INTEGRATIVE ASSESSMENT OF KICK BOXERS' BRAIN BLOOD CIRCULATION AND BIO-ELECTRICAL ACTIVITY IN CONDITIONS OF CORRECTION TECHNOLOGIES' APPLICATION

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Abstract. *Purpose:* to scientifically substantiate the role of para-vertebral impacts on blood circulation and bio-electrical activity of kick boxers' cortex. *Material:* in the research participated kick boxers (main group, n=62) and university students (control group, n=25) of 18-23 years' age. Assessment of para-vertebral impacts with device "Armos" and classic massage was fulfilled with the help of the following methodic: trans-cranial dopplerography of head main arteries and cortex EEG of the tested. *Results:* it was found that with the help of para-vertebral impacts by device "Armos" linear velocity of cerebral blood flow reduces to normal limits and in- and inter-hemispheres' interaction strength increases. *Conclusions:* para-vertebral impacts by device "Armos" activate integrative processes and inter-hemispheres' interactions of different cortex areas of kick boxers. It can witness about better formation of functional systems, ensuring sports efficiency.
Key words: kickboxing, device "Armos", cerebral dopplerography, electroencephalography, linear velocity of blood flow, coherence.

Introduction

Kickboxing is characterized by high physical, psycho-physiological and emotional tension, in connection with kick/punch impacts; by rather high temp of duels and actions of high static-kinetic level. That is why, in our work modern approaches to training technologies is presented. In basic period technology includes training of local-regional muscular endurance, accurate actions and formation of resistance to hypoxia. It requires assessment of blood flow borders (cerebral inclusive and bio-electrical activity of brain). It is connected with the fact that kick-boxers' sports functioning often is accompanied by brain micro-traumas and disorders in sportsmen's body segments. Kick-boxers endure muscular-fascial imbalance and disorder of static-kinetic stability. Comparative analysis of correction technologies' influence showed high effectiveness of some of them in influence on cerebral blood circulation and brain's bio-electrical activity. We showed some priorities of the applied technologies, comparing our data with control data received in fitness technologies' practicing. We also found specific mechanisms of functional changes, characteristic for this kind of sports.

Kickboxing requires from sportsman comprehensive fitness and adaptive ability to fulfill intensive motor actions in short periods of time. In connection with the above said, kick-boxers can endure muscular-fascial imbalance, resulting in fatigue and risk of traumas [8, 16, and 20]. It should be also noted that kick/punch impacts in head area can cause micro-traumas [17, 18, 19, and 25] and other deeper disorders of organs [21, 23, and 24]. Application of brain bio-electric activity and dopplerography methodic in trainings permits to open sports potentials of the tested [6, 10].

In materials of sports physiology and kinesiology there is quite a number of works on rehabilitation of sportsmen with nervous-muscular disorders [2, 3, and 9]. In these works weak links are revealed and technologies of manual-muscular testing, functional eating are offered; creation of artificial training-correction medium system, reflex moving to sports influences are described [1] (including overloads and disorders of adaptation).

The researches of N.A. Volynkina [4] showed that compensated compression of peripheral tissue was a factor, reducing sportsmen's adaptation reserve. Correction influences permit to increase the reserves, spent on adaptation-compensatory processes in conditions of average degree traumas. O.G. Sukhorukova [12] offered technique of dura mater restoration during 2-5 minutes, in conditions of competitions. In works of Shitikov T.A. [15] potentials of manual therapy and applied kinesiology in correction of athletes with post traumatic vascular

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disorders are shown. Such correction causes reduction of increased excitability of brain's segmental structures, which ensure tonic reactions of cranial and cervical muscles, normalization of muscle tonus under metabolic-trophic disorders. These integrative processes facilitate strengthening of connections between neuron chains and mobilization of organism's reserves for sports efficiency. Klimesch W. [22] found that organism's integrative functioning is based on cortical/sub-cortical connections and mobilization of neuron circuits with frequency of external rhythm. It happens against the background of increase of nervous organization's plasticity, which regulates processes in conditions of unexpected factors.

Hypothesis: It is assumed that the conducted rehabilitation measures permitted for complex scientific group and coach to timely eliminate appearing dysfunctions and, at the same time, use organism's reserves for increasing of its functioning. Sportsmen's relaxation increase resistance of brain structures to synchronization and activation at inter-neuron level. Integrative processes and inter-hemisphere interactions of different areas of kick-boxers' brains are activated. It can witness about better formation of functional systems, ensuring sports efficiency.

The purpose of the research is to scientifically substantiate the role of manual-correction influence with devise "Armos" and classis massage impacts on blood flow and bio-electrical activity of kick boxers' cortex and comparison of these data with the data of fitness practices.

Material and methods

Participants: in the research participated kick-boxers from first spots grade to masters of sports (main group, n=62 and students of ФГБОУ ВПО "South-Ural State university". The students practiced fitness technologies 2 times a week (control group, n=25). All participants were of 18-23 years' age. Kick-boxers were the main group (2^{nd} group, n=62), which was divide into two sub-groups: 3^{rd} (n=40) and 4^{th} (n=22).

Procedure (organization of the research): By standard methodic all tested kick-boxers and control group students (n=87) twice (before and after corrections) endured two diagnostic procedures. The first was supersonic trans-cranial dopplerography («Digi-lite» of «Rimed» Co, Israel) for study of blood flow in frontal, middle, vertebral (4^{th} segment) brain arteries of both hemispheres; main (basilar) artery (MA), basal vein of Rosenthal. Then we registered electroencephalogram (EEG) from symmetric outlets of occipital (O1, O2), parietal (P3, P4), central (C3, C4), forehead (Fp1, Fp2, F3, F4, F7, F8), temple (T3, T4, T5, T6) with separate ear indifferent electrodes. In the range from 1 to 35 Hz we calculated spectrums of coherence with resolution by frequency of 0.2 Hz for segments 2 from monopole EEG. Average coherence level is calculated automatically for all EEG frequency band in the whole and for separate physiological rhythms. On the base of mean coherence level we assessed coherence spectrums. Besides, we studied statistical linear connections of electric processes of two brain areas. They were assessed by value of connection by every separate frequency of oscillations independent on their amplitude [5].

After preliminary testing by two above mentioned methodic, 2^{nd} main group of kick-boxers was divided into two sub-groups. With device "Armos" we conducted 10 days' course of influencing on para-vertebral areas in sub-group 3 (n=40) and 10 days' course of classis massage (back and neck) in sub-group 4 (n=22).

Device "Armos" is a rigid structure with special protrusions. Lying on back, sportsman puts this device turn-by-turn under cervical, thoracic and lumbar spines. After dozed pressing by weight of own body on the mentioned backbone segments unloading is achieved. It reduces possible pain and increases backbone mobility. This method is based on deep penetration of "Armos" device protrusions in muscular fascial tissues of backbone system. It stretches shortened muscles and opens bootastic joints that restore their mobility [14]. Technology and methodic of apparatus-manual correction "Armos" implied stimulation of nervous-muscular and fascial segments of backbone, ensuring keeping of dynamic postures, support and defense of organism from shocks. Fascias have cell memory and form myo-fascial chains. Fascias ensure regulation of neighboring muscles and other organs' tonus. In case of patho-bio-mechanical dysfunctions there happens disordering of impulses' passing from muscles to organs, ensuring static-kinetic balance. EEG and brain blood stream registration permits to find left- or right hemisphere motor- cerebellum thalamo basilar conductivity for diagnosis of main and compensatory sides of affection.

Statistical analysis: statistical processing of the research material was fulfilled with the help of programs Statistica 10.0, SPSS 17 on the basis of key methods. Confidence of differences between groups was determined with Mann-Whitney test.

Results of the research

Results of testing of kick-boxers' and control group blood flow are given in table 1. Comparison of kick-boxers' and control group indicators before and after correction influences with apparatus-manual method showed confident differences by all spectrum of brain arteries ($p \leq 0.05$-0.01). Exclusion was left front brain artery, right brain artery and main artery. It can be assumed that higher diameter of left carotid and left backbone arteries (as well as asymmetry of kick-boxers' dynamic positions in duel) results just in such re-distribution of blood stream. In most of arteries, under impact of apparatus-manual complex "Armos" excess of brain blood flow substantially decreased. Vein blood flow in basal vein of Rosenthal was studied with method of trans-cranial dopplerography. Parameter of blood flow systolic velocity (LVBF – linear velocity of blood flow with norm of not more than 19 cm/sec) and indicator of artery-vein balance (correlation of final diastolic velocity in carotid artery with maximal systolic velocity in internal jugular vein) are the main indicators of brain vein blood circulation. In control group these indicators were in reference limits.

Table 1. Characteristics of brain blood flow in the tested groups before and after corrections

Parameters of cerebral blood stream		**1st control group (n=25)**	**2nd group before correction (n=62)**	**I3rd subgroup after "Armos" (n=40)**	**IV subgroup after massage (n=22)**
Linear velocity of blood flow in middle brain artery (cm/sec.)	right	93.9±18.8	136.3±18.1*	95.48±16.11**	128.95±17.93
	left	96.3±19.7	124.85±18.9*	95.5±16.0**	121.38±19.09
Resistivity index in middle brain artery	right	0.56±0.07	0.64±0.04*	0.55±0.05**	0.62±0.07
	left	0.55±0.21	0.73±0.17*	0.54±0.02**	0.68±0.77
Linear velocity of blood flow in frontal brain artery (cm/sec.)	right	77.1±13.20	87.15±15.82*	87.03±11.94**	91.05±13.27
	left	77.3±18.1	83.76±17.31*	81.88±13.28**	84.92±16.08
Resistivity index in frontal brain artery	right	0.58±0.03	0.69±0.05*	0.55±0.07**	0.64±0.06
	left	0.54±0.05	0.66±0.11*	0.55±0.34**	0.60±0.24
Linear velocity of blood flow in back brain artery (cm/sec.)	right	54.7±17.1	78.95±13.2*	54.39±8.11**	68.60±10.13
	left	56.9±16.3	64.34±10.25*	58.01±9.35**	60.65±10.53
Resistivity index in back brain artery	right	0.56±0.19	0.75±0.25*	0.54±0.12**	0.59±0.09
	left	0.56±0.08	0.75±0.09*	0.53±0.07**	0.68±0.09
Linear velocity of blood flow in 4th segment of backbone artery (cm/sec.)	right	57.2±8.1	31.97±12.45*	58.10±7.11**	43.91±9.21
	left	56.1±4.1	37.22±13.17*	56.95±7.89**	41.56±12.24
	right	0.53±0.06	0.60±0.06	0,52±0,04	0.59±0.72

Parameters of cerebral blood stream	**1st control group (n=25)**	**2nd group before correction (n=62)**	**I3rd subgroup after "Armos" (n=40)**	**IV subgroup after massage (n=22)**
Resistivity index in 4th segment of left backbone artery	0.54±0.05	0.66±0.07*	0.51±7.21**	0.62±0.08
Linear velocity of blood flow in main brain artery (cm/sec.)	59.1±12.3	74.43±14.14	67.55±13.78	72.09±13.33
Resistivity index in main brain artery	0.51±0.05	0.64±0.07*	0.54±0.05**	0.60±0.25
Inter-hemisphere asymmetry by middle brain artery, (%)	4.2±1.5	10.99±11.2*	0.98±1.5**	8.03±11.87
Inter-hemisphere asymmetry by frontal brain artery, (%)	2.5±1.5	4.6±0.7*	0.8±0.05**	6.99±13.83
Parameters of cerebral blood flow	1st control group (n=25)	2nd group before correction (n=62)	I3rd subgroup after "Armos" (n=40)	IV subgroup after massage (n=22)
Inter-hemisphere asymmetry by back brain artery (%)	3.9±2.8	16.9±16.1*	4.9±2.9**	16.05±19.02
Inter-hemisphere asymmetry by backbone arteries, (%)	1.3±12.0	13.5±8.9*	4.8±2.8**	12.15±11.10

Notes: * - confident differences between indicators of 1st and 2nd groups ($p < 0.05$); ** - confident differences between indicators of 2nd group and 3rd subgroup ($p < 0.05$); *** - confident differences between indicators of 2nd group and 4th subgroup ($p < 0.05$).

In group of kick boxers indicator of artery-vein balance before correction was less than 1 and velocity of blood stream in basal vein of Rosenthal was by 43% higher than normal. In the whole it worsened blood circulation because of complicated vein outflow of dystonic character. After fulfilled corrections in subgroups 3 and 4 we registered physiological orientation of both parameters – statistically significant in "Armos" group. In conditions of ischemic progressing of brain substance it is important to realize self-regulation of brain circulation. We found parameters of blood circulation regulation reserves (anatomic, myogenic and metabolic) when making compressing test, tests with breathing pauses and hyper-ventilation with calculation of cerebral vascular reactivity index. The results of these tests are presented in table 2.

With computer electroencephalograph "Neuron-Spectr – 4" ("Neuro-Soft", Russia) we registered EEG from symmetric occipital (O1, O2), parietal (P3, P4), central (C3, C4), forehead (Fp1, Fp2, F3, F4, F7, F8), temple (T3, T4, T5, T6) outlets with separated ear indifferent electrodes. In frequency band from 1 to 35 Hz we calculated coherence spectrums with resolution by frequency 0.2 Hz for segments 2 of monopole EEG. On the base of mean coherence level (calculated automatically for all frequency band of EEG in the whole and for separate physiological rhythms) we assessed coherence spectrums. Besides, we studied statistical linear connections of electric processes of both brain areas. They were assessed by value of connection by every separate frequency of oscillation, independent on their amplitude.

Table 2. Characteristic of vein outflow in tested contingent before and after corrections, (M±m)

Indicator	1st control group (n=25)	2nd group before correction (n=62)	I3rd subgroup after "Armos" (n=40)	IV subgroup after massage (n=22)
Linear velocity of blood flow in basal vein of Rosenthal (cm/sec.)	19.00±3.15	27.22±4.92*	18.89±4.15**	22.78±5.75
Artery-vein balance	1.00±0.65	0.78±0.45*	0.97±0.15*	0.83±0.37
Circle of Willis (%of separation)	55.35	35.15	39.58	34.76
Auto-regulatory response (myogenic reserve), %	75.18±2.46	66.39±16.35*	83.68±10.45**	72.69±17.54***
Metabolic reserve (index of cerebral vascular reactivity), %	52.41±2.95	29.66±12.98*	59.89±18.01	41.15±21.22

Notes: * - confident differences between indicators of 1st and 2nd groups ($p < 0.05$); ** - confident differences between indicators of 2nd group and 3rd subgroup ($p < 0.05$); *** - confident differences between indicators of 2nd group and 4th subgroup ($p < 0.05$).

In table 3 we present in-hemisphere coherences of different cortex areas of three groups' kick boxers. We found high coherence in frontal lobe, significant coherence in other areas, in left- right side correlations in conditions of apparatus-manual influence "Armos". According to the found coherences kick boxers have rather good functions of prediction, formation of movement's idea, pre-motor programming of movement and its realization. A little less coherence was noticed when influencing on analyzers' systems as well as with visual perception of movements, in which frontal brain artery (FBA), middle brain artery (MBA) and back brain artery (BBA) are engaged. Concerning regulation of movements, in the order of significance frontal lobe, central, parietal and occipital areas are engaged.

Table 3. Indicators of in-hemisphere coherences of alpha rhythm in tested groups

Cortex zones	Background electroencephalogram			Electroencephalogram with hyper-ventilation		
	II, n=62	III, n=40	IV, n=22	II, n=62	III, n=40	IV, n=22
Fp1-Fp2	0.62±0.004	0.66±0.005	0.61±0.007	0.62±0.004	0.68±0.005	0.63±0.006
F3-F4	0.65±0.003	0.69±0.006	0.64±0.007	0.63±0.004	0.67±0.004	0.62±0.006
C3-C4	0.63±0.003	0.70±0.005	0.61±0.008	0.63±0.005	0.64±0.006	0.61±0.007
P3-P4	0.60±0.004	0.67±0.006	0.60±0.007	0.59±0.005	0.62±0.005	0.61±0.006
O1-O2	0.53±0.005	0.61±0.007	0.56±0.008	0.49±0.005	0.54±0.006	0.53±0.007
F7-F8	0.44±0.004	0.52±0.007	0.47±0.008	0.39±0.004	0.42±0.006	0.41±0.007
T3-T4	0.40±0.005	0.46±0.007	0.39±0.008	0.35±0.004	0.36±0.006	0.33±0.007
T5-T6	0.35±0.005	0.39±0.007	0.31±0.008	0.27±0.005	0.25±0.007	0.21±0.008

Notes: Fp1-Fp2 – pole of frontal lobe; F3-F4 – frontal lobe (pre-motor cortex); C3-C4 – central area (motor cortex); P3-P4 –parietal area; O1-O2 –occipital area; F7-F8 – back forehead area (additional motor area); T3-T4 – frontal temple area; T5-T6 – back temple area; * − confidence of differences $p \leq 0.05$.

In 3rd subgroup of kick boxers we registered confident distinction of in-hemisphere coherence from group 2 by central, back forehead, parietal-occipital and temple areas of analyzers' fields. We also found prevailing (by 8-15%) development of 3rd subgroup sportsmen's two motor regulation components: involuntary, caused by sensor stimuli and arbitrary, caused by internal motive.

By alpha frequencies range of kick boxers we studied compatibility degree in short and longs pairs of in-hemisphere coherences (see table 4)

Table 4. Indicators of in-hemispheres' coherences of alpha rhythm in tested groups

Cortex zones	Background EEG			EEG with hyper-ventilation (HV)		
	II, n=62	III, n=40	IV, n=22	II, n=62	III, n=40	IV, n=22
Fp1F3	0.74±0.004	0.75±0.005	0.74±0.006	0.72±0.004	0.74±0.005	0.74±0.006
F3C3	0.71±0.004*	0.76±0.005	0.70±0.007	0.68±0.004	0.72±0.005	0.68±0.006
C3P3	0.67±0.005*	0.73±0.005	0.66±0.006	0.63±0.004	0.69±0.006	0.68±0.006
P3O1	0.65±0.004	0.67±0.006	0.68±0.007	0.65±0.005	0.65±0.006	0.67±0.006
Fp2F4	0.73±0.004*	0.81±0.006	0.79±0.007	0.75±0.004	0.82±0.005	0.79±0.006
F4C4	0.72±0.005	0.72±0.006	0.68±0.008	0.70±0.004	0.71±0.007	0.68±0.007
C4P4	0.65±0.005	0.66±0.007	0.60±0.008	0.63±0.004	0.61±0.006	0.60±0.006
P4O2	0.76±0.005	0.72±0.007	0.65±0.008	0.75±0.004	0.65±0.006	0.61±0.007
F7T3	0.72±0.005	0.75±0.006	0.73±0.008	0.69±0.004	0.71±0.007	0.67±0.007
T3T5	0.60±0.005	0.64±0.006	0.53±0.006	0.55±0.005	0.59±0.007	0.52±0.008
F8T4	0.71±0.005	0.73±0.007	0.69±0.006	0.66±0.005	0.64±0.007	0.66±0.006
T4T6	0.57±0.005	0.61±0.006	0.57±0.007	0.53±0.005	0.54±0.007	0.51±0.007

Notes: * – confident differences form indicator of control group, ** – in groups of sportsmen, $p<0.05$. FpF3 – pre-frontal cortex of frontal lobe from the left; F3C3 – pre-motor cortex of frontal lobe from the left; C3P3 –motor cortex of frontal lobe from the left; P3O1 –parietal-occipital area from the left; Fp2F4 – pre-frontal cortex of frontal lobe from the right; F4C4 – pre-motor cortex of frontal lobe from the right; C4P4 – motor cortex of frontal lobe from the right; P4O2 – parietal-occipital area from the right; F7T3 – forehead-temple area from the left; T3T5 – temple area from the left; F8T4 – forehead-temple area from the right; T4T6 – temple area from the right.

Discussion

In the course of writing the article there appeared some discussible moments. In opinion of M.V. Koroliova [7], increased brain blood circulation is an adequate functional reaction to muscular impacts. They require increased oxygen supply to motor cortex neurons. However, in opinion of Shevtsov A.V. [14] increased brain blood circulation shall be regarded as a state of system's tension, which can result in pre-morbid status and even in pathology of brain blood vessels. It should be added that excessive blood flow trail in rest state requires additional energy supply. Probably, myocardium shall work more intensively. Results of our mutual researches permitted to specify mechanisms of the processes, which take place and take neutral position in this duel of opinions. Actually, Koroliova M.V. is right, thinking that the found in our researches (see table 1) increased blood flow in kick boxers can be regarded as a symptom of working hyperemia. It witnesses about increasing of functional demand of motor neurons depending on the following: the higher neurons' demand in oxygen and glucose are the higher is blood flow. But Shevtsov A.V. is also right to some extent because owing to continuous increase of competition and training functioning's tension in muscular-skeletal apparatus of practically healthy sportsmen different physiological-bio-mechanical disorders are diagnosed. It can become a factor, provoking a number of borderline states of different organs and systems, for example myo-fascial pain syndrome with "trigger" zones, initiating pain, local muscular hyper-tonuses and etc. [11, 26, and 27]. Technique of many kick attacks, especially in kickboxing disciplines "low-kick" and "K1", results in twisting of backbone, when attacking legs, because of torso inertia, one-side overload and over tension of muscular skeletal apparatus. It causes tissues' lesion [6]. In parallel with it trophic dysfunctions of metabolic, autogenic and vascular-vegetative character appear. It results in imbalance of central, periphery and cerebral blood circulation [13]. There appears a question if increase of cerebral haemo-dynamic parameters occurs only as a result of increase of motor neurons' functional demands. The answer was received after rick boxers' recreational correction with device "Armos". Such correction influence on reflex areas in muscular-ligament apparatus of disordered segments, recovers static dynamic disorders of backbone and blocked joints' functions. These manipulations permit to eliminate blockages in joints and muscles with normalization of cerebral blood circulation and improvement of vein outflow. Our experiment showed confident reduction of brain blood circulation velocity parameters. Though, we observed increase of control data. It witnessed in favor of Koroliova's M.V. opinion about working hyperemia in perfusion-metabolic coupling. To

the above said it should be added that we had not found referent borders of cerebral blood flow in different areas of localization velocity parameters. Now information material is accumulated, which will permit to analyze differentially localization of linear blood flow velocities. It is the task of next researches.

Conclusions

1. Analysis of indicators of kick boxers' brain cortex bio-electrical activity, fulfilled with technology "Armos", permitted to determine bran resistance to stress impacts and better stability of functional state, comparing with group of kick boxers, who endured classic massage and control group.

2. In hyper-ventilation test we registered increase of inter-hemisphere interaction strength in pre-frontal cortex in group 3. We found confident distinctions from control group in increase of in-hemisphere coherence in forehead pre-frontal cortex from the right by 12% in group 3 and decrease by 15% in right parietal-occipital region in groups 3 and 4.

3. Application of device-manual procedure "Armos" reduced brain blood flow and increased reserves of 3rd group kick boxers' functional system (decrease in right and left middle brain arteries, in right and left back brain arteries, $p \leq 0.001$). Besides, we found increase of blood flow linear velocity (earlier reduced) up to referent borders in right and left backbone arteries ($p \leq 0.001$).

4. We also observed inter-hemisphere asymmetry in middle, front and back brain arteries ($p \leq 0.01$). In resistive indices confident shifts were registered in right and left middle brain arteries, in right and middle back brain arteries; in right and left backbone arteries and main basilar artery.

Conflict of interests

The authors declare that there is no conflict of interests.

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