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Original Article

Effect of special exercises on blood biochemical indices in highly skilled athletes of cyclic sports events with endurance manifestation during pre-start preparation

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Abstract.
The paper presents complexes of physical exercises and mobilization sports massage for skilled female athletes specialized in rowing. The positive influence of such complexes on pre-start preparation, which is quite relevant, is shown. **Objective of study:** Evaluating the influence of different complexes of pre-start special exercises and mobilization massage in two versions of their combinations on biochemical indices of blood serum in highly skilled female athletes specialized in rowing during pre-start preparation. **Subjects and methods of study:** The study involved 4 female athletes - international-class masters of sports in rowing. Questionnaire was conducted before the first test to assess the subjective state of female athletes on a 10-point scale, a biochemical blood test (Mindray BS200 Chemistry Analyzer). Athletes performed different exercise complexes during pre-start warm up. Blood serum cortisol and testosterone levels, their ratio (T/C index), as well as the activity of cellular enzymes: ALT, AST, LDH, GGT, ALP were determined before and after application of impacts. Testosterone and cortisol content were determined by means of BECKMAN COULTER Access 2 and immunoenzymatic method (MR-96A Mindray), respectively. **Results**. The influence of complexes of impacts on female athlete hormonal status alteration has been shown. After performing complex 1, the decrease of blood cortisol content was observed in all subjects after 5 and 40 minutes of rest. After 40 minutes of rest blood cortisol level decreased by 40%, 34% and 24 % in the first, the second and the third, and the fourth female athlete. Total average decrease of testosterone level constituted 27 %. After completing complex 2 blood cortisol level decreased by 24 % and 21 % in the first and the second female athlete. Testosterone content decreased by 2 % and 7 %. T/C index constituted 0,0037 before and 0,0047 after in the first female athlete and 0,0030 before and 0,0036 after in the second one. A 25 % increase in the T/C ratio after performing this complex was noted in the second athlete. To analyze the results of the study, methods of statistical data processing and those of nonparametric statistics were used. **Conclusions.** The peculiarities of biochemical reactions in the body of highly skilled female athletes to the impacts of special exercises. Different degree and direction of changes in blood serum cortisol and testosterone content, the T/C index of athletes, depending on the type of applied complexes, have been identified.
Keywords: highly skilled female athletes, cortisol, testosterone, blood biochemical indices, special exercises.

Introduction.

Pre-start preparation of elite female athletes for the upcoming competitions and realization of functional capacities during them are of tremendous importance for successful performance. This period seems jittery for many athletes, and includes physiological and psychological stressors; slight increase in cortisol awakening response (CAR) on the threshold of sports competitions may be interpreted as a possible habituation of the basal hypothalamus-pituitary-adrenal activity [Salvador A. at al., 2003;Strahler K.at al., 2009] .

Various programs and approaches to pre-start preparation are known:

- passive strategies that increase the core temperature (shower, bath, heatable garments Adidas Clima 365, AG, Germany, Blizzard Protection Systems Ltd, Bangor, UK);
- active warmup;
- usage of special movements based on neural mechanisms, such as post-activation potentiation (PAP) - a phenomenon in which muscle efficiency increases rapidly if preceded by maximal or close to maximal neuromuscular activation exercises.

It is noteworthy that during the development of PAP, stimulating exercises with preload, one should take into consideration factors of individual training experience, the intensity of exercise performance [Mcgowan

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C.at al., 2015]. The use of such and similar impacts during pre-start preparation of athletes can significantly influence the readiness to perform work [Vinogradov V. E., 2010, Vinogradov V. E.at al., 2019].

It should be mentioned that the features of pre-start warmup must account for the athlete's experience, depending on the type of competitive load and its energy constituent. The content of pre-start activity should be highly specific and individual, and the effect of warming-up and additional, specially selected exercises in this part of preparation for the start should be clearly predictable [Vinogradov V. E.at al., 2011].

Muscle stretching has long been used in many physical loads to increase the range of motion (ROM) around a joint. If the warm-up is aimed at increasing the joint ROM and muscle strength and/or power, then dynamic stretching seems to be a suitable alternative to static stretching. Nevertheless, numerous studies in which changes or deterioration in performance were not revealed, paid attention to possible mitigating factors such as duration of stretching, amplitude, speed of movement. Accordingly, ballistic stretching as a form of dynamic stretching with high speed will be less advantageous as compared to controlled dynamic stretching. Literature data show that an inconsistent description of stretching procedures represented an important deterrent to achieving a clear consensus [Opplert J.at al., 2017].

The concept of static stretching (SS) and proprioceptive neuromuscular facilitation (PNF) in the warm-up has changed recently. Great interest is given to dynamic stretching (DS), which provides slight or moderate performance improvements. All forms of training that usually lasted less than 30 minutes resulted in ROM improvement. The differences could be caused by a sharp decrease in muscle and tendon stiffness or by adaptation of the nervous system, which caused an increase in tolerance to stretching. Some studies have shown that small and medium changes immediately after stretching are recommended during warm-up, which includes additional dynamic activity after stretching. It is fulfilled to reduce muscle injuries and increase joint ROM, while DS involves performing controlled displacement of stress through the ROM of active joints with little effect on subsequent athletic performance.

DS is deemed preferable in preparation for physical activity when:

- there may be close resemblance between the models of stretching and motion [Behm, D.at al., 2015];
- DS activity may elevate core temperature, which can increase nerve conduction speed, muscle elasticity and the enzymatic cycle, thus accelerating energy production;
- DS and dynamic activity tend to increase rather than decrease the central drive, as may happen with prolonged static. Unlike fast muscle elongation, static stretching fails to increase the reflex activity of stretched muscle, but instead reduces the excitability of the spinal reflex [Guissard N.at al., 2006].

Dose-response ratios have been precisely determined for PNF and DS. Therefore, for higher efficiency, the duration of SS and PNF should be greater and they might be applied, for instance, 10 minutes before the competition. DS can be performed closer to the competition. It is shown that DS within more than 2 minutes contributes to higher increase of performance [Behm D.at al., 2015].

Our studies also present the positive effects of enhancing the athletes' work capacity, confirmed by the practice of using such complexes and their combinations at the major sports competitions (6 Olympic Games, 23 World Championships) [Vinogradov V. E., 2012, Vinogradov V. E.at al., 2016]. It is not unlikely that a positive impact of presented exercise complexes and their combinations with the mobilization technique of sports massage on sports performance may be associated with a change in the body hormonal level and, in particular, cortisol and testosterone. Control for the level of blood cortisol in athletes, as an index of the hypothalamus – pituitary – adrenal system excitation, is thought to be of great importance during preparation for competitions [Hoffman J.at al., 1997;Lac G.at al., 2000]. Decreased level of cortisol or body reactivity may indicate a high degree of stress tolerance, and a moderate increase in cortisol level prepares athletes for vigorous activity [Mazur A., 1985;Stansbury K.at al., 1997]. Significant increase in the content of corticosteroids in the blood of highly trained athletes at rest may be indicative of the body physical overloads or physiological stress [Viru A.A.at al., 1983] and leads to low sports performance [Erickson K.at al., 2003]. Determination of testosterone/cortisol ratio is used as a potential hormonal marker of temporary incomplete recovery and overtraining syndrome after prolonged training loads [Adlercreutz H.at al., 1986;Banfi G.at al., 1993;Lac G.at al., 2000]. The change of these indices before competition in athletes, whose sports activity is associated with highly intensive motor activity, may reflect the level of physiological stress conditioned by either psychological state or metabolic needs [RogolaA.D., 2008]. At the same time, a decrease in the level of free testosterone at rest and lower maximum increase of its concentration caused by physical activity may be considered as the first sign of adaptability decrease in athletes [Jarek M.at al., 2005].

In view of the aforesaid, to assess the functional state of the body of skilled female athletes specialized in rowing before competitions and reveal the effects of various complexes, a biochemical analysis of cortisol and testosterone content was carried out, and the activity of a number of blood serum indicator enzymes was determined to control possible damage of muscular and other tissues of the body.

Objective of work. Evaluating the impact of various complexes of pre-start special exercises and mobilization massage in two variants of their combinations on the blood serum biochemical indices in the body of highly skilled female rowers during pre-start preparation.

Methods and organization of studies

To identify the impacts of various utilized complexes on the body of female athletes, a biochemical blood test was run (Mindray BS200 Chemistry Analyzer with ISE Module Complete).

Blood serum levels of cortisol and testosterone were determined, as well as the activity of a number of cellular enzymes, being biochemical markers that characterize the state of skeletal muscles and other organs: ALT (alanine aminotransferase), AST (aspartate aminotransferase), LDH (lactate dehydrogenase), GGT (gamma-glutamyltranspeptidase), ALP (alkaline phosphatase). Content of testosterone was determined by means of BECKMAN COULTER Access 2 device, whereas that of cortisol by immunoenzymatic method (microplate reader MR-96A Mindray). A biochemical blood test was performed the day before the use of extra-training complexes (basic data), immediately before the complex performance and after 5 and 40 minutes of rest after the complex execution. The standard conditions for taking biological material and preventing the degradation of the biologically active substance in the samples were observed.

The studies were conducted at the training base of athletes' preparation in Belarus (Brest). The study involved 4 female rowers (n = 4), international-class masters of sports competing at 2000 m distance. The age of the subjects ranged from 23 to - 28 years. According to the data of the calendar prophylactic medical examinations, the athletes were practically healthy and gave consent to participate in the examinations. Athletes were examined at the stage of pre-competitive preparation before and after performing complexes of special exercises and mobilization massage. The authors modified exercise complexes for use by female rowers and tested in training and competitive periods with female athletes of Belarus and Ukraine. Similar complexes of exercises and methods of their usage in some sports events have been described previously [Vinogradov V. E., 2010]. The methods of nonparametric statistics were used. The significance of differences was assessed by the test of marginal homogeneity of two dependent samples (Marginal Homogeneity Test) [Sharon L.W.at al., 2005].

Results and discussion.

On the pre-start day, before the testing day, the individual (basic) hormonal and enzyme indices of each female athlete were determined; on the day of testing, a questionnaire was conducted among athletes.

It is known that sleep quality mayexert a significant impact on sports resultsand, especially performance of submaximal, lengthy exercises. Sleep disturbance may also affect learning, memory, cognition, pain perception, immunity and inflammation. Besides that, changes in glucose metabolism and neuroendocrine function as a result of chronic partial sleep deprivation may lead to alterations in carbohydrate metabolism, appetite, food consumption and protein synthesis [Halson S., 2014]. Therefore, before the first testing, a questionnaire was conducted to evaluate subjective state of female athletes on a 10-point scale: the duration and quality of night's sleep (hours), the quality of falling asleep in the evening and awakening in the morning, nervousness, appetite (Table 1).

Table1

Self-assessment of sleep quality by female athletes (n = 4) in the morning before the first testing.

Athletes	Night's sleep duration (h)	Night's sleep quality	Falling asleep quality	Awakening quality	Nervousness	Appetite
1	8	9	7	8	0	9
2	8	8	6	8	0	9
3	7	8	5	8	1	8
4	8	9	10	8	0	9
Fmed. (1, 3 кв).	8,00 (7,25; 8,00)	8,50 (8,00; 9,00)	6,50 (5,25; 9,25)	8,00 (8,00; 8,00)	0,00 (0,00; 0,75)	9,00 (8,25;9,00)

As follows from questionnaire results, all female subjects reported good indices of falling asleep, sleep quality and duration and awakening quality, and assessed their state as optimal according to sleep parameters.

Morphological characteristics of examined athletes are presented in table 2, which shows insignificant differences in the height of female athletes (176 ± 2,8 cm). At the same time there were differences in body mass, chest volume and BMI between the subjects (Table 2).

Table 2

Morphological data of examined female athletes (n = 4)

Athlete	Age	Height, m	Mass, kg	Chest volume, cm	BMI
1	25	1,77	70	90	22,34
2	23	1,73	72	92	23,78
3	28	1,79	57	83	17,79
4	26	1,74	58	86	19,16

In these studies, two different complexes of impacts were used in pre-start preparation of athletes for competitions. The following were used in the experiment:

Complex 1 - “basic” pre-start complex in combination with mobilization massage - 4 female athletes, complex 1, (table 3);

2 - mobilization massage and pre-start warm-up (20 minutes, Concept), 2 athletes participated, complex 2;

Complex 1. "Basic" complex of precompetitive impacts.Each movement was performed with accentuated exhalation and concentric and eccentric resistance (partner) before special part of the warm-up. Towards the end of the complex, the athlete models efforts with the partner according to her subjective feelings, close in rhythm and resistance to the competitive ones.

Initial position – lying on the stomach

1. Straight arms movement from top to bottom, the partner holds the hands clenched into fists.
2. Arms at side, to raise and lower overcoming partner’s resistance.
3. I.P. – arms on the nape, backbend, the partner supports the elbows, the athlete lowers down, tensing abdominal muscles.
4. I.P. – arms rearward on the lower back, backbend, the partner supports the shoulders, the athlete’s efforts aimed at tensing the long muscles of the back.
5. Right shin movement (i.p. – shin in vertical position), the partner holds the shin, providing resistance (anterior thigh muscles are involved).
6. Backward-upward right shin movement (i.p..- shin in horizontal position) the partner holds the shin with resistance (posterior thigh muscles are involved).

7. I.P. - the right shin vertically, the partner presses the foot, upward foot movement (plantar flexion), overcoming partner’s resistance.

8. Repeat for the left leg, then for the two legs simultaneously.

Initial position - lying on the back. .

9. I.P. - the right thigh is flexed in the knee, the foot is near the left knee outside. Outward knee movement, overcoming partner’s resistance.

10. I.P. - the right thigh is flexed in the knee, the foot is near the inner surface of the left knee. Knee inward movement, overcoming partner’s resistance.

11. I.P. – as above, but the foot before the beginning of movements is outside of the lying leg; shortened movement is performed, as in exercise 10 and 11.

12. I.P. - legs extended. Upward right thigh movement to the shoulder, overcoming partner’s resistance.

13. I.P. - the right knee at the right shoulder. The partner extends leg in the knee, overcoming athlete’s resistance.

14. I.P. - right leg in vertical position. Foot downward movement, overcoming partner’s resistance.

15-20 – repetitions by left foot.

21. I.P. - legs bent at the knees, at right angles to the trunk. To hold in this position, the partner tries to straighten the athlete's legs with jerks.

22. I.P. - legs bent at knees, the feet on the support, the arms pressed to the chest, the body elevated. Standing behind the athlete’s head, the partner pushes the shoulders; the athlete holds the position, overcoming the partner’s resistance.

Time of performing the “basic” complex exercises – about 8 minutes.

Immediately after completing the complex of exercises and before getting on a boat, a *pre-start stimulating massage (Complex 1 and Complex 2)* was performed. It included massage techniques lasting 6 minutes, 30 seconds, performed by a massage therapist, physiotherapist, kinesiotherapist or team doctor. It is applied 50 minutes before the competitive activity and is combined with the “basic”, “shortened” complex of special exercises, in isolation or before special part of the warm-up. The sequence of techniques:

1) impacts on the area of neck and trapezius muscle 2 min. from each side;
2) impacts on the area of adrenal gland 2 min. from each side;
3) impacts on the lumbar region, the area of lumbar quadrate muscle 2 min. from each side;
4) pushing the liver area from the right of the abdomen (the athlete lies on her left side),
5) pushing the spleen area from the left (the athlete lies on her right side) - 25 times;
6) simultaneous pushing the areas of the liver and spleen with two hands (the athlete lies on her back) - 25 times.

Stimulating massage time 6 min 30 sec, total time of the impacts of exercises and massage about 15 minutes. The choice of complexes, their combinations or isolated pre-start massage is tested in advance, in the program of training or model competitions.

Immediately after completing the complex of exercises and before getting on a boat, a pre-start stimulating massagewas performed. Total time of impacts - 12 minutes.

Complex 2 was concluded with a special part of the warm-up performed on the Concept simulator.

The following factors were taken into consideration while assessing the effects of complexes impacts:

1) *sleep quality before competitions*mayexert a negative impact on athlete’s metabolic and endocrine status, thus potentially decreasingsports results.Therefore, athletes were questioned before testing. Balanced psycho-

emotional state after a day of rest and assessment of night's sleep quality before testing according to the questionnaire, the absence of nervousness and other characteristics of pre-start state. That was athletes'assessment of their state as optimal in terms of sleep and less nervousness;

2) professional level of physiotherapists - massage therapists with over 10 years of experience of work with highly skilled female athletes provided qualitative performance of all complexes of exercises and mobilization massage;

3) total time of the complexes impacts, the number of movements in each complex, each movement duration, amount of efforts in each movement, amplitude, special warm-up after exercises, duration of rest after exercises or special warm-up;

4) peculiarities of spatial and tempo-rhythmic structure of athlete's movements with a partner, modeling the upcoming competitive rowing efforts in the boat.

It is not unlikely that athletes' response to short-term exercises with a partner and a significantly smaller number of movements in terms of biochemical parameters of changes are shown just in connection with "modeling competitive efforts" with a partner mindset.

On the pre-start day (before the test day) as well as before performing the complexes, it was important to know the individual (basic) hormonal and enzyme indices of each female athlete. On the day of testing, before the "basic" complex of exercises and massage, the level of cortisol in the 1st – 3rd athletes was lower than the baseline (370.3-453.0), whereas in the 4th athlete, it was higher and constituted 554.6 nmol / l (table 3). As far as cortisol is one of the main stress hormones, the level of which increases in response to stress, fatigue, physical load, starvation, fear, and other extreme situations [RogolaA.D., 2008;Halson S., 2014], then the state of stress was absent in three athletes. The 4th athlete had a slight tension of the hypothalamus-pituitary-adrenal system, since it is known that under conditions of severe stress, the level of blood cortisol rises by 6–10 times compared to the norm [Halson S., 2014].

As Table 3 shows, the basic level of testosterone in the blood serum of examined female athletes constituted 3.6 - 4 nmol/l and was significantly higher than the physiological norm (0.34-2.6 nmol/l). Nevertheless, on the day of testing before complex 1, the level of blood serum testosterone of all athletes was almost two times lower than the baseline, ranged from 1.3 to 1.8 nmol/l, but was within the physiological norm. We considered individual biochemical blood indices of female athletes, since it is believed that generalization of the indices of endocrine system response and enzyme activity in several athletes to the same training program can lead to leveling of individual peculiarities [RogolaA.D., 2008; Hooper S.L.at al.,1993]. Biochemical control for the influence of the "basic" complex and mobilization massage during pre-start preparation on the individual level of hormones in the blood serum of the athlete's body showed a decrease in blood cortisol level of all athletes after 5 and 40 minutes of rest after the above complex completion. However, the degree of changes was individual and depended on the duration of rest.

For instance, after 5 minutes of rest the lowest decrease was noted in the third athlete (8%), and the highest - in the second (about 24%). Total average decrease in cortisol level was 15%. After 40 minutes of rest, the blood cortisol level was maximally reduced in the first athlete (by 40%), in the second and third - by 34%, in the 4th - by 24%. Total average decrease constituted about 33%. Blood testosterone content did not decrease after 5 minutes of rest in the 1st and 2nd athlete, whereas in the 3rd and 4th athletes it decreased by 23 and 16%. After 40 minutes of rest, a decrease in testosterone level was observed in all female athletes, while the decrease in the 1st, 2nd and 4th athletes was 25-28%, and in the 3rd athlete - 38%. Total average decrease in testosterone level constituted 27%, as can be seen in Table 2.

Generalized data on the dynamics of cortisol (a) and testosterone (b) content changes in female athletes before and after performing the "basic" complex in combination with mobilization massage (complex 1) during pre-start preparation are presented in Table 3.

The observed decrease in the level of blood serum cortisol of female athletes after performing the "basic" complex in combination with mobilization massage (complex 1) may indicate its optimizing effect on the body, leading to reduced stress, decreased activity of the processes of catabolism and hypoxia and, probably, the *acidity* of the *internal environment*. It is known that a decrease in the level of blood hormones may be associated either with a suppression of the rate of their synthesis and secretion, or increased excretion from the body. For cortisol, the ability to inhibit the secretion of stimulators of its secretion through negative feedback chain and to regulate its own level has been shown [Keller-Wood M.at al.,1984;Arlt W.at al.,2005]. However, it is more likely that the implementation of the complex contributed to cortisol excretion; it is known that the rate of cortisol excretion from the body is relatively high. The half-life of cortisol is 0.5-1.5 hours [RogolaA.D., 2008].

Table 3

Blood serum content of cortisol and testosterone in female athletes before and after the impact of "basic" pre-start complex in combination with mobilization massage, complex 1, (n = 4), females.

Hormones	Time of control	Content of hormones in blood serum of athletes (nmol/L)				
		1	2	3	4	Median value (1, 3 kv)
Cortisol	Basic data	500,4	427,9	472	503,9	486,2 (438,9; 503,0)
	Before complex completion	453	370,3	436,8	554,6	444,9 (386,9; 529,2)
	After 5 min of rest	381	282,5	405	476,2	393,0 (307,1; 458,4)
	After 40 min of rest	272,7	243	289,5	418,8	288,1 * (250,4; 386,5)
Testosterone	Basic data	3,6	4	3,7	3,8	3,7 (3,6; 4,0)
	Before complex completion	1,6	1,3	1,3	1,8	1,4 (1,3; 1,8)
	After 5 min of rest	1,7	1,3	1,0	1,5	1,4 (1,1; 1,6)
	After 40 min of rest	1,2	1,0	0,8	1,3	1,1 * (0,8; 1,3)
Ratio of T/C content	Before complex completion	0,0035	0,0035	0,0030	0,0032	0,0034 (0,0030; 0,035)
	After 40 min of rest	0,0044	0,0041	0,0028	0,0031	0,0036 (0,029; 0,0043)

NOTE: * - significance of differences between data before complex completion and after 40 min of rest at the level of $p<0,05$

The ratio of testosterone to cortisol in blood serum of female athletes, which is considered a marker of physical work capacity and athletic performance [Lac G.at al., 2000], constituted 0.0034 before the complex execution and did not change significantly after performing the "basic" complex in combination with mobilization massage (0.0036). This may indicate the relative stability of anabolic and catabolic processes in the tissues and a high level of athletes' physical fitness. A decrease in the T/C ratio is a sign of body physiological overstrain [La Monica M.at al., 2017]. However, it is still unclear, how the balance between anabolic and catabolic processes in the athlete's body before the start will contribute to realization of her metabolic capacities during the competitions. In addition to hormones, the activity of blood indicator (cellular) enzymes was studied before and after performing the "basic" complex in combination with mobilization massage, according to which the functional state of individual organs (skeletal muscles, myocardium, liver, pancreas, etc.) is controlled. An increase in the activity of enzymes in blood serum is usually associated with alteration in permeability of the cell membranes of those organs in which they function, as well as damage or death of cells of these organs, for instance, in athletes as a result of strenuous physical training or injuries.

The value of the individual activity of blood serum indicator enzymes in female athletes before and after the "basic" complex of pre-start impacts in combination with mobilization massage, complex 1, (n = 4), was presented as follows: the activity of ALT, AST, LDH, GGT and ALP enzymes in the blood serum of the first, second and fourth athlete before and after performing the "basic" complex in combination with mobilization massage did not change significantly and was within the upper limits of the physiological norm. The third athlete had increased activity of the ALT and LDH enzymes before performing the "basic" complex in combination with mobilization massage, which remained the same after the complex completion. This may indicate a possible under recovery of the body.

Analysis of the impacts of complex 2, which included mobilization massage and pre-start warm-up, demonstrated a decrease in blood cortisol content in the first and second female athlete by 24% and 21%, respectively. Testosterone level decreased by 2% and 7 %. T/C ratio after complex 2 constituted 0,0037 (before) and 0,0047 (after), and 0,0030 (before) and 0,0036 (after) in the first and the second athlete, respectively. T/C ratio increase by 27 % after the above complex performance was observed in the second athlete only. Activity of blood indicator enzymes after complex 2 did not change significantly in the second athlete, whereas in the first one increased activity of LDH and ALP was noted.

Therefore, based on the results of biochemical control for the functional state of female athletes before and after two precompetitive preparation complexes for the start, an individual response of their bodies to the impacts of special pre-start preparation means has been established. A different degree and direction of changes in blood cortisol and testosterone content of female athletes were revealed after all the complexes used, which is comparatively presented in Table 4. Significant changes in the activity of blood serum indicator enzymes were not observed.

Table 4

Comparative characteristics of the degree and direction of changes in the content of cortisol and testosterone in the blood serum of female athletes, the ratio of t/c in females after performing two precompetitive preparation complexes

Hormones, T/C ratio	Degree & direction of changes in the blood serum hormone content of female athletes at the 40th min of rest after 2 different pre-start impacts	
	1 **«Basic» + massage**	**2** **Massage + pre-start warmup**
Cortisol	Decrease by 24-40 %	Decrease in females by 21 and 24%
Testosterone	Decrease by 25 -38%	Decrease in females by 2 and 7 %.
Ratio of hormone content T/C: before complex- after 40 min rest	Did not change and constituted 0.0033 - 0,0036 (summarized data)	Did not change in athlete 1 (0,0030-0,0036). Increase in athlete 2 (0,0037 - **0,0047)**;

As shown in Table 4, after performing extra-training complexes of exercises and massage, the ratio of testosterone to cortisol content increased to a certain extent only in some female athletes after execution of complex 2 of special impacts.

The T/C index is sometimes regarded as an endocrine marker of visceral systems restoration processes after muscle tension; it is noteworthy that this index tends to decrease in conditions of recovery after physical loads [Gryaznykh, A.V. 2011]. Nevertheless, in the pre-start preparation it may be more important for athletes that cortisol is reduced, as was observed during performing complex 1, while testosterone is increased.

Discussion.

It is known that under conditions of competitive stressbefore competitions, the level of blood hormones and other body fluids increases, triggering stress reactions and elevating levels of cortisol, testosterone and catecholamines, in particular [Viru A.A., 1983; RogolaA.D., 2008;Volkov, N.I.at al., 2013]. An increase in the basal level of cortisol during pre-competitive preparation period was revealed in athletes of various sports events – canoeists, marathon runners, footballers [Hoffman J.at al., 2002;Déborah A.at al., 2008], elite field hockey players [Hudson J.at al., 2004], regardless of skill level and sports experience. However, after the end of training season, no changes in the basal plasma cortisol level in women and men engaged in jogging, middle and long distance runners, professional swimmers after 12 weeks of intensive physical training [Mujika I.at al.,1995] were observed, which is explained by decreased body resistance to stressors with an increase in fitness level, and hence the response of the adrenocortical system.

Complex 1, the “basic” pre-start complex in combination with mobilization massage, total time of performance is about 15 minutes, the number of movements is about 70, the execution time of each movement is 2–4 seconds, the degree of effort and rhythm is set by the athlete, based on individual efforts in the competition.

On the day of testing, before performing complex 1, the level of blood serum testosterone in all female athletes was almost twice lower than the baseline, ranged from 1.3 to 1.8 nmol/l, but was within the physiological norm. After 5 and 40 minutes of rest after performing complex 1, a decrease in blood cortisol level was observed in all female athletes and depended on rest period. Total average decrease in cortisol constituted 15%. After 40 minutes of rest, total average decrease in cortisol and testosterone content constituted about 33% and 27%, respectively. The T/C index did not change significantly. The individual activity of indicator enzymes in the blood serum of female athletes before and after the application of complex 1: ALT, AST, LDH, GGT and ALP in the blood serum of the first, second and fourth athletes did not change significantly before and after the complex performance and was within the upper limits of physiological norm. In the third athlete, increased activity of ALT and LDH enzymes was observed before complex 1 performance and remained unchanged after its completion. This may indicate a possible under-recovery of the body.

Complex 2, mobilization massage and pre-start warmup (20 min, Concept, 36-38 strokes/min), total time and number of motions – 26 min and 750, respectively.

After the complex, a decrease in blood cortisol levels was noted in the first and the second female athlete by 24% and 21%, respectively. Testosterone content in female athletes decreased by 2 % and 7%, the T/C index constituted 0.0037 (before) and 0.0047 (after) and 0.0030 (before) and 0.0036 (after) in the first and the second athlete, respectively. The increase in the ratio of the amount of hormones T/C after performing this complex by 27% was noted in the second athlete. The activity of blood indicator enzymes after complex 2 did not significantly change in the second athlete, whereas in the first one the activity of LDH and ALP increased, which may indicate the active impact of the complex on her body.

It should be noted that blood cortisol level in female athletes after performing the “basic” complex of exercises with mobilization massage (complex 1) may be indicative of the optimizing effect of the complex impacts on the body, leading to decrease of stress, the activity of catabolism, hypoxia and, possibly, acidity of internal environment. However, it is more likely that the implementation of the complex contributed to cortisol

excretion. The ratio of testosterone to cortisol in blood serum of female athletes (a marker of physical work capacity and athletic efficiency) before the complex was 0.0033 nmol/L and did not change significantly after the first complex - 0.0036 nmol/L. This may indicate the relative stability of anabolic and catabolic processes in the tissues and high level of physical fitness of female athletes.

T/C ratio decrease indicates athlete's body physiological overstrain. The literature data highlight that an increase in the T/C ratio correlates with improvement of swimmers' sports results [RogolaA.D., 2008;Hudson J.at al., 2004]. It is noteworthy that people with low cortisol and high testosterone levels excel at set task, for instance, the results of a group with a biological inclination to achieving status (high testosterone level) combined with reduced activity on the stress axis (low cortisol level) are involved in decision-making [Akinola M.at al., 2016]. The results are consistent with the hypothesis that people with high testosterone level are motivated to obtain status (good indices in individual competition), whereas those with low levels are motivated to cooperate with others (good indices in intergroup competition) [Mehta P.at al., 2009].

In conclusion, we may agree with the position that the hormonal correlates of work capacity remain largely unexplored. Although the rapid increase in testosterone and cortisol associated with competition is probably adaptive, we still know little about the psychological benefits of these hormonal changes [Casto K.V., Edwards D.A. , 2016].

Conclusions.

Biochemical response of athletes' body to the impact of different complexes of special exercises and mobilization massage is due to individual peculiarities of metabolic and endocrine status (or hormonal profile) according to degree of changes in blood cortisol and testosterone content, T/C ratio and cellular enzyme activity.

Changes in the body biochemical response after each complex execution were registered. After completing complex 1 the indices of testosterone decreased by 27 % in female athletes. After complex 2, blood cortisol level decrease by 24 % and 21 % in the first and the second athlete, respectively, was observed; testosterone content decreased by 2 % and 7 % on the average; the ratio of T/C constituted 0,0037 and 0,0047, and 0,0030 и 0,0036 in the first and the second athlete, respectively.

Research prospects. There is still unanswered question - how the balance between the processes of anabolism and catabolism in the athlete's body before the start will contribute to realization of her metabolic capacities during the competitions. To determine the degree of individual efficiency of various complexes, individual response to impacts, association with the previous load, mobilization of the body of top level female athlete to participate in competitions, pre-start influence on sports performance, additional studies of athletes' hormonal changes are needed.

Conflict of Interest Statement. Authors declare no conflict of interest

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