CORRELATION BETWEEN THE CADMIUM, CALCIUM AND POTASSIUM IN THE BODY AND INDICES OF CARDIOVASCULAR SYSTEM OF ATHLETES

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Annotation. Performed a functional examination of the cardiovascular system in 80 students (40 players, 40 students are not involved in sports). Used the method of electrocardiography and computer rheography. The study was conducted in a state of physiological rest during exercise and during the recovery period. The level of chemical elements in the hair was determined by X-ray fluorescence analysis. The element of balance of athletes showed that the elemental balance of athletes in terms of the built environment is more satisfactory than the students. Students have a shortage of essential items. The study features of response of the cardiovascular system to exercise physiological significance of cadmium found in athletes. Character correlations essential elements with indices cardiovascular system conform to their known roles in physiological processes at the cellular level.
Keywords: cardiovascular system, sportsmen, chemical elements, cadmium, potassium, calcium.

Introduction

Worsening of human population's health state, which takes place recent decades, is to large extent conditioned by high rates of biosphere's anthropogenic transformation and decreasing of organism's adaptation abilities under influence of anthropogenic pressing [4; 5].

Adaptation of organism to unfavorable effects of environment, especially chemical loads, requires wide range of functional abilities and adequate re-switching of most important physiological systems to new mode of life activity 7]. It is known [6] that this process goes the most quickly and "painlessly" in organisms of sportsmen and people, who systemically practice physical exercises. On the other hand, just human organism in conditions of systemic physical loads, especially organisms of highly qualified sportsmen, need full-fledged micro- and macro-elements' provision. With it, special attention shall be paid to cardio-vascular system, the state of which, on the one hand reflects the state and effectiveness of adaptation processes [1;6] and, on the other hand, provides the most objective picture of sportsmen's adaptation abilities. From the point of view of this system's provision with chemical elements, the following elements are the most interesting: calcium (Ca^{++}) [3], potassium (K^{+}) and (Cd^{+}), which is antagonist to Ca^{++} and is considered to toxic one.

At present, in literature there is rather limited quantity of works about interconnections of microelements' content and indicators of sportsmen's heart activity; and available works do not give sufficiently complete picture about how interaction of microelements is realized in organism and how this interaction reflects in circulation system's functioning and in training and competition activity [9, 10].

The researches were fulfilled as per plans of scientific & research work of Tavricheskiy national university, named after V.I. Vernadskiy, "Medical-biological foundation of physical education system. Development and perfection medical-pedagogical observations' methods in training process" State registration number 0101U005752), as well as in compliance with plan of Crimea state medical university, named after S.I. Georgiyevskiy, by program "Physiological approaches to evaluation of ecological risks for health" (State registration № 0102U006172).

Purpose, tasks of the work, material and methods

The purpose of the work – determination of specific features of cardio-vascular system's functional state and its response to sport physical load, depending on content of Cd^{++}, Ca^{++} and K^{+} in organism.

The methods and organization of the research. The research covered 80 sportsmen (mail) of 18-22 years old age, from whom: 40 sportsmen – professional football players (1^{st} group) and 40 students, training physical exercises in the frames of academic program – (2^{nd} group). The tested were examined for content of Cd^{++}, Ca^{++} and K^{+} in biologically stable tissues (hairs) with the help of X-ray-fluorecent method in laboratory of scientific & research center "VIRIA" (Kiyev).

Evaluation of cardio-activity was conducted by registration of indicators with method of electric cardiography (ECG) with apparatus "Ergocard" (Italy). In the course of examinations the following ECG indicators were registered: intervals PQ (s) and QPST(s), segment ST (s), complex QPS (s), and interval R-R (s).

ECG was taken in state of physiological rest with combined step-by-step physical load on bicycle ergometer, which consisted of 8 stages (each stage – 3 minutes) and in restoration period (5 minutes duration).

For registration of indicators of central cardio-haemo-dynamics we used rheo-analyzer PA5–01. Rheograms were recorded in state of physiological rest after 12 minutes of physical load on bicycle ergometer and 5 minute of restoration. The following indicators were registered: stroke volume (SV, ml), minute blood volume (MBV. l.p.min.); cardiac index (CI, l.p.min.m); stroke index (SI, ml.p.m ^{2}); total peripheral resistance of vessels (TPRV, dyne s.p.cm $^{-5}$).

Statistical processing of data was carried out with non parametrical correlation analysis by Spirman and with statistical comparison by Manna-Wittny.

doi: 10.6084/m9.figshare.775332

Results of the researches

First of all it should be noted that average content of chemical elements in organisms of the tested sportsmen was in the limits of conventional accepted , as on to day, norm [4; 8]**,** while students, who did not practice sports, had deficit of essential elements (see table 1).

Table 1.

Concentration (mkg.p.g) of of chemical elements in hairs of tested students

Chemical element	Minimal	Maximal	X±Sx	Con
Cd^{++} (cadmium)				
1st group	0.00	0.28	0.08±0.01	0-1
2nd group	0.00	0.17	0.05±0.01**	
Ca^{++} (calcium)				
1st group	183.67	929,69	353.31±28.40***	300-700
2nd group	145.62	718.19	179.50±25.38	
K^{+}(potassium)				
1st group	0.00	185.34	84.90±10.26	70-170
2nd group	0.00	301.21	40.49±8.87***	

Notes: Differences between groups are confident ** – with $p<0.01$; *** – with $p<0.001$.

Reduced content of essential elements in students' (not going in for sports) organism can be conditioned by a number of reasons: their low content in food, increased consumption connected with stress situation, excessive using of products with caffeine, smoking [2; 6]. At the same time obtained by us data comply with data about differences in elements' content in hairs of professional sportsmen, which is higher by concentration of most of chemical elements in comparison with healthy persons, who are not sportsmen [5], but it should be noted that increased concentration of calcium in hairs can reflect not so its increased content in organism as point at increased metabolism of this element and its excretion from organism with systemic physical loads.

Results of correlation analysis of students' cardio-vascular system indicators with content of studied chemical elements in organism permitted to state the following.

The most substantial influence on ECG characteristics was registered from the side of toxic Cd^{++} (see table 2).

Table 2.

Data of correlation analysis of cadmium content and cardio-vascular system's indicators of the tested students

Stages of research	Indicators	Sportsmen		Students (not sportsmen)	
		r	p	r	p
rest	Interval PQ	-0.47	0.01		
	Complex QRS	-0.47	0.01		
	SI	-0.55	0.02	0.31	0.05
load	Interval PQ	0.54	0.01	0.40	0.01
	Complex QRS	-0.35	0.02		
	Interval QRST	-0.53	0.01		
	Segment ST		.	0.46	0.02
	Interval R-R	-0.45	0.02	0.35	0.02
	SI	-0.56	0.01		
restoration	Interval PQ	-0.43	0.05		
	Interval QRST	-0.56	0.01		
	Segment ST	0.52	0.01	-0.37	0.01

Concerning sportsmen, such dependence was observed even in state of physiological rest, pointing at direct dromotropic and chronotropic action of Cd^{++}.

For cadmium we have registered confident reverse correlation connection with SI indicators of sportsmen, i.e. the more was content of cadmium, the less quantity of blood was pumped by heart per one systole (see table 2). In not practicing sports students' organisms cadmium acted in the opposite way.

Rendering of physical load permitted to find more correlation connections both for sportsmen and for students-not sportsmen, in whose organisms, besides it, there was registered negative chronotropic effect of Cd^{++}. As far as mechanical work of heart concerns, it also in a certain way responded to level of Cd^{++} organism by character opposite to its manifestation in sportsmen's organisms. Less than with physical load, but greater that in state of physiological rest sensitivity of heart ECG parameters to presence of Cd^{++} in organism was observed also in restoration period.

Thus, we can note that significance of Cd^{++} for functional state of cardio-vascular system was, mainly, of cardiotropic character, as far as it manifested, mainly, in relation to cardio-indicators.

The revealed physiological significance of essential elements is of special interest. For example, K+ showed a lot of correlation connections in students' organisms and proved negative chronotropic effect. It facilitated increasing of

ventricles' excitation time and, owing to it, all cardio cycle, with physical load of students, not practicing sports, while, at the same time, in sportsmen's organisms K^+ influenced in opposite way on ventricle complex in general. It also, probably, "improved" mechanical work of heart, showing positive correlation connection with a number of heart work parameters (see table 3).

Table 3.

Data of correlation analysis of potassium content and cardio-vascular system's indicators of the tested students

Indicators	Sportsmen		Not sportsmen					
	load		rest		load		restoration	
	r	p	r	p	r	p	r	p
Complex QRS					0.36	0.01	0.31	0.05
Interval QRST	-0.54	0.01			0.40	0.03	0.40	0.02
Segment ST					-0.45	0.02		.
Interval R-R					0.40	0.03		.
MV			0.51	0.01	0.44	0.01	0.40	0.02
SV			0.54	0.01	0.39	0.04	0.41	0.02
SI			0.61	0.01	0.45	0.02	0.42	0.01
CI			0.57	0.02	0.37	0.04	0.41	0.02
TPRV			-0.52	0.01				

Essential Ca^{++} rendered classical positive chronotropic effect, facilitating decreasing of cardio cycle's duration of sportsmen, while for students, not going in for sports, this effect was insignificant.

With the help of rheography it was found that Ca^{++} significant for two indicators of cardo activity (MV andf CI) of sportsmen that points at well-known role of this element in providing of myocardium contraction ability (see table 4).

Table 4.

Data of correlation analysis of calcium content and cardio-vascular system's indicators of the tested students

Stages of research	Indicators	Sportsmen		Students (not sportsmen)	
		r	p	r	p
rest	MV	0.45	0.02		
	CI	0.40	0.07		
load	Interval QRST	0.44	0.05		
	Interval R-R	-0.46	0.01		
restoration	Interval R-R	-0.47	0.04		

Total quantity of correlation connections witnesses about high sensitivity of cardio-vascular system of students, who are not sportsmen, to imbalance of essential elements, first of all – K^+, probably in connection with its low content in organism, then Cd^{++} and Ca^{++}.

In sportsmen's organisms, for which normal balance of the studied elements was characteristic, the most substantial influence was rendered by Cd^{++}, and then – by essential Ca^{++} and K^+.

Besides, basing on total quantity of the found correlation connection, we may state that their maximal quantity was found with applying physical load, then – in restoration period and minimally – in state of physiological rest, that permits to say about compensated changes of cardio-vascular system's responsiveness and its adaptation potentials, conditioned by change in content of appropriate chemical elements.

Conclusions:

1. It has been found that mean content of chemical elements in sportsmen's organisms was within conventional physiological norm, while students, who did not practice sports, had deficit of calcium and especially potassium in organism.

2.It has been stated that cadmium rendered certain influence on cardio indicators of sportsmen; both on electric-physiological: interval PQ, complex QRS, interval QRST, segment ST, interval R-R with $-0.35 \le r \le -0.56$ и $0.01 \le p \le 0.04$, - and on parameters of rheogram (SI; $r=-0.55$; $p \le 0.02$), in state of physiological rest, with physical load and in restoration period. In organisms of students, who were not sportsmen, cadmium was not so significant, excluding its general influence on duration of cardio cycle with, by the way, in opposite than in sportsmen's organisms way and practically only under physical load.

3.Functional significance of essential elements for students, who do not practice sports, manifested only after physical load and, to rather less extent, in restoration period, while in sportsmen's organisms such dependence was observed also in state of physiological rest, pointing at higher need on micro-elements' provision with systemic physical loads.

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Cite this article as: Reshetniak O.A. Correlation between the cadmium, calcium and potassium in the body and indices of cardiovascular system of athletes. *Pedagogics, psychology, medical-biological problems of physical training and sports,* 2013, vol.10, pp. 68-72. doi:10.6084/m9.figshare.775332

The electronic version of this article is the complete one and can be found online at: http://www.sportpedagogy.org.ua/html/arhive-e.html

Received: 02.08.2013
Published: 30.09.2013