental arousal, but only up to a point; when levels of arousal become too high, performance decreases".

Reduces the level of anxiety:

• Reduces the level of reactive and personal anxiety;

Normalizes sleep:

• Facilitates the process of falling asleep and waking up, including before the competition;

• Reduces need for sleep

Improves athletic performance:

• Accelerats the recovery processes after training and competition;

• Correction of prelaunch "fever" and prelaunch "apathy";

• Increased focus;

• Increases the effectiveness of mental training and anger management:

• Promotes intense reasoning;

• Promotes better absorption of the formulas of self-hypnosis.

COMPUTER MODELLING AND DIAGNOSTIC SYSTEM "BRIS"

Use in the training process modeling computer-diagnostic trainer systems created new opportunities and helped to improve sports and technical skills of athletes in rowing. In St. Petersburg Research Institute of Physical Culture a system for rowing "BRIS" is created, its operation conditions are close to the real rowing of academic boat.

Basis complex "BRIS" - trainer for rowing in the pool of new design (patent for invention from 31.10.2013, registration number 2013148858). In addition to the trainer, the complex includes a set of instrumentation and computer with a special testing program.

The main part of the trainer - single compartment pair rowing, with mounted sliding seat (the bank), footrest, brackets and swivels with oars. Features of the trainer are:

1). Possibility of longitudinal reciprocating movement of the movable part of the simulator (one reciprocation cycle for propeller).

2). Rotatable suspended part of the simulator in the transverse plane (the possibility of balancing).

3). Ability to change the height of the axis of rotation in the transverse plane of the system "rower - trainer" (this allows to change the degree of difficulty of balancing).

Complex "BRIS" may be recommended for training and preparation of both of initial and top level athletes.

INNOVATIVE TELEMETRY SYSTEM FOR ROWING (BIOROWTEL V4.0)

The system is a complex consisting of sensors, electronics, laptop computer and software. The system is designed based on years of experience and the latest developments in electronics and engineering, made in Russia, Australia and the UK. System BioRowTel™ - is a versatile and multi-purpose tool. It can work both in a rowing basin, and with any class of boats from singles to eights. The system is quickly installed on the boat (30 minutes at 1x, 2 hours for 8 +) and removed (5-20 min). It does not affect the setting of the boat, which is especially important for important regattas. Two-axis (2D) sensor of paddle angle measures the spatial parameters of the oars in the horizontal and vertical planes. This allows to determine the trajectory of the blade relative to the water level and errors in rowing. The force sensor measures the force applied to the handle. Unique method allows to calibrate the paddle in just 1 minute and gives a very precise definition of rowing power. Sensor is light, tiny and can be used both for a pair and a swing paddle. Unique averaging algorithm embodied in software allows you to accurately analyze large amounts of data, it is easy to compare different samples (the rowers in the boat, different stroke rate, past and current data). Position sensors of a torso and banks allow to calculate the velocity of the body segments and their contribution to the total power that allows detailed analysis of the technique and define the style of rowing. Boat speed sensors, satellite navigation (GPS), 3D measuring the acceleration of the boat and its roll can accurately determine the parameters of motion rower-boat system. BioRowTel can work together with a feedback system VFS and provide instant feedback on biomechanical parameters, assessment model with respect to the issuance of automatic and even verbal commands. In addition, each workstation is equipped with a portable "traffic light" indicator, which shows the performance of any of the parameters of rowing technique (the length of the stroke, effort, power, etc.). Coach can see the same value for all paddler on the computer screen and easy program evaluation criteria.

Technical data of BioRow Tel v 4.0 system

Weight of electronic unit with battery 300g,
Weight of the entire system, not more than 1 kg for 1st, 2; 1.5 kg for 2x, 4; 2,5 kg for 4x, 8+
The time of operation not less than 4 hours;
The number of channels 24 - 128;
The polling rate of each channel 25, 50, 100Hz; ADC resolution: 12 bit

COMPLEX ANALYSIS OF TECHNICAL AND TACTICAL PREPARATION OF SWIMMERS

The complex analysis of the technical and tactical preparation of swimming athlete allows to use the following techniques and technologies for analysis and correction of swimmer preparedness:

1 mobile underwater, multi - flat video recording of swimming technique.

2 improving the technical preparedness of the swimmer, including in the process of preparation of the strongest athletes additional anthropogenic factors: biofeedback semantic feedback, "artificial control environment."

3 improving athlete biomechanical and hydrodynamic characteristics of aquatic locomotion, at the start and at the turn.

Control tasks using the system are:

- determining the structure of aquatic locomotion, tempo, "step", speed, timing analysis of individual phases of swimming movements;

- measuring and analyzing inter-cycle displacement, velocity, acceleration of the control points of the athlete's body;

- shaping the image of the model swimming technique, at the start and at the turn.

The system equipment includes: System of free-board video, high-speed digital video HDV camera; underwater video monitoring system on the basis of 4 underwater cameras, providing analysis of the technical and tactical training of athlete in 4 planes; independent, safe power supply (12V); complex control system, a digital recording HDV device, the mixer; system control and visualization of video information, additional external monitors, lights; system calibration and verification of the complex; sensors checkpoints mounted on the body of an athlete; sensors control points established in the basin; workplace researcher hydro-protection of the electronic modules, special boxes for moving and installing of the system.

System is used both in the training camp, and in the conditions of competition.

Using the system allows you to:

1) Identify the individual relationship swimmer speed, pace, "step", heart rate;

2) analyze the structure of aquatic locomotion, the time of the individual phases of swimming movements of arms, legs and breathing while swimming;

3) Analyze intra-cyclic displacements, velocity, acceleration of athlete to compare these characteristics with the structure of aquatic locomotion;

4) perform computer analysis of speed and hydrodynamics of a swimmer in the cycle, to identify the potential for raising the speed;

5) develop a model of perfection of the sports equipment, to implement innovative technologies of this model;

6) an objective control of sports equipment and hydrodynamics, improve control and self-control;

7) increase knowledge and validity of coach when preparing the swimmer.
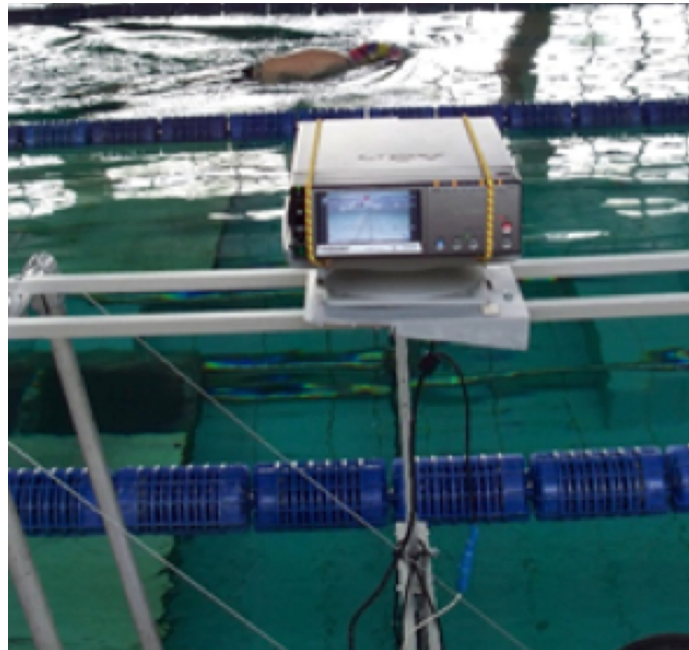
SYSTEM OF VISUAL FEEDBACK VFS-3

Video shooting is widely used in modern training of athletes. Proverb says: "It is better to see once than hear a hundred times" and indeed it is. However, in the traditional use of video-recording the time between motion execution and analysis of the visual information by the athlete is very long, so the muscular sensations and motor image partially disappear and the athlete cannot associate them with the visual image obtained when viewing the video. Modern technologies allow us to reduce the time delay to zero.

The use of visual feedback system (VFS), based on the use of special glasses of virtual reality allows the athlete to see himself at the moment of the exercise. Moreover, according to the task, the coach can focus athlete's attention on certain segments of the body or details of the equipment (eg, work the blade when kicking, legs, hands, etc.); make shooting with the required angle, shoot one athlete or the entire team as a whole. Through the built-in micro-headset and audio system athlete can receive synchronous comments of the coach. Another very effective technique - demonstration of a "model" rowing technique by the elite teams in the intervals of rest between rowing or even during it. It does not require any additional equipment: the coach only need to switch video camera to playback mode.

VFS is widely and successfully used for the preparation of the strongest teams for the Olympic Games and World Championships. By the review of athletes and coaches, "virtual glasses are the most effective means of improving the sport in the history of the art of rowing." Set of VFS-3 includes mobile personal head-mounted display (MTD to a control device, battery and receiver and video transmitter with a micro-antenna).

REHABILITAITON OF ATHLETES

Continuously increasing intensity of training in today's sports leads to excessive strain on all functional systems of the body of the athlete. Therefore, recovery in sport should be an integral part of the training process, as well as the load itself. A special place among the physical means of recovery in athletes should take unloading spine rehabilitation with the ARMOS device and different types of massages: sports, medical, vacuum, reflex-segmental, connective tissues, post-isometric relaxation of muscles, using different hardware systems. Sports massage and unloading of the musculoskeletal system is vital for each athlete.

First of all, it is important in order to improve and enhance the action of the functional systems of the body, the condition of the musculoskeletal system, preventing surge micro-traumas and various biomechanical disorders. It is very important to prevent the accumulation in time of the growing nervous tension, leading to overloading of individual organs and body systems, including the attenuated disease and sports injuries. In the proper organization of recovery considerable potential is being laid not only to the prevention of injuries and diseases, but also to the development of large training loads with high achievements in sports, while maintaining the health of the athlete. Systemic application of individually tailored recovery tools actually increases the level of action of the functional systems of the body, prevents the development of pathological changes of the musculoskeletal system and helps to speed up the recovery process. Properly executed sports massage really can affect even the results of the competition. After the massage, all the muscles, ligaments and joints are much freer, the athlete becomes less tiring, he increases reserves of the cardiovascular and respiratory systems and resistance to stress. A regular massage workout of muscles, including the deepest, helps maintain excellent physical shape for many years and win the competitions at various levels, without compromising the health of the athlete.

In SPbRIPC original methods of sports massage and hardware techniques to accelerate the recovery processes of athletes and enhance the action of the functional systems are developed. Method ARMOS and copyrights massage techniques are successfully used in Olympic and Paralympic sports and help athletes to better cope with the training load.

COMPUTER SYSTEM FOR PHYSICAL STATE MONITORING (CSM)

Computer system CSM is designed for mass screening of population to identify the level of physical development, neuro-psychological adaptation, motor fitness and the formation of individual recommendations for individual and group physical exercise.

CSM provides the following conclusions:
- Morphological and functional parameters;
- Indicators of mental stress;
- Indicators of motor fitness.

CSM provides the following recommendations:
- Recommended course of the physical exercises;
- The way to reduce the level of anxiety;
- Principles of eegulation of body weight;
- Hardening.

Based on repeated surveys CSM enables to adjust the program of exercise and to monitor the dynamics of positive changes, as well as receive characteristics of different age groups. CSM provides database support for the results of testing.

Current CSM version is designed to work on IBM-compatible computers in MS Windows environment. The developed method is patented: RF № 2364324 from 20.08.2009 "A method for determining the physical readiness of the person in mass surveys" and 2216266 from 20.11.2003 "A method for determining aerobic endurance person in mass screening."

NUTRITIONAL STATUS AND DIETARY INTAKE OF ATHLETES

Food for athletes has its main purpose to provide the body with the necessary amount of energy and nutrients. Nutrition is a crucial factor in ensuring optimal conditions of growth and development of an athlete, increase his/her sport efficiency, expanding the boundaries of adaptation to muscular activity with increased intensity and volume. Catering for athletes depends primarily on sports specialization, climatic conditions of the region, range and cost of food. When organizing a balanced diet is necessary to consider the stages of the annual training cycle, the nature and direction of metabolic processes and competitive pressures, in particularly for athletes, who have to travel to different countries changing climate and environmental conditions. In organizing a balanced diet for athletes is necessary, first of all, to assess the basic nutritional status and characteristics of the everyday diet. To solve these problems in the SPbRIPC a number of methodologies for assessment of nutritional status on a range of medical and biological methods such as hygiene, morphological, biochemical, and genetic techniques have been developed. Genetic testing for the identification of susceptibility genes to metabolic disorders and possibilities for development of multifactorial diseases allows to identify possible weaknesses and organize individual functional diet for each person. Evaluation of actual energy expenditure of the athlete is held using modern gas analysis of the exhaled air and cardiac monitoring when tested in the process of specific muscle activity. Computer program "Catering of athletes" is developed, which allows:
- To study of the chemical composition and energy value of diets;
- To analyze diet for different groups of athletes, by comparing the actual values with known standards;
- To offer an exemplary diet, taking into account the preparation phase and metabolic orientation of physical activity;
- Compose diurnal range of products and menus depending on the tasks;
- To correct daily needs for nutrients and energy, taking into account both team and individual parameters.

BIOCHEMICAL METHODS OF DIRECTION AND PORTABILITY OF TRAINING LOADS

In the SPbRIPC an extensive research aimed at identifying the most informative biochemical control methods of athletes fitness is being performed for many years. We study the metabolic reactions of athletes in various sports both during training and competitive activities. The most frequently used methods of study are as follows:

1. Concentration of lactic acid (lactate) in the blood serum.
2. Contents of urea in the blood serum.
3. Serum activity of creatine phosphokinase (CPK), aspartate aminotransferase (AST) and alanine-minotransferase (ALT).
4. The concentration of hemoglobin in the blood.

Loads of varying intensity and duration are made at different balance of aerobic and anaerobic (glycolytic and phosphocreatine) energy processes of muscular activity. The level of concentration of lactate as an end product of anaerobic glycolytic energy production mechanism, the serum and its dynamics during physical exercse and recovery indicate the orientation of training, the rate of biochemical restitution, which allows to identify the weak links of adaptation. The end product of protein metabolism in the decomposition of ammonia formed during the collapse of the amino acids is urea, the concentration of which reflects the degree of reduction of plastic metabolism in the body. Urea content in the blood serum in the morning on an empty stomach in a state of physiological rest gives an indication of the lag prior to restoring the body after physical activity of varying intensity and duration.

Muscle enzyme creatine phosphokinase activity gives an indication of the extent of damage and the rate of recovery of muscle fibers after intense exercise.

An important indicator of the functional state of the peripheral blood is the hemoglobin content. For the determination of biochemical parameters in serum 500 mcl of whole blood is taken from the pulp of the index finger. Serum was prepared by centrifugation for 20 min at 10,000 rpm. on a desktop laboratory centrifuge Mini Spin (Eppendorf company, USA). Biochemical analyzes are carried out using modern methods of clinical biotests produced by "Olvex Diagnostikum" (St. Petersburg) on a semi-automatic biochemical analyzer "Screen Master Point LIHD 101" (Hospitex Diagnostics, Italy).

As additional research methods are used:

1. The concentration of blood glucose.

2. The protein concentration in the serum.

3. The number of blood cells.

4. Calculation of leukocyte.

5. Immunological studies.

6. Determination of pro-and antioxidant systems, etc.

7. Genetic analysis.
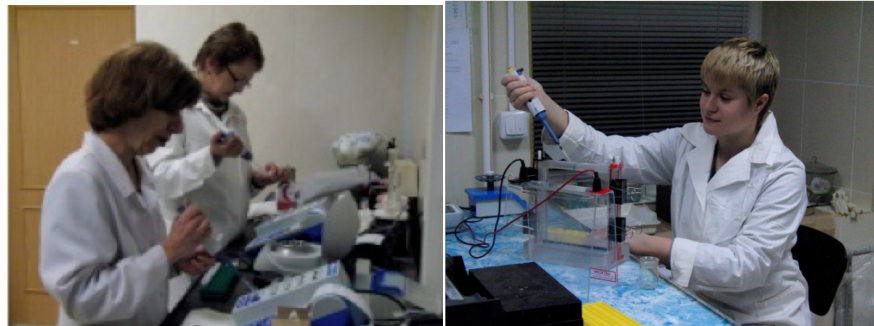
Molecular genetics of sport - a scientific discipline that studies the molecular mechanisms and patterns of inheritance of human motor behavior. The central idea of the molecular genetics of sports is the idea that individual differences in the degree of development of certain physical and mental qualities of man are largely due to DNA polymorphisms. In accordance with the detected effects of polymorphisms of genes isolated alleles or genetic markers associated with the development and display of endurance, speed-strength, and combinations thereof, as well as anthropometric (height, weight, etc..) and composite (muscle and fat mass, of the muscle fibers, etc.) indicators are detected. There are also alleles associated with limited physical capacity. The consequence of this limitation is at best halting of sports results, in worse - the development of pathological conditions such as, for example, expressed left ventricular hypertrophy resulting with the heart failure.

On the basis of some success in the detection of such markers, sports genetics today are able to solve problems that are aimed at the prevention of occupational pathologies of athletes, helping in the selection of sports, as well as in planning and correction of the training process.

According to the current ideas of genetics, based on data from elucidation of the structure of the human genome, it is believed that polymorphisms (variations) determine individual differences in many anatomical, physiological and biochemical characteristics.

EXPERT SYSTEM "HEALTH AND BEHAVIOR OF SCHOOL CHILDREN"

A central place in social development are the problems of the formation of the younger generation, preparing children for a full independent life. The success of the formation of students' healthy lifestyle and largely depends on the correct interaction of organized education and the influence of the social environment. The most important parameters describing a combination of factors of social infrastructure and educational system, as a basis for the formation of strategy of health and healthy lifestyle of the younger generation in Russia.

Since 1992, the SPbRIPC is the representative of the Russian Federation in the long-term program of scientific cooperation "Health and behavior of school children» HBSC, implemented under the auspices of WHO. The program currently involves specialized scientific organizations from 42 countries of Europe and North America. Profile contains clusters of issues, which include standard items that are used for the implementation of the research program, and more to be added and changed every four years for the next survey cycle. Mass survey of school children in the program "Health and behavior of school children" are aimed at the study of aspects of lifestyle and activity in the context of improving the health of children, adolescents and young adults. Questionnaires are conducted among school children aged 10-16 years during one school lesson by experts from the region participating in the program. Data obtained with the help of socio-pedagogical monitoring, directed not only to the solution of scientific problems, but also to increasing the efficiency of the educational process, consolidating students' fitness and sports needs, motives and interests. According to the results of many years of research at the Institute a database with special software was developed, which includes profiles of more than 25 thousand respondents from seven federal districts of Russia (North-West, Central, Volga, Southern, Ural, Siberia, Far East) for the period 1994-2014.

Aspects of lifestyle:

physical activity;

social differences;

dietary habits;

body structure;

bad habits;

school conditions;

family culture;

peer culture;

disorderly conduct and injury;

sedentary behavior style.

Physical activity:

value orientations: motives, needs and interests;

physical activity: sports, play and active recreation;

attitude to physical education lessons: the importance, satisfaction, knowledge;

sports: sport, sporting achievements;

self-assessment of physical fitness: in general, the physical qualities;

self-assessment of physical development: weight, height, figure.

The computer system of data preparation and subsequent analysis through the creation of a subsystem data preparation to detect erroneous data, auto-fill fields in the database (such as the year of the survey, the generation of numbers through questionnaires), the transformation of the data from the Russian profiles (having an increased number of questions relative to the international) to the HBSC format was developed. In most cases, the panel with "Batch" features is enough, but it is possible to carry out in-depth analysis based on "free calls panels."

Prospects for the use of expert systems in the formation of a healthy lifestyle:

• International: Participation in international scientific cooperation program "Health and behavior of school children" under the auspices of the WHO;

• Federal: implementation of the program of socio-pedagogical monitoring in seven federal districts of Russia;

• Regional: improving social and educational programs based on periodic surveys of students;

• Municipal: evaluation of the effectiveness of existing programs and innovative projects based on data from a sociological survey;

• Educational institution: the adjustment of educational programs in physical education, the formation of valeologicheskih programs;

• Children: developing an individual profile of physical training and preparation of recommendations for the implementation of individual student route.

EXAMPLES OF THE RESEARCH WORKS USING INNOVATIVE TECHNOLOGIES

INNOVATIVE TECHNOLOGIES IN EXPRESS-EVALUATION OF THE PSYCHO-PHYSIOLOGICAL CONDITION OF THE PARALYMPIC ATHLETES

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Abstract

Objective: Evaluation of elite athletes' psycho-physiological condition at various stages of preparation and in international competition.

Design: Athletes were tested during training and participation in international competition using methods of Galvanic Skin Response (GSR) and Gas Discharge Visualization (GDV).

Setting: Saint Petersburg Federal Research Institute of Physical Culture and Sport, Russia; Paralympic athletic training camp, Norway.

Participants: 18 athletes from Russia's Skiing and Biathlon Paralympic Team. All athletes had some level of damage to their musculoskeletal system.

Main Outcome Measures: Stress Level (SL), Energy Potential (EP), and Psycho-Emotional Tension (PET).

Results: It was found that the higher the level of EP achieved by the athlete in the training period, the lower the SL in the competition time. The SL of an athlete recorded in the training period significantly correlates with the SL both before and at the time of competition. The PET and SL before the World Cup was negatively correlated to the results of skiing competitions.

Conclusions: Evaluation of PET, EP and SL through GSR and GDV offers a fast, highly precise, non-invasive method to assess an athlete's level of readiness during both training and at the time of competition.

Key words: Paralympic sport; express-analysis; Galvanic Skin Response (GSR); Gas Discharge Visualization (GDV).

Introduction

A distinctive feature of the 2014 Winter Olympic and Paralympic Games in Sochi was that many of the sporting events took place at high altitude. The venue for holding the cross country skiing and biathlon competitions was located on the Psekhako Ridge in the Krasnaya Polyana village. The field was located at an altitude of 850-1430 meters (2790-4660 feet) above sea level. The choice of altitude for the venue was not random: according to the requirements of the FIS and IBU internationals federations, 1400 -1600 meters (4600-5250 feet) above sea level is the optimal altitude for biathlon and cross-country skiing competitions. These conditions called for serious analysis of the psychophysiological adaptation of athletes, in particular the Paralympians (skiers, biathletes, athletes with lesions of the musculoskeletal system), to high altitudes. This problem has already been studied by us during the training period[20]. The next step was to study the adaptation of Paralympians to high altitudes during the pre-competition and competition periods, as well as a search for specific psychophysiological qualities contributing to successful adaptation to high-altitude training and competition burdens.

The challenge of express-evaluation of the psycho-physiological condition of athletes for timely correction of the training process is common in all sports. [1-4] This is particularly important for highly competitive athletes in which a significant amount of money and resources are being invested into their training processes. Currently, such evaluations are made both through subjective and objective measures. With each type of measurement being beneficial in its own way, and each type of measurement having its respective drawbacks. Subjective tools are often in the form of questionnaires for athletes and those working with the athletes. Objective tools include functional lung, heart rate variability and electroencephalogram tests.

While the information obtained form subjective tools does have its place, it faces a problem inherit to non-objective metrics; subjectivity. As such, the information provided can be skewed by inaccurate perceptions on the part of the reporter. For example, a coach may choose to focus on a particular area with an athlete during practice. If the athlete improves in this area as a result of the coach's attention, the coach may believe the athlete ready for competition and report such on a questionnaire. However, the coach's perception does not take into account that this same athlete may be dealing with significant mental stress in their home life, and has serious doubts about their ability to perform certain other tasks on the athletic field. In short, subjective metrics can only report what they see or experience directly. What is seen and experienced directly is heavily

influenced by perception. If the reporter's perception is in some way skewed, what is seen will also be skewed and thus reported.

Objective metrics on the other hand are less influenced by perception, yet still face a different hurdle with regards to training; logistics. One logistical limitation is that many devices used for these types of measurements are large, cumbersome and not easily transportable. Another such limitation is the processing time necessary for feedback. If the results are going to be implemented in some way in order to enhance training quickly, they must be obtained quickly. This should be done with as little effort as possible on the parts of the athlete and coaching staff. An athlete's daily routine is often tightly scheduled, and leaves little room for time-intensive measurements. This is especially true during competition periods. A final limitation is the often invasive nature of many currently available tests. For example, energy assessments obtained from infrequently having one's blood drawn to measure various levels of key metabolites may be uncomfortable yet understandable to an athlete. However, daily blood withdrawals to measure those same parameters would no doubt be less palatable to that same competitor. It is for these reasons portable, rapid, non-invasive evaluation devices are desirable.[6]

The goals of this study were 1) to test the ability of different instruments to provide rapid-evaluation of athletes' levels of preparedness in training and competition, and 2) to identify the most sensitive parameters for assessing athletic preparedness. Previously, similar Russian studies have looked at a host of outcomes in order to determine athletic preparedness.[5-7] These studies have been very important in laying the ground-work for this our current research. It is from these works that the authors believe the outcome measures of SL, EP, and PET may be the most informative parameters to assess athletic preparedness. It is our belief that this work is the first to examine sensitivity of exclusively these three parameters for this purpose.

Methods

The following methods and corresponding hand-held devices for athletes' express-analysis were used in the study:

1) Evaluation of the psycho-emotional tension (PET) by measuring Galvanic Skin Response with "Mirage" device ("MEDPASS" Co, St. Petersburg, Russia); measuring electrodes were fixed on the pads of the index and ring fingers.[8]

2) Evaluation of energy potential (EP) and stress level (SL) by Gas Discharge Visualization technique with "GDV-Sport" device (www.ktispb.ru,

www.bio-well.com). Measurements were taken from all 10 fingers.

Energy Potential (EP) is a measure of psycho-physiological condition of an athlete; it is calculated as a percentage ranging from 0 to 100%. EP = 100% is correlated with high level of competitive readiness and high energy reserve.

Stress Level (SL) is characteristic of the level of anxiety and stress, measured on a scale from 0 to 10. SL = 10 is correlated with high anxiety level and poor competitive readiness. Interpretation criteria are given in Table 1.

Table 1. Interpretation criteria for Energy Potential (EP) and Stress Level (SL) indexes

EP	SL		
	0-4	4-5	5-10
100%-80%	High level of psycho-physiological condition, low emotional tension	High level of psycho-physiological condition, moderate emotional tension	High level of psycho-physiological condition, high emotional tension
80%-60%	Moderate level of psycho-physiological condition, low emotional tension	Moderate level of psycho-physiological condition, moderate emotional tension	High level of psycho-physiological condition, moderate emotional tension
60%-40%	Affordable level of psycho-physiological condition, low emotional tension	Affordable level of psycho-physiological condition, moderate emotional tension	Affordable level of psycho-physiological condition Energy and emotional depletion is possible; risk of traumas; overtraining.
40%-0%	Low level of psycho-physiological condition, low emotional tension	Low level of psycho-physiological condition, moderate emotional tension	Energy and emotional depletion; high level of stress; risk of traumas; overtraining. Detailed medical analysis is needed.

GDV Technology is based on the well-known Kirlian effect: when an object is placed on a glass plate and stimulated with current, a visible glow occurs, the gas discharge. With gaseous discharge visualization (GDV) bioelectrography cameras, the Kirlian effect is quantifiable and reproducible for scientific research purposes. Images captured of all ten fingers on each human subject provide detailed information on the person's psycho-somatic and physiological state.[9] The GDV camera systems and their accompanying software are being used in medicine and psychology.[10-14] Through investigating the fluorescent fingertip images, which dynamically change with emotional and health states, one can identify areas of congestion or health in the whole system. The mild electrical stimulation initiated by the GDV creates a neurovascular reaction that registers on the skin. The characteristics of this reaction are influenced by the nervous-humoral status of all organs and systems. Images of these reactions are digitally captured and analyzed. In addition, for most healthy people GDV readings vary less than 10% over time, indicating a high level of precision in this technique.[15,16] It is interesting to note that using GDV technology over the course of several years to study Russian paralympic teams, no significant differences between paralympic athletes and healthy population were found.[5] At the same time analysis of data for handicapped individuals in Russia with the same type of problems indicated much worse states of their psycho-physiological condition. This suggests that athletic training may play a vital role in maintaining the body's energy level along with other key homeostatic parameters. For years GDV technology has been accepted by the Russian Ministry of Sport as one of several techniques used to rapidly evaluate an athletes' psycho-physiological state.[17]

Athletes were measured every day in the morning before breakfast. Throughout this study 204 measurements were taken in the training camp and 189 measurements were taken before and during the process of the World Cup competition.

Participants

This study was conducted in an athletic research facility at Saint Petersburg Federal Research Institute of Physical Culture and Sport, Russia as well as at the following sporting events: 2011, from November 16 to December 18, Norway; 2013: 1) TC1, 08.01-19.01, St. Moritz, Switzerland, 2) TC2, 27.01-05.02, St. Moritz 3) 07.02-12.02, Russian Cross-Country Skiing and Biathlon Championship and TC3, 13.02-20.02, Sochi, 4) TC4, 08.03-12.03, St. Moritz; 14.03-21.03, Cross-Country Skiing and Biathlon World Cup Finals, Sochi. All sporting events were held at an altitude of about 2000 meters (6600 feet) above sea level. A total of 14

athletes from Russia's Skiing and Biathlon Paralympic Team volunteered to participate in this study.   During this time athletes were in the preparation process for the upcoming World Cup competition. A total of 18 athletes from Russia's Skiing and Biathlon Paralympic Team volunteered to participate in this study. The athletes included 4 women and 14 men; 9 athletes of top level, age 32.5+/- 8, (LW5/7, LW6, LW8, LW10, LW12 in accordance with International Paralympic Committee classification), 6 athletes of middle level, age 24+/- 5 (LW2, LW12) and 3 preparatory level, 17 years old (LW8). All athletes participated in the study voluntary and with great interest; ethical considerations were taken into account.

At the World Cup 2011, participants in this study earned 6 medals in biathlon (3 gold, 1 silver and 2 bronze); 9 medals in skiing (5 gold and 4 silver) at the World Cup.

Statistical Analysis

Statistical analyses were carried out using the programs GDV Scientific Labartory™ and Statistica™ with one-way analysis of variance modeling (ANOVA). This modeling was selected as the data adhered to each of the necessary assumptions for its use (independence of observations, normal distribution of dependent variables and homogeneity of variance across groups).

Using the R-values derived from the ANOVA, correlations between the stated variables were determined to be either strong (R>.75 p<0.05), moderate (.49<R<.75 p<0.05), or weak (R<.49 p<0.05). For determining negative correlations, the same absolute values were used. This provided the statistical basis for assessment of our outcome measures.

Results

Part 1. Express-evaluation of the psycho-physiological condition of the Paralympic athletes

Figure 1 presents the averaged indexes of psycho-emotional tension (PET), Energy Potential (EP) and Stress Level (SL) for all participants. Figure 2 presents the same individual data for each participant. Tables 2-5 present correlations between the aforementioned indexes and athletic performance. Table 2

compared PET and EP at various stages of training and competition. Here, a strong correlation (R=0.953, p<0.001), was observed between the EP at the World Cup and the EP at the training camp. Moderate correlations were observed between EP before the World Cup and EP at the training camp (R= 0.674 p<0.01), as well as between EP at the World Cup and EP before the WC (R= 0.728 p<0.01). All other variables considered in Table 2 were only weakly correlated.
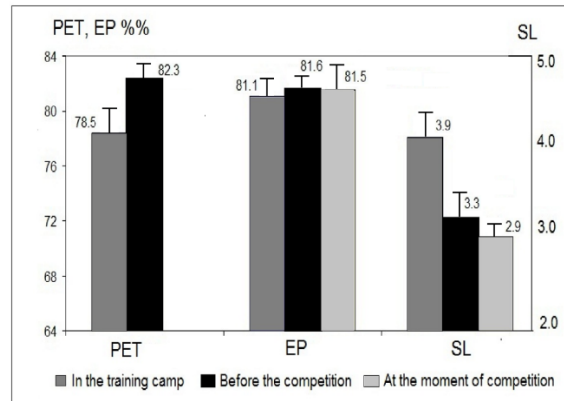

Fig.1. Averaged on the group parameters of athletes measured at the different moments: in the training camp; before the World Cup; at the moment of competitions.
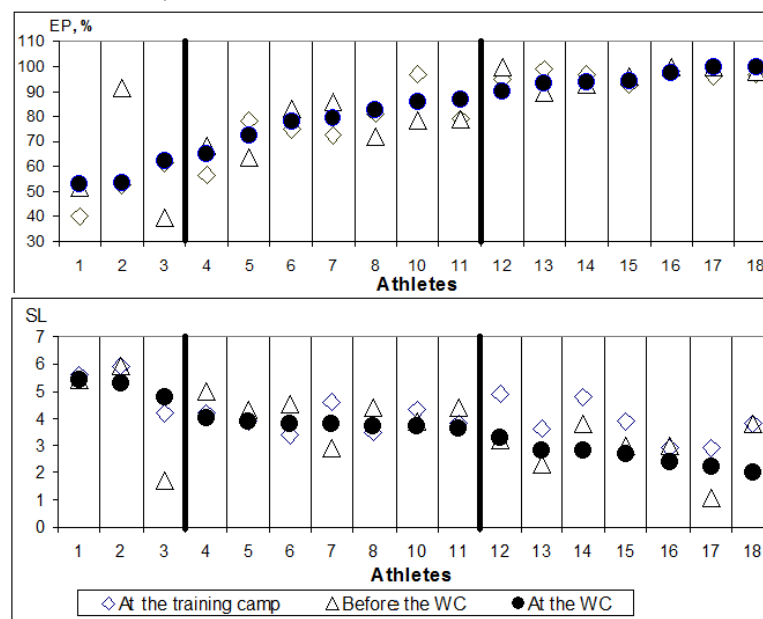
Fig.2. Energy Potential and Stress Level for individual athletes measured at the different moments: in the training camp; before the competition; at the moment of competitions.

Table 2. Correlations between Psycho-Emotional Tension (PET) and Energy Potential (EP) before and in the process of the World Cup (WC) competitions.

Indexes	PET at the training camp	PET before the WC	EP at the training camp	EP before the WC	EP at the WC
PET at the training camp	X	0.377	0.024	0.307	0.013
PET before the WC		X	-0.291	-0.243	-0.366
EP at the training camp			X	0.674**	0.953***
EP before the WC				X	0.728**
EP at the WC					X

** - p<0.01; *** - p<0.001.

Table 3 compared PET and SL at various stages of training and competition. Here, moderate correlations were observed between SL and PET at training camp (R= 0.498 p<0.05), SL at the World Cup and PET at the training camp (R= 0.491 p<0.01), SL's at the World Cup and training camps (R= 0.688 p<0.01), SL before the World Cup and SL at the World Cup (R= 0.554 p<0.05) and SL before the World Cup and SL at the training camp (R= 0.541 p<0.05). All other variables considered in Table 3 were only weakly correlated.

Table 3. Correlations between Psycho-Emotional Tension (PET) and Stress Level (SL) before and in the process of the World Cup (WC) competitions.

Indexes	PET training camp	PET before the WC	SL training camp	SL before the WC	SL at the WC
PET at the training camp	X	0.377	0.498*	0.064	0.491*
PET before the WC		X	0.353	0.054	0.425
SL at the training camp			X	0.541*	0.688**
SL before the WC				X	0.554*
SL at the WC					X

* - p<0.05; ** - p<0.01.

Table 4 compared EP and SL at various stages of training and competition. Here, moderate negative correlations were observed between SL and EP before the World Cup (R=-0.620 p<0.01), SL at the World Cup and EP at the training camp (R=-0.622 p<0.01), SL at the World Cup and EP before the World Cup (R=-0.495 p<0.05), SL and EP at the World Cup and EP (R=-0.699 p<0.01). All other variables considered in Table 4 were only weakly negatively correlated.

Table 4. Correlations between Energy Potential (EP) and Stress Level (SL) before and in the process of the World Cup (WC) competitions.

Indexes	SL at the training camp	SL before the WC	SL at the WC
EP at the training camp	-0.343	-0.290	**-0.622****
EP before the WC	-0.204	**-0.620****	**-0.495***
EP at the WC	-0.273	-0.294	**-0.699****

* - p<0.05; ** - p<0.01

Table 5 compared the results from skiing and the biatholon against SL and PET at various stages of training and competition. In the biathlon, there was a moderate negative correlation in between PET before the World Cup and sprints run on 10.12.11, PET before the World Cup and long distance races run on 13.12.11, as well as PET before the World Cup and total results.

Table 5. Correlations between competition results and parameters of psycho-physiological condition before and in the process of the World Cup (WC) competitions (11 athletes took part in biathlon and 15 athletes in skiing).

Indexes of psycho-physiological condition	Results in the biathlon			
	10.12.11 Sprint	11.12.11 Pursuit	13.12.11 Long dist.	Total result
SL at the training camp	-0.407	-0.349	-0.465	-0.413
PET before the WC	-0.540	-0.446	-0.570	-0.531
	Results in skiing			
	15.12.11 Long dist.	17.12.11 Sprint	18.12.11 Middle dist.	Total result
SL at the training camp	**-0.622***	**-0.713****	-0.429	**-0.707****
SL before the WC		**-0.590***		

PET before the WC	-0.574*	-0.540*	-0.567*	-0.683**

* - $p<0.05$; ** - $p<0.01$;

In skiing there was a moderate negative correlation between SL at the training camp and long distance races on 15.12.11 (R=-0.622 $p<0.05$), SL at the training camp and sprints on 17.12.11 (R=-0.713 $p<0.01$), and SL at the training camp and total results (R=-0.707 $p<0.05$).   There was a moderate negative correlation obseveved between SL before the WC and sprints on 17.12.11 (R=-0.590 $p<0.05$).   There was also a moderate negative correlation between PET before the World Cup and and long distance races on 15.12.11 (R=-0.574 $p<0.05$), PET before the World Cup and sprints on 17.12.11 (-0.540 $p<0.05$), PET before the World Cup and middle distance on 18.12.11 (R=-0.567 $p<0.05$), and PET before the World Cup and total results (R=-0.707 $p<0.01$). All other variables considered in Table 5 were only weakly negatively correlated.

Finally, numerous statistical analyses were completed with each of the study's outcome measures at various stages of training and competition. The outcome measures were also analyzed against the results of each competition. Due to the large number of results that could potentially be reported, the authors elected to fix the absolute value of 0.200 as the minimum R-value necessary for inclusion into the tables provided in this work.

Part 2. Evaluation of the psycho-physiological adaptation of Paralympic athletes to high altitudes and its relation to the properties of the nervous system

The hypothesis of the study: the properties of the nervous system constitute one of the factors associated with successful psychophysiological adaptation of athletes to high altitudes, that is, there exists a such set of PNS (which can be dubbed 'positive'), whereby the athletes who possess it are more likely to achieve a higher level of adaptation to training and competition burdens in high-altitude conditions

To analyze the factors responsible for the psychophysiological adaptation of athletes to high altitudes during the pre-competition and competition periods, the study used sensorimotor measurement techniques for assessing the following properties of the nervous system (PNS):

1. The strength of the nervous system. From the perspective of strength, three nervous system types can be identified: a strong nervous system, a medium-strength nervous system, and a weak nervous system.

2. From the perspective of the mobility of excitation and inhibition processes in the nervous system, the following types can be identified: the high excitation mobility, low excitation mobility, high inhibition mobility, low inhibition mobility, medium mobility for both processes.

3. We can identify two types of nervous process balance: "external" balance of nervous processes (the ratio of excitation to inhibition on the emotional-motivational level); "internal" balance of nervous processes (the ratio of excitation to inhibition on the energy level, where the need for activity emerges). Accordingly, there are three options of the ratios: the predominance of excitation, the balance of nervous processes, and the predominance of inhibition.

For convenience, the full duration of each of the sporting events mentioned above was subdivided into three-day phases (First phase – day 1,2,3; second phase – day 4,5,6; et cetera). When analyzing the results of the study the GDV parameters were calculated as the arithmetic mean of the parameters for all athletes during the given phase. The dynamics of the GDV parameters, as indicators of psychophysiological state of athletes during the pre-competition and competition periods of 2013, are shown on the graph in Figure 3.
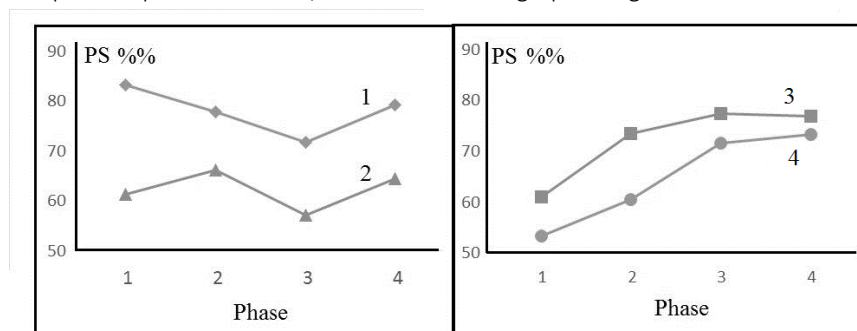

Figure 3. The change in the Psychophysiological Stability parameter during the 2013 sporting events: 1 - TC1, 08.01-19.01, St. Moritz; 2 - TC2, 27.01-05.02, St. Moritz; 3 – Russian Championship, 07.02-12.02 and TC3, 13.02-20.02, Sochi; 4 - TC4, 08.03-12.03, St. Moritz and World Cup finals, 14.03-21.03, Sochi.

The charts in Figure 3 show that that over the TC1 and TC2 periods (curves 1 and 2) during phase 3 (days 7,8,9), there was a decrease in the team's average PS parameter. Over the last phase of the event (days 10,11,12) PS values reached maximum levels, which characterizes the process of the athletes'

adaptation to high altitudes. In the days of the Russian Cross-Country Skiing and Biathlon Championship, as well as during TC3, which was held immediately thereafter, the PS parameter was increasing every day, reaching high values by the end of the analyzed period. These trends in the dynamics of parameter values may indicate the presence of certain regularities in the processes of the adaptation of athletes to the training and competition burdens under the conditions of high altitudes. Over the TC4 period before the World Cup finals, (graph 4), PS was 52% in the early days. These lower PS levels could be tied to the fact that the team arrived at the event immediately after the Cross-Country Skiing and Biathlon World Cup (22.02-06.03, Sweden). By the beginning of the World Cup finals athletes sufficiently adapted to the altitude (see 3rd and 4th phases, graph 4) and the average PS values of the team had stabilized at a fairly high level (above 70%).

When considering the issue of adaptation to training burdens at high altitudes, it may be of interest to compare data regarding the changes in the psychophysiological state of athletes during events that are similar in terms of the kind of sports offered, but distinct temporally. For example, consider the changes in PS: 1) at the beginning of the competition season in 2012 and in 2013; 2) on the eve of the Russian Championship in 2012 and in 2013. The data are presented graphically in Figure 4.
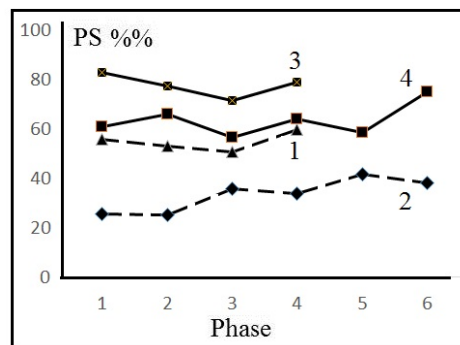

Figure 4. EP and SL values in Russia'a cross-country skiing team (curves 1 and 3) and biathlon (curves 2 and 4) during a high-altitude TC: 1) at the beginning of the competition season of 2012 and of 2013. (curves 1 and 2); 2) on the eve of the Russian Championship in 2012 and in 2013 (curves 3 and 4).

When comparing curves 1 and 2, as well as 3 and 4 on the graphs in Figure 4, we can see that PS values of skiers and biathletes at high-altitude, the time difference between them being about a year, are higher in 2013.

Results of studying the process of the Paralympians' psychophysiological adaptation to high altitudes in pre-competition and competition periods, as show

in the Fig. 3 and Fig. 4, may indicate that the adaptive capacity of skiers and biathletes increase with the number of training cycles in high-altitude conditions. This is phenomenon of, so to speak, "adaptive memory," when a man who has already gone through the adaptation process in the mountains adapts faster when finding himself in the mountains even many months later. Our data support the need for multiple trips to the alpine training camps during preparation for important competitions that take place at high altitudes.

In order to investigate a possible connection between PNS and the characteristics of human adaptation to high-altitude conditions, the same group of Paralympic athletes was split into subgroups according to the degree of the five typological features of their nervous system:

1) with a medium-strength or strong nervous system – 9 people, with a weak n.s. - 5 people;

2) with a medium or high mobility of excitation - 6 people., with a low mobility of excitation - 8 people;

3) with a medium or high mobility of inhibition - 7 persons., with a low mobility of inhibition - 7 people;

4) with a predominance of excitation in the external ratio (external excitation) - 11 people, with a predominance of inhibition in the external ratio (external inhibition) - 3 people;

5) with a predominance of excitation in the internal ratio (internal excitation) - 9, with a predominance of inhibition in the internal ratio (internal inhibition) - 5 people.

Given a balance in the external and internal ratios, the classification of an athlete into a particular typological group utilized an additional criterion – a balance with a shift in the direction of excitation or inhibition. In the first case, the diagnosis was external or internal excitation; in the second - external or internal inhibition.

Next, when considering the impact of PNS on adaptation processes, sporting events are presented separately - five TC, Russian Championship, and the 2013 World Cup finals. The list also includes the event, which was held January 20-26 (Einsiedeln, Switzerland) at a lower altitude. The criterion of adaptation of athletes, is derived by averaging the values of PS for the athletes in each group during a given sporting event. The obtained relations for each of the five PNS are presented in Figures 5-8.

The graphs in Fig. 5-8. show the 2013 sporting events in the following order (1-7 phases of the graphs): 1) TC, 08.01-19.01, St. Moritz 2) TC, 20.01-26.01, Einsiedeln 3) TC 27.01-05.02, St. Moritz 4) Russian Championship, 07.02-12.02,

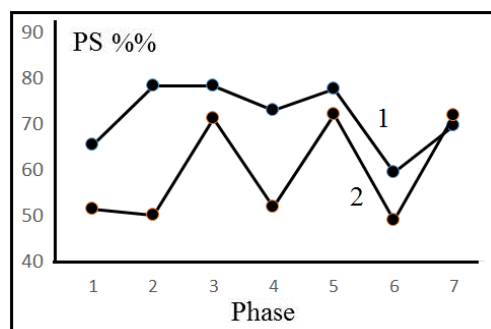Sochi, 5) TC 13.02-20.02, Sochi, 5) TC 08.03-12.03, St. Moritz 7) World Cup finals, 14.03-21.03, Sochi.

Figure 5. Changes in PS during the 2013 sporting events for the groups of Paralympic athletes with a strong (curve 1) and weak (curve 2) nervous system.

From the graphs shown in Figure 5 it follows that the group of athletes with a strong nervous system was characterized by a higher level of PS than the group of athletes with a weak nervous system, in which the PS parameter significantly changed during the year.
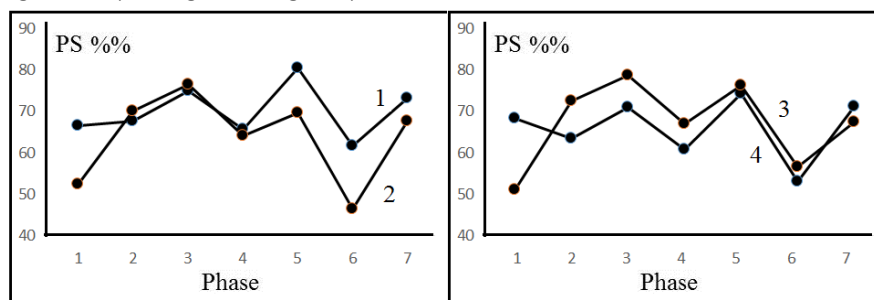

Figure 6. Changes of PS during the 2013 sporting events in the groups of Paralympic athletes with low mobility (curve 1) and high mobility (curve 2) of the excitation processes, and with low mobility (curve 3) and high mobility (curve 4) of inhibition.

The graphs in Figure 6 show that the group of athletes with low mobility of excitation was characterized by a higher level of PS after a period of adaptation than were the athletes with high mobility of excitation. At the same time, the group of athletes with high mobility and with low mobility of the inhibition processes differed little from each other in terms of the PS parameter.
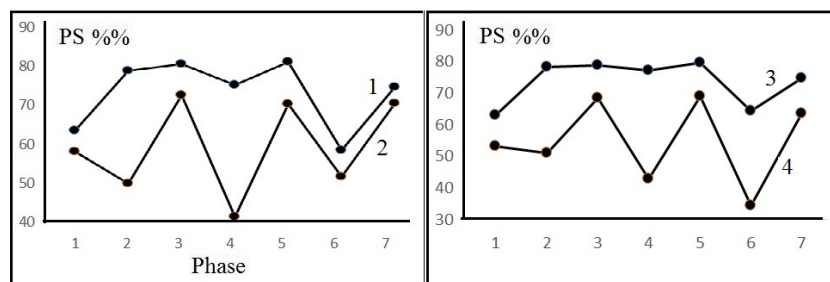
Figure 7. Changes in PS during 2013 sporting events in the groups of Paralympic athletes with a predominance of excitation (curve 1) or inhibition (curves 2) in the external ratio and excitation (curve 3) or inhibition (curves 4) in the internal ratio.

From the graphs in Figure 7 it follows that the group of athletes with a predominance of both external and internal excitation was characterized by a higher level of PS than in the group of athletes with a predominance of inhibition, in which the PS parameters only stabilized toward the end of the competition season.

To summarize the patterns identified in the analysis of data in Fig. 5-7 graphs, it can be assumed that athletes with a specific typological set of PNA which can be dubbed 'positive', that is: - strong nervous system, - low mobility of excitation, - predominance of excitation in the external and internal ratios, have a higher level of adaptive capacity for training and competitive processes at high altitudes.

Conversely, athletes with a typological set of PNA which can be dubbed 'negative', that is: - weak nervous system, - high mobility of excitation processes, - predominance of inhibition processes in the external and internal ratios, are characterized by a reduced level of adaptive capacity for training and competitive processes at high altitudes.

The dynamic of changes in PS in groups of athletes with positive and negative typological complexes of PNS is summarized in Fig. 8.
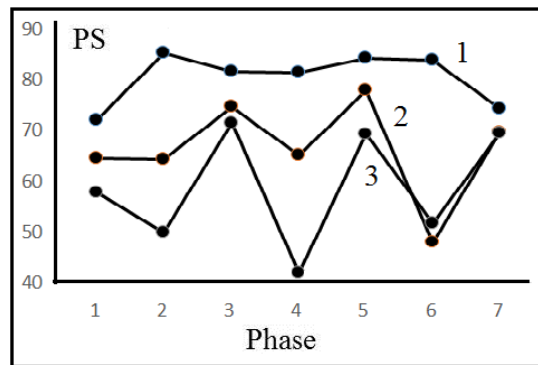
Figure 8. The dynamic of the changes in EP and SL in the groups of athletes with positive and with negative typological set of PNS. 1 - athletes with four PNS that are part of a positive typological set (4 people); 2 – athletes with three PNS that are part of a positive typological set (7 people); 3 – athletes with four PNS that are part of negative typological set (3 people).

From the graphs shown in Figure 6 it follows that the group of athletes with PNS consistent with the composition of the positive typological set is characterized by significantly higher values of PS than are the athletes with a negative typological set, this holding true during all 2013 sporting events.

Identified trends may serve as possible predictors of the competitive success of athletes. A good illustration of this are the graphs in Figure 9, which show the averaged data for PS and performance success level at the 2013 international competitions for the top 11 athletes of the Russian Cross-Country Skiing and Biathlon Paralympic Team. Competition results were calculated as average from all the places taken by the athlete during the year at competitions of the national and international level. This result was subtracted from the number of competitions (from 10 to 15 for different athletes). For example, athlete took 3 first, 2 second and 5 fourth places; average is 2.7; Competition Rating is 10 - 2.7 = 7.3.
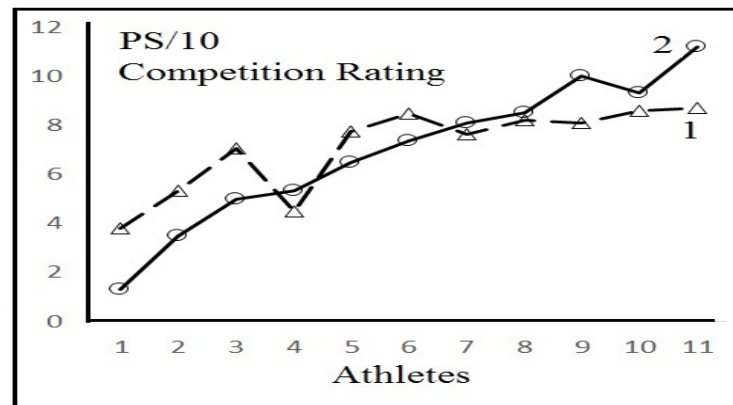
Figure 9. Averaged parameters based on the results of the 2013 season. 1 – Psychophysiological Stability (PS/10); 2 – performance success level.

As can be seen from Figure 7, highly skilled athletes are characterized by high levels of PS (i.e. high EP and low SL).

Discussion

Among all outcome measures examined, the strongest correlation was observed between the EP at the World Cup and the EP at the training camp ($R=0.953$ $p<0.001$), (Table 2). The strength of this correlation suggests that a high EP in training camp leads to a high EP during the actual competition. Data in Table 2 shows at least moderate correlations for EP at all other times measured. This also suggests that EP is a relatively static metric for assessing athletic readiness.

Currently, the exact mechanism detailing how a high EP leads to athletic readiness is unclear. However, a theoretical model proposed by the authors postulates that EP may act like a psycho-physiological reservoir for an athlete. The larger the reservoir the more the psycho-physiological resources an individual has access to when energetic resources are demanded, as is the case during athletic competition. If the reservoir is large, then many small, or even few large demands placed upon it will not cause any major depletion. However, if a person begins training with a small energetic reservoir, even tiny demands may prove unbearable and lead to a rapid depletion of EP. For this reason, the hypothesized relative static nature of EP underscores the importance of achieving a high EP during training camp. Once an athlete has their particular EP established they have in essence set their homeostatic EP level. It should be noted that this EP level exhibits relative homeostasis and while this can fluctuate, it generally maintains within a given range for a period of time once it has been set[18]. The

correlation data in Table 2 along with a visual inspection of Figure 2 lend supports this hypothesis.

Another key factor that may lead to the depletion of an individual's energetic reservoir is having inadequate rest and time for replenishment of their reservoir. In a recent study looking at necessary rest intervals during athletic training, Artioli et. al found that repeatedly exposing the body to the rigors of training without adequate rest, leads to steady erosion of physical and mental status[19]. This erosion may ultimately lead to breakdown of the system.

Another important aspect of EP is its relationship to stress. In all correlations analyzed, EP was negatively correlated to SL (Table 4). This was most pronounced for SL at the World Cup. These results suggest that a high EP may serve a protective function against high stress levels. A low-level stress response is the body's normal physiological answer when it is challenged in some way. This adaptation is not only beneficial, but also necessary for the maintenance of health and wellness. When the stress response is disproportionate to the stressor, or the stress response is prolonged in some way, other downstream negative effects can take place. A high EP seems to attenuate the stress response in order to keep SL low and within acceptable levels for health and wellness. However, if an individual has a high SL in conjunction with a low EP, not only is their athletic preparedness compromised, they may actually be in need of medical or psychological intervention. In training camp, athletes exhibiting low EP's and high SL's had consultations with professional sports psychologists per study protocol.

A second key observation regarding SL is that it exhibits its own degree of homeostasis. Table 3 shows that the SL of an athlete recorded in the training period significantly correlates with the SL both before and at the time of competition. Therefore, the SL's a person records during the training period, will most likely be similar SL's that same person records at different times throughout the training process. Although SL and EP both tend towards homeostasis, it is the belief of the authors that EP serves as the baseline psycho-physiological marker that resists changes in SL, and not the other way around. This is based on the assumption that as athletes trained and competed in different circumstances (training camp, before WC, at WC), their stressors changed as well. If SL were unregulated by some other mechanism, changes in stressors would directly register as changes in SL. It was assumed that as time approached the actual World Cup competition the stressor associated with competing would increase. However, SL actually decreases as an athlete moved from training camp, to before World Cup, and at the World Cup (Figure 1). Figure 1 shows that athletes with the greatest EP consistently demonstrated the lowest SL in each the various settings.

Similar to SL, PET was showed a consistent, inverse relationship to other positive outcomes. Table 5 shows multiple negative correlations.

Conclusions:

A direct measurement of Energy Potential and Stress Level in the fast, non-invasive manner used for this study is a rather new approach developed in recent years in Russia. It has been tested for several years with teams at different athletic levels and sport types.   The equipment and procedures have demonstrated high efficiency and reliability. The measuring process takes 1-2 minutes, and can be done practically anywhere. The instruments used may be run either from a power outlet or from a battery. The parameters explored for this study SL, PET, and EP are very important in understanding athletes' levels of preparation for competitions. This paper is the first attempt to use these specific parameters for the assessment of athletic preparedness for the clinical sport medical community.

The level of Energy Potential of an athlete established in the training period directly influences the level of Energy Potential observed throughout training and competition. The Stress Level of an athlete recorded in the training period significantly correlates with the athlete's Stress Level both before and at the time of competition. The higher the level of Energy Potential achieved by the athlete in the training period, the lower the Stress Level in the competition time, which may contribute to the competition efficiency. The higher the Stress Level and Psycho-Emotional Tension in the training period, the lower the probability of high competition results.

Hand-held computer complexes "Mirage" and "GDV Sport" used in this study allow for the express-analysis of psycho-physiological conditions of athletes with high precision at all phases of competition. Calculated parameters help to carry out corrective actions directed to optimization of the athletes' condition in the biofeedback regime.

While the ability to use GDV technology in this capacity provided great benefit, both the technology and the current study design are not without their limitations. In medicine GDV has been primarily used as an adjunct tool for evaluation that offers healthcare providers more insight into a patient's condition. Despite the fact that there is a great deal of potential yet to be uncovered from this technology, it's principal use has not been as a stand-alone diagnostic procedure. With regards to future studies, in order to get a more complete picture of an athlete's psycho-physiological landscape, the use of GDV in conjunction with additional metrics may be of benefit. Another way in which

further research may offer more understanding would be in varying the types of competitions in which athletes compete. Though there is nothing to suggest that biatholon and skiing are in any way poor arenas to test the desired outcome measures, including different types of high-level athletic competitions would provide a greater volume of information from which to draw conclusions.

As this was an observational, pilot study, another point of concern was the sample size. While the authors feel confident in the reliability of the devices used and the reproducibility of the data collected, the small participant number makes it difficult to draw firm conclusions from this data. Future studies may offer additional insight by increasing participant population to ensure proper powering, adding an experimental intervention, and including self-reported participant questionnaires as well as questionnaires for trainers and coaches on their perceptions of each athlete with regard to the selected outcome measures to compare against GDV/GSR results. Finally, further research may also focus on elucidating the mechanism for the setting of Energy Potential. As it is believed to be a significant importance, determining how it is established and thus how it may be increased is of great interest.

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IMPACT OF DRINKING WATER QUALITY ON THE ATHLETES' CONDITION

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Abstract

Integrated studies utilizing methods from physiology, psychophysiology, psychology, and biophysics were conducted. Athletes had the parameters of their condition measured before they began consuming graphene-filtered water as well as after a 30-day period of its consumption during training cycle. The obtained results were compared with the data from a control group of athletes who drank bottled water. It is shown that athletes drinking water passed through a graphene filter experienced growth in aerobic capacity, physical performance, energy potential, and their bodies' adaptive reserves.

Key words: grapheme water filter, non-doping methods of improving performance.

Introduction

Water is the main component of the internal environment of an organism. For people whose work involves intense physical activity, the state of water-salt metabolism is an important physiological requirement for maintaining optimum performance. The Federal Service for Supervision of Consumer Rights Protection and Human Welfare notes the poor quality of drinking water in Russia. About 19% of samples from the water supply do not satisfy the sanitary-chemical standards and about 8% do not satisfy the bacteriological standards. Nationwide, up to 30% of the samples of surface water sources do not meet health standards for sanitary-chemical reasons, and up to 25% - for bacteriological reasons. A serious problem is posed by water distributing systems - between 40% and 70% of them are in need of replacement. According to a March 18, 2005 Service memo, "as a result of this, accidents at these systems and the subsequent microbial contamination of drinking water constitute an epidemic risk." The memo states that out of all the disease outbreaks reported in 2004, 77.3% were of an "AQUATIC" nature and were related to the poor state of the water system. As such, the quality of drinking

water may, along with a number of other factors, play a certain role in determining the effectiveness of human activity. This holds especially true for activities involving extreme exertion - in particular for sports. This study focuses on identifying the impact of specially prepared water on the organisms of athletes.

ORGANIZATION AND METHODOLOGY OF THE STUDY

Sample

The sample consisted of 40 athletes between the ages of 14 and 25, coming from the Olympic Reserve School (St. Petersburg). Their skill level ranged from first-class sportsmen (regional champions) to candidates for master of sport (nationally ranked players) and masters (national champions) in different kinds of sports - athletics, rowing, triathlon, and basketball. Two 20-person groups were randomly selected - experimental and control. Groups were randomized by age, gender, skill level, and sports type. Subjects were aware of the goal of the experiment, but were not told which kind of water they would drink.

For 30 days athletes in the experimental group drank water passed through an HRCM graphene filter [1]. Athletes in the control group consumed bottled water.

Water source

The filtering process utilizes the high-reactivity carbon mix (HRCM) - a new carbon material created based on a discovery that Russian Academy of Natural Sciences member V. I. Petrik first laid out as "The Phenomenon of the Formation of Nanostructured Carbon Complexes". HRCM is obtained by cold destruction of graphite through a patented method [1]. HRCM contains carbon nanostructures that have an enormous surface area (about 2000 m^2 per gram). As such, when moistened, HRCM carbon nanostructures form a mass, which "entangles" even the tiniest impurities and suspended particles both of an organic and of an inorganic origin.

Methods

The following methods and corresponding hand-held devices for athletes' express-analysis were used in the study:

1. Heart Rate Variability (HRV) measurements by "Cardio-meter – MT" ("Mycard-Lana" Co. St. Petersburg, Russia, www.mikard.ru).

HRV indicators, which reflect features of cardiovascular regulation (a total of 24 indicators) serve primarily to characterize the adaptive reaction of an athlete to the stressful effects of graduated exercise. Statistical, spectral, and integrated indicators characterizing the state of different levels of the cardiac cycle regulation were used. [2]

2. The Profile of Mood States (POMS) test [3] was used to determine the psychoemotional state and arrive at an integrated assessment of the mood and stress levels of the athletes.

3. To determine the level of the athletes' physical ability peak oxygen consumption (POC) based on the PWC170 sample was measured. These data access the optimality and efficiency of the athletes' cardiovascular systems.

4. Stress system "General Electric Healthcare Cardiosoft" with the cycle ergometry "Bike General Electric Healthcare" (General Electric USA).

5. Evaluation of energy potential (EP) and stress level (SL) by Gas Discharge Visualization technique with "GDV-Sport" device (www.ktispb.ru, www.bio-well.com). Measurements were taken from all 10 fingers.

Energy Potential (EP) is a measure of psycho-physiological condition of an athlete; it is calculated as a percentage ranging from 0 to 100%. EP = 100% is correlated with high level of competitive readiness and high energy reserve. Stress Level (SL) is characteristic of the level of anxiety and stress, measured on a scale from 0 to 10. SL = 10 is correlated with high anxiety level and poor competitive readiness.

GDV technology has been accepted by the Russian Ministry of Sport as one of several techniques used to rapidly evaluate an athletes' psycho-physiological state. It is interesting to note that using GDV technology over the course of several years to study Russian paralympic teams, no significant differences between paralympic athletes and healthy population were found. At the same time, analysis of data for handicapped individuals in Russia with the same type of problems indicated much worse states of their psycho-physiological condition. This suggests that athletic training may play a vital role in maintaining the body's energy level along with other key homeostatic parameters.

Experimental protocol

First, athletes were given psychological tests, and their heart rate variability parameters (HRV) and gas discharge visualization parameters (GDV method) were measured. The athletes then used a velo ergometer (bicycle exercise, a variant of the PWC test 170), and their heart rate (HR) and arterial blood pressure (ABP) were recorded. At the end of the exercise HRV and GDV

data were again recorded, along with the time it took to recover baseline heart rate and blood pressure. Psychological testing was then repeated. All this was conducted before and after the 30-day period.

The variance of the data was analyzed. Indicator changes relative to the baseline in the two groups of athletes were analyzed using Student's t-test. Fisher's exact test was used to assess the significance of differences in the sampling fractions.

RESULTS

Based on the analysis of obtained data we can make the following conclusions:

1. The criteria for measuring the impact of graphene-filtered water on the athletes were their bodies' reactions to exercise. During the standard veloergometric test in the experimental group, the analysis of the mean values of hemodynamic parameters comparing the initial and final test results yielded statistically significant differences in the dynamics of the following seven (out of nine) parameters. Systolic ABP prior to the exercise ($p = 0.015$), diastolic ABP prior to the exercise ($p = 0.012$), HR prior to the exercise ($p = 0.001$), systolic ABP after exercise ($p = 0.001$), peak oxygen consumption ($p = 0.001$), ABP recovery time ($p = 0.018$), HR recovery time ($p = 0.003$). The values ABP, HR and their recovery times decreased, while POC values increased (Fig. 1). The direction of these changes indicates a tendency toward the optimization of the functioning of the athletes' cardiovascular system in the experimental group

These changes indicate the economization in the functioning of the cardiovascular system when that system is at rest, a reduction in the hemodynamic cost of exercise for the subjects, a reduction in recovery time following exercise, and an enhancement of the athletes' aerobic capacity. This, in turn, shows a reduction in the physiological price of exercise and an increase in the athletes' performance following a month of drinking graphene-filtered water.
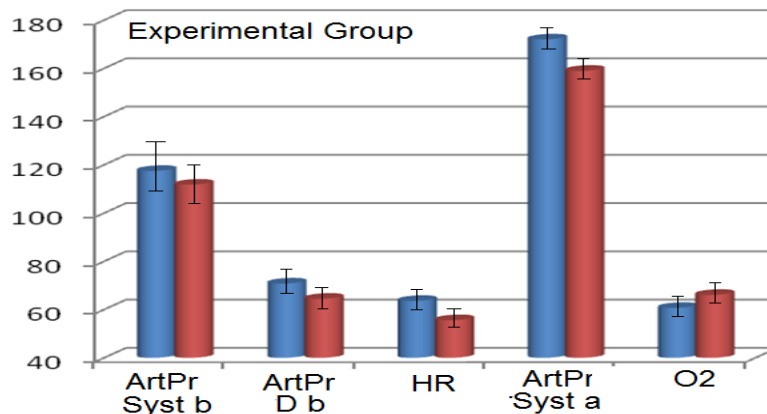
Fig.1. Dynamics of the statistically significant changes in the values of hemodynamic parameters in the experimental group.

2. Out of the corresponding parameters in the control group only post-exercise HR values had statistically significant changes (p = 0.001). Even this HR decrease was small.

3. In the control group of athletes a statistically significant reduction was found in the values of the pre-exercise energy potential (EP) when comparing data from the initial and the final test (p ≤ 0.001). There was no statistically significant change after the exercise.

4. In the experimental group baseline EP values slightly increased during the active period of the training cycle and this increase was different for different systems and organs in accordance with GDV measurements.

5. The analysis of the energy performance of individual organs and organ systems showed a substantial increase in the EP values obtained during the final testing in the experimental group relative to those obtained in the control group. This applies to a number of organs and organ systems, as illustrated by Figure 2, which shows the difference in the EP values of athletes in the experimental group and those in the control group in the first and second trials.
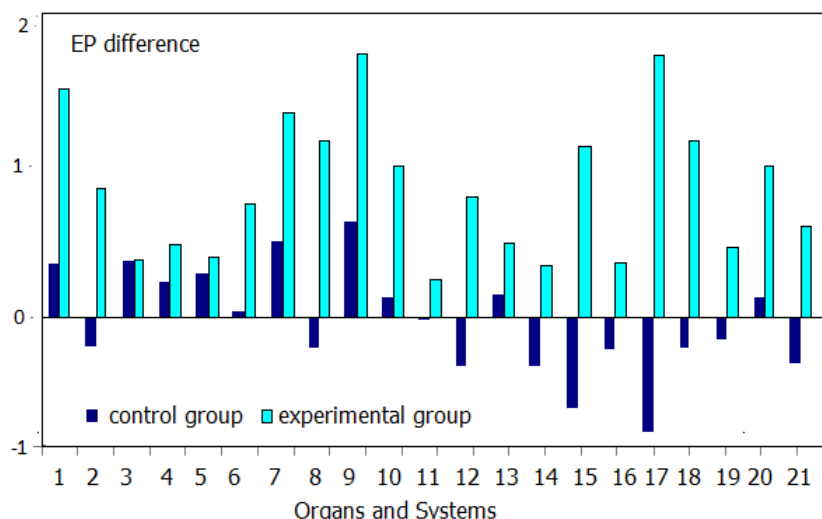
Fig. 2. The difference between the values of the indicator of the energy potential of athletes in the experimental and control groups in the first and the second trials. EP is measured in the scale from 0 to 10. 1 - Cardiovascular system, 2 - heart, 3 – blood vessels, 4 – mammary glands, 5 - hypothalamus, 6 – pineal gland, 7 – pituitary gland, 8 - pancreas, 9 - adrenal glands, 10 - genitourinary system., 11 - the spine, 12 – sigmoid colon, 13 - Rectum, 14 - cecum, 15 – ascending colon, 16 – transverse colon, 17 - the liver, 18 - pancreas, 19 – appendix, 20 - genitourinary system, 21 - kidney.

6. At the same time the difference in the values of averaged on the group parameters obtained through the GDV method when comparing samples of data from the experimental and control groups, either in the initial or in the final test was not statistically significant. Nor were such differences found before or after dosed exercise.

7. The use of rhythmocardiography made it possible to evaluate the state of the system of regulation of the HRV and the adaptive capacity of the athletes. In the experimental group comparing the data of the initial and the final testing prior to physical activity revealed statistically significant differences (by the t-test) in the dynamics of 14 indicators. I.e. the average duration of the cardiac cycle (P = 0.006), mode (p = 0.001), the minimum duration of the cardiac cycle (P = 0.007) and the maximum duration of the cardiac cycle (p = 0,002); SDNN (p = 0,048); RMSSD (p = 0,010); NN50count (p = 0,025); pNN50 (p = 0,025); MD (p = 0.007), vegetative equilibrium index (VEI) (p = 0.041); vegetative index of rhythm (VIR) (p = 0.030), indicator of the adequacy of regulatory processes (IARP) (p =

0.023), stress index (SI) (p = 0,034); VLF (p = 0.029). The F-test also found statistically significant differences for the vegetative equilibrium index (VEI) (p = 0.043) and the stress index (SI) (p = 0.005). The direction of changes in the indicator values reflects a downward trend in the sympathicotonic activity, an increase in the parasympathetic effects, and a centralization of heart rhythm management. This testifies to the improving capabilities of the body.

8. Particularly noteworthy was the decrease in the average of the vegetative index of rhythm (VIR) from 3.0 to 2.5 units. The predictive value of VIR in respect to the athletes' aerobic capacity is shown above [2]. Similarly, in this series of experiments, the increase in the peak oxygen consumption (POC) was 8.9%. In the control group of athletes a similar dynamic of the parameters was not seen. Instead, there were shifts of indexes (VEI, VIR, and SI) in the other direction. For example, the value of VIR increased from 2.3 to 2.8 units (p = 0.01).

9. There were no significant changes in the values of HRV parameters for athletes in experimental group after a bicycle exercise. But the overall trend of their dynamic shows the growth in their bodies' adaptive capacities, primarily due to the activation of the sympathetic nervous system (the LF parameter). At the same time, control group data included indicator values changing significantly in the opposite direction. This is evidence of some reduction of the functional reserves of athletes in the control group during the bicycle exercise test.

10. While examining the psychological state of the athletes the POMS test was conducted twice - before and after exercise. No significant changes in the groups' values of psychological profile indicators were found. The exception was the increase in the mental strength factor following exercise in the experimental group (the V factor p=0.001) (Fig. 3). At the same time, the trends in the psychological states, as measured by the POMS test, in the two groups went in opposite directions. Prior to exercise, the total cumulative index S in the experimental group had an optimizing tendency. Other parameters moved slightly in the direction of optimization. In the control group comparing the data from the initial and final tests prior to exercise revealed a decrease in values of mental strength (V) and the cumulative index (S). The values of depression and fatigue indicators increased.
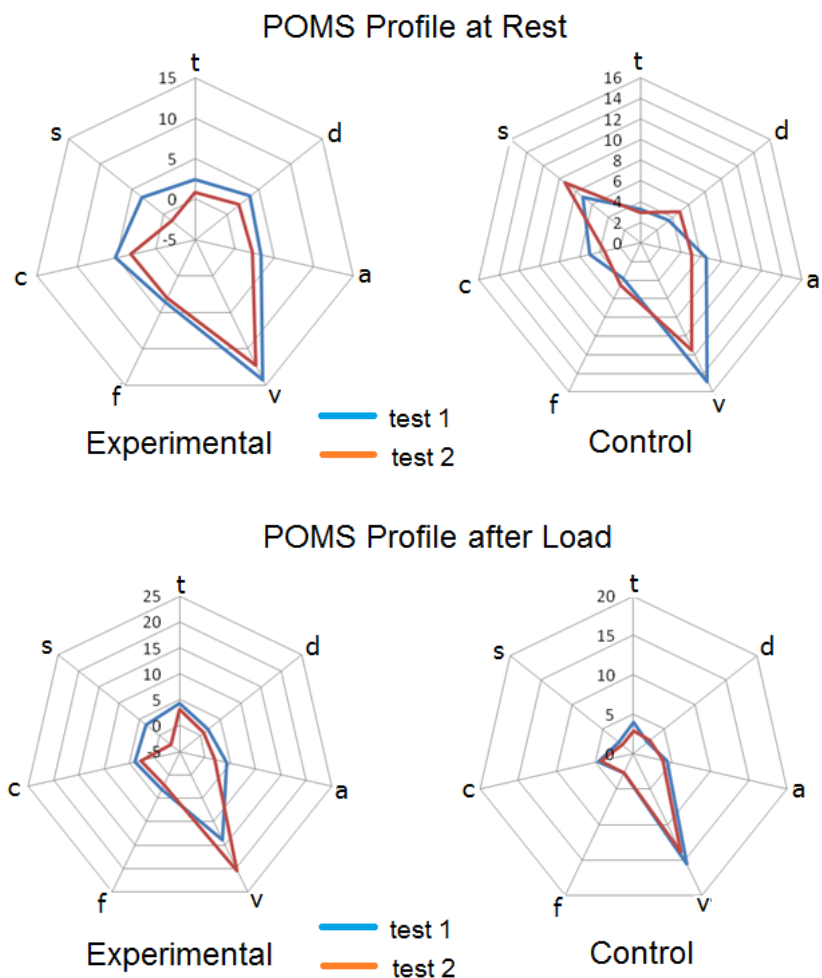
Figure 3. The dynamic of the POMS psychological profile in the experimental and control groups.

CONCLUSION.

1. The results of the experiment have shown that after a month of drinking water passed through a graphene filter, athletes experienced statistically significant changes in their cardiovascular system. The values of HR, ABP at rest, and diastolic blood pressure after exercise decreased. POC increased by 9%, while HR recovery time following exercise decreased by 18% - and ABP by 10%. These

data indicate improvement in physical performance, optimization of the circulatory system, and enhanced exercise tolerance. Such trends were not observed in the control group.

2. Based on variation pulsometry data, members of the experimental group had a tendency towards the optimization of the vegetative balance (increased parasympathetic effects on the HRV and decreased sympathetic ones). This testifies to the improving body capabilities of the body.

3. In response to exercise athletes in the experimental group saw an increase in the values of their mental strength factor, reflecting the level of competitive readiness.

4. Data obtained using the GDV method suggest that the values of energy parameters for the athletes in the experimental group remained stable, whereas the control group exhibited a decline in the values of these parameters. At the same time, in the experimental group there was a significant increase in energy potential values pertaining to specific organs and organ systems.

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