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Abstract

The lactate concentration significantly increases during exercise destabilizing the cellular acid-base balance. In this study, we examined the relationship between alkaline water usage and muscle fatigue recovery measured as the change in lactate concentration. Thirty healthy subjects were asked to pedal on a cycle ergometer for 25 min at a constant pace. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two conditions were separated by an interval of 24 h. The concentration of the lactate was measured just after the physical exercise and after the water consumption. In control condition, there was not significant change in lactate concentration ($p = 0.097$), whereas, in the experimental condition, the lactate concentration measured after the alkaline water consumption was significantly lower than the concentration measured just after the physical exercise ($p < 0.000001$). The observed results have proven the beneficial effects of the alkaline water on the reduction of the lactate concentration thus accelerating the muscle fatigue recovery process.

Keywords: Alkaline water usage - Lactate dehydrogenase - Muscle fatigue recovery

On the Analysis of the Relationship Between Alkaline Water Usage and Muscle Fatigue Recovery

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Abstract. The lactate concentration significantly increases during exercise destabilizing the cellular acid-base balance. In this study, we examined the relationship between alkaline water usage and muscle fatigue recovery measured as the change in lactate concentration. Thirty healthy subjects were asked to pedal on a cycle ergometer for 25 min at a constant pace. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two conditions were separated by an interval of 24 h. The concentration of the lactate was measured just after the physical exercise and after the water consumption. In control condition, there was not significant change in lactate concentration ($p = 0.097$), whereas, in the experimental condition, the lactate concentration measured after the alkaline water consumption was significantly lower than the concentration measured just after the physical exercise ($p < 0.000001$). The observed results have proven the beneficial effects of the alkaline water on the reduction of the lactate concentration thus accelerating the muscle fatigue recovery process. AQ1 AQ2

Keywords: Alkaline water usage · Lactate dehydrogenase · Muscle fatigue recovery

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1 Introduction

In the human body, the production of energy in the form of adenosine triphosphate (ATP) is mainly driven by aerobic processes thus needing oxygen. When the level of cellular oxygen is too low, the cells produce energy through anaerobic mechanism with a lower efficiency than the aerobic one [1]. Lactic acid is a by-product of energy production in the anaerobic state, as example during an intense muscular activity [2]. The lactic acid is generated by the interconversion of pyruvate into lactate that is mediated by the lactate dehydrogenase (LDH). Hence, the concentration of lactic acid within the blood can be seen as a direct evaluation of the oxygen availability [3]. Since the lactic acid is a weak acid, it dissociates in water resulting in ion lactate and H^+. Such accumulation of H^+ is the main cause of the cell acidity increase (Figs. 1 and 2). AQ3

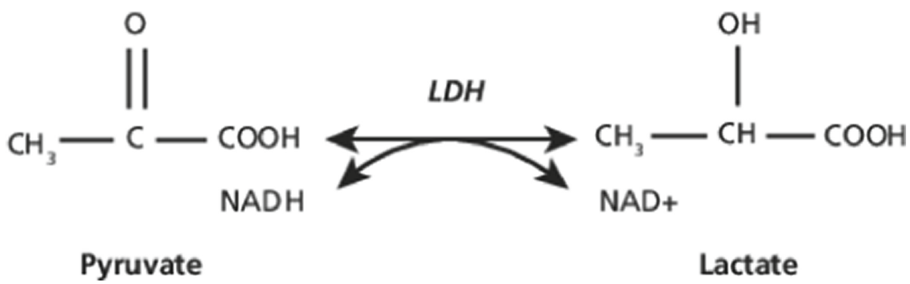

Fig. 1. Lactate dehydrogenase (LDH) conversion of pyruvate and lactate.

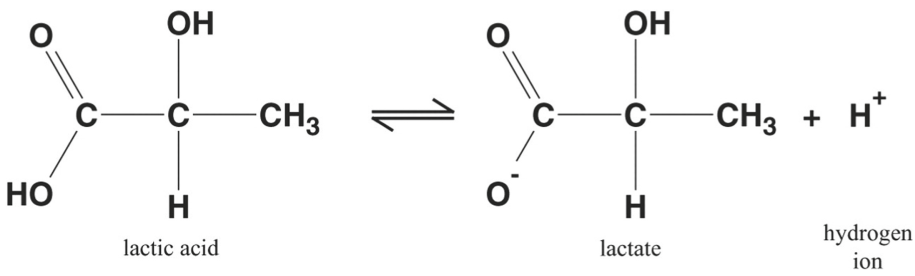

Fig. 2. Lactic acid deprotonation.

In medical practice, the acid-base balance is often underestimated even though it is well known that lifestyle changes, especially in food, produce substantial benefits. An incorrect diet can indeed lead to an acid-base imbalance with consequent negative symptoms, such as cramps, muscle fatigue and accumulation of lactic acid. Basic therapy can be used to treat numerous pathologies and several studies have already focused attention on the benefits deriving from the consumption of alkaline water. However, the relationship between alkaline water usage and muscle fatigue recovery is not yet fully understood.

The main goal of this study regards the analysis of the relationship between the usage of alkaline water and muscle fatigue through the quantitative evaluation of hematochemical parameters, in detail we have analyzed the change in concentration of the lactate within the blood after the consumption of two different water: normal water with a pH equal to 6.9 and alkaline water featuring a pH ranging in [8.5–9.3].

2 Materials and Methods

2.1 Subjects

Thirty healthy males (age: 30.2 ± 4.1 years old) volunteered to participate as subjects for this study after being fully informed of the procedures and possible side effects. The exclusion criteria were: 1) being a smoker, 2) practicing either amateur or professional physical activity, and 3) suffering from neuromuscular diseases.

2.2 Experimental Protocol

All subjects underwent two experimental conditions presented randomly and unknown both to them and to the clinical staff. Exercise testing was the same in each of the two conditions and consisted in pedaling on a cycle ergometer for 25 min without any resistance at a pace of 15 km/h. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two conditions were separated by an interval of 24 h.

The alkaline water used in this study has been produced with a domestic reverse osmosis plant equipped with two osmotic membranes characterized by a salt rejection lower than 97.5% and a chlorine tolerance lower than 0.1 ppm. The used domestic plant is also able to remineralize the post-osmotic water by constantly introducing an alkaline concentrate (Patent n. 0000276383; Class I Medical Device BD/RDM 1438157) [4].

The concentration of the LDH within the blood was assessed 1) five minutes before the beginning of the exercise test, 2) two minutes after the end of the exercise test and 3) after the consumption of the defined amount of water (one hour from the end of the physical exercise). The accumulation of LDH was determined by analyzing a peripheral blood sample with the spectrophotometric reader CR 4000 – Callegari [5]. The employed reader has the following technical features: 1) wavelength equal to 505 nm, 2) sample path length equal to 1.0 cm, 3) volume of the blood sample equal to 5 μl, and 4) reaction time equal to 180”. AQ4

3 Results

The difference between the control (water with pH = 6.9) and experimental conditions (water with 8.5 < pH < 9.3) has been assessed comparing the LDH concentration measured just after the end of the exercise test with the LDH level observed after the water consumption (1 h after the end of the exercise test). The statistical significance has been evaluated with a paired t-test ($p < .05$) and data normality was checked with Kolmogorov-Smirnov test. All statistical analyses have been performed using the IBM SPSS software [6].

Concerning the control condition (see Fig. 3), no significant difference was observed between the LDH concentrations measured after the exercise test (M = 33.7 mg/dl, SD = 16.0 mg/dl) and after water consumption (M = 26.9 mg/dl, SD = 16.4 mg/dl); $t(29) = 1.713$, $p = .097$.

Regarding the experimental condition (see Fig. 4), there was a significant difference between the LDH concentrations measured after the exercise test (M = 32.4 mg/dl, SD = 14.7 mg/dl) and after water consumption (M = 20.3 mg/dl, SD = 13.2 mg/dl); $t(29) = 7.317$, $p < .000001$.

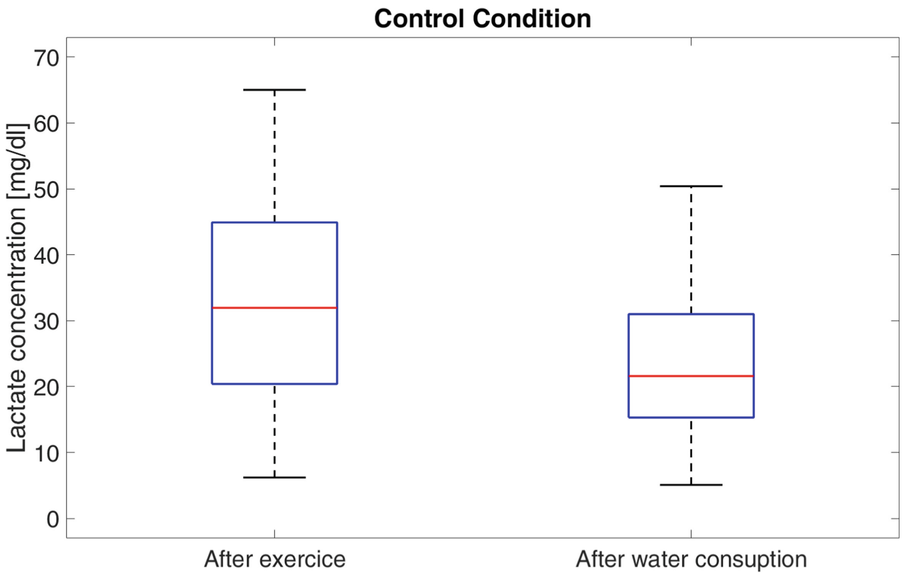

Fig. 3. Comparison of the LDH concentration after the exercise and the water consumption acquired in the control condition.

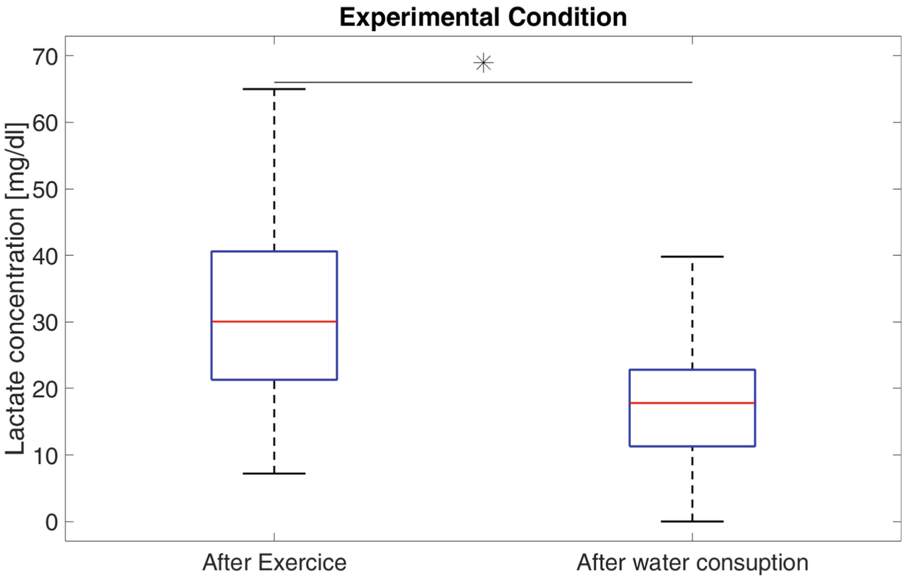

Fig. 4. Comparison of the LDH concentration after the exercise and the water consumption acquired in the experimental condition (* indicates $p < 0.001$).

4 Discussions and Conclusions

In the presented work we have investigated the effect of alkaline water on the muscle fatigue recovery. Thirty healthy subjects were involved in the study and underwent two different conditions: control and experimental. During both conditions, subjects were asked to pedal on a cycle ergometer for 25 min at a constant pace. At the end of the physical exercise, each subject was asked to drink, in one hour, either one liter of water with a pH equal to 6.9 (control) or one liter of alkaline water with a pH value ranging between 8.5 and 9.3 (experimental). The two experimental conditions were separated by an interval of 24 h. The observed results have shown a substantial difference between the effect of the normal (control) and the alkaline water (experimental). The consumption of water with a pH equal to 6.9 had no significant effect on the lactate concentration. Infact, the levels of lactate measured both just after the exercise test and after the water consumption, i.e. after one hour from the end of the physical exercise, were comparable ($p = 0.097$). Differently, we observed a significant decrease in the lactate concentration when subjects drank alkaline water ($p < .000001$). These results have proven the significant effect of the alkaline water consumption on the reduction of the lactate concentration. According to such evidence, future studies might prove that the regular consumption of alkaline water has beneficial effects on the muscle fatigue recovery due to its relationship with the lactate concentration. Future studies will also investigate the effect of the alkaline water on the muscle fatigue through an objective analysis of the surface electromyographic signals and movement quality [7–10].

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