CHANGE OF CENTRAL HEMODYNAMICS OF QUALIFIED ATHLETES FOR TESTING THE USE OF CONTROLLED BREATHING AND EVALUATION

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Annotation. Using spiroarteriocardiorhythmography surveyed 174 qualified athletes (121 male and 53 female). The examination consisted of three consecutive two-minute registrations - spontaneous, controlled breathing 6 and 15 breaths per minute. Found that the hemodynamic change substantially when the respiratory tests in the first place, cardiac output, cardiac index, total peripheral vascular resistance and specific peripheral vascular resistance. To develop criteria for evaluation of hemodynamic changes carried percentile variance analysis of all indicators in the performance tests. Testing of the evaluation criteria for different types of hemodynamics in athletes allowed to establish that eukinetic type characteristic is the reduction in heart rate and pulse blood pressure under test with controlled breathing 6 times per minute for hypokinetic – pronounced increase in systolic blood pressure and pulse blood pressure during the breath tests 6 and 15 times per minute for hyperkinetic – reducing end-diastolic volume, end-systolic volume, stroke volume, in vivo performance of both tests and an increase in systemic vascular resistance during test 15 breaths per minute.

Keywords: athletes, hemodynamics, controlled breathing.

Introduction

Modern practice of medical control of persons, who deal with physical education and sports, requires implementation of express, low-invasive methods of research of organism's functional state, which, in conditions of current and urgent examinations, would permit to receive as much information as possible about state of organism's system, ensuring organism's adaptation to physical loads and showing physical condition [7, 8, 11, 12]. Integral indicators of cardio-vascular system's indicators, characterizing central haemo-dynamics, are as important as indicators of myocardium, vessels, breathing, sensing-motor, vegetative nervous system's functions [1, 2, 3]. As a rule, in sports practice they use calculated parameters, because application of instrumental methods (US, rheography) is rather difficult at stage of current medical examinations. Exactly owing to this fact development of new methods of central haemo-dynamics' evaluation is of undoubted importance for further improvement of medical control, conditioned by need in taking prompt decisions on sports selection, on planning of training loads, determination of level of their endurance and predicting possible adaptation's frustrations [4, 5, 9, 10, 13-15].

The role of spontaneous and controlled factors is very important for ensuring central haemo-dynamics, which is realized through a number of neuro-reflex mechanisms, connected with switching in baro-reflex, metabolic, mechanical and extra-cardiac factors of blood circulation's activation [6].

Just owing to this, studying of regulation mechanisms of spontaneous and controlled breathing's influence on cardio-vascular functioning can play a key role in determination of functional abilities of a sportsman's organism.

In our previous publications we analyzed influence of controlled breathing on vegetative provision of cardio-vascular and breathing systems and determined substantial influence of breathing system [8, 16].

The present work has been fulfilled as per topic: "Differentiation of application of physical education means and methods, considering poly-functional criteria of physical development, functional state of cardio-vascular, breathing and sensing-motor systems" № 0109U000210.

Purpose, tasks of the work, material and methods

The purpose of the research – is determination of peculiarities of changes in sportsmen's central haemo-dynamics in the process of tests with controlled breathing and development of criteria for evaluation of the changes.

In order to achieve our target, with the help of up-to-date poly-functional methods of spiro-artery-cardiac rhytmography (SACR) we examined 174 qualified sportsmen, specializing in different kinds of sports. From them 53 women of 21.7±2.4 years old age; among them 1 international master of sports, 14 masters of sports, 19 candidates master of sports, 19- had 1st and 2nd sport grades, period of their sport life was 9.0±2.7years. Also there were 121 sportsmen of 24.3±5.4 years old age, among them 2 international masters of sports, 23 masters of sports, 43 candidates master of sports, 53 – of 1st and 2nd sport grades, period of their sport life was 8.4- 4.1 years.

Record of sportsmen's examination stipulated fulfillment of three successive two-minutes' measurements with the help of SACR with usual breathing, with controlled breathing 6 times/min. (CB_6) and 15 times/min (CB_{15}), which were fulfilled in forced rhythm with duration of inhale and exhale 5 sec. and 2 sec. accordingly. Additionally, after tests we determined main indicators of physical conditions (length of body, mass of body, circumference of chest, content of fat and other) and level of physical workability by results of Harvard step-test. All additional tests were carried out as per traditional methodic.

Let us remind that SACR is a method which, register simultaneously myocardium (electric cardiography in 1st branch), BP (by Penaz's method) and breathing pattern (ultrasonic spirography).

In table 1 we present characteristics of physical condition of examined sportsmen and sportswomen.

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Table 1.

Characteristics of physical condition of examined group of sportsmen/sportswomen

Indicator	Men n=121	Women n=53
Mass of body, kg	75.2 ± 9.7	58.7 ± 6.6
Length of body, cm	176.2 ± 7.1	166.0 ± 4.7
Length of body in sitting position, cm	95.1 ± 4.6	87.7 ± 4.3
Area of body surface, m^2	1.91 ± 0.16	1.64 ± 0.11
Diameter in shoulders, cm	40.6 ± 1.8	36.1 ± 1.4
Diameter in pelvis, frontal, cm	28.7 ± 2.1	27.5 ± 1.6
Diameter in pelvis, sagittal, смД	21.1 ± 1.6	19.7 ± 1.6
Neck circumference, cm	36.7 ± 2.2	30.8 ± 1.5
Abdomen circumference, cm	81.1 ± 7.2	73.6 ± 5.5
Chest circumference (relaxed), cm	96.1 ± 6.7	85.9 ± 3.9
Chest excursion, cm	8.3 ± 2.2	7.1 ± 1.7
Circumference of upper arm (relaxed), cm	28.8 ± 2.3	24.9 ± 2.0
Circumference of upper arm (contracted) cm	32.8 ± 2.6	27.2 ± 2.3
Circumference of forearm, cm	26.6 ± 1.9	22.2 ± 1.2
Circumference of thigh, cm	53.8 ± 3.9	53.3 ± 3.9
Circumference of shin, cm	36.1 ± 2.2	34.4 ± 2.0
Dynamometry of right hand, kg	48.2 ± 7.6	28.1 ± 4.6
Dynamometry of right hand, kg	44.9 ± 8.0	25.0 ± 4.3
Dynamometry of back, kg	142.2 ± 21.5	74.7 ± 15.6
Vital capacity of lungs, l	4.94 ± 0.70	4.19 ± 1.24
Fat content, %	16.0 ± 4.8	26.3 ± 3.9
Body mass index, $kg.p.m^2$	23.8 ± 2.2	21.6 ± 2.0
Shtange's test, sec.	74.9 ± 17.4	57.4 ± 15.2
Genchy's test, sec.	38.9 ± 11.9	34.0 ± 10.9
Index of Harvard step-test	96.8 ± 13.0	92.9 ± 18.3

Results of the researches

Researching of central haemo-dynamics was carried out with the help of SACR and envisaged calculation of indicators of final-systolic volume (FSV), final diastolic volume (FDV), stroke volume (SV), heart emission (HE) as per parameters of cardiac interval metering, considering changes of pressure in finger cuffs with further extrapolation to pressure in aorta. The obtained data permitted, considering weight-height indicators, to calculate parameters of heart index (HI),, stroke index (SI), total (TPVR) and specific (SPVR) peripheral vessels' resistance, on the base of which heamo-dynamics' type of certain sportsman is determined.

Haemo-dynamic types of examined sportsmen/sportswomen are given in table 2.

Table 2

Haemo-dynamic types of organisms' provisioning of man and women (%)

Type of haemo-dynamics	жінки	чоловіки
Hypo-kinetic, hypo-volemic	8.0	6.2
Hypo-kinetic	48.0	82.3
Eu-kinetic	22.0	6.2
Hyper-kinetic	20.0	4.4
Hyper-kinetic, atonic	2.0	0.9

As it can be seen in table 2, haemo-dynamic provision of examined sportsmen's and sportswomen's organisms is to some extent different. Great majority of the first (82.6%) have hypo-kinetic type of blood circulation, the rest (48%) have hypo-kinetic (48%), eu-kinetic (22%) and hyper-kinetic (20%) variants of haemo-dynamics. Attention should be also paid to the fact that hypo-volemic variants of men and women are nearly identical (6.2 and 8.0% accordingly), while hyper-kinetic atonic variants are rather rare and are characteristic for women that, to some extent, witnesses about abnormalities of vessels' tonus of the latter.

SACR methodic, having no analogues in the world, permits to register parameters of cardiac intervals metering and BP with every heart stroke, while combined with them registration of spirographic curve with the help of US sensor permits to determine changes of HBF and BP parameters (systolic BPS, diastolic BPD, pulse – BPP and average – BPA) at different phases of breathing cycle.

First of all, analyzing parameters of central haemo-dynamics in the process of tests with controlled breathing, it was necessary to pay attention to significant parameters of cardio-vascular and respiratory systems' functioning, which determine mechanisms of their responsiveness.

It should be noted that controlled breathing tests results in sportsmen's and sportswomen's substantial response of main parameters of cardio-respiratory system. First of all response to controlled breathing manifests as HBF change, which moderately increases during test CD_6 (from 69.1±0,8 to 73.2±0.75 of sportsmen and from 72.1±8.7 to 74.3±8.6 of sportswoman and significantly increases during test CD_{15} (from 69.1±0.8 to 80.9±10.05 of sportsmen and from 72.1±8.7 to 80.0±10.6 of sportswomen. Rather informative is dynamics of changes of standard duration of electric systole of ventricles (QTC, sec.), which, at CD_6 moderately unconfidently increases both of women and men (from 0.407±0.015 to 0.0412±0.014 and from 0.426±0.014 to 0.428±0.013, accordingly). At CD_{15} this changes are confident and are 0.421±0.016 ($p<0.05$) and 0.436±0.015 ($p<0.05$), accordingly. The latter permits to assume that controlled breathing strains pumping function of heart, especially at CD_{15}.

Speaking about parameters of respiratory system's functioning it should be noted that in final state, with spontaneous breathing, frequency of breathing (BF) of men and women was 14.4±3.0 and 15.7±3.3 1.p.min accordingly. Concerning breathing volume (BV) it, in final state, had some differences, which, in our opinion, were connected with sex specificities and stipulated greater increasing (both of men and women) at test CD_6 (from 0.705 ± 0.228 to 2.190±0.628 l and from 0.552±0.171 to 1.773±0.538 l accordingly) and less increasing of men's (to 1,273±0.496 l) and women's (to 0.832±0.272 l) at test CD_{15}. In general, test CD_6 results in triple increasing of BV both of men and women, while CD_{15} increases BV approximately 1.8 times independent on sex.

Table 3.

Changes of central haemo-dynamics' indicators during tests CD_6 and CD_{15} in comparison with spontaneous breathing of sportsmen (n=121)

Indicator	Spontaneous breathing	CD_6	CD_{15}
FDV, cm^3	101.8 ± 16.5	102.0 ± 17.7	99.9 ± 16.6
FSV, cm^3	33.1 ± 8.5	34.1 ± 9.1	34.3 ± 8.8
SV, cm^3	68.6 ± 9.0	67.9 ± 9.0	65.6 ± 8.7
HE, l.p.min.	4.7 ± 0.6	5.0 ± 0.6**	5.2 ± 0.6**
SI, $l.p.min^2$	2.51 ± 0.38	2.66 ± 0.41	2.81 ± 0.45*
TPVR, $din.p.sec.p.cm^5$	1631.5 ± 220.6	1539.3 ± 210.8	1468.5 ± 194.7*
SPVR, mm.p. $merc.col.p.l.min.p.m^2$	39.0 ± 6.9	36.6 ± 6.5	34.9 ± 6.2*
SI, $cm^3p.m^2$	36.6 ± 5.7	36.4 ± 5.8	35.5 ± 6.0

* - $p<0,05$

** - $p<0,01$

In tables 3 and 4 we present data of central haemo-dynamics' measurements in tests CD_6 and CD_{15} of sportsmen (table 3) and sportswomen (table 4).

In table 3 we can see that the most substantial confident changes in tests for controlled breathing, fulfilled by sportsmen, are present at indicators HE (l.p.min), SI ($l.p.min.p,m^2$, TPVR ($din.p.sec.p.cm^5$) and SPVR (mm.p. $merc.col.p.l.min.p.m^2$), which witness about increasing of heart emission, systolic index and reduction of vessels' resistance both during CD_6 and CD_{15}. The latter shows more substantial changes.

Table 4.

Changes of central haemo-dynamics' indicators during tests CD_6 and CD_{15} in comparison with spontaneous breathing of sportswomen (n=53)

Indicator	Spontaneous breathing	CD_6	CD_{15}
FDV, cm^3	93.9 ± 14.2	92.7 ± 13.6	91.7 ± 14.3
FSV, cm^3	28.1 ± 7.4	27.9 ± 6.8	28.1 ± 7.2
SV, cm^3	65.8 ± 7.6	64.8 ± 7.6	63.7 ± 7.8
HE, l.p.min.	4.7 ± 0.7	4.8 ± 0.6	5.0 ± 0.7
SI, $l.p.min^2$	2.90 ± 0.49	2.94 ± 0.40	3.07 ± 0.46*
TPVR, $din.p.sec.p.cm^5$	1476.9 ± 250.1	1443.4 ± 214.7	1387.4 ± 195.7*
SPVR, mm.p. $merc.col.p.l.min.p.m^2$	30.4 ± 5.8	29.7 ± 5.1	28.6 ± 4.8*
SI, $cm^3p.m^2$	40.3 ± 5.1	39.7 ± 5.1	39.0 ± 5.4

* - $p<0,05$

** - $p<0,01$

Nearly the same, but less confident data were shown by women (see table 4). This fact permits to say that during tests for controlled breathing extra-cardiac factors of blood circulation are activated and it results in increasing of heart emission and reduction of periphery vessels' resistance. Such mechanism of haemo-dynamics' adaptation is possible in conditions of adequate switching of sucking-in function of chest and diaphragm pump, which supplements baro-reflex mechanism of heart emission's regulation and keeping of BP.

In table 5 we presented generalized results of increment of absolute values of central haemo-dynamics' indicators for men and women in the process of tests for controlled breathing.

Analysis of the obtained data of increment of central haemo-dynamics' indicators witnesses that besides mentioned above, confident differences are present also in dynamics of FDV (cm^3) in men's results during test CD_{15} and decreases within 3 cm^3 , SV (cm^3), in men' and women's results during test CD_{15} – within 3.3 cm^3 and 2.2 cm^3, accordingly.

To certain extent, the obtained data are supplemented by results of analysis of absolute values MPS and BPD changes, which confidently, though not significantly (within 2-4 mm.p. merc.col) reduce during tests CD, independent on sex of the tested. In the same way BPA also reduces. The least substantial changes were observed in BPP indicators.

Table 5.

Dynamics of increment of indicators of central haemo-dynamics in CD_6 and CD_{15} tests, comparing with spontaneous breathing of sportsmen (n=110)and sportswomen (n=51) (M±m)

Indicators	men			women		
	initial	Δ in CD_6	Δ in CD_{15}	final	Δ in CD_6	Δ in CD_{15}
HBF, 1p.min.	68.5±0.9	4.4±0.5	11.9±0.8	72.0±1.6	2.3±0.5	8.1±0.8
FDV, cm^3	102.7±2.2	-0.4±0.9	-2.6±0.9	94.0±2.6	-1.2±1.6	-2.3±2.2
FSV, cm^3	33.4±1.2	0.8±0.5	0.8±0.5	28.2±1.4	-0.2±0.8	-0.1±1.2
SV, cm^3	69.2±1.1	-1.1±0.4	-3.3±0.5	65.8±1.4	-1.0±0.8	-2.2±1.0
HE, l	4.7±0.1	0.3±0.0	0.5±0.0	4.7±0.1	0.1±0.1	0.3±0.1
SI, $l.p.min^2$	2.51±0.06	0.16±0.03	0.29±0.03	2.89±0.08	0.05±0.04	0.17±0.06
TPVR, $din.p.sec.p.cm^5$	1630.4±27.3	-143.0±16.7	-208.5±19.9	1481.3±42.7	-79.3±28.4	-129.8±31.6
SPVR, mm.p. $merc.col.p.l.min.p.m^2$	39.0±0.8	-3.5±0.4	-5.2±0.5	30.6±1.0	-1.7±0.6	-2.7±0.7
SI, $cm^3.p.min^2$	37.0±0.9	-0.4±0.3	-1.3±0.4	40.2±0.9	-0.6±0.5	-1.3±0.6
BPS mm.p.merc.col.	123.2±1.2	-3.8±1.0	-3.6±1.4	111.0±1.3	-2.9±1.4	-1.9±1.9
BPD mm.p.merc.col.	78.6±0.9	-2.9±0.6	-2.9±0.8	71.3±1.1	-2.4±0.9	-2.7±1.1
BPP mm.p.merc.col.	44.7±0.9	-0.9±0.8	-0.7±1.2	39.7±1.1	-0.6±1.4	0.8±1.9
BPA mm.p.merc.col.	93.5±0.9	-3.2±0.7	-3.1±0.8	84.5±1.1	-2.6±0.9	-2.4±1.1

At the next stage of the research we analyzed indicators of increment of central haemo-dynamics' parameters, which were calculated considering individual changes of central haemo-dynamics parameters' components, concerning their final state, registered with spontaneous breathing. Such approach, with application of non-parametrical method of evaluation permitted to range responsiveness of cardio-vascular system, considering deviation of all indicators within the most frequent (from 25 to 75% counter-closing) to the most rare (from 0 to 5% and from 95 to 100% of their counter closing) variants of relative increment of the researched indicators.

In table 6 and 7 we presented criteria of ranged evaluation of separate indicators' responsiveness of sportsmen's and sportswomen's central haemo-dynamics during tests for controlled breathing.

Analyzing the presented evaluation criteria, we should note that they substantially differ from the most of indicators, obtained in tests CD_6 and CD_{15} and have characteristic specificities for women and men.

Table 6.

Evaluation of increment of central haemo-dynamics' indicators before final level (%) in tests for controlled breasing , fulfilled both by sportsmen and sportswomen

	CD_6					CD_{15}				
	↓↓	↓	N	↑	↑↑	↓↓	↓	N	↑	↑↑
Δ HBF	<-1.6	-1.6-1.2	1.3-11.4	11.5-21.1	>21.1	<1.3	1.3-8.8	8.9-26.9	27.0-42.4	>42.4
Δ FDV	<-13.2	-13.2--4.3	-4.2-4.2	4.3-14.7	>14.7	<-13.2	-13.2--7.5	-7.4-2.0	2.1-11.1	>11.1
Δ FSV	<-16.2	-16.2--3.8	-3.7-9.8	9.9-24.6	>24.6	<-15.3	-15.3-5.5	-5.5-8.3	8.4-24.3	>24.3
Δ SV	<-11.7	-11.7--4.9	-4.7-2.3	2.4-10.5	>10.5	<-13.9	-13.9--8.9	-8.8—0.2	-0.3-7.3	>7.3
Δ HE	<-6.2	-6.2-1.9	2.0-11.5	11.6-21.1	>21.1	<-2.2	-2.2-3.7	3.8-17.6	17.7-27.4	>27.4
Δ SI	<-6.2	-6.2-1.9	2.0-11.6	11.7-23.7	>23.7	<-2.2	-2.2-3.7	3.8-18.6	18.7-30.0	>30.0
Δ TPVR	<-23.4	-23.4--14.4	-14.3—1.4	-1.3-6.9	>6.9	<-30.3	-30.3--21.1	-21.1—4.1	-4.0-6.7	>6.7
Δ SPVR	<-24.6	-24.6--14.4	-14.3—1.4	-1.3-6.9	>6.9	<-32.4	-32.4--21.9	-21.9—4.3	-4.2-67	>6.7
Δ SI	<-11.7	-11.7--4.8	-4.7-2.4	2.5-12.0	>12.0	<-13.9	-13.9--8.9	-8.8-0.1	0.2-8.0	>8.0
Δ BPS	<-16.8	-16.8--8.5	-8.4-2.7	2.8-9.4	>9.4	<-19.0	-19.0--11.4	-11.3-2.5	2.6-15.9	>15.9
Δ BPD	<-14.6	-14.6--8.6	-8.5-0.1	0.2-10.4	>10.4	<-20.1	-20.1--9.9	-9.8-1.2	1.3-13.1	>13.1
Δ BPP	<-33.3	-33.3--11.9	-11.8-8.2	8.3-27.9	>27.9	<-43.2	-43.2--16.6	-16.6-11.1	11.2-49.6	>49.6
Δ BPA	<-14.9	-14.9--8.0	-7.9-1.5	1.6-8.8	>8.8	<-17.9	-17.9--9.0	-8.9-2.5	2.6-10.2	>10.2

Notes: ↓↓ - expressed hyper activity;↓ - moderate hyper activity; N – optimal responsiveness; ↑ - moderate responsiveness; ↑↑ - expressed responsiveness.

As it can be seen in table 6 optimal variant of men's response for CD_6 is trend to increasing of HBF within 10%, increasing of FSV up to 9.8%, increasing of HE and SI to 11%, reduction of TPVR and SPVR to 14%, reduction of BPS and BPD to 8.5% and BPA – within 8%. Optimal men's response to CD_{15} was increasing of HBF within from 9% to 27%, reduction of SV to 9%, reduction of FDV to 7.5%, increasing of HE from 3.8 to 17.6%, SI – from 3.8 to 18.6%, substantial reduction of TPVR and SPVR from 4 to 21%, reduction of SI to 8.8% and reduction of BPS and BPS within from 9.8 to 11.3%.

Table 7

Evaluation of increment of central haemo-dynamics' indicators before final level (%) in tests for controlled breasing , fulfilled by sportswomen

	CD_6					CD_{15}				
	↓↓	↓	N	↑	↑↑	↓↓	↓	N	↑	↑↑
Δ HBF	<-4.2	-4.2--0.3	-0.2-6.7	6.8-12.4	>12.4	<1.6	1.6-5.8	5.9-16.7	16.8-27.0	>27.0
Δ FDV	<-18.7	-18.7--5.5	-5.4-2.2	2.3-22.0	>22.0	<-22.6	-22.6--6.7	-6.6-1.3	1.4-14.1	>14.1
Δ FSV	<-28.9	-28.9--6.8	-6.7-3.0	3.1-41.7	>41.7	<-30.0	-30--7.5	-7.4-7.2	7.3-23.7	>23.7
Δ SV	<-14.6	-14.6--5.7	-5.6-3.0	3.1-16.7	>16.7	<-18.9	-18.9--6.8	-6.7-0.2	0.3-11.7	>11.7
Δ HE	<-12.3	-12.3--2.3	-2.2-7.5	7.6-23.4	>23.4	<-12.5	-12.5-0.7	0.8-15.1	15.2-26.8	>26.8
Δ SI	<-12.3	-12.3--2.3	-2.2-7.5	7.6-23.4	>23.4	<-12.5	-12.5-0.7	0.8-15.1	15.2-26.8	>26.8
Δ TPVR	<-23.7	-23.7--10.4	-10.3-3.4	3.5-18.2	>18.2	<-25.1	-25.1--17.2	-17.1—2.5	-2.4-15.8	>15.8
Δ SPVR	<-23.7	-23.7--10.4	-10.3-3.4	3.5-18.2	>18.2	<-25.1	-25.1--17.2	-17.1—2.5	-2.4-15.8	>15.8
Δ SI	<-14.6	-14.6--5.7	-5.6-3.0	3.1-16.7	>16.7	<-18.9	-18.9--6.8	-6.7-0.2	0.3-11.7	>11.7
Δ BPS	<-14.8	-14.8--7.5	-7.4-2.4	2.5-12.8	>12.8	<-18.6	-18.6--9.3	-9.2-4.8	4.9-19.2	>19.2
Δ BPD	<-13.7	-13.7--8.8	-8.7-0.3	0.4-11.2	>11.2	<-15.4	-15.4--9.7	-9.6-0.3	0.4-16.4	>16.4
Δ BPP	<-31.9	-31.9--11.4	-11.3-10.8	10.9-48.7	>48.7	<-42.8	-42.8--16.5	-16.5-16.0	16.1-69.2	>69.2
Δ BPA	<-13.4	-13.4--7.6	7.5-0.9	1.0-10.5	>10.5	<-17.8	-17.8--7.9	7.8-1.6	1.7-17.2	>17.2

Notes: ↓↓ - expressed hyper activity;↓ - moderate hyper activity; N – optimal responsiveness; ↑ - moderate responsiveness; ↑↑ - expressed responsiveness.

As far as women concern, their optimal responsiveness for CD_6 test is accompanied by less significant increment than men's one: HBF – up to 7%, increasing of HE and SI – within 7.5%, decreasing of TPVR and SPVR to 10%, reduction of BPD and BPS within 7.4 – 8.7%. I.E., in general, women's central haemo-dynamics responsiveness for CD_6 test is less significant than men's one.

At CD_{15} test, women's optimal responsiveness of haemo-dynamics system is characterized by increasing of HBF from 6-to 17%, reduction of FDV and SV within 6.7%, increasing of HE to 15%, reduction of TPVR and SPVR to 17%, BPS and BPD – to 9.6%.

I.e. responsiveness of women's central haemo-dynamics system to test CD_{15} nearly does not differ from men's one.

Attention should also be paid to expressed hypo- and hyper-responsiveness, which can witness about insufficient or excessive switching of compensatory-adaptation mechanisms under physical loads.

From these positions it should be purposeful to analyze distinctions of indicators of central haemo-dynamics system at tests for controlled breathing, fulfilled by sportsmen with different types of haemo-dynamic provision in final stage.

Таблиця 8.

Comparative characteristics of expressed indicators' changes of central haemo-dynamics at tests for controlled breathing, fulfilled by sportswomen with different types of blood circulation

Indicators	Тест	Type of haemo-dynamics					
		Hyper-kinetic n=10		Hypo-kinetic n=25		Eu-kinetic n=11	
		↓↓	↑↑	↓↓	↑↑	↓↓	↑↑
Δ HBF	CD_6	0.0	10.0	4.0	4.0	**18.2**	0.0
	CD_{15}	0.0	10.0	8.0	4.0	9.1	0.0
Δ FDV	CD_6	**20.0**	0.0	0.0	8.0	9.1	0.0
	CD_{15}	**20.0**	10.0	4.0	4.0	0.0	0.0
Δ FSV	CD_6	**20.0**	0.0	0.0	8.0	9.1	0.0
	CD_{15}	**20.0**	10.0	0.0	4.0	9.1	0.0
Δ SV	CD_6	**20.0**	0.0	0.0	8.0	9.1	0.0
	CD_{15}	**20.0**	10.0	4.0	4.0	0.0	0.0
Δ МОК	CD_6	10.0	0.0	4.0	8.0	9.1	0.0
	CD_{15}	10.0	10.0	4.0	4.0	9.1	0.0
Δ SI	CD_6	10.0	0.0	4.0	8.0	9.1	0.0
	CD_{15}	10.0	10.0	4.0	4.0	9.1	0.0
Δ TPVR	CD_6	10.0	10.0	4.0	4.0	0.0	9.1
	CD_{15}	10.0	**30.0**	4.0	0.0	0.0	0.0
Δ SPVR	CD_6	10.0	10.0	4.0	4.0	0.0	9.1
	CD_{15}	10.0	**30.0**	4.0	0.0	0.0	0.0
Δ SI	CD_6	**20.0**	0.0	0.0	8.0	9.1	0.0
	CD_{15}	**20.0**	10.0	4.0	4.0	0.0	0.0
Δ BPS	CD_6	10.0	0.0	4.0	**12.0**	0.0	0.0
	CD_{15}	10.0	0.0	4.0	**12.0**	0.0	0.0
Δ BPD	CD_6	10.0	10.0	8.0	4.0	0.0	9.1
	CD_{15}	10.0	10.0	4.0	8.0	0.0	0.0
Δ BPP	CD_6	0.0	0.0	4.0	**12.0**	**18.2**	0.0
	CD_{15}	10.0	0.0	8.0	**12.0**	0.0	0.0
Δ BPP	CD_6	10.0	10.0	8.0	8.0	0.0	0.0
	CD_{15}	0.0	10.0	8.0	8.0	0.0	0.0

Notes: ↓↓ - expressed hypo-responsiveness; ↑↑ - expressed hyper-responsiveness.

Considering the fact that most of sportsmen (82.3%) had hypo-kinetic type of blood circulation and other variants were rather rare, we analyzed distinctions of expressed hypo- and hyper-responsiveness of sportswomen with hypo-kinetic, eu-kinetic and hyper-kinetic types (see table 8).

Analyzing results, given in table 8, it should e mentioned that blood circulation types are quite clearly differentiated by indicators of increment of central haemo-dynamics' parameters at tests for controlled breathing. First of all it is necessary to note that only values, which in the range of extreme deviations exceed 10%, are considered to be confident; that is why special attention should be concentrated on them.

For hyper-kinetic type of women's blood circulation the following is characteristic:

Expressed reduction of FDV, FSV, SV and SI in tests CD_6 and CD_{15} (registered at every fifth sportswomen) and expressed increasing of TPVR and SPVR in test CD_{15} (30% of sportswomen).

For hypo-kinetic type of women's blood circulation the following is characteristic:
Expressed reduction of BPS and BPD in tests CD_6 and CD_{15} (12% of all cases).
For eu-kinetic type of women's blood circulation the following is characteristic:
Expressed reduction of HBF and BPP in test CD_6 (18.2% of sportswomen).

Conclusions:

As per results of SACR- examination we determined sufficiently clear criteria of central haemo-dynamics' evaluation, which witness about peculiarities of its change with fulfillment of tests for controlled breathing and permit to differentiate functional state of blood circulation system of qualified sportsmen in case of express examinations.

The obtained results open new direction in evaluation of sportsmen organisms' functional state on the base of simultaneous registration of indicators of HBF, BP and breathing during tests for control breathing and can be used in practice of stage-by-stage or currents sportsmen's examinations.

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