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*Original Research Article*

# The role of drinking hydrogen-rich water produced by alkaline stick on resistance exercise in athletes

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## ABSTRACT

In the double-blind study, the effect of drinking Hydrogen-Rich Water (HRW) producing by alkaline stick and tap water (placebo) on 9 male athletes in resistance training during 24 h were studied, and Lactate Dehydrogenase (LDH), Creatine Kinase (CPK) and Lactic Acid (LAC) levels in their blood samples were tested. The decrease of LAC and LDH values in the HRW group compared with the placebo were significant. However, the changes of CPK was not significant in neither of the experience. The results show that once drinking HRW has the appropriate effect on LAC decrease, LDH decrease and the resulted tiredness in resistance exercise. Henceforth, it could improve sport efficiency in professional athletes.

***Keywords*:** Alkaline stick, hydrogen-rich water, resistance exercise, lactate dehydrogenase, lactic acid, creatine kinase

## INTRODUCTION

Resistance exercise is a form of exercise that constricts skeletal muscles, no autonomous muscles such as the heart and lungs. In this exercise, one external torque, such as Dumbbell, is used for twitch skeletal muscles and this contraction ends to increase muscle mass, vigor, endurance and muscles' integrity [1].

Regarding recent developments in the sports field for reinforcing athletes efficiency, different resistant indicators are used. When sports activities are increased, the body uses

anaerobic glycolysis for producing enough energy which ends to lactate accumulation. Considering lethargy and inflammation in resistance exercise resulted from lactate accumulation and the effect of pH of blood during activity, the molecular responses of human skeletal muscles have been studied [2].

Delayed onset muscle soreness (DOMS) is related to the extrication of creatine kinase, lactate dehydrogenase, and aspartate aminotransferase. This increase can be measured in blood. Creatine kinase is a crucial enzyme in muscle cells' metabolism and expedites the conversion of keratin to phosphate or vice versa [3]. This enzyme is intracellular in healthy people and its amount is low in the blood. Creatine kinase is a reliable indicator inside the cell as it is found only in skeletal muscles and heart muscles. Therefore, the destruction of Z lines and sarcolemma impairment, facilitate the emission of soluble enzymes such as creatine kinase to the inter-tissue fluid. This can be a sign of muscle impairment and inflammation [4]. Lactate dehydrogenase is an enzyme that presents in a great amount in the cytoplasm of all body tissues with different concentrations. This enzyme facilitates the conversion of the propionic acid to lactic acid and vice versa through anaerobic glycolysis pathway [3].

Return to normal condition after exercise which is accompanied by lactic acid accumulation should be with the complete repulsion of this acid from both blood and muscle that were active during physical exercise. The incomplete relapse to normal conditions between physical sessions or match sessions ends with the decreased capability of body movements. This insufficient recovery tends to the fact that the athlete transfers his lethargy to the next session. Less lactic acid accumulation its fast repulsion from blood and muscles give this chance to the athlete to exercise more on the same day. If the exercise is more principled and better, the chance of getting a score will be increased as well. So, postpone the lethargy during exercise can end to increase the intensity of exercise [4,5].

### *The effect of antioxidants during physical exercise*

Free radicals are destructive material that is so active and can deteriorate cells and are a carcinogen. There is a balance between the immune system and free radicals in the body. When the body can not neutralize this material, In case of excessive increasing free radicals succumb to the immune system and oxidative stress happens. Antioxidants, material that averts oxidative stress through the neutralization of free radicals, can stop this process. The lack of oxygen, hypoxia, is

a prevalent reason for cell impairment and cell death and harms aerobic cell respiration. Loss of perfusion, ischemia, that happens by disturbance of artery blood, from arteriosclerosis or thrombosis, is the reason for hypoxia.

Oxidative stress originated from ischemia or inflammations, can cause serious tissue damages. Prolonged oxidative stress is a causative agent of prevalent impairments such as physical ones [6].

The evidence shows that lactate is produced in the absence of enough oxygen, but its production is also observed in the presence of enough oxygen [7].

Coaches and athletes use additives, drinks, and/or special physical training to increase the anaerobic threshold (AT), reduce the lactate accumulation, endure lethargy, and prevent oxidative stress. Some minerals like potassium and vitamins are important drink's additives. Group B vitamins can affect cell metabolism and vitamin C and vitamin E can have antioxidant activity.

Also, using alkaline drinks such as bicarbonates is prevalent in resistance athletes. The side effects of using such drinks are about 25 % and considerable. Hence, using alternative drinks with antioxidant effects and the alkaline trait is necessary [8].

***Hydrogen-rich water studies***

Hydrogen therapy theory was first introduced in 1975 in Science journal to eradicate cancer [9]. However, the most important studies have been conducted over the last two decades. In 2001, the study of Hanaoka *et. al,* showed that alkali water can reduce free radicals in cell culture. In this study, the antioxidant ability of alkali-water related to hydrogen production in water. Active hydrogen can attach donor hydrogen antioxidants, enzymatically or non-enzymatically, and increase the antioxidant capacity [10].

Ohsawa *et. al* showed in 2007 that hydrogen-rich water is an antioxidant naturally. It is effective in preventive and therapeutic programs. Hydrogen-rich water distributes through inside the cell due to its fast absorbance and neutralizes free radicals in cell culture and prevents oxidative stress. So, it can be used as an efficacious antioxidant treatment [11].

Also, Salemi *et al.* studied the effect of alkaline water on the lipid profile in Wistar rats. They confirmed that the "Alkaline stick" can have a positive effect on the oxidative stress-related disease [12]. In recent years, studies have been focused on human society. Nakao *et al.* in 2010 assessed the effect of magnesium stick by

metabolic syndrome patients. This study conducted for 8 weeks and on 30 metabolic syndrome patients. Using hydrogen-rich water for 8 weeks resulted in a 39 % increase in antioxidant enzymes' activity. They concluded that magnesium stick is an innate novel therapeutical and preventive strategy for metabolic syndrome. In this study, the magnesium stick proposed as a safe, easy, and efficacious way to produce hydrogen-rich water for daily use [13].

In the clinical study, 10 male athletes who were about 31 years old, were physically tested. Their blood was tested as well. Tests were conducted twice; first after drinking normal tap water and second after drinking hydrogen-rich water produced by magnesium stick. It was proved that drinking hydrogen-rich water before exercise, decreases the lactate level in blood and improves physically related recession and muscle efficiency. These preliminary results show that hydrogen-rich water can be suitable water for athletes [14].

LeBaron *et al.* in 2019 have shown that drinking HRD have therapeutic and ergogenic effects on submaximal aerobic exercise performance by lowering exercising heart rate. In this study, twenty healthy men and women between the ages of 18 and 45 years were selected to evaluate the acute effects of H2 tablets on exercise performance. HRW significantly reduced the mean respiratory rate and heart rate ($p<0.05$). These studies suggest that HRW can be a good option for athletes looking to improve aerobic training performance [15].

In the last studies, Nogueira *et al.* the effect of Molecular hydrogen inhalation on the decrease of hippocampal inflammation induced by severe acute exercise has studied. In addition, the oxidative status of the hippocampus has been evaluated. TNF-α, IL-6 and IL-10 increased immediately after exercise, while no change in IL-1β levels was observed. In contrast, exercise did not alter SOD, TBARS and NOx activity. These data are consistent with the notion that H2, as a potent anti-inflammatory agent, down-modulates anti-inflammatory cytokines (TNF-α and IL-6), as well as an increased up-regulation of anti-inflammatory cytokines (IL-10). These data suggest that H2 effectively reduces exercise-induced inflammation in the hippocampus [16].

The goal of the present study is to assess the effect of hydrogen-rich water, HRW, on indicator enzymes of the muscles in resistant athletes. In this study expected that hydrogen-rich water could reduce enzymes that are related to muscle impairment meaningfully and also increases the resistance vigor of athletes.

## MATERIALS AND METHODS

Regarding the mentioned introduction, this study was conducted to measure the effect of drinking hydrogen-rich water produced by Alkaline Stick on indicator parameters of cell impairment and lactate in athletes who are doing bodybuilding for years in a row. For this reason, 9 athletes with an average age of 25 years who were doing these sports continuously were chosen. The minimum exercise history was 4 years and the maximum was 10 years. Subjected athletes were chosen from the gym with 150 members and none of them used any sports nutrition supplement, energetic drinks, or drugs for at least 4 months before this study. Selected athletes did not use any motivating material such as smoking, narcotics, alcohol or any other material.

The athletes were informed about the object and plausible dangers before entering the test. Also, questionnaires about their testimony to participate in the study, physical activity and medical history were completed by them. The subjects did not have any cardiovascular or hormone or any other disease. They also were not subjected to any medical treatment which could affect cell impairment and lactate. The subjects exercised as a two-member group in two different sessions with tap water and hydrogen-rich water. The descriptive information is summarized (Table 1).

### *Preparation of hydrogen-rich water*

To prepare hydrogen-rich water, the portable alkaline filter produced by Diba Tejarat Khavarmyaneh company and presented by Biolife Production Europe Kft was used (Alkaline stick with health license: 22/1035-3) according to previous studies [12]. (Figure 1) Alkaline stick is a portable filter that when put in a half-litre of water, can donate the alkaline metals such as magnesium and calcium which ends to health effects [13]. Alkaline metals can balance the acid-alkaline in the body in one way and deionize water in the other way and produce active hydrogen that has an elevated level of antioxidant activity in the body [14].

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

Alkaline metals can be effective in lactate reduction but, recent studies have shown that the major health benefits of this product are water-soluble hydrogen production.

### *Practice design*

The study used exercises that included using a percentage of a maximum repetition for a one-time weight training. One-Repetition Maximum (1RM) means the maximum weight you can lift in just one repetition. In the designed practice for athletes, the ascending pyramid training was used and

machine leg extensions, parallel squat, lying leg press, machine hack, machine leg curl, and lift leg curl were considered (Table 2) [17].

In this study, 2 litres of water allocated to each person that half litres were given from 2 h before the exercise of 1.5 litres was given at the time of exercise. To produce every 2 litres of water, alkaline stick put in water for 2 h (pH 8.4, soluble hydrogen 0.55 mM and 0.65 mM). Sampling conducted in 4 sessions that in each session, 3 ml of blood samples from the right cubital vein were tested (Table 3). Pars Azmoon kit was used. The samples were transferred immediately and in a warm condition to Shahrood medical university laboratory and analyzed.

**Table 1.** Physical characteristics of athletes

| **Variables** | **Amounts** |
|---|---|
| Age | 27-23 years |
| Sporting experience | 4-10 years |
| Diet | Fixed and specific |
| Ingredients, supplements and drugs | no use |


**Figure 1.** Alkaline stick in box and water bottle.

**Table 2.** Exercise program

| **Practices** | **Percentage 1RM** | **The number of repetitions** |
|---|---|---|
| Machine leg extensions | 70-75-80-80 | 12-10-8-8 |
| Parallel squat | 70-75-80-80 | 12-10-8-8 |
| Lying leg press | 70-75-80-80 | 12-10-8-8 |
| Machine hack | 70-75-80-80 | 12-10-8-8 |
| Machine leg curl | 70-75-80-80 | 12-10-8-8 |
| Lift leg curl | 70-75-80-80 | 12-10-8-8 |

**Table 3.** Sampling stages

| Time | Sampling stages |
|---|---|
| 2 h before exercise | Stage 1 |
| Exactly after exercise | Stage 2 |
| 1 hafter exercise | Stage 3 |
| 24 h after exercise | Stage 4 |

## RESULTS

According to these indicators, mean, variance, the minimum and maximum were measured for each parameter in tap water and hydrogen-rich water. Then, by paired-sample- t-test, the significant level of the test on lactate dehydrogenase, LDH, creatine kinase, CPK, and lactic acid, LAC, was assessed and so the effect of using hydrogen-rich water compared to tap water was measured on them (Figures 2,3,4).

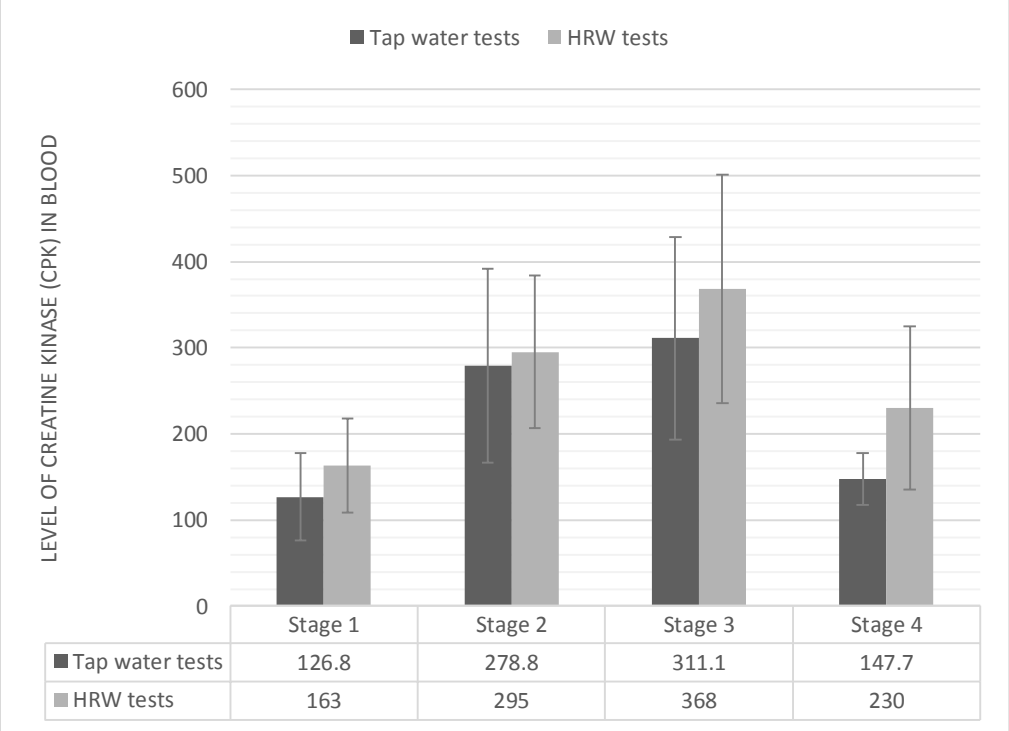


**Figure 2.** The column graph of creatine kinase (CPK) in the blood of tap water group and hydrogen-rich water group; light columns indicate the values in tap water and dark columns indicate the values in hydogen-rich water (IU/L).

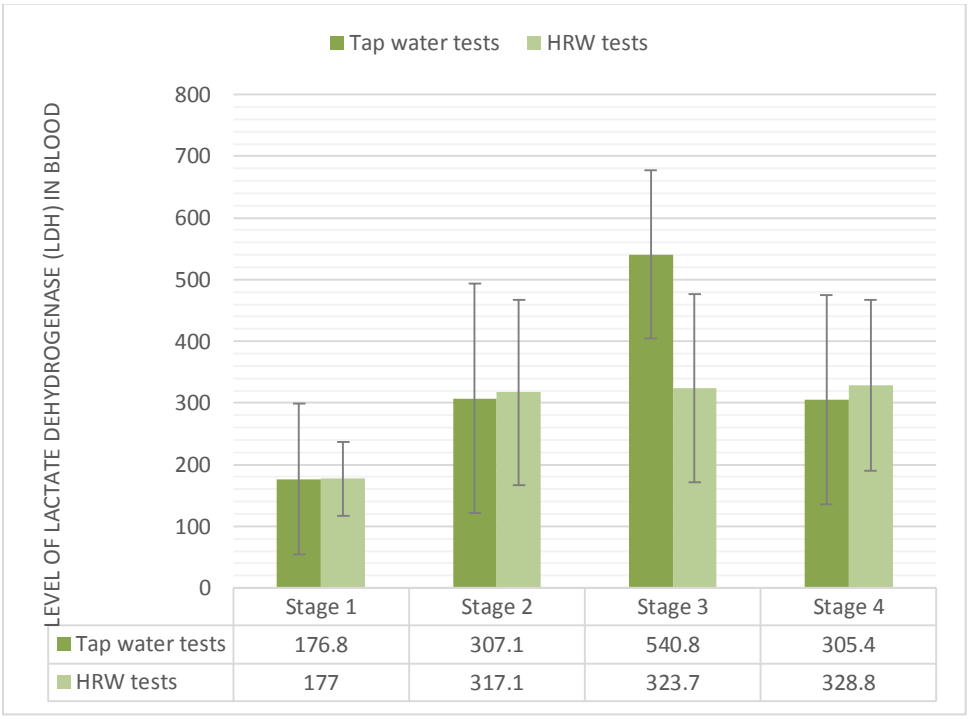


**Figure 3.** The column graph of lactate dehydrogenase (LDH) in the blood of tap water group and hydrogen-rich water group; the light columns indicate the values in tap water and dark columns indicate the values in hydrogen-rich water (IU/L).

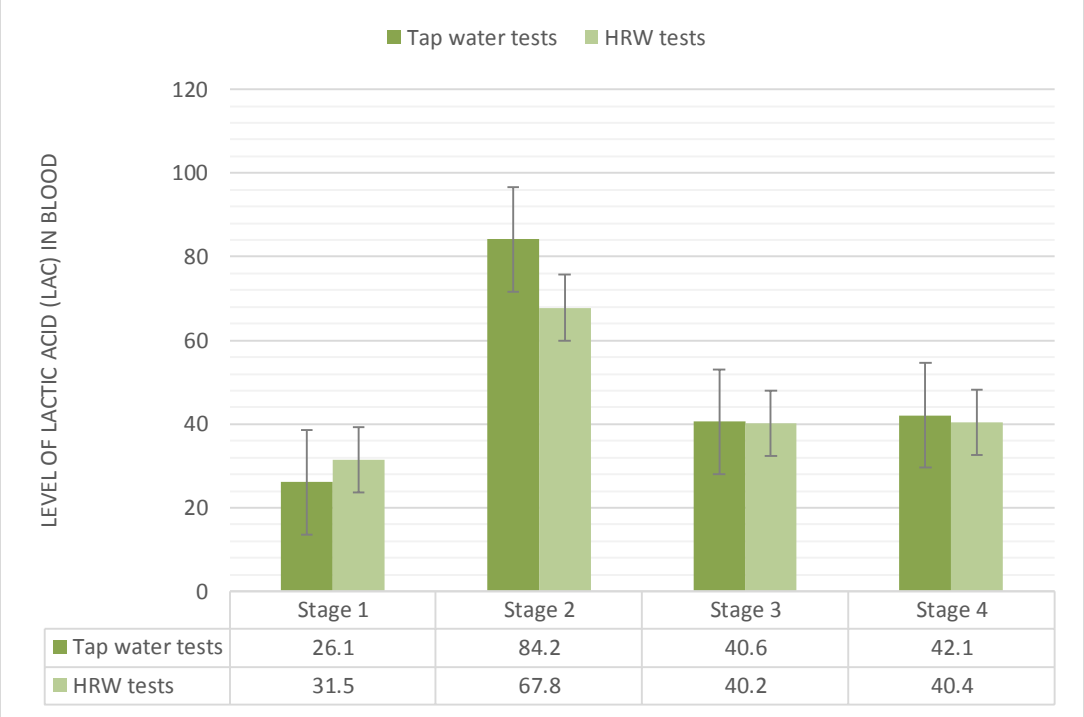


**Figure 4**. The column graph of lactic acid (LAC) in the blood of tap water group and hydrogen-rich water group; the light columns indicate the values in tap water and dark columns indicate the values in hydrogen-rich water (IU/L).

## DISCUSSION

Some recent studies have shown that molecular hydrogen affects cellular signal transfer and acts as an alkaline agent. These new mechanisms can have wide use in clinical medicine. Specifically, treatment with hydrogen can be a novel and efficacious therapy for oxidative stress resulted from exercise and physical impairment that makes the improvement of exercise possible. Ostojic assessed the effect of molecular hydrogen in a comprehensive study and considered three physiological roles for molecular hydrogen in the body.

When magnesium particles react with water, water-soluble hydrogen is produced (e.g. hydrogen-rich water) with high pH, low soluble oxygen, and high molecular hydrogen. Previous studies have investigated the effect of hydrogen-rich water on exercise, the main result of which is to regulate the acid-alkaline balance of blood while using H2. In some researches, the effect of hydrogen-rich water on the reduction of blood pH was assessed and so it was not needed to study this parameter in the present study again [19].

In the present study, creatine kinase (CPK) as a molecular signal, lactate dehydrogenase (LDH) and lactic acid (LAC) as alkaline agents were measured as well. The levels of creatine kinase during the experiment, from 24 h before exercise to one hour after exercise, increased and it decreased 24 h after exercise. Using hydrogen-rich water ended with the same results. In other words, using hydrogen-rich water did not have a positive effect on creatine kinase level compared to tap water which is by the last studies [14].

The recent studies affirmed the effect of hydrogen-rich water on lactic acid reduction. Ostojic *et al*. studied the improvement of the ability of male and female athletes through drinking drinks with the alkaline ability and negative oxidative-reductive potential (NORP). They showed that blood lactate was lower in the NORP group meaningfully ($p<0.05$). In this study, the health benefits attributed to hydrogen production in water [8].

Also, Drid *et al*. studied the effect of hydrogen-rich water in Judo exercises. Six individuals drank HRW. Also, 6 individuals took a placebo as a control group. Based on the results of this study, the lactate concentration increase in both groups was meaningful after exercise in comparison to the first measurement. Also, the lactate concentration was lower compared to the control group ($p< 0.05$) [20].

In the present study, the lactate level increased by 84.22 U/L from 24 h before exercise to right after the exercise and decreased 24 h after exercise. However, when hydrogen-rich water is used, the mean numbers indicate that the level reaches to 62.88 U/L right after exercise. In other words, hydrogen-rich water has a direct effect on lactic acid reduction at the peak of the exercise and the level of lactic acid decreased by 19.39 % compared to the control group ($p<0.05$).

The recent studies focused on the effect of hydrogen-rich water in more than one session. However, in the present study, it is shown that even drinking one session of hydrogen-rich water can reduce lactic acid.

In the study of Drid *et al*. the effect of molecular hydrogen on improvement after exercise in female athletes was assessed. In this study, 8 young Judo athletes, 21.2±2.2 years old, were chosen to consume hydrogen-rich water for 30 minutes before exercise randomly and assessed. Hydrogen-rich water decreased pH and lactate after exercise compared to the placebo group meaningfully ($p< 0.05$). No difference in heart pulse in placebo and test group was observed. There was no side effect in neither of the groups. The results of the present study showed that hydrogen-rich water can be a suitable and safe hydration strategy that even can help athletes in one session, which was like the mentioned study. Also, it helps that athletes suffer from physically related acidosis allergy to a lesser extent [21].

The effect of drinking hydrogen-rich water on lactate dehydrogenase was not assessed in previous studies. In the present study, lactate

dehydrogenase increased by 540.88 U/L, from 24 h before exercise to one h after exercise and decreased 24 h after exercise. Nevertheless, after using hydrogen-rich water, the mean values indicated that lactate dehydrogenase reaches 323.77 U/L right after exercise and lasts to one hour after exercise that has a 40.2 % reduction compared to the control group ($p< 0.05$).

These values indicate that drinking hydrogen-rich water has an obvious effect on the reduction of lactate dehydrogenase compared to the control group and lactate dehydrogenase can be a critical element in this field.

Using hydrogen-rich water even in the extensive muscle exercise can reduce more lactate dehydrogenase ad lactic acid and in the long-term can increase the individual resistance and decreased the muscle damage. Other studies have conducted in the field of the effect of hydrogen-rich water on the reduction or improvement of physical impairments that can highlight the importance of this material in athletes [18].

## CONCLUSION

In the present study, only once drinking hydrogen-rich water was assessed and presumably, the long-term using of the water type can bring more health benefits for athletes. Although the present study is assessed in a finite statistical community and with more comprehensive information, more complete and concise results can be obtained. Hydrogen-rich water that was produced by the alkaline stick portable filter, provides ideal water for athletes and its use is recommended to all people.

## REFERENCES

**[1].** Bickel CS, Slade J, Mahoney ED, Haddad F, Dudley GA, Adams GR. Time course of molecular responses of human skeletal muscle to acute bouts of resistance exercise. *J Appl Physiol*, 2005; 98(2): 482-88. doi:10.1152/japplphysiol.00895.2004.

**[2].** Nanang M, Fuad N, Didik R, Topo S, Panuwun J. Effect of alkaline fluids to blood pH and lactic acid changes on sub maximal physical exercise. *Earth Env Sci*, 2018; 197(1): 12049. doi:10.1088/1755-1315/197/1/012049.

**[3].** Namani F, Kashef M, Lari A. The effect of warm up on the relationship between CK and LDH in female athletes recovery. *Olympic*, 2004; 28: 97-107.

**[4].** Nieman DC, Henson DA, McAnulty SR, McAnulty L, Swick NS, Utter AC, Vinci DM, Opiela SJ, Morrow JD. Influence of vitamin C supplementation on oxidative and immune changes after an ultramarathon. *J Appl Physiol*, 2002; 92(5): 1970-77. doi:10.1152/japplphysiol.00961.2001.

**[5].** Robertson A, Watt JM, Galloway SD. Effects of leg massage on recovery from high intensity cycling exercise. *Br J Sports Med*, 2004; 38(2): 173-76. doi:10.1136/bjsm.2002.003186.

**[6].** Adams AK, Best TM. The role of antioxidants in exercise and disease prevention. *Phys Sportsmed*, 2002; 30(5): 37-44. doi:10.3810/psm.2002.05.281.

**[7].** Swank AM, Robertson RJ. Effect of induced alkalosis on perception of exertion during exercise recovery. *J Strength Condit Res*, 2002; 16(4): 491-99. doi:10.1152/jappl.1989.67.5.1862.

**[8].** Ostojić SM, Stojanović MD, Calleja-Gonzalez J, Obrenović MD, Veljović D, Medjedović B, Kanostrevac K, Stojanović M, Vukomanović B. Drinks with alkaline negative oxidative reduction potential improve exercise performance in physically active men and women: Double-blind, randomized, placebo-controlled, cross-over trial of efficacy and safety. *Serb J Sports Sci*, 2011; 5(3).

**[9].** Dole M, Wilson FR, Fife WP. Hyperbaric hydrogen therapy: a possible treatment for cancer. *Science*, 1975; 190(4210): 152-54. doi:10.1126/science.1166304.

**[10].** Hanaoka K. Antioxidant effects of reduced water produced by electrolysis of sodium chloride solutions. *J Appl Electrochem*, 2001; 31(12): 1307-13. doi:10.1023/A:1013825009701.

**[11].** Ohsawa I, Ishikawa M, Takahashi K, Watanabe M, Nishimaki K, Yamagata K, Katsura KI, Katayama Y, Asoh S, Ohta S. Hydrogen acts as a therapeutic antioxidant by selectively reducing cytotoxic oxygen radicals. *Nat Med*, 2007; 13(6): 688. doi:10.1038/nm1577.

**[12].** Salemi Z, Farahani H, Moradi B, SharifMoghadasi R. Effect of alkaline water on the lipid profile in wistar rats. *Alborz Uni Med J*, 2015; 4(3): 184-90. doi:10.18869/acadpub.aums.4.3.184.

**[13].** Nakao A, Toyoda Y, Sharma P, Evans M, Guthrie N. Effectiveness of hydrogen rich water on antioxidant status of subjects with potential metabolic syndrome an open label pilot study. *J Clin Biochem Nutr*. 2010;46(2):140-9. doi:10.3164/jcbn.09-100

**[14].** Aoki K, Nakao A, Adachi T, Matsui Y, Miyakawa S. Pilot study: Effects of drinking hydrogen-rich water on muscle fatigue caused by acute exercise in elite athletes. *Med Gas Res*. 2012; 2(1): 12. doi:10.1186/2045-9912-2-12.

**[15].** LeBaron TW, Larson AJ, Ohta S, Mikami T, Barlow J, Bulloch J, DeBeliso M. Acute supplementation with molecular hydrogen benefits submaximal exercise indices. Randomized, double-blinded, placebo-controlled crossover pilot study. *J Lifestyle Med*, 2019; 9(1): 36. doi:10.15280/jlm.2019.9.1.36.

**[16].** Nogueira JE, de Deus JL, Amorim MR, Batalhão ME, Leão RM, Carnio EC, Branco LG. Inhaled molecular hydrogen attenuates intense acute exercise-induced hippocampal inflammation in sedentary rats. *Neuroscience letters*, 2020; 715: 134577. doi:10.1016/j.neulet.2019.134577.

**[17].** Kraemer WJ, Fleck SJ. Optimizing strength training: designing nonlinear

periodization workouts. *Human Kinetics*; 2007.

**[18].** Ostojic SM. Molecular hydrogen in sports medicine: new therapeutic perspectives. *Int J Sports Med*, 2015; 36(04):273-79. doi:10.1055/s-0034-1395509.

**[19].** Ostojic SM. Serum alkalinization and hydrogen-rich water in healthy men. *Mayo Clin Proc*, 2012; 87(5): 501-502. Elsevier. doi:10.1016/j.mayocp.2012.02.008.

**[20].** Drid P, Ostojic SM, Stojanovic M, Trivic T. SECTION 4. Actual problems of training in combat sports (Psycho-physiological, spiritual and ethical aspects).



**[21].** Drid P, Trivic T, Casals C, Trivic S, Stojanovic M, Ostojic SM. Is molecular hydrogen beneficial to enhance post-exercise recovery in female athletes? *Sci Sports*, 2016; 31(4): 207-13. doi:10.1016/j.scispo.2016.04.010.