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Original article

METABOLIC COST OF THE EFFORT SPECIFIC TO WATER POLO GAME, BASED ON THE RELATIONSHIP BETWEEN PH AND LACTIC ACID CONCENTRATION IN JUNIOR III

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Abstract

Aim. To make a diagnosis of specific effort during the water polo game, in order to translate this effort towards some stimulating training means that are consistent with the requirements of competitive effort. The element of originality of our research is that there were tested and assessed, for the first time in the world, the demands to which junior III water polo players are subjected during the match.

Methods. There were tested 6 athletes (junior III), components of the water polo team from "Steaua" School Sports Club no. 3, in an official match. We mention that, in order to objectively assess the demands, there were analyzed 27 biochemical parameters during the game progress ("interrupted trial") and after each quarter. The devices used were the Automatic blood gas analyzer ABL835 RADIOMETER and the Dry chemistry analyzer SPOTCHEM EZ Model SP-4430 - Arkray. In this paper, we chose to examine the evolution of two biochemical/ metabolic parameters: blood lactic acid (L.A.) and blood acid-base balance (pH). Methods used: test method, statistical and mathematical method - arithmetic mean, graphical method.

Results. The average value of blood lactic acid concentration at the beginning of the match (basal metabolism) is 1.7 mmol; at the first break, the average value is 8.09 mmol of lactic acid; at the second break, the average value is 5.5 mmol of lactic acid; at the third break, the average value is 5.6 mmol of lactic acid, and at the end of the game, the average value is 6.2 mmol of lactic acid. In the "interrupted trial", the athlete C.D. recorded a value of 12.2 mmol of lactic acid following an effort specific to an attack phase (attack ended with a shot on goal, fallback, counterattack with a successful shot on goal).

Conclusions. The highest L.A. value, 12.2 mmol of lactate recorded in the "interrupted trial", shows that the effort is performed within a lactate tolerance zone (S1) and, correlated to the lowest pH value, it shows that, during the exercises involving sprints, muscle glycogen (anaerobic glycolysis) generates a large amount of lactic acid and H+ ions, which results in a decrease of the pH value that may reach a level between 7.1 and 6.7 (see the lactic acid metabolism); consequently, the pH value of 7.238 is normal and falls within the tolerable limits for arterial blood, 6.9 to 7.5, because lactate has been measured in the blood, not in the muscles.

Keywords: water polo, effort zones, lactic acid, metabolic cost, pH.

Introduction

In water polo game, acyclic movements are predominant, and the metabolic characteristic of effort is represented by strength endurance with anaerobic penetrations (Marinescu et al., 2004).

The latest changes in the game regulations have led to increased speed and complexity during the attack and defense phases. The ratio between the dominant energy systems in water polo game is the following: 10% alactacid, 30% lactacid, 60% aerobic, and the performance-limiting factors are represented by: acceleration power, throwing power, etc., all of them relying on a solid aerobic basis (Bompa, 2003). The specificity of an effort is given by the muscular characteristic, the metabolic one, and by tempo- and rhythm-related characteristics (Marinescu, 2003).

Dragnea (quoted by Cordun, 2011) states that the exercise capacity is "limited by those organs which, after reaching maximal functional capacity, hinder continuation of the exercise, although other organs and systems still allow it".

Traditionally, performance training is divided into physical, technical, tactical and psychic components, consequently each component is grafted a specific work/ effort on a given quality.

But the concept of "total training" encompasses, inevitably, a totally indissoluble effort, where each means for stimulating one or other of the training

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factors has global anatomic-physiological-metabolic and psychic effects on the performance components, involving vectorization from learning the motor gesture to the overview of the future preparation cycles within a given time (Guejd et al., 2006).

From the research conducted (Dragnea, Cordun Teodorescu-Mate, 1990, quoted by Dragnea, Teodorescu-Mate, 2002) on a team of water polo players at the prepubertal age and the early stage of puberty, it has been found that the acid-base balance undergoes unessential changes (within normal limits) after heavy efforts.

Endurance and strength-endurance training sessions highlight that the buffer systems and the balance keeping ones are developed as well, therefore they are also trained (Dragnea, Teodorescu-Mate, 2002).

Specialty literature is poor in data regarding the metabolic cost of effort in children and juniors - water polo, comparatively to seniors. Platanou and Geladas (2006) report lactic acid values comprised between 2 and 12 mmol, with an average of 3.9 mmol in a friendly match played by the senior representative team of Greece.

As to the directly usable markers for controlling exercise intensity, the anaerobic threshold still remains a fashionable training concept (Guejd et al., 2006).

Aim of the research. The research aims to make a diagnosis of specific effort during the water polo game, in order to translate this effort towards some stimulating training means that are consistent with the requirements of competitive effort. The element of originality of our research is that there were tested and assessed, for the first time in the world, the demands to which junior III water polo players are subjected during the match.

Research hypothesis**.**

Knowing the evolution of metabolic parameters of the effort, pH and acid lactic (L.A.) during the match will lead to establish the effort zones exerted in water polo game.

Methods

There were tested 6 athletes (junior III), components of the water polo team from “Steaua” School Sports Club no. 3, in an official match.

We mention that, in order to objectively assess the demands, there were analyzed 27 biochemical parameters during the game progress (“interrupted trial”) and after each quarter. The devices used were the Automatic blood gas analyzer ABL835 RADIOMETER and the Dry chemistry analyzer SPOTCHEM EZ Model SP-4430 - Arkray (figure 2).

In this paper, we chose to examine the evolution of two biochemical/ metabolic parameters: blood lactic acid (L.A.) and blood acid-base balance (pH).

Methods used: ascertaining pedagogic experiment with one single variable, test method, statistical and mathematical method - arithmetic mean, graphical method (Popa, 2008).

Results

Figure 3 shows the evolution of average lactic acid values recorded before the match (basal values) and at the end of the 4 quarters, during a water polo game. At the beginning of the match (basal moment), the average value of blood lactic acid is 1.7 mmol, which indicates a slight fatigue before the match. Taking into account that a quarter lasts 8 minutes, the measurement of blood lactic acid reaches the value of 8.09 mmol, which means that the work zone at the end of the first quarter is VO_2 max (to reach VO_2 max, one of the methodical-metabolic conditions is that the effort should last over 3 minutes, so that the body uses energy in the upper aerobic zone). At the end of the second quarter, the average value of blood lactic acid is 5.5 mmol, which indicates that the body undergoes a “drift” (Guejd et al., 2006), a cardiovascular adaptation process determined by the work within the anaerobic threshold zone. At the end of the third quarter, the average value of blood lactic acid is 5.6 mmol, the body undergoing a cardiovascular adaptation process similar to that occurred at the end of the second quarter, which shows that the effort in this quarter is also situated within the anaerobic threshold zone.

At the end of the match, the average lactate value is 6.2 mmol of lactic acid, so it can be considered that the exercise has been more demanding and the work has been done within an incipient VO_2 max zone.

To conclude, we can state that the first and the last quarters are the most demanding, in terms of exercise intensity (it is noted that work is done in VO_2 max, exercise intensity towards 90%), while in the second and third quarters, due to specific adaptation, the effort falls within the anaerobic threshold zone.

Figure 1. Acid-base balance analyzer - ABL835 RADIOMETER [RADIOMETER, 2006]

Figure 2. Dry chemistry analyzer - SPOTCHEM EZ Model SP-4430 - Arkray [ARKRAY, 2009]

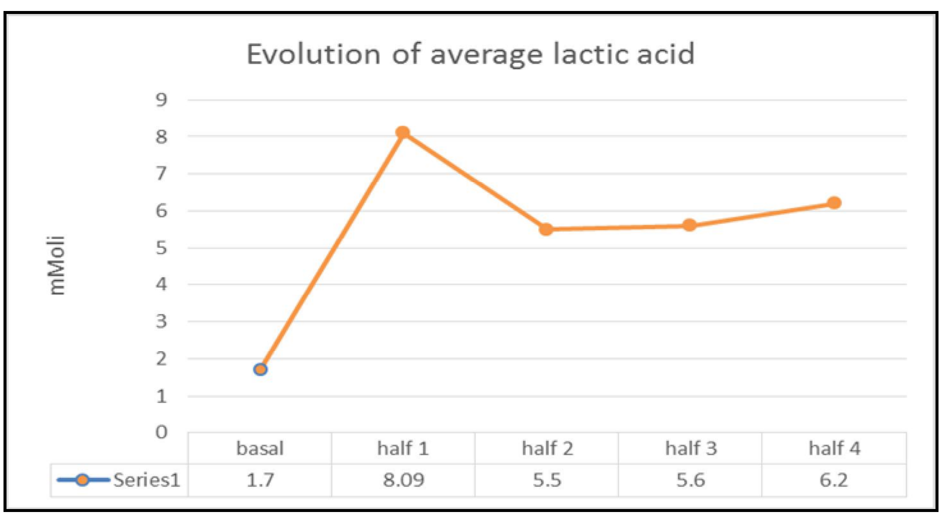

Figure 3. Evolution of average lactic acid values recorded by 6 athletes during a water polo match (5 moments: the basal one, the 3 breaks and the end of the match)

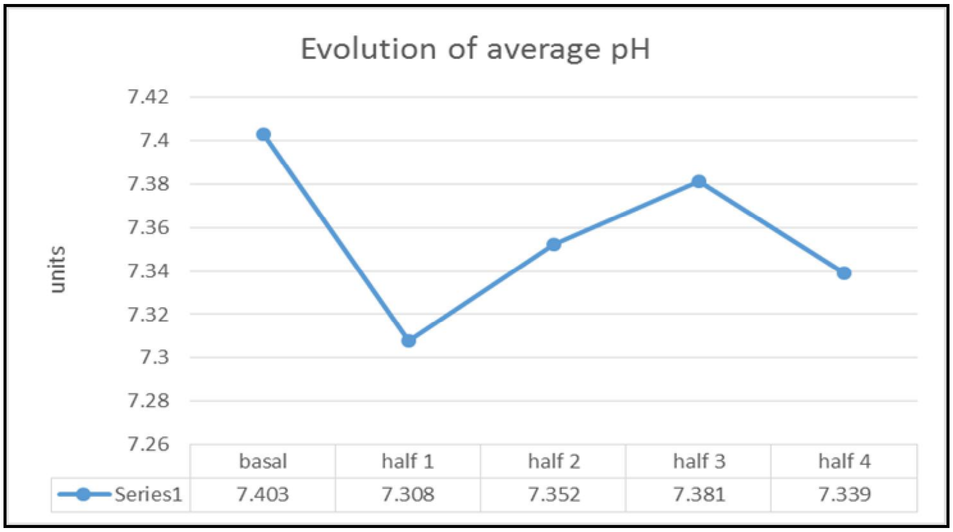

Figure 4. Evolution of average pH values recorded by 6 athletes during a water polo match (5 moments: the basal one, the 3 breaks and the end of the match)

Figure 4 shows the evolution of average pH values recorded before the match (basal values) and at the end of the 4 quarters, during a water polo game. At the beginning of the match (basal moment), the average pH value is 7.403, which indicates an acid-base balance state in the blood. The pH value of 7.308 at the first break shows the onset of an acid-base imbalance state in the blood, which indicates the state of blood acidosis due to increased exercise intensity. The pH value of 7.352 at the second break and the pH value of 7.381 at the third break still reveal an acid-base imbalance state, but it can be noted its improvement compared to the average value recorded at the first break, which indicates an adaptation to the type of exercise performed. The pH value of 7.339 at the end of the match shows again an acid-base imbalance state in the blood, on the background of increased exercise intensity during this quarter. To conclude, we can state that the first and the last quarters are the most demanding, in terms of exercise intensity, acting on the blood acid-base imbalance (onset of an acidic state).

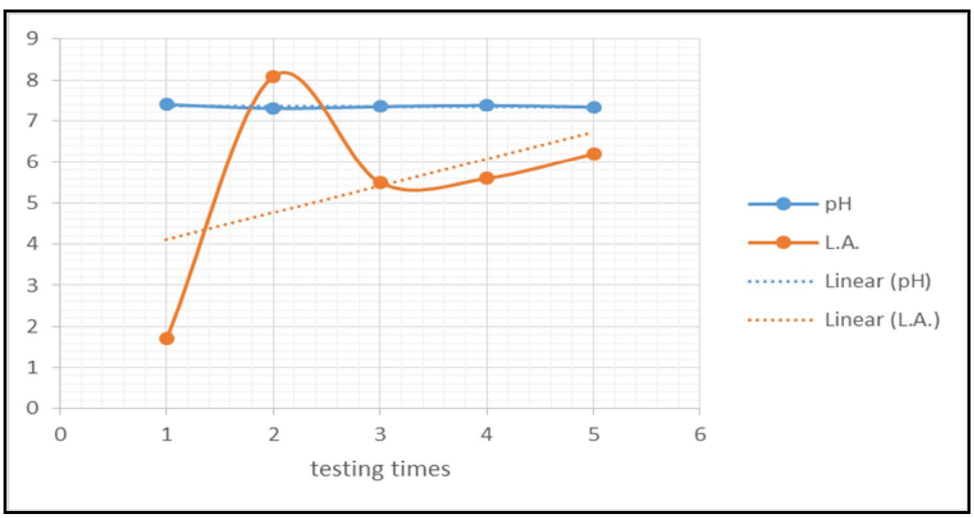

Figure 5. Evolution of average pH and L.A. values recorded by 6 athletes during a water polo match (5 moments: the basal one, the 3 breaks and the end of the match)

Figure 5 and table 1 show the tendency of increase in the average L.A. values recorded by the 6 athletes, while for the average pH values in the 5 testing moments, the tendency is downwards, so we can assert that, in most cases, an increase in the L.A. value is closely related to a decrease in the pH value.

Table 1. Average pH and L.A. values recorded by 6 athletes during a water polo match (5 moments: the basal one, the 3 breaks and the end of the match)

	Basal moment	1st quarter	2nd quarter	3rd quarter	4th quarter
pH	7.403	7.308	7.352	7.381	7.339
L.A.	1.7	8.09	5.5	5.6	6.2

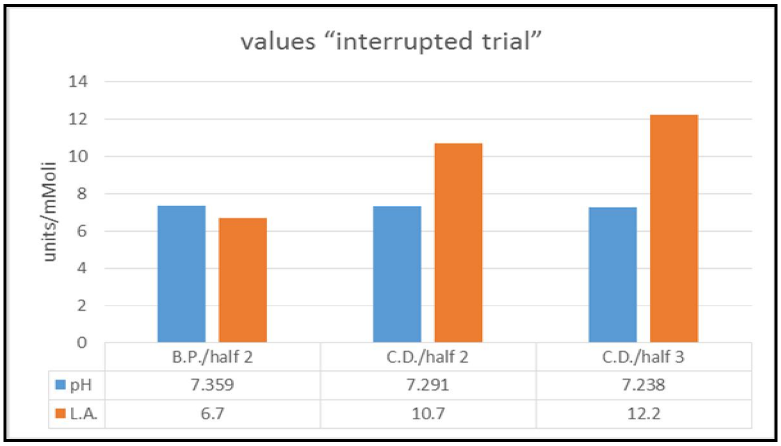

Figure 6. The pH and L.A. values recorded by 2 athletes tested in the "interrupted trial" (after some technical-tactical attack and counterattack actions, the athletes came out of the water and were tested)

Figure 6 shows the pH and L.A. values recorded in certain moments of the game, considered by us as peak moments of exercise intensity. Following a counterattack ended with a shot on goal, the athlete B.P. comes out of the water to be tested. The pH value of 7.359 indicates a slight acid-base imbalance in the blood, and the L.A. value of 6.7 mmol reveals that the effort performed after this action falls within the VO_2 max zone; this is explained by the fact that, working within an upper aerobiosis zone, close to the minimal lactate limit specific to VO_2 max zone, the body is able to bring/ consume a larger amount of oxygen that will metabolize/ buffer the lactic acid, which will also result in maintaining the pH values close to normal limits. After a counterattack – pass - pass - goal scoring, the athlete C.D., who headed the ball and scored, goes out of the water to be tested. The pH value of 7.291 shows a slight decrease and the L.A. value of 10.7 mmol shows that the effort performed during this action is situated at the upper limit within the VO_2 max zone. In the "interrupted trial", in the third quarter, after a tactical attack action (blocked counterattack, fallback, counterattack with a blocked finalization followed by the goal scoring), the athlete C.D., who scored the goal and was the most active in this phase, goes out of the water to be tested. He reaches an amount of 12.2 mmol of lactate, which shows that the action has been carried out within a lactate tolerance zone (S1) and, correlated to the lowest pH value of 7.238, it shows that, during the exercises involving sprints, muscle glycogen (anaerobic glycolysis) generates a large amount of lactic acid and H+ ions, which results in a decrease of the pH value that may reach a level between 7.1 and 6.7 (see the lactic acid metabolism). Consequently, the pH value of 7.238 is normal and falls within the tolerable limits for the acid-base balance in arterial blood, 6.9 to 7.5, because lactate has been measured in the blood, not in the muscles (Wilmore et al., 2008).

Discussions

The tendency of increase in the average L.A. values recorded by the 6 athletes is inversely proportional to the pH values.

From the analysis of test results, we can conclude that the effort specific to water polo game is carried out within an upper aerobiosis zone (average L.A. value = 6.1 mmol per match => VO_2 max zone) penetrated by anaerobic efforts (L.A. = 12.2 mmol => lactate tolerance zone = S1).

The veracity and accuracy of data collected "on the field" entitle us to assert/ sustain that, regardless of the type of effort specific to the sports discipline, in children and juniors, the effort should basically aim to improve the upper aerobic capacity, which will also induce, inevitably, the development of anaerobic capacities.

Knowing the evolution of metabolic parameters of the effort, pH and acid lactic (L.A.) during the match will lead to establish the effort zones exerted in water polo game **- the research hypothesis is confirmed**.

Extrapolating the correlation between L.A. and pH, at an RQ = 1.18 (respiratory quotient), it can be noted that, as the exercise intensity increases in the athletes of our experiment, the energy to sustain it is supplied by the anaerobic glycolysis, not by the lipid system, as it would be normal for the economy of effort (CrossOver phenomenon).

The assessment of these parameters indicates that, for acyclic sports (sports games, combat disciplines, etc.), it should be used mixed training means, similar to those in the game - VO_2 max for central level and AA/AL (capacity 5-15sec) for peripheral level (recruitment of type II muscle fibers and velocity work). Exercise intensity for AA should be 1.2-1.4 of MAV (maximum aerobic velocity - MAV must not be confused with VO_2 max) (Guejd et al., 2006).

Regardless of the major type of effort (aerobic or anaerobic one) used in the next training lesson, immediately after the warm-up, pure velocity (anaerobic power and capacity) is recommended to be worked, because it stimulates/ improves neuro-neuronal and neuro-muscular coordination and prepares the enzymatic equipment for the future specific effort. Children and prepubertal adolescents are recommended quality aerobic training, associated to velocity training, for exerting the type I, IIa and IIb fibers, which ensures a good cardiovascular and psychomotor development (Guejd et al., 2006).

Conclusions

The highest L.A. value, 12.2 mmol of lactate recorded in the "interrupted trial", shows that the effort is performed within a lactate tolerance zone (S1) and, correlated to the lowest pH value, it shows that, during the exercises involving sprints, muscle glycogen (anaerobic glycolysis) generates a large amount of lactic acid and H+ ions, which results in a decrease of the pH value that may reach a level between 7.1 and 6.7 (see the lactic acid metabolism); consequently, the pH value of 7.238 is normal and falls within the tolerable limits for arterial blood, 6.9 to 7.5, because lactate has been measured in the blood, not in the muscles (Wilmore et al., 2008).

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