**Effect of cranial electro-stimulation on athletes’ recovery after practice of different load intensity**

*Prof. Andris Rudzitis, Prof. Viesturs Larins, Prof. Leonids Chupriks, Asoc. Prof. Leonids Zhilinskis, Aleksandra Chuprika*

**Latvian Academy of Sports Education**

**Summary**

The purpose of the research was to detect the effect of Cranial Electrical Stimulation (CES) on athletes in general and under different load intensity in their practice body recovery process quality. Optimal restoring of athletes’ body capacity under loads of training and competition processes is as essential as optimal choice of physical and psychological loads in practice.

The cranial electrical stimulation (CES) method has attested the usefulness of their application in various fields. The data confirm that athletes use CES to improve their coordination ability, to increase their concentration ability and even to improve the indicators of the body functional condition before competitions as well. The cranial electrical stimulation was applied by Alpha‑Stim stimulators; their effect mechanism is described in the theoretical part of the article. 12 participants of the Latvian national bobsleigh men team and 14 participants of the Latvian Academy of Sport Education handball team were analyzed for the study. The general parameters of functional diagnosis were automatically stated by “Omega-S” system and revealed quantitative criteria (in percent) that defined health qualities of the cardiovascular system: adaptation level of the cardiovascular system (A); autonomous regulation of the vegetative system (B); the central heart rate regulation (C); psycho-emotional state (D); integral indicator of the functional condition (H).

The highest increase of the indicators after CES procedures was observed with the participants of the sports game team. The increase in bobsleigh athletes’ indicators were more modest. Though, we can affirm that the recovery of these athletes was also positively affected by CES procedure. The basic conclusions: 1. Generally, the CES procedure speeds up the athletes’ physical condition of recovery after practice. 2. The efficiency of recovery after CES depends on physical load intensity in practice, athlete’s qualification, and time provided for the rest.

**Keywords:** athletes, recovery, cranial electric stimulation, parameters of functional preparedness.

**Introduction**

In athletes’ preparation process, it is important to find new ways to optimize their pre-competition and practicing conditions as training theories and methodologies used to prepare for competitions have been well researched. Today, in high qualification athletes’ preparation process, much attention is paid to seemingly less important details of this process such as athletes’ diet, sportswear, pharmacology, etc. Optimal restoring of athlete’s body capacity under various loads of training and competition process is as essential as optimal choice of physical and psychological loads in practices. Full recovery of the body functions up to next training or competition will provide not only athlete’s optimal work capacity and higher effectiveness of training work but, in most cases, higher results and achievements in competitions (Kraukst, 2002; Fernate, 2003).

The cranial electrical stimulation method, also known as trans-cranial electrical therapy (TCET) and neuro-electrical therapy (NET), have attested the usefulness of application in various fields. Besides psycho-therapeutic effect, the cranial electrical stimulation method has also pain decreasing impact that is based on microwave electro-therapeutic (MET) effect used in CES method. The cranial electrical stimulation (CES) is approved as a non-pharmacological way to treat depression, anxiety, and insomnia. It is testified by research carried out in the USA where the usefulness and effect of CES application is irrefutably proved (Heroes, Hope, 2013). The cranial electrical stimulation (CES) therapy is regarded to be absolutely safe. The data are available that athletes use CES to improve their coordination ability, to increase their concentration ability, and even to improve the indicators of the body functional condition before competitions (Molotanovs, 2013). The cranial electrical stimulation is based on electric signal of micro-power. Nowadays a precise physiological CES functioning mechanism is still intensively researched and more and more new scientific experiments are continuously carried out. There are hypotheses that CES indirectly affects the brain tissue in the region of...
“hypothalamus”, thus, stimulating neuro-hormones until the pre-stress condition homeostasis recovers (Gilula, Kirsh, 2004).

The purpose of the research was to detect the effect of Cranial Electrical Stimulation (CES) on athletes in general and under different load intensity in their practice body recovery process quality.

Theoretical background
There is well-known but a figurative thesis coinciding with today sports specialists’ acknowledged conclusion that athletes, either they are sports game players or take part in individual sports – “everything takes place in the head”. So, first of all, let us find out answers on two questions: what is the cranial electrical stimulation and how it works?

Today the cranial electrical stimulation is applied with portable device – micro power generator – and through electrodes power signals are sent to the brain where these waves – “vibrating cells” – help “to collect one’s thoughts”. Essentially, CES is one of those electrical therapy types that activate the endogenous opiate peptide system of the brain, mostly β-endorphin that is considered as a bio-stimulator of various physiological actions of the human body. The cranial electrical stimulation therapeutically affects the central nervous system stimulating the sensory centres, hypothalamus, hypophysis, reticular formation, and vagus nerve of the brain, i.e., “puts the brain in order”. During the therapy, particular substances – neuro-hormones, neuro-mediators (serotonin), beta endorphine, acetilhonin, dopamine, epinephrine, norepiphерine – are excreted in the brain. These substances create good mood and decrease the sense of pain.

CES affects the body through the parasympathetic nervous system, as a result the blood vessel tone decreases, oxygen amount in the blood increases, and the functioning of the cardio-vascular system normalizes. Under the effect of electrical stimulation, breathing slows down and becomes deeper. At the same time the secretion of the intestinal canal activates along with the exchange of carbohydrates, lipids, mineral substances and liquids in the body.

The effect of the cranial electrical stimulation is seen in two regimes: firstly, retardation and, secondly, activation. The first expresses as the sense of sleepiness, decrease of the heart frequency, breathing bradycardia, and the decrease of the brain bio-electric activity. But in the second case (activation), there is improvement of self-feeling, the increase of alertness and freshness, the decrease of tiredness as well as the increase of work capacity, and the activation of the cardio-vascular system functioning (Heroes, Hope, 2013).

How does it happen? The human brain is a self-adjusting system that continuously strives to the optimal functioning condition. The more harmonious human brain functions, the more a person starts to follow the choices that are the most suitable and rational for his / her individuality. Optimal brain functioning provides the brain wave harmonious activity in both hemispheres. Up to now the cranial electrical stimulation is an acknowledged non-pharmacological way to treat depression, anxiety, and insomnia. It is based on electrical signal of micro-power. Nowadays a precise physiological CES functioning mechanism is still intensively researched and more and more new scientific experiments are continuously carried out. There are hypotheses that CES indirectly affects the brain tissue in the region of “hypothalamus”, thus, stimulating neuro-hormones until the pre-stress condition homeostasis recovers. CES affects the delta, theta, alpha, and beta brain waves. Each of these brain waves becomes active in definite situations as well as during a definite load. It is important that the cranial electrical stimulation affects definite parts of the brain and as the result of the stimulation bio-potential vibrations of the brain are harmonized. The highest division of the central nervous system is the brain where the most difficult body function – thinking – is realized.

In the brain, there are definite mechanisms that through the changes of mediator activity level in the brain system, control body’s functional conditions, and activity balance. The brain motor system is structured by the motor centres in different parts of the brain, the movement impulse sends signals to the brain as well as the movement nervous fibres, which as a part of the spinal cord and the brain nerves, stretch to the muscles.

The cranial electrical stimulation therapy is regarded to be absolutely safe. It is based on electrical signal of micro-power. The electrical signal sends the body electrical waves of different form in the border of 600 microamperes (see Fig. 1). The physiological mechanism of the cranial electrical stimulation functioning is still researched and scientific experiments are carried out (Gilula, Kirsh, 2005).

Today sport science plays a big role. Often one hundredth of a second, centimetres, even millimetres determine winner or loser in competitions. How
to find out, where the mistake was made and why the opponent managed to overcome our athletes? Using the recent achievements of science, coaches can analyze their methodological failures in athlete preparation better and more clearly as well as study the parameters of preparation process in details emphasizing strong and weak sides of every preparation phase. The research on athletes’ training system rapidly develops in biology, especially in the field of muscle structure, regulation peculiarities, and energy supply mechanisms as well as on adaptation of functional systems in different conditions (Chupriks, Rudzitis, Chuprika, 2014). Many researchers have promoted significant corrections when the principles of athlete preparation were reconsidered (Komi, 1990; Fernāte, 2002; Krauksts, 2003).

Kovalov (2004) came to the conclusion that the cranial electrical stimulation session increases subject’s functional condition (p< 0.05), decreases the arterial tension in 11 % and anxiety level in 15 %, and improves results of the short time memory in 25 %. One cranial electrical stimulation session is enough to improve human functional condition and work capacity.

A situation is pointed out that the biggest effect of the cranial electrical stimulation was when subjects had a big fatigue (Kirsch, Smith, 2004). Milostnoj in his research worked out the methodology of optimal cranial electrical stimulation frequency application to wrestlers. Stimulation with the power strength from 0 up to 3.5 mA was applied for four minutes during the maximal load, and then impulse frequency, length, and power strength were changed. The session lasted for 24 minutes. After the session, a positive dynamics of beta-endorphins in wrestlers’ blood was observed. It was established that the cranial electrical stimulation affected positively the recovery of wrestler hemodynamical and psycho-physiological processes under maximal loads (Milostnój, 2007).

Trojanov came to the conclusion that, when applying the cranial electrical stimulation, it is possible to do corrections of the vegetative condition, which is characterized by the changes of the heart rhythm variability. Highly trained athletes are affected more effectively by the cranial electrical stimulation (Trojánov, 2005).

The USA scientists have received excellent results in anxiety, despondency, insomnia, pain, headache, and undue stress of soldiers from wars treatment. A. Rudzitis and S. Freiverte have found out that, under the effect of CES procedure, athlete brain waves harmonize both in the psychological and physical tiredness conditions (Freiverte, Rudzitis, 2014).

Any physical activity causes the formation of the free radicals that negatively affects both muscle work and recovery after load. Oxidants continue influencing muscles even after the end of the practice (Chupriks, Rudzitis, 2006). They cause the oxidation of the cell membrane, DNS, and proteins, thus, inciting damage and inflammation of muscle tissues. It can be stated by the sense of tiredness and pain in the damaged place. Athletes struggle with the negative effect of the free radicals by dosing load and observing a strict daily regime during practices. The more they train and tire out muscles, the more time they need to recover and regain strength after the training. Rest has a vital importance, although, muscle growth is stimulated under the effect of physical load, they develop and grow during the rest period (Cupriks, Cuprika, Rudžītis, 2014).

For athlete body to recover effectively enough it is usually necessary to observe the following conditions:

- regular training regime and the load adequate to the athlete functional condition;
- observing of training and resting regime;
- cooling down after physical load;
- rational and balanced diet including water consumption;
- sufficient sleep;
- recovery procedures – massage, cold baths, etc.;
- pharmacological means of recovery: vitamins, minerals prescribed by a sports doctor (Krauksts, 2003).

So, two vital components derive form the basis of a sports training: the preparation process and athlete’s preparedness as a result of the training process. The most important task of a coach is to find the most effective way, how to prepare his / her athlete so he / she could achieve the highest work capacity in the most appropriate moment and be able to realize it. In this respect, the application of the cranial electrical stimulation...
stimulation in sport has not been fully researched. The effect of the cranial electrical stimulation on athlete’s functional condition, movement dynamic parameters as well as on body recovery processes has not been analyzed in detail.

Materials and methods

Two different, according to the training intensity, athletes’ groups participated in the research. The first group: 12 participants of the Latvian national bobsleigh men team, their average physical load intensity in the practices (according to the participant heart rate frequency) varied from medium to high with short time sub-maximal intensity when performing separate exercises. These were mainly training sessions where exercises with medium and high resistance and with big movement execution speed were used so they would develop the most effectively power necessary for this sport (Chupriks, Rudzitis, Chuprika, 2014). The second group: 14 participants of the Latvian Academy of Sport Education women handball team, who worked in their practices with medium high and sub-maximal physical load intensity. The practice length in both sports was practically similar: 90-120 minutes.

The cranial electrical stimulation was applied by Alpha-Stim stimulator; its effect mechanism is described in the theoretical part of the article.

The equipment „Omega S2“ (St. Petersburg, „Dynamics“, 2009) is a complex diagnostic equipment that extensively analyses and interprets the electrical signals of cardiac rhythm. The analysis of the body biorhythmic processes is based on up-to-date information technologies and the latest findings in biology, psychology, genetics, and clinical medicine. Any changes in the body are reflected in heart rate. In response to the impulses of the central nervous system, the heart rate determines the rhythm of the entire body so, on the basis of the heart rate dynamics, it is possible to determine objectively the functional state of the body and predict even possible changes in the nearest future. The screening diagnostics of athletes’ heart rate was performed by the equipment “Omega S2” and the heart rate of all participants was determined at rest position and within 3 to 5 minutes 300 cardio-complexes were recorded. This system is based on fractal neuro-dynamic heart rate analysis. The method analyses five stages of heart rate but, as a result of neuro-dynamic analysis, a double code combination is elaborated, which consists of sequentially registered heart impulses with equal parameters. Such methodical algorithm obtained in a particular time period provides information on the functional state of human body based on basic levels of heart rate regulation (see Fig. 2).

For this study we chose general parameters of functional diagnosis, which are automatically stated by “Omega-S” system, revealing quantitative criteria (in percent) and define health qualities of the cardiovascular system: 1) the parameter A – adaptation level of the cardiovascular system; 2) the parameter B – autonomous regulation of the vegetative system; 3) the parameter C – the central heart rate regulation; 4) the parameter D – psycho-emotional state; 5) the parameter H (health) – integral indicator of the functional condition.

The research algorithm was the following: in the first research phase the parameters determining the functional condition of the sport game group athletes were stated 4-5 times for each of them immediately after the training and 50-60 minutes after the training (after shower, changing, and rest). In the second research phase sport game players’ functional parameters were obtained immediately (4-5 minutes) after the training, then they had CES procedure, and 50-60 minutes after the training the parameters of the functional condition were stated again.

The testing of the bobsleigh athletes took place as follows: in the first research phase of the experiment the parameters stating the functional condition of the athletes were stated several times each day of the training camp (5 training days). For the first time it was done in the mornings after getting up, for the second time – after the first training of the day, for the third time – after the afternoon rest and
before the second training of the day. In the second research phase CES procedure was carried out after the first training of the day. Then the testing of the athletes’ functional parameters was done following the first stage algorithm. In the third research phase CES procedure was carried out after the second training day and about 2-3 hours before going to bed. The tests of the athletes’ functional condition were done in the described succession. The identity of the physical load was provided both in trainings which were not followed by CES procedure and in trainings after which it was applied.

The obtained parameters of the measurements were processed with the methods of mathematical statistics. The following statistical methods were chosen for the analysis of the experimental results: the method of descriptive statistics – arithmetic mean; standard errors and deviations, rate of difference of results; t-test (Student’s t-test).

Results and discussion

As it was already mentioned, both time and quality of athlete’s body recovery process after physical loads plays an essential role in trainings and competitions. It goes without saying that in trainings of various sports, the parameters of training loads are different. These differences are determined by specifics of particular sport (goal to achieve) and the applied training means and methodology. Therefore, one important direction of our research was the research not only about athletes’ recovery after training load in general but also about recovery after trainings when athletes had loads of different intensity. The results of the obtained measurements are shown in the figures below.

A sport game practice is characterized by the load of a changeable intensity. However, usually the average training intensity is high. It is particularly high at the end of the training when there is a game played and the load intensity is very close to the one of competitions. Trainings should be finished with a cool down that already includes the body recovery processes. We excluded the cool down and started measurements just after the main part of the training. The obtained results are shown in the figure below. The left column shows the “Omega” test measurements immediately after the training, the middle column – the parameters of the athlete physical condition after 50-60 minutes of the recovery (shower, changing, and passive rest) time, the right column shows the parameters after 50-60 minutes of the recovery when before going to the changing rooms and CES procedure was applied to the participants. As we see, after the application of CES procedure all parameters characterizing athlete functional condition have recovered more rapidly.

As it is shown in the Figure 3, just after the training HR parameters in a group on average were 86.2 beats/min. After 50-60 minutes recovery time athletes’ mean pulse decreased up to 79.2 beats/min but, under the effect of CES procedure, after the same time period the heart frequency decreased up to 77.1 beats/min. The parameter of the adaptation possibility to physical load (A) changed the following: just after the training load it was 52.1 %, after 50-60 minutes it had increased up to 65.3 % from maximally possible but after CES procedure and 50-60 minute recovery it exceeded 71.7 %. The parameter B – autonomous regulation of the vegetative system – changed the following: immediately after the training it was 47.5 %; without CES procedure after about one hour rest – 67.5 % but after the application of CES procedure – 79.5 %. The parameter C – the central heart rate regulation – immediately after the training decreased up to 58.9 %, in 50-60 minute recovery period it increased up to 62.5 % but, under the effect of CES, this parameter increased up to 68.2 %. The parameter D – the psycho-emotional state – changed from 56.8 % immediately after the training, after one hour rest it increased up to 61.9 % but, after one hour recovery and after the training applying stimulation, it increased up to 70.3 %. The indicators of health parameter – the integral indicator of the functional state – were the following: 53.8 % after the training, without application of stimulation – 64.3 %, and with electrical stimulation – 72.5 %.

![Fig. 3. Exchange of bobsleigh team participants’ parameters of physical condition without and with CES (procedure after afternoon training and afternoon rest)](image_url)

Bobsleigh is a sport with average physical load intensity in trainings. Sure, in bobsleigh trainings there are loads of maximal and sub-maximal
intensity, however, their proportion is not as big as in sport games. The next figures show the changes of bobsleigh athletes’ physical condition parameters before the second training of the day when the morning training and three-hour rest are over as well as after the night sleep before morning exercises.

The testing results of functional condition of athletes who in the training camp had three trainings with moderate intensity every day under CES effect and after three hours of recovery period changed as follows: the parameter of the team participants’ pulse mean frequency (HF) after CES application decreased only in 0.3 beats/min (>0.05). Though, the indicators of the parameters characterizing athletes’ functional condition with and without CES procedure were the following: the parameter A – 70.6 % without CES and 71.01 % with CES (p>0.05); the parameter B – 86.0 % and 87.01 %; the parameter C – 67.8 % and 73.4 % (p<0.05); the parameter D – 69.9 % against 75.0 % (p>0.05); and the integrated parameter H – 73.7 % without stimulation and 76.6 % after stimulation procedure (p<0.05).

As it is seen in the Figure 4, in the second morning after the application of the cranial electrical stimulation in the previous evening the mean of the heart frequency has decreased from 65.2 beats/min. to 63.7 beats/min., the difference is not statistically significant (p>0.05). Also, the changes of the indicators of the parameter A, under the effect of electrical stimulation, were not statistically significant (p>0.05), although, they have increased from 69 % just to 69 %. The changes of physical work capacity indicator (the parameter B) after the night rest did not show a statistically significant difference – 84.0 % against 88.01 %. However, the indicators of the athletes’ body energy reserves (the parameter C), under the effect of electrical stimulation, were statistically significant (p<0.05) as have improved from 67.7 % to 73.0 %. The indicators of athletes’ psycho-emotional condition (the parameter D) under the effect of CES have been higher – 72.1 % without CES against 76.3 % with stimulation (p<0.05). Also, the total indicator of the athletes’ functional condition after the applied electrical stimulation was higher in 3.53 % than at the same time after the same training loads obtained indicators.

When starting our research, we did not manage to study results of many researches that could have given us information about positive or negative effects of the cranial electrical stimulation on athlete’s body recovery after training and competition loads. But knowing the results of the USA medical scientists and their practical activity, we defined the hypothesis that CES could also mobilize the abilities of human body in other aspects of their activity. This idea seemed perspective also because our research results had confirmed the positive effect of CES on several athletes’ psycho-physiological abilities and, thus, the parameters of human psycho-functional conditions could be improved (Kirsch, Smith, 2004; Molotanovs, 2013; Chupriks, Rudzitis, 2014).

A. Rudzitis and S. Freiverte have found out that under the effect of CES procedure athletes’ brain waves harmonize both in the psychological and physical tiredness condition (Freiverte, Rudzitis, 2014) with sport practices induced on either of them.

So, we tried to find out whether it was possible to activate athletes’ recovery after physical loads and what an integral part of athletes’ preparation process was. What do we see? In the Figure 5 it is shown how the indicators of the functional condition test have changed under the effect of CES procedures. In all cases, it is stated that the indicators have increased. So, in total we can assert that the procedures of the cranial electrical stimulation increased recovery of athletes’ functional condition indicators. The highest increase of the indicators was observed in participants of the sports game team. Their mean indicators about one hour after load under CES
effect were higher for the parameter A in 6.2 %, for the parameter B – 12 %, for the parameter C – 5.7 %, for the parameter D – 9.4 %, and for the parameter H – 8.2 % than they were after the same time period without CES procedures.

The increase in bobsleigh athletes’ indicators were more modest. Three hours rest after the training and CES procedures provided higher test results for the parameter A – 0.4 %, for the parameter B – 1.1 %, for the parameter C – 5.6 %, for the parameter D – 5.1 %, and for the parameter H – 2.9 %. We stated slightly different changes of results in the tests after longer rest and in the morning after getting up. During the testing, after CES application about 2-2.5 hours before going to sleep, the indicators of the parameter A were higher in 0.6 % than when testing athletes at the same time without CES application in the previous evening. The indicator of the parameter B was higher in 4.07 %, C – 5.3 %, D – 4.2 % and the integrated parameter H was the highest – 1.4 %. We can affirm that the recovery of these athletes was also positively affected by CES procedure. Quite small differences of increase in indicators can be explained by the fact that bobsleigh athletes were extra class athletes with perfect preparedness. Their bodies had high adaptation ability to physical loads and perfectly regulated body recovery processes. This research and CES application regimen unambiguously show the usefulness of CES procedure as all the parameters characterizing physical condition without CES procedure have been lower than when applying this procedure. However, some athletes complained about afternoon sleep disturbances. Eventually, it testifies that CES procedures could not be applied similarly to all athletes as well as it shows the necessity to research other, more hidden processes in the body, for example, the changes of the brain wave activity under the effect of CES and link them to athletes’ individual reaction to CES procedure. To our mind, there is one of the most perspective moments of the research results of the project that requires continuing this research and finding out more optimal CES parameters to optimize recovery after loads.

Conclusions

1. In general, the CES procedure speeds up athletes’ physical condition of recovery after practices. The biggest changes caused by the CES procedure were shown in players of sport games, who practiced for 1.5 hours at high and sub-maximum rates of load intensity but recovery time was from 50 to 60 minutes: the adaptation level of the cardiovascular system (6.2 %); the autonomous regulation of the vegetative system (12.5 %); the central heart rate regulation (7 %); the psycho-emotional state (9.4 %); and the indicator of functional condition (8.2 %).

2. The efficiency of recovery after CES depends on physical load intensity in practice, athlete’s qualification, and time provided for athletes’ rest. The difference was estimated in recovery time as well as in functional condition indicators when testing with and without CES. For example, bobsleigh athletes are described as follows: the parameter A – after recovery of 3 h – 0.6 %, after 10-11 h – 0.4 %; the parameter B – 1.01 % and 4.07 %; the parameter C – 5.6 % and 5.3 %; the parameter D – 5.1 % and 4.2 %; the parameter H – integral indicator of the functional condition – 2.9 % and 1.4 %.

REFERENCES


**KRAINALINĖS ELEKTROSTIMULIACIJOS POVEIKIS SPORTININKŲ ATSIGAVIMUI PO ĮVIRAUS INTENSYVUMO FIZINIŲ KRŪVIŲ**

**Prof. Andris Rudzitis, prof. Viesturs Larins, prof. Leonids Chupriks,**
**doc. Leonids Zhilinskiis, Aleksandra Chuprika**
**Latvijos sporto edukologijos akademija**

**SANTRAUKA**

Tyrimo tikslas – ištirti kranialinės elektrostimuliacijos (KES) poveikį sportininkams normaliomis sąlygomis ir atsiraudant po įvairaus intensyvumo fizinio krūvio. Optimalus sportininkų organizmo atsigavimas po treniruotės ir varžybų yra tiek pat svarbus, kiek ir optimalus fizinio ir psichologinio krūvio parinkimas per pratybas.