

Original Article

Effect of special exercises on blood biochemical indices of highly skilled male rowers during pre-start preparation

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Abstract

The paper presents complexes of special impacts for qualified athletes - men specializing in rowing. Reliable markers of the body's adaptation to the loads of highly qualified rowing academics are hormonal indicators in the blood serum. The influence of various complexes on the change in blood biochemical parameters in athletes - rowers is shown. **Objective.** Evaluating the complexes of special prelaunch exercises and mobilization massage impact in different versions of their combinations on the biochemical parameters of the blood serum of the body of highly qualified athletes –man rowers during prelaunch training. **Methods of study:** the study involved 6 athletes - male with qualifications of masters of sports of international class in rowing. Questionnaire surveys and biochemical blood tests were conducted before the first test of athletes (Mindray BS200 Chemistry Analyzer). Level of cortisol was determined by means of BECKMAN COULTER Access 2, whereas that of cortisol by immune-enzymatic method (MR-96A Mindray). **Results.** The influence of complexes of impacts on the change of athletes' hormonal status has been shown. Changes of the body biochemical reaction after each complex performance have been registered. After performing complex 1, cortisol content decreased by 26% and 7% in the first and the second athlete, respectively. The T/C index in the first athlete increased 1.4 times. After performing complex 2, cortisol content increased by 35% and 44%, whereas that of blood testosterone by 54% and 15% in the first and the second athlete, respectively; the T/C ratio before and after exposure was at the level of 0.085 and 0.098 units and 0.073 and 0.059 units in the first and the second athlete, respectively. After complex 3 execution, the athlete's testosterone level decreased by 13%, and the change in T/C index constituted 0.072 and 0.067. After complex 4, a gradual decrease in blood cortisol by 23% was observed. Testosterone content did not change immediately after the massage, whereas by the 40th minute of rest it reduced by 21%. **Conclusions.** It was discovered that depending on the different complexes performed the results showed different level and directions of changes in the level of cortisol and testosterone, T/C index in blood serum of the athletes' bodies.

**Keywords:** highly skilled athletes – man, special exercises, cortisol, testosterone, blood biochemical indices

Introduction.

Conditioned reflex pre-start metabolic changes in sports fulfill the function of “mental warm-up”, contribute to the mobilization of the body's capabilities and better workability. The magnitude of changes in the level of hormones in the blood depends on the power capacity and duration of the exercise, as well as on the training level of the athlete [Ivanchykova N., 2012; Akinola M. et al., 2016; Selezniova I.S., 2019]. It is known that an increase in the concentration of stress hormones is a positive adaptation to the current training load.

Significant relationships between hormonal and perceived recovery-stress states suggest that metabolic and psychological changes should be carefully monitored to avoid a negative effect on the training status of the elite rowers during heavy exercises. The first sign of declined adaptivity in rowers is a decline of the free testosterone level at rest and a lower maximal exercise-induced increase in free testosterone concentration. Testosterone and cortisol are more sensitive to changes in training volume than the growth hormone or perceived recovery-stress state during the training of elite rowers [Mäestu J. et al., 2005; Purge P. et al., 2006]. Steroid hormones cortisol and testosterone play a critical role, high testosterone level and low cortisol level are sometimes connected with social aggression [Terburg D. et al., 2009], in sports, the ratio of testosterone/cortisol levels is used as a potential hormonal marker of temporary incomplete recovery and overtraining syndrome after lengthy training loads [Lac G., Berthon P., 2000]. The change in these indicators before the competition in athletes whose sports activity is associated with high-intensity physical activity can reflect the level of physiological stress due to either a psychological state or metabolic needs [Rogol A.D., 2008; Halson S., 2014; Vinogradov, V. E. et al., 2016; Vinogradov, V. E. et al., 2019; Vinogradov, V. E. et al., 2020; Kong Xianglin et al., 2018-2020]. At the same time the decline in the free testosterone level at rest and lower maximal exercise-

induced increase in free testosterone concentration caused by the physical exercises may be considered as the first sign of decline in the athletes' adaptiveness.

Various programs and approaches to pre-start preparation are known. The use of specially designed impacts during the pre-start training of athletes can significantly affect the readiness to perform work. The structure and content of each complex is based on taking into account the direction of the impact, the magnitude and intensity of exercise modes. Differentiation of movement parameters in exercises is combined with manual influences. Optimization of the duration, depth and strength of influences, their influence on the neurogenic components of the reaction should correspond to the parameters of the efforts of the performance movements [Vinogradov V.E., Mishchenko V.S., 2011; Behm D. et al., 2015; McGowan C. et al., 2015; Opplert J., Babault N., 2017]. It should be noted that the peculiarities of the pre-start workout should take into account the athlete's experience, depending on the type of the competitive load and its energy component. The scope of the pre-start activity should be highly specific and personalized, and the effect of the warm-up and additional, specifically selected exercises at this stage of preparation for the start should be clearly predictable [Vinogradov V. E., 2010]. Quite possibly that positive impact on the sports results of the complex of exercises presented may be connected with the change of hormonal level of the body and, in particular, of the cortisol and testosterone levels.

**Objective of work.** Evaluate the impact of complexes of special pre-start exercises and mobilization massage in different versions of their combinations on the biochemical parameters of the blood serum of the body of highly qualified athletes –man rowers during the pre-start training.

#### **Methods and organization of studies.**

A biochemical blood test was run to reveal the effects of various complexes used by us on the body of athletes (Mindray BS200 Chemistry Analyzer with ISE Module Complete).

Blood serum was examined to identify the levels of cortisol and testosterone, as well as the activity of a number of cellular enzymes, being the biochemical markers that characterize the state of skeletal muscles and other organs: ALT (alanine aminotransferase), AST (aspartate aminotransferase), LDH (lactate dehydrogenase), GGT (gamma glutamine transferase), ALP (alkaline phosphatase). Composition of testosterone was determined by means of BECKMAN COULTER Access 2 device, whereas that of cortisol by immuno-enzymatic 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 studies involved 6 male athletes (n = 6), international-class masters of sports in rowing, who perform at a distance of 2000 m. The age of the athletes was 23 – 27 years. According to the data of the calendar prophylactic medical examinations, the athletes were practically healthy and agreed to participate in the examinations. The information received from the athletes was used solely for the research purposes; the norms of confidentiality and respect for the individual were observed during the study at the data collection stage and in the processing of the results. 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 the use by rowers and tested in training and competitive periods. Similar complexes of exercises and methods of their use in some sports events have been described previously [Vinogradov V. E., 2010]. The methods of nonparametric statistics were used. The accuracy of differences was assessed by the test of marginal homogeneity of two dependent samples (Marginal Homogeneity Test) [Sharon, L.W., Sarah, K.A., 2016].

#### **Ethical approval**

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki.

#### **Results of studies.**

The day before the test, individual (basic) hormonal and enzymatic indices of each athlete were determined; on the day of testing, in the morning, the athlete's studies was conducted. Various nutritional changes are known to improve sleep, such as high glycemic index evening meals, melatonin, tryptophan-rich protein, sour cherry juice, kiwi and trace elements. At the same time, sleep disturbance and short sleep duration are health risks. For the recovery effect of sleep, it must be of an adequate duration and quality, especially for athletes whose physical and mental recovery needs may be higher due to the high physiological and psychological requirements for them during training and competition. It has been shown as sleep has a recovery effect of immune system, endocrine system, helps restore the nervous system and metabolic disorders while awake, and plays an integral role in learning, memory and synaptic plasticity, which can affect both athletic recovery and performance [Doherty, R. et al., 2019]. Therefore, before the first testing, a questionnaire was conducted to evaluate subjective state of athletes with a 10-point scale: the duration and quality of night sleep (hours), the quality of falling asleep in the evening and awakening in the morning, nervousness, appetite (Table 1).

Table 1 Self-assessment of sleep quality of male athletes (n = 6) 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.	7	8	6	8	1	9
2.	9	9	9	10	1	9
3.	6	8	7	6	2	7
4.	8	8	7	6	2	7
5.	7	8	6	6	1	8
6.	4	5	3	4	1	3
M. med. (1, 3 kv).	7,00 (5,50; 8,25);	7,00 (7,25; 8,25)	6,50 (5,25; 7,50)	6,00 (5,50; 8,50)	1,00 (1,00; 2,00)	7,50 (6,00; 9,00)

Questionnaire results show that among male athletes, only one reported the presence of fatigue from a previous load, which affected the quality of falling asleep, the duration of sleep, awakening and lack of appetite. Morphological characteristics of examined athletes are presented in table 2, which shows that the athletes' height, body mass, chest volume and BMI constituted on average  $196 \pm 2,4$  cm,  $97 \pm 3,7$  kg,  $106 \pm 2,7$  cm and  $25.25 \pm 1.107$ , respectively (Table 2).

Table 2 Morphological data of examined athletes (n = 6)

Athletes	Age	Height, m	Mass, kg	Chest volume, cm	BMI
1.	28	1,94	97	104	25,77
2.	29	1,93	93	106	24,96
3.	27	1,98	92	102	23,47
4.	37	1,99	99	108	24,99
5.	34	1,97	97	108	25,51
6.	28	1,95	102	109	26,82

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

- 1 – complex 1; “shortened” complex in combination with mobilization massage with participation of 2 athletes;
- 2 – complex 2; “shortened” complex in combination with mobilization massage and pre-start warm-up after impacts - 2 athletes;
- 3 – complex 3; mobilization massage and pre-start warm-up (20 minutes, Concept), 1 athlete participated;
- 4 – complex 4; pre-start mobilization massage, 1 athlete.

Pre-start mobilization massage included massage techniques lasting 6 minutes, 30 seconds, performed by a qualified massage therapist, which had experience of working with elite athletes. It was applied 50 minutes before the model conditions of the competitive activity. The impacts are combined with the “shortened” complex of special exercises, in isolation or before the 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 quadratus muscle 2 min. from each side;
- 4) pushing the liver area from the right of the abdomen (the athlete lies on his left side),
- 5) pushing the spleen area from the left (the athlete lies on the right side) - 25 times;
- 6) simultaneous pushing the areas of the liver and spleen with two hands (the athlete lies on his back) - 25 times.

Stimulating massage time was 6 min 30 sec, the total time of the impacts of exercises and massage was about 15 minutes. The choice of complexes, their combinations or isolated pre-start massage was tested in advance, in the training programs. "Shortened" complex of pre-start impacts

Movements with a partner were performed in the following sequence:

1. I.P. (Initial Position). – standing support. The left leg is abducted back to a horizontal position. The partner supports the left thigh with the left hand and the lower leg with the right hand. The athlete lifts the thigh straight up to the shoulder, overcoming the resistance of the partner. Repeat 3 times.
2. I.P. – as above. The athlete holds the left thigh as high as possible at the left shoulder; the partner forces him to lower the leg, while simultaneously abducting it back. Repeat 3 times.
3. I.P. – as above. The left leg is flexed in the knee joint. The athlete holds the lower leg, while his partner extends leg in the knee joint, supporting it below the knee joint. Repeat 3 times.
4. I.P. – as above, the left leg is abducted aside and flexed in the knee joint. The partner supports the left leg with both hands, while the athlete lowers it due to effort of the adductors, overcoming the resistance of the partner, and performing several right leg squats. Repeat 3 times.

5. I.P. – as above. Extended left leg is abducted back and maximally up. The athlete holds, the partner lowers the foot down intermittently, overcoming the athlete's resistance. Repeat 10 times.
6. I.P. – as above. Extended left leg is abducted aside at maximum height. The exercise is performed as the previous one. Repeat 10 times.
7. I.P. – as above, perform transverse swings with the left leg, repeat 5 times.
8. I.P. - standing with the back to the support, the left leg is half bent in the knee joint and raised by the partner straight up to the maximum height. The athlete lowers his leg, overcoming the resistance of a partner. Repeat 3 times.
9. I.P. - basic stance, perform 5 forward swings with the left leg, hand support is possible.
10. Then, exercises are performed for the other leg (the right one in this case) in the same sequence, dosage and effort.

Immediately after completing the complex of exercises and the pre-start mobilization massage was performed for 12 minutes. Complexes 2 and 3 were concluded with a special part of the warm-up performed on the Concept simulator.

The results of determining the baseline (initial) level of cortisol in the blood serum of athletes during precompetitive period showed that for all subjects it ranged from 425 to 504 nmol / l, within the upper limit.

After applying complex 1 (n = 2, male) and receipt of results prior to and after the impact, the influence of the "shortened" complex of exercises and mobilization massage on the level of cortisol and testosterone, as well as the activity of indicator enzymes in athlete's blood before and after exposure, were analyzed.

The complex was performed by athletes preparing for 2000 m rowing race. The basic amount of cortisol in the blood serum of both athletes was within the upper limit, whereas testosterone level in the second athlete was higher than the reference norm, which for men varies from 8.4 to 28.7 nmol / l.

The average testosterone level for men aged 25-29 years constitutes 23.2 nmol / l. The body of athletes reacted differently to this complex of impacts. Individual amount of blood cortisol in athletes changed unidirectionally, but the degree of changes expression was different. The first athlete's cortisol content declined by 26%, whereas in the second one only by 7%. The content of the testosterone in the athletes' blood after performing the "shortened" complex of impacts in combination with mobilization massage has not changed significantly. Testosterone/cortisol concentration ratio by the 40th minute of rest after performing "shortened" complex increased by 1.4 times (before 0.064 and after 0.092) in the first athlete and did not change (before 0.062 and after 0.065) in the second one.

Analysis of the impact of the pre-start complex 2 (n = 2, male), which included a "shortened complex" of exercises, mobilization massage and pre-start warm-up (Concept), on the amount of cortisol and testosterone, as well as the activity of the blood indicator enzymes, demonstrated the following. Increased blood cortisol and testosterone content was observed in athletes (n = 2, male), especially after 40 minutes of rest. Blood cortisol concentration increased by 35% and 44% in the first and the second athlete, respectively. Testosterone concentration increased by 54% and 15% in the first and the second athlete, respectively. After performing the complex, the T/C ratio in the first athlete corresponded to 0.085 units before completion and 0.098 units after completion, whereas in the second athlete it constituted 0,073 before complex performance and 0,059 after 40 minutes of rest, that is, in the first athlete an increase in the T/C ratio was noted, which probably occurred due to a larger increase in testosterone level, whereas in the second athlete such a ratio was lower because of small increase in testosterone level. A tendency to an increase in enzyme activity after 40 minutes of rest after the complex was fulfilled, which may indicate a strong influence of the complex not only on skeletal muscles.

Results of analysis of complex 3 influence on the athlete body (n = 1, man), which included mobilization massage and pre-start warmup, demonstrated insignificant (2 %) decline of blood cortisol level.

Testosterone level declined by 13 % in the athlete. The T/C ratio after complex 3 execution constituted 0,072 before and 0,067 after, whereas the activity of the blood indicator enzymes did not change significantly.

Isolated effect of pre-start stimulating massage on the blood hormonal and enzyme levels was also studied (complex 4). The procedure was performed before special part of the warm-up 50 minutes before the model competitive activity. Gradual decline in blood cortisol level was noted in the athlete during the rest period after mobilization massage, and by the 40<sup>th</sup> minute of rest it constituted decline by 23%. Testosterone level immediately after the massage did not change, whereas by the 40th minute of rest it declined by 21%. The activity of blood cellular enzymes did not change significantly. The ratio of the amount of testosterone to that of cortisol before and after the stimulating massage, especially after 40 minutes of rest, did not change significantly and amounted to 0.046 - 0.048 units.

Therefore, based on the results of biochemical control of the functional state of athletes before and after four different precompetitive preparation complexes for the start, an individual response of the body of athletes to the impacts of special pre-start preparation means has been established. A different degree and direction of changes in blood cortisol and testosterone levels of male athletes were revealed after all the complexes used, which is comparatively presented in Table 3.

Significant changes in the activity of blood serum indicator enzymes were not observed.

*Table 3* Comparative characteristics of the degree and direction of changes in the level of cortisol and testosterone in the blood serum of athletes, the ratio of t / c in men after performing four different precompetitive preparation complexes

Hormones, T/C ratio	Degree & direction of changes in the blood serum hormone content of athletes at the 40 <sup>th</sup> min of rest after 4 different pre-start impacts			
	1 «Shortened» + massage	2 «Shortened» + massage, + pre-start warmup	3 Massage + pre- start warmup	4 Pre-start massage
Cortisol	Decline in 1 and 2 athletes by 26% and 7%	Increase by 35 - 44%	Decline by 2%;	Decline by 23%.
Testosterone	Did not change significantly	Increase by by 54 and 15 %	Decline by 13%,	Decline by 21%.
Ratio of hormone content T/C: before complex- after 40 min rest	Increase in athlete 1 (0,064 - <b>0,092</b> ); no changes in athlete 2 (0,062- 0,065)	Increase in athlete 1 (0,085 - <b>0,098</b> ); Tendency to decline in athlete 2 (0,073 -0,059)	Did not change (0,072 - 0,067)	Did not change (0,046 - 0,048)

As shown in Table 3, after performing extra-training complexes of exercises and massage, the ratio of testosterone to cortisol content increased to a certain extent only in some athletes after execution of 1, 2 and 3 complexes of special impacts.

#### Discussion.

Complex 1, the “shortened” complex of pre-start impacts in combination with mobilization massage, the total time is about 12 minutes; the number of movements is about 50. After complex 1 was completed, cortisol level declined by 26% and 7% in the first and the second athlete, respectively. Testosterone level did not change significantly. The T / C index at the 40<sup>th</sup> minute of rest increased by 1.4 times in the first athlete and did not change in the second athlete.

Complex 2, the “shortened” complex in combination with mobilization massage and pre-start warm-up after impacts (20 minutes, Concept, 36-38 strokes / min), total time about 33 minutes, number of movements during complex performance is about 50, whereas with a warm-up - about 800.

After 40 minutes of rest, cortisol and testosterone levels were observed to increase by 35% and 44%, and 54% and 15% in the first and the second athlete, respectively. The T / C ratio after performing the complex in the first athlete corresponded to 0.085 units before and 0.098 units after completion, whereas that in the second athlete, 0.073 before the complex was completed and 0.059 after 40 minutes of rest. An increase in the T / C ratio noted in the first athlete was probably due to a higher increase of testosterone level. Meanwhile this ratio was lower in the second athlete due to a small increase in the testosterone level. After 40 minutes of rest, there was a tendency to an increase in the activity of enzymes after the complex was completed, which may indicate a strong effect of the complex not only on skeletal muscles, but also on the heart, liver, and kidneys.

Complex 3, mobilization massage and pre-start warm-up (20 minutes, Concept, 36-38 strokes / min), total time about 26 minutes, number of movements about 750.

After the complex was performed, a slight decline (2%) in blood cortisol was observed in the athlete. Testosterone level and the T/C index in the athlete constituted 13% and 0.072 before and 0.067 after. The activity of blood indicator enzymes after performing complex 4 did not significantly change in the male athlete.

Complex 4, isolated impact of mobilization massage (1 athlete). Gradual decline in blood cortisol level during the rest period after mobilization massage and by the 40th minute a decline by 23% was observed in the athlete. Testosterone level immediately after the massage did not change, whereas by the 40th minute of rest it declined by 21%. The activity of blood cellular enzymes did not change significantly. The T/C ratio before and after the application of stimulating massage, especially after 40 minutes of rest, did not change significantly and constituted 0.046 - 0.048 units.

The T/C index is sometimes regarded as an endocrine marker the processes of visceral systems restoration after muscle tension, and in conditions of recovery after physical exertion, a decline in this indicator is observed. So, the studies containing comparison of free testosterone/cortisol ratio (FTCR) during a season of elite rowing training are of interest. The results show that during the periods of heavy training (training camp) the rest levels of the FTCR decline (range 5-50%) in most of the rowers. During the periods of less intensive training the changes of the FTCR are opposite. Moreover, declines in the FTCR by more than 30% in comparison to the preceding results were often found. These declines are not indicative for overstrain but should be related to the temporary incomplete recovery from intensive training [Vervoorn, C. et al., 1991]. Then the correlation of FTCR and hormonal changes with daily training volumes and performance on an ergometer in

elite women rowers was studied. In training practice, the FTCT seems useful as an indicator of the hormonal training status of elite female rowers when complemented with data about total and free testosterone, performance parameters and knowledge concerning cyclic variations of the FTCT [Vervoorn. C. et al., 1992]. In conclusion, we can agree with the fact that hormonal correlates of working capacity remain unchanged. Although the rapid increase in testosterone and cortisol is probably adaptive, little is known about the psychological effect of these hormonal changes [Casto, K.V. et al., 2016].

### Conclusions.

Changes in the body biochemical response after each complex execution were registered. After completing complex 1, the cortisol level declined by 26% and 7% in the first and the second athlete, respectively. The T / C index in the first athlete increased by 1.4 times. After completing complex 2, the cortisol level increased by 35% and 44% in the first and the second athlete, respectively; blood testosterone increased by 54% and 15% in the first and the second athlete, respectively; the ratio of T/C before and after impact was at the level of 0.085 and 0.098 units, and 0.073 and 0.059 units in the first and the second athlete, respectively. After completing complex 3, the athlete's testosterone level declined by 13%, the change in T / C index constituted 0.072 and 0.067. After complex 4, gradual decline in blood cortisol level by 23% was observed. Testosterone level immediately after the massage did not change, and by the 40th minute of rest it declined by 21%.

The obtained results show: biochemical response of athletes' body to the impacts of different complexes of special exercises and mobilization massage is conditioned by individual peculiarities of metabolic and endocrine status (or hormonal profile) according to degree of change in blood cortisol and testosterone levels, T/C ratio and cellular enzyme activity. Perspectives for the study of special exercises use in athlete's pre-start preparation appear depending on the tasks: mobilization of functional reserves; fatigue correction; stimulation of recovery process.

Conflict of Interest Statement. Authors declare no conflict of interest.

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