

Biochemical monitoring of trainings in 10–15-year-old water polo players

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Abstract:

Biochemical monitoring of the adaptation of young water polo players to physical activity specific to this kind of sport is of immense importance. The content and objectives of biochemical monitoring are enhanced due to the fact that this cohort (from 10 to 15 years) undergoes complex phases of puberty. Exercise regulation should be strictly dosed according to the adaptive capabilities of young athletes. The sport training has a positive influence only in the absence of stress response of the body of adolescent athletes. At the same time, physical activity should promote the development of physical qualities. According to the theory about the sensitive periods of development of physical qualities, it is known that such qualities as flexibility and speed types are inherent to people of a younger age who play sports, but their improvement at the level of the highest manifestation of sportsmanship will be uniformly prolonged in time.. This article proposes a scheme of biochemical monitoring of a standard training of young water polo players. Based on the results of performed analysis we have come to the conclusion that the training regimen promotes the development of anaerobic characteristics. Comparative analysis of biochemical monitoring of different age groups indicates the peculiarities of their energy supply while overcoming the same physical load, which is the PWC-170 Cycle Test. In particular, the younger the organism, the greater is the share of the anaerobic component of energy supply. This means that during the monitoring of younger groups of water polo players, special attention should be paid to the indicator of changes in lactic acid, which is a criterion that characterizes adequate changes in anaerobic metabolism, namely in glycolysis. Regarding the older age groups of athletes, urea acquires special importance in biochemical monitoring. It is known to be a biomarker of protein energy metabolism, which is precisely the last critical component of aerobic energy transformations. Dissimilation of proteins increases its contribution to aerobic energy exchange under the conditions of overcoming physical loads of a critical level. As a result of the conducted scientific experiment, as well as according to the results of one-way analysis of variance (One Way ANOVA), we recorded the fact of a significant influence of the age of the athlete on the indicators of energy exchange, which can be used in biochemical monitoring of the state of development of energy systems during the long-term training of young water polo players.

Key Words: biochemical monitoring, lactic acid, urea, inorganic phosphorus, young water polo players, training regimen, anaerobic and aerobic adaptation of energy systems.

Introduction.

In water polo, like in no other sport, general physical training is closely related to special physical training. However, among young water polo players, the share of developing of speed, strength and endurance, which make up the basis of general physical training, dominates over special training, which is characteristic of highly qualified athletes at the stage of their training at the level of mastery improvement. According to sports theory, these components of general physical training interfere with each other's development. In particular, the athlete's speed of action and their strength are in diametrically opposite fundamental dependence at the level of the sarcomere length, at the very least. However, from the point of view of energy supply, it is just the opposite. Both during strength training and during speed training, the same mechanisms of energy supply are involved,

namely creatine kinase and glycolytic. Therefore, by training speed, we create a basis for the development of strength, and by training strength, we promote the development of speed, because the same energy supply mechanisms work in both cases. Depending on the period of development, young water polo players go through stages in the process of their professional development, when at the beginning the development of varieties of speed dominates, and at the later - varieties of strength. Since inorganic phosphate and lactic acid are metabolites of these energy supply mechanisms and indirect criteria, it makes sense to use them to control the development of both qualities that are decisive in the activities of young water polo players.

The physical qualities of a person manifested during muscle work (strength, various types of speed, dexterity, endurance, etc.) first of all depend on the biochemical characteristics of a person for the transformation of chemical energy into mechanical energy. Research of the adaptive capabilities of the energy systems of the athlete's body in order to further improve sports skills, expand functional reserves and preserve health is an urgent problem of many years of sports training. The most important factor from the point of view of biochemistry, which determines it, is the mobility, capacity, power and efficiency of both aerobic and anaerobic (alactic and lactic) energy supply mechanisms (Hofman et al., 1994; Sybil et al., 2004; Pervachuk et al., 2015; Drachuk, 2005).

It follows from this that in order to improve physical qualities, and therefore to increase sports results, it is necessary to improve both ways of energy productivity. It is known that purposeful improvement of the aerobic and anaerobic components of energy supply can be carried out with the help of various modes of physical training. (Kalinskii et al., 1986; Sybil, 1996; Platonov, 2004). However, the problem of improving both aerobic and anaerobic pathways of ATP resynthesis by physical exercises cannot be considered solved in water polo, particularly, what concerns teenagers. Until now, the issue of regulation of physical exertion depending on the functional readiness of the body and the issue of the most effective biochemical express control of this process remains controversial and insufficiently researched. (Astrand, 1992; Sybil & Ostrovskii, 2005; Pervachuk et al., 2016; Dennis et al., 1995; De Jesus et al., 2012; Cvjeticanin et al., 2012).

The contingent of participants – 10–15-year-old water polo players are in different phases of puberty. This is the most difficult period of formation of a person in general, and an athlete in particular. Because, on the one hand, playing sports contributes to physical development and manifestation of physical qualities. And, on the other hand, constant physical exertion is an additional burden factor on the body during this period. Thus, biochemical control of adaptation to physical exertion becomes especially relevant. (Poproshaev & Polishchuk, 2006; Chaplins'kyi et al., 2018).

All these data are based mainly on scientific ideas about age features and the order of formation of various energy supply systems (Korobeinikov & Dudnik, 2008; Mokhan et al., 2001). According to the theory about the sensitive periods of development of physical qualities, it is known that such qualities as flexibility and speed types are inherent to people of a younger age who play sports, but their improvement at the level of the highest manifestation of sportsmanship will be uniformly prolonged in time. As for the physical quality of strength, it acquires a pronounced manifestation with the onset of puberty due to the influence of sex hormones. As for endurance, none of their varieties – speed, strength or general physical endurance for long-term work is inherent in children and adolescents. It follows from this that additional informative means of monitoring the physical activity of children and adolescents is a mandatory task to ensure the growth of sports skills without harming the health of young athletes. In this case, the biochemical monitoring of both anaerobic and aerobic energy systems of young athletes performs this role. Various biochemical markers of response to physical exertion have long been used to track the state of development of adaptive energy capabilities of athletes. Namely, creatinine, lactic acid, urea, inorganic phosphorus, etc. (Sybil et al., 2004, 2018, 2020).

In scientific sources, there are different, often diametrically opposed references to the specifics of the impact of physical exertion on the aerobic and anaerobic performance of the body of 10–15-year-old water polo players. Therefore, the problem of monitoring the development of physical capacity (according to the PWC-170 Cycle Test) in combination with the biochemical monitoring scheme remains relevant. This approach will make it possible to distinguish the state of anaerobic - alactic and lactic systems of energy supply, as well as the aerobic component. Separately, as a result of the obtained data, it is possible to draw a conclusion about the state of health of young athletes, which is the most important (Osipenko, 2007; Bottonis et al., 2019, 2021; Claus, 2017; Sybil, 2020).

Materials & methods

Objective: Examination of the state of adaptation of energy systems of water polo players of different age groups based on the indicators of biochemical monitoring under the influence of training physical activity.

Task: To determine the content of energy indicators in the urine of water polo players of different age groups (10,11,12,13,14,15 years old) in response to the PWC-170 Cycle Test.

Organization of the study. 15 water polo athletes aged 10,11,12,13,14,15 years old participated in the monitoring. Urine collection for lactic acid, inorganic phosphorus, and urea was performed 15–30 minutes before training and 15–30 minutes after the PWC-170 Cycle Test.

Research methods. Quantitative evaluation of inorganic phosphorus in urine by the Bell-Doisy-Briggs' method; Quantitative evaluation of urea content in urine by diacetylmonoxide method according to the test of "Lachema" company (Czech Republic); Quantitative evaluation of lactic acid excretion by Stromm's method.

Statistical processing of experimental data. Statistical processing of the obtained experimental results was carried out using the application software package Excel. To compare the data about the content of energy indicators Student's *t*-test was used.

Research results and their discussion.

The results of the research of the content of energy indicators among athletes of different age groups are presented in fig. 1-6.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 15-year-old water polo athletes before and after physical exertion are shown in fig. 1

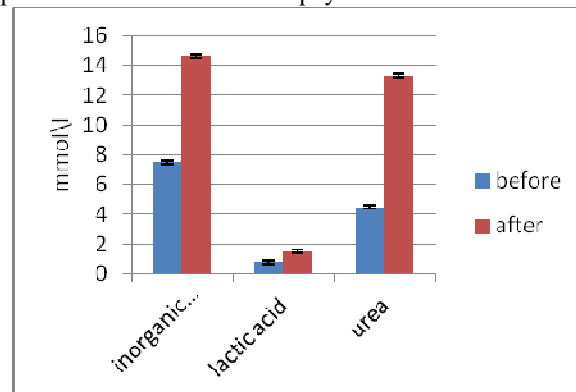


Fig. 1. Excretion of lactic acid, inorganic phosphate and urea from 15-year-old water polo athletes

Notes: *** – $p \leq 0.999$

As it can be seen from fig. 1. among athletes of this age group, the content of inorganic phosphate increases significantly, which indicates significant total expenditure of the body to overcome physical exertion. The indicator of the content of inorganic phosphate reliably increases by 2 times (*** – $p \leq 0.99$).

The content of urea also increases significantly after physical exertion. The indicator increased by 2.6 times ($p \leq 0.999$), which indicates active involvement in the process of energy supply of the aerobic pathway. Since the content of urea in urine serves as an indicator of the stress reaction to physical exertion, it can be argued that this kind of physical exertion increases the presence of the strength component in the energy metabolism of 15-year-old athletes, but only at the early stages of overcoming it.

The increase in the content of lactic acid in the urine of water polo players after physical exertion indicates involvement in the general energy balance and the anaerobic lactate pathway, therefore, during physical exertion, the young body uses all links of energy supply.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 14-year-old water polo athletes before and after physical exertion are presented in fig. 2.

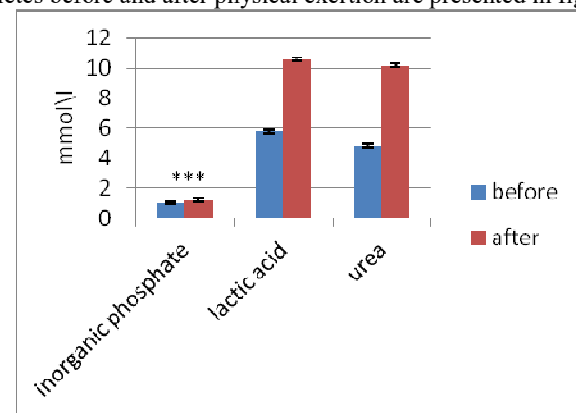


Fig. 2. Excretion of lactic acid, inorganic phosphate and urea from 14-year-old water polo athletes before and after exercise

Notes: *** – $p \leq 0.999$

Analyzing the results of monitoring the body's energy supply processes of 14-year-old athletes, we observe an increase in all indicators after physical exertion. The content of urea in the urine of water polo players increases significantly, which indicates active involvement in the process of energy supply of the aerobic pathway. At the same time, the indicator of urea content in an athlete's urine is used to detect a stress reaction to physical activity, so this ergometric load was found for 14-year-old athletes as well as for 15-year-old athletes as such that increases the share of proteins in their energy metabolism.

An increase in the content of inorganic phosphate in the urine of water polo players indicates the total energy expenditure of the body to overcome this physical load. The growth of the indicator is reliable ($-p \leq 0.999$). The content of lactic acid in the urine of 14-year-old athletes also increases significantly after physical exertion, so the aerobic lactate pathway was also involved in energy supply processes, which indicates that the athlete's body used all energy supply pathways to overcome physical exertion.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 13-year-old water polo athletes are presented in fig. 3.

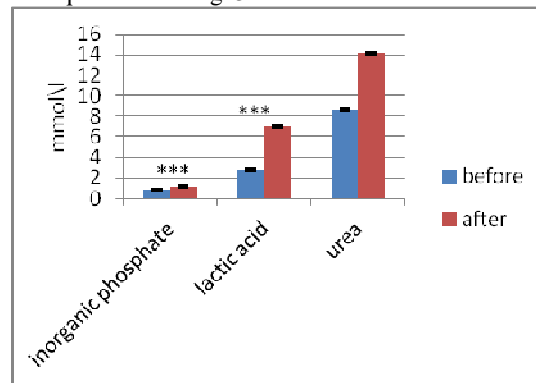


Fig. 3. Excretion of lactic acid, inorganic phosphate and urea in 13-year-old water polo athletes

Notes: *** – $p \leq 0.999$

The data we obtained allow us to state that all energy supply pathways are involved in sportsmen aged 13 during physical exertion. The content of inorganic phosphate in the urine of water polo players after physical exertion increases by 1.3 times, so the total energy expenditure is moderate.

The increase in the content of lactic acid as an indicator of the involvement of the anaerobic pathway of energy supply indicates that 13-year-old athletes spend more time in the anaerobic mode than older water polo players to perform the cycle ergometer test. The content of lactic acid in the urine of athletes increased by 2.5 times ($-p \leq 0.999$). And, therefore, they have more anaerobic components of the lactate type.

The rate of urea content in the urine of young water polo players increased by 1.5 times, so the aerobic pathway of energy supply was moderately involved in the total energy expenditure of the body. Thus, physical exertion did not cause a significant stress reaction, which is positive and indicates a moderate expansion of the limits of aerobic adaptation of 13-year-old water polo players.

A significant increase in the indicators of the energy supply of the athlete's body indicates the low qualification of young water polo players, weaker overall physical fitness and adaptability to significant physical exertion. In the process of preparing for the competition, it is advisable to equally use exercises of both aerobic and anaerobic ways of energy supply of the body.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 12-year-old water polo players are presented in fig. 4.

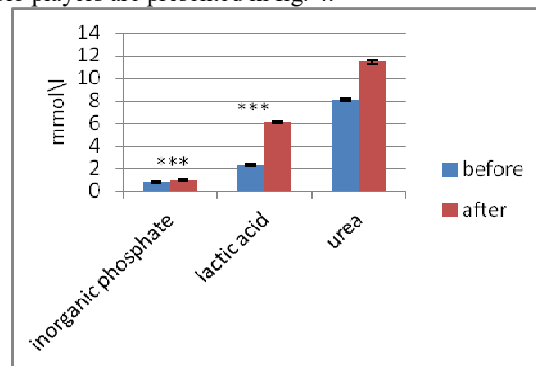


Fig. 4. Excretion of lactic acid, inorganic phosphate and urea from 12-year-old water polo players

Notes: *** – $p \leq 0.999$

Analyzing the data presented in fig. 4, we see a similar increase in the content of all energy indicators in the urine of water polo players after physical exertion, as in 13-year-olds. The increase in all indicators is statistically reliable ($p \leq 0.999$).

The content of lactic acid increases the most (by 2.4 times), so the anaerobic lactate mechanism is most actively involved in providing the body's energy needs.

The total energy expenditure is moderate, which is indicated by relatively low indicators of the content of inorganic phosphate in the urine of water polo players after physical exertion in the case of the PWC-170 Cycle Test.

Urea content increases by 1.4 times after physical exertion. This indicates the use of the aerobic pathway of energy supply in the process of overcoming physical stress. In addition, the content of proteins in urea before exercise in both 13-year-olds and 12-year-olds is high, which does not indicate a high level of protein metabolism in general.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 11-year-old water polo players are presented in Fig. 5.

Carrying out a comparative analysis of the content of the studied indicators of the energy supply of the body of athletes (based on indicators of Student's *t*-test) allows us to draw conclusions about the peculiarities of the energy supply of the body of young athletes.

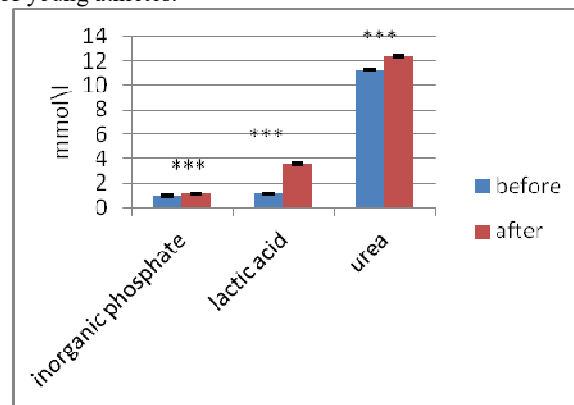


Fig. 5. Excretion of lactic acid, inorganic phosphate and urea from 11-year-old water polo players
 Notes: *** – $p \leq 0.999$

As evidenced by the data shown in fig. 5, 11-year-old water polo players have a significant amount of urea in their urine, both before physical exertion and after the PWC-170 Cycle Test. This fact may indicate that among young athletes there is an increased nitrogen balance associated with the first stage of puberty, which is due to the increase in protein synthesis and breakdown in the process of life, and especially under the influence of physical exertion of a sports nature.

We also observe a 3-fold increase in the content of lactic acid after physical exertion. Such an active inclusion of the anaerobic mechanism of energy supply indicates that such physical loads dominate in solving tasks of enhanced energy exchange.

The results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 10-year-old water polo players are presented in fig. 6.

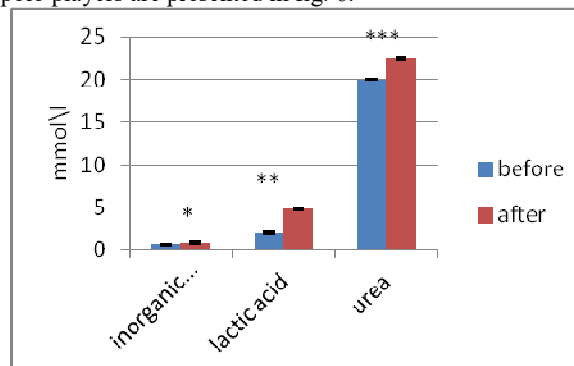


Fig. 6. Results of a comparative analysis of the content of lactic acid, inorganic phosphate and urea in the urine of 10-year-old water polo players
 Notes: *** – $p \leq 0.999$

Similarly to 11-year-old athletes, high urea content was found in the urine of water polo players before and after physical exertion. After conducting the experiment, the content of urea increases significantly ($p \leq 0.999$), which indicates the involvement of the aerobic mechanism of energy supply to overcome physical exertion.

The content of lactic acid in the urine of athletes increases by 1.8 times and this indicates the inclusion of the anaerobic mechanism of energy supply in the total energy expenditure of the body.

Since the increase in the indicator of the content of inorganic phosphate is insignificant, but statistically reliable - $p \leq 0.95$, it can be argued about an insignificant increase in the total energy expenditure of the athletes' body, which is adequate for this age category.

The results of the one-factor variance analysis of the influence of the athlete's age on the body's energy indicators are presented in fig. 7

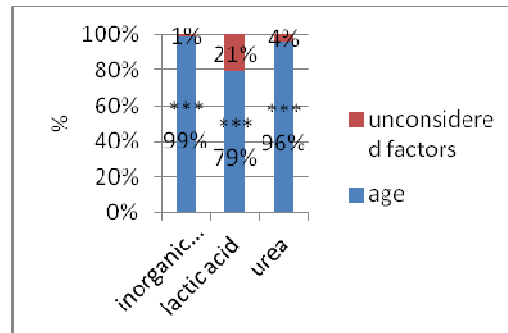


Fig. 7. Results of a One Way ANOVA

Notes: *** – $p \leq 0.999$

Fig. 7 shows that the athlete's age has a significant effect on the content of inorganic phosphate in the urine of water polo players after physical exertion (the share of influence is 99%).

The content of lactic acid also depends on the age of water polo players, but to a lesser extent (the share of influence is 79%).

The share of the influence of the age of the athlete on the urea content in the urine of water polo players is 96%, which indicates a significant dependence of this indicator on the age of water polo players.

Factor analysis data confirm the informativeness of the choice of biochemical markers to ensure biochemical monitoring during the training of young water polo players of various ages. Therefore, the obtained characteristics can be objective criteria for evaluating adaptive changes in energy systems for ensuring muscle activity, which expands its boundaries with the transition from younger to older age.

Discussion

As a result of the conducted experiment, it should be noted that 15-year-old water polo players experienced the greatest changes in energy exchange as a result of the PWC-170 Cycle Test. This can be seen from the largest increase in response to the load of all 3 criteria of biochemical monitoring in comparison with other age groups. Namely, inorganic phosphorus, lactic acid more than 2 times, and urea 2.6 times. This indicates the uniform development of anaerobic and, to a special extent, aerobic mechanisms, which brings these changes closer to changes among adult athletes. A similar trend was observed in 14-year-old athletes, with the exception of changes in inorganic phosphorus indicators (by 0.5 times) and 13-year-old athletes, whose urea indicator was even lower than in 14- and 15-year-old athletes. The difference among 13-year-olds between before and after the PWC-170 Cycle Test is more than 1.5 times plus against 2.6 among 15-year-olds and 2 times among 14-year-olds. Among 10, 11, and 12-year-old water polo players, the most sensitive was the glycolytic mechanism of energy supply, where the increased lactic acid as a result of the PWC-170 Cycle Test was, respectively: 1.8 (10-year-old), 3 (11-year-old), 2.4 (12- summer) times. Separately, the difference between the urea index before and after the test load among 12-year-olds should be pointed out, which was proportional to 13-year-olds, and amounted at its increase (1.4 times greater among 12-year-olds versus 1.5 times among 13-year-olds). This indicates an insignificant difference in the state of development of aerobic energy exchange between 12- and 13-year-old athletes.

According to the obtained results, we made the following **conclusions**:

1. Different reactions of biochemical indicators of the body's energy supply to physical exertion are observed among athletes of different age groups.
2. Among water polo players of all age groups, there is a 2-3 times increase in the lactic acid index, with the highest point of increase at 11 years (three times) and 13 years (2.6 times).
3. Athletes aged 14–15 respond to physical exertion with high levels of inorganic phosphate and urea, which indicates the physiological features of the age of increasing anaerobic capabilities. The share of the anaerobic

lactate component prevails at a younger age, and with the transition to an older age category, the expansion of energy exchange adaptation changes becomes more and more aerobic in nature.

4. One Way ANOVA indicates a significant influence of the athlete's age on the indicators of the body's energy supply, which can be used in biochemical express monitoring of the state of development of adaptive energy systems during the system of multi-year training of water polo players.

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