# THE EFFECT OF AN EXHAUSTIVE EXERCISE AND SODIUM BICARBONATE SUPPLEMENTATION ON LDH, CPK AND CPR INDEXES IN NON-ATHLETE WOMEN STUDENTS

**A. HABIBINEGHAD[1]**
**M. SAMAVATISHARIF**
**H. SEIAVOSHY**

## Abstract

*This research investigated the impact of an exhaustive exercise with short-term consumption of sodium bicarbonate supplement on LDH, CPK and CRP indexes in non-athlete student women. The participants of this study were 30 non-athlete women volunteers with the age average of 23±2.77 years, weight of 59.75±7.96 Kg, height of 160.63±4.89 Cm and BMI of 23.52±3.15 kg/m$^2$. Participants were randomly divided into two experimental and control groups and two-direction method was utilized to study them. Both groups participated in an exhaustive aerobic activity. One hour before the experiment, participants in experimental group consumed 0.065 g bicarbonate sodium for each one Kg of their weight and participants in control group had starch as placebo.*

*Blood samples were taken in pre-experimental level, two and 30 minutes after test to measure serum level of CPK, LDH and CPR and the obtained data was analyzed utilizing co-variance ( ANCOVA P<0.05.).*

*The result showed significant increase in CPK and LDH levels in control group but there was no significant change in CPK and LDH levels in experimental group (P<0.05), although, the level of CPR in both control and experimental groups has showed significant difference (P<0.005).*

*Findings show that the consumption of bicarbonate sodium may be effective in reducing CPK and LDH's levels after athletic activities.*

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**Keywords**: *Physical activity, Exhaustive exercise, Inflammation, Supplement*.

**JEL classification:**: *I23, O15, I29*

[1] A. HabibiNeghad, Master of Physical Education and Sports Science, Chamran University, Ahvaz, Iran, azarhabibi95@gmail.com
M. Samavatisharif, Department of Physiology of exercise, Bu-Ali Sina University, Hamadan, Iran
H. Seiavoshy, Department of Physiology of exercise, Sport Sciences Research Institute of Iran (SSRI), Tehran, Iran

## Introduction

Exhaustion reduces the athletic function and disrupts the activity (1). Studies have indicated that reasons for exhaustion to occur include; disruption in sources of energy machines (ATP-PC, glycolysis and aerobic oxidization), congestion of metabolism by-products, nervous system and disruption in contraction mechanism of muscular fabrics (2). Among the reasons for exhaustion is the increase in viscosity of hydrogen ion, which disrupts inductive connection stage through reduction of releasing of calcium ion from sarcoplasmic matrix of T conduits that defers muscle function (3). Since cell's metabolism is sensitive to and associated with the viscosity of hydrogen ion (pH), the degree of acidity-basic of body's liquid must be adjusted based on definite and accurate biochemistry boundaries (4). Sodium bicarbonate (NaHCO3) as a strong Lactic acid tampon in one of the supplements which are common among athletes to transfer and discharge of H in order to maintain muscular contraction and to defer exhaustion (5,6). Studies on sodium bicarbonate, titled (bicarbonate loading), has proved to be impressive in exhaustion deferral due to increase in physical performance (3). Investigations have indicated that in activities which last less than 30 seconds (7) and in power-oriented exercises (8) sodium bicarbonate has not been much effective but in longer-than-30 minutes exercises or in intermittent short exercises, the effectiveness has increased (9-12). What causes inner-cell pH reduction is the actions and reactions in glycolysis along with the increase in hydrogen ion, certain amount of lactate with hydrogen ion leaves the muscular cell that impacts the out-cell buffering capacity which moves certain amount of hydrogen ion, otherwise, it reduces inner-cell pH to some extent that causes disruption in cellular function (1). Certain research has been conducted to explore the effect of sodium bicarbonate consumption on fluctuations in blood's PH. Studies have indicated that after athletic activities and following the sodium bicarbonate supplement consumption, the blood's pH level increases (10, 12-15).

On the other hand, many researchers believe that inflammation process (even in systematic or general mode) is one of the main causes of atriovascular and cardiovascular diseases (16-18) therefore, since past decades researchers have paid attention to those inflammatory indexes that more accurately anticipate the possibility of cardiovascular diseases occurrence (19-21). In this regard, C-Reactive Protein (CRP) been indicated as the most sensitive and powerful independent factor in anticipation of cardiovascular diseases (22, 23). Meyer and colleagues (2001) commented that the amount of the CRP increases after short rigid exercises (24). In another research, it has been indicated that 24 hours after marathon, the amount of the CRP increases dramatically (25). Few studies have been conducted over the impact of sodium bicarbonate on the CRP. In a research, it was shown that the consumption of bicarbonate sodium in an acute or long mode did not have any effect on the CRP (26). Certain investigations show that

performing tough physical exercises damages cellular structure, particularly muscular receptions (27-29). There is a probability that free radicals with their specific features such as oxidative and through inactivating of enzymes and by damaging Nucleic acids, proteins and acid's membrane, have negative effects on cells and textures (30). Based on certain reports, rigorous and exhaustive exercise leads to the production of free radicals (31, 32). One of the methods to measure oxidative pressure that is fomented by cellular texture destruction is through assessing of anti-oxidative enzyme's secretion (33). Lactate dehydrogenase (LDH) and Creatine Phosphate Kinase (CPK) are enzymes, which show the amount of oxidative pressure (33, 34). During hard physical exercise, LDH and CPK enzymes increase and they reduce to the pre-physical exercise period during the recycling phase (35, 36). Another investigation showed that power-oriented exercises increase CPK and LDH plasma (40, 41). In addition, reports show that by 48 hours after stamina-oriented activities, CPK plasma levels increase (33). Clarkson and Thompson (2000) reported that regular exercise increases levels of anti-oxidative enzymes in muscles and decreases other oxidative pressure indexes (42) of course by increase in exercise rigidity and transformation of activity from aerobic into non-aerobic, the amount of Lactate increases and following that the amount of LDH too (34). Regarding the impact of sodium bicarbonate consumption on blood Lactate's response, research has shown that after consumption of this supplement and alongside with the improvement in performance, the amount of congestion of blood's Lactate has significantly increased after an intermittent hard activity (4,11,13,14). Since there is an agreement that consumption of sodium bicarbonate increases the viscosity of bicarbonate plasma, buffering extra hydrogen ion and also by increasing blood's pH reduces the clinical symptoms of acidosis, furthermore its consumption in little doses is safe (3), and regarding the contrasting nature of other investigations' findings (43, 44) and with respect to this fact that research on short time consumption of sodium bicarbonate on women is rare and paying attention to this reality that occasionally physical education students have to participate in practical classes twice or trice in a day without taking sufficient rest, researcher of this project decided to examine the effect of short period sodium bicarbonate consumption on certain oxidative pressure indexes such as LDH, CPK and also on CRP.

## Methods

The present research is semi-experimental and included 30 student women (23±3.76 Years, 59.75±7.96 kg, 160.63±4.89cm, 23.12±2.51 kg/m$^2$). All participants presented a normal health level with no chronic disorders or other respiratory by a physician. All participants granted written permission and the experiment was approved by Ethics Committee of the Hamadan University of Medical Science in Iran. Participants were excluded if they had participated in a

heavy physical activity program or had eaten each drug or supplements in the 48-h prior to the trial. The subjects were divided into two groups: Experimental group (Exp, N=15); and Control group (Con, N=15). Height was measured using a stadiometer (with accuracy of 0.1cm) with the participants barefoot and standing upright. Body weight was assessed by digital scale (with accuracy of 0.1 kg; Model: 7071314004; Made in Germany). Body mass index (BMI) was calculated by dividing body weight measured in kilograms by height in square meters (kg/m2). Other anthropometric values of subjects are presented in Table 1.

**Table 1**. Descriptive characteristics of participants (Mean ± SD)

| **Group** | **Exp (N=15)** | **Con (N=15)** |
|---|---|---|
| Age (year) | 23 ± 2.77 | 23 ± 4.75 |
| Weight (kg) | 62.07 ± 8.38 | 57.42 ± 7.53 |
| Height (cm) | 162.5 ± 3.21 | 158.75 ± 6.56 |
| BMI (kg/m2) | 23.52 ± 3.15 | 22.71 ± 1.87 |

*Abbreviations:* Exp=Experimental Group, Con=Control Group, BMI=Body mass index

The last inclusion criterion was ascertained by asking subjects to complete the Physical Activity Readiness Questionnaire (PAR-Q).

One hour before the beginning of exhaustion tests, the experimental group was taken 0.065 (g/kg) of sodium bicarbonate, and The control group consumed only placebo (Starch).

The exercise intervention was performed on a treadmill according to the Bruce Protocol, and required the subject to run for as long as possible on a treadmill whose speed and slope incremented at timed intervals. The treadmill was started at 2.74 km/h (1.7 mph) and at a gradient (or incline) of 10%. The speed and incline of the treadmill was increased every three minutes. The test was stopped when the subject was unable to continue (45).

Before the intervention and after 2 and 30 minute the trial was completed and following a 12-h overnight fast, blood samples (10 ml) were drawn from the antecubital vein for analysis of Creatine Phosphate Kinase (CPK), Lactate dehydrogenase (HDL) and C-Reactive Protein (CRP). All blood samples were measured using the Auto Analyzer, Bio Tecnicon BT3000 and Immunoturbidometry's method, according to the manufacturer's instructions (Manufactured by: Beckman Coulter, Inc., 250 S. Kraemer Blvd. Brea, CA 92821, USA).

## Data analysis

The data were initially treated by means of descriptive statistics, with mean values and variability. Data were analyzed with one-way ANOVA for repeated measures (46). When significant differences were revealed, the LSD post hoc test

was applied (47, 48). Statistical significance was assumed for P-values ≤0.05. The data were treated in the Statistical Package for the Social Sciences (SPSS), version 18.

## Result

The 30 participants were divided into two groups: 15 in the experimental group, and 15 in the control group. The experimental and control groups were homogeneous regarding BMI (Table 1).

Table 2 displays the mean ± SD for physiological measures for all groups at pre and post-intervention as well as the differences between, and within, the groups post-intervention. The control group experienced a significant increase in CPK, HDL and CRP whilst experimental group does not displayed significant changes in this value (Table 2).

**Table 2.** Characteristics of physiological variables: all groups at pre-test and 2 and 30 min after intervention.

| Value | Group | Time | Means ± SD | P-value † | | |
|---|---|---|---|---|---|---|
| | | | | Pre-Test | 2 min | 30 min |
| CPK (U/L) | Con | Pre-Test | 92.20±29.09 | - | 0.006** | 0.008** |
| | | 2 min | 116.47±30.62 | 0.006** | - | 0.005** |
| | | 30 min | 103.87±26.37 | 0.008** | 0.005** | - |
| | Exp | Pre-Test | 124.53±98.18 | - | 0.652 | 0.002*** |
| | | 2 min | 125.80±97.22 | 0.652 | - | 0.006** |
| | | 30 min | 135.40±101.06 | 0.002*** | 0.006** | - |
| HDL (U/L) | Con | Pre-Test | 304.07±83.06 | - | 0.050* | 0.058 |
| | | 2 min | 347.33±48.14 | 0.050* | - | 0.047* |
| | | 30 min | 324.57±56.86 | 0.058 | 0.047* | - |
| | Exp | Pre-Test | 296.87±57.85 | - | 0.931 | 0.009** |
| | | 2 min | 298.40±46.93 | 0.931 | - | 0.056 |
| | | 30 min | 334.53±50.10 | 0.009** | 0.056 | - |
| CRP (mg/L) | Con | Pre-Test | 4.30±1.42 | - | <0.001**** | 0.416 |
| | | 2 min | 5.63±1.27 | <0.001**** | - | 0.123 |
| | | 30 min | 4.78±1.57 | 0.416 | 0.123 | - |
| | Exp | Pre-Test | 3.06±1.46 | - | 0.001**** | 0.002*** |
| | | 2 min | 4.03±1.55 | 0.001**** | - | 0.002*** |
| | | 30 min | 3.55±1.43 | 0.002*** | 0.002*** | - |

*Abbreviations:* Exp=Experimental Group, Con=Control Group.

† one-way ANOVA for repeated measures was used to establish differences between pretest and 2 and 30 min after intervention measures for each group (LSD post hoc test). * Significant difference between the values obtained (P ≤ 0.05). ** Significant difference between the values obtained (P ≤ 0.01). *** Significant difference between the values obtained (P ≤ 0.005). ****Significant difference between the values obtained (P ≤ 0.001).

## Discussion

In this study, it has been tried to investigate the effect of sodium bicarbonate supplement consumption on LDH, CPK enzymes and the CRP in an exhaustive activity. While conducting hard, short period athletic activities due to the production of lactic acid, certain changes occur in acid-base balance. How much lactic acid is produced depends on the intensity and duration of athletic performance and the numbers of engaged moving units. In time of blood's acidose and alcalose, sodium bicarbonate works as a tampon and by consuming sodium bicarbonate supplement, environment returns to normal (44). Studies indicate that mechanism of ergogenic Buffers as a strong acid lactic tampon and hydrogen ion, helps return pH environment to natural state and consequently leads to function improvement and deferring of exhaustion (49). In literature of studies, there is no direct information regarding the effect of bicarbonate supplement on LDH and CPK's vicissitudes but in many other similar studies, the effect of this supplement on blood's lactate has been discussed. Results of this study showed that the consumption of sodium bicarbonate did not foment any significant changes in LDH and CPK's levels following a phase of exhaustive exercise. This result is in line with findings of McNaughton LR & Thompson D (2001) (50), Zajac (2009) (10) and Tofighi (2013) (26). In the most recent research, Tofighi investigated the impact of bicarbonate sodium supplement on blood's lactate following an exhaustive activity in young men. The findings of this result showed that the long consumption of sodium bicarbonate blocks blood's lactate consumption (26). While investigating the response of lactate and levels of blood LDH after consuming sodium bicarbonate, some researchers found that consumption of sodium bicarbonate causes increase in blood's lactate level (4, 11, 13, 14) which is in contrast with results of present research. It may be commented that the possible difference between findings is due to the difference in subjects of two experiments; in presents study the subjects were non-athlete female whereas in other research the experiment was conducted on race horses (14). Other causes for this difference may lie in differences in the amount of supplement consumption, type of experiment, numbers of conducting the research, duration of experiment and other possible reasons.

Regarding the CRP, results of this study show that exhaustive exercise Bruce test causes significant increase of the CRP in serum. In line with what above-mentioned results, Feng and colleagues (2000), Meyer and colleagues (2001), Church and colleagues (2002) and, Stauffer and colleagues (2004) reported increase in the CRP levels following exhaustive exercise. Concerned with same topic, Scharhag and colleagues (2004) in a research on various groups of athletes conclude that exhaustive exercise regardless of its type - could increase levels of the CRP in both athletes and non-athletes which may prepare the ground for atherosclerosis and cardiovascular diseases to develop in those who are

susceptible (51,24,52,53,54). Collins and colleagues (2006), Tofighi (2013) stated exhaustive exercise in healthy people does not increase the CRP. One of the probable reasons for this result may lie in type and numbers of subjects and intensity and type of exhaustive exercise. About the intensity of exercise in Collins research, intensity exhaustive exercise was measured by counting the average of covered distance on running track with 5 degree steep by ill people, which caused healthy people not to become exhausted. It must be stated that the type of activity has the most significant since the intensity and duration of exercise must reach such a level that causes acute phasic response.

## Conclusions

Generally based on this presented research obtained results, it may be stated that receiving sodium bicarbonate supplement probably could be effective in preventing and balancing the inflammatory condition and reducing the CPR in non-athlete women students but the ultimate conclusion cannot be reached without conducting more research.

## REFERENCES

1. Ron Maughan, Michael Gleeson, and Paul L. Greenhaff. *Biochemistry of Exercise and Training*. New York: Oxford university press 1997.
2. Wilmore, J.H. David L. Costill and Jack H. *Physiology of Sport and Exercise*. Champaign IL: Human Kinetic publications, 1994.
3. Scott K. Powers, Edward T. Howley. *Exercise Physiology: Theory and Application to Fitness and Performance Paperback* – International Edition, 2011.
4. Hirakoba K, Maruyama A, Misaka K. "Effect of acute sodium bicarbonate ingestion on excess CO2 output during incremental exercise". *Eur J Appl Physiol Occup Physiol* 1993; 66(6): 536-41
5. Kayser B, Ferretti G, Grassi B, Binzoni T, Cerretelli P. "Maximal lactic capacity at altitude: effect of bicarbonate loading". *J Appl Physiol* 1993; 75(3): 1070-4
6. Douroudos II, Fatouros IG, Gourgoulis V, Jamurtas AZ, Tsitsios T, Hatzinikolaou A, Margonis K, Mavromatidis K, Taxildaris K. "Dose-related effects of prolonged NaHCO3 ingestion during high-intensity exercise". *Med Sci Sports Exerc* 2006; 38(10): 1746-53
7. McNaughton L. "Sodium bicarbonate ingestion and its effects on anaerobic exercise of various durations". *Journal of Sports Sciences* 1992; 10(5): 425-35
8. Webster MJ, Webster MN, Crawford RE, Gladden LB. "Effect of sodium bicarbonate ingestion on exhaustive resistance exercise performance". *Med Sci Sports Exerc* 1993; 25(8): 960-5

9. Laura E. Kahle, Patrick V. Kelly, Kathrin A. Eliot, Edward P. Weiss. "Acute sodium bicarbonate loading has negligible effects on resting and exercise blood pressure but causes gastrointestinal distress". *Nutr Res* 2013; 33(6): 479–86
10. Zajac A, Cholewa J, Poprzecki S, Waskiewicz Z, Langfort J. "Effects of sodium bicarbonate ingestion on swim performance in youth athletes". *J Sports Sci Med* 2009; 8(1): 45–50
11. JadidiPouzash R, Azarbayjani M, JadidiPouzesh J, AlamdariAzali K. Fatolahi H. "The Effect of Sodium Bicarbonate Supplement on Lactic Acid, Ammonia and the Performance of 400 Meters Male Runners". *Gdansk University of Physical Education and Sport in Gdansk* 2012; 4(2): 84-90
12. Costill DL, Verstappen F, Kuipers H, Janssen E, Fink W. "Influence of HCO3 Acid-base balance during repeated bouts of exercise". *Int J Sports Med* 1984; 5(5): 228-31
13. Price MJ, Simons C. "The effect of sodium bicarbonate ingestion on high-intensity intermittent running and subsequent performance". *J Strength Cond Res* 2010; 24(7): 1834-42
14. Harkins JD, Kamerling SG. "Effects of induced alkalosis on performance in thoroughbreds during a 1,600-m race". *Equine Vet J* 1992; 24(2): 94-8
15. Price MJ, Singh M. "Time course of blood bicarbonate and pH three hours after sodium bicarbonate ingestion". Int *J Sports Physiol Perform* 2008; 3(2): 240-2
16. Sullivan GW, Sarembock IJ, Linden J. "The role of inflammation in vascular diseases". *J Leukoc Biol* 2000; 67(5): 591-602
17. Langheinrich AC, Bohle RM. Atherosclerosis: humoral and cellular factors of inflammation". *Virchows Arch* 2005; 446(2): 101-11
18. van Leuven SI, Franssen R, Kastelein JJ, Levi M, Stroes ES, Tak PP. "Systemic inflammation as a risk factor for atherothrombosis". *Rheumatology* (Oxford) 2008; 47(1): 3-7
19. DabidiRoshan VA ,Gaeni AA, Ravasi AA, Javadi E. "The effect of the continuous training on CRP of strain wistar 14848 rats". *Journal Olympic* 2005; 13(2): 7-22
20. Ridker PM, Rifai N, Rose L, Buring JE, Cook NR. "Comparison of C-reactive protein and low-density lipoprotein cholesterol levels in the prediction of first cardiovascular events". *N Engl J Med* 2002; 347(20): 1557-65
21. Robert O. Bonow, Douglas L. Mann MD, Douglas P. Zipes MD. 9th ed. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine*. 2011
22. Turk, JR, Carroll JA, Laughlin H, Thomas TR, Casati J, Bowles DK, Sturek ML. "C-reactive protein correlates with macrophage accumulation in coronary arteries of hypercholesterolemic pigs". *J Appl Physiol* 2003; 95(3): 1301-4

23. Ridker B. (2001). "Novel clinical markers of vascular wall inflammation". *Circ Res*. 89(9):763-771.
24. Meyer T, Holger HWG, Ratz M, Mullr HJ, Kindermann W. "Anaerobic exercise induces moderate acute phase response". *Med Sci Sports Exerc* 2001; 33(4): 549-54
25. Kasapis CH, Thompson PD. "The Effects of Physical Activity on Serum C-Reactive Protein and Inflammatory Markers". *A Systematic Review. J. Am. Coll. Cardio* 2005; 45(10): 1563-9
26. Tofighi A, Saedmocheshi S. "C-reactive protein and lactate response to consumption of sodium bicarbonate supplementation and exhaustive in young active men". *Journal of Kermanshah University of Medical Sciences* 2013; 17(2): 97-102
27. Banerjee, A.K.,Mandal A, Chanda D, Chakraborti S. "Oxidant, antioxidant and physical exercise". *Mol Cell Biochem* 2003; 253(1-2): 307-12
28. Ji L, Leeuwenburgh C, Leichtweis S, Gore M, Fiebig R, Hollamder J, Eejma J. Oxidative Stress and Aging: "Role of Exercise and Its Influences on Antioxidant Systems". *Annals of the New York Academy of Sciences* 1998; 20: 102-17
29. Schröder H, Navarro E, Tramullas A, Mora J, Galiano D. "Nutrition antioxidant status and oxidative stress in professional basketball players: effects of a three compound antioxidative supplement". *Int J Sports Med* 2000; 21(2): 146-50
30. Kostka T, Drai J, Berthouze SE, Lacour JR, Bonnefoy M. "Physical activity, aerobic capacity and selected markers of oxidative stress and the anti-oxidant defence system in healthy active elderly men". *Clin Physiol* 2000; 20(3): 185-90
31. Inayama T, Kumagai Y, Sakane M, Saito M, Matsuda M. "Plasma protein-bound sulfhydryl group oxidation in humans following a full marathon race". *Life Sci* 1996; 59(7): 573-8
32. Meydani M, Evans WJ, Handelman G, Biddle L, Fielding RA, Meydani SN, Burrill J, Fiatarone MA, Blumberg JB, Cannon JG. "Protective Effect of Vitamin E on Exercise-induced Oxidative Damage in Young and Older Adults". *American Journal of Physiology* 1993; 264(5 Pt 2): 992-8
33. Sacheck JM, Blumberg JB. "Role of vitamin E and oxidative stress in exercise". *Nutrition* 2001 17(10):809-14
34. Spriet LL, Howlett RA, Heigenhauser GJ. "An enzymatic approach to lactate production in human skeletal muscle during exercise". *Medicine and Science in Sports and Exercise* 2000; 32(4): 756-63
35. Kashef M. "The effect of two kinds of active and inactive recovery on blood enzymes and gases on the young athletes". *Olympic* 2001; 19: 29-38

36. Kobayashi Y, Takeuchi T, Hosoi T, Yoshizaki H, Loeppky JA. “Effect of a marathon run on serum lipoproteins, creatine kinase, and lactate dehydrogenase in recreational runners”. *Res Q Exerc Sport* 2005; 76(4): 450-5
37. Machado M, Koch AJ, Willardson JM, Pereira LS, Cardoso MI, Motta MK, Pereira R, Monteiro AN. “Effect of varying rest intervals between sets of assistance exercises on creatine kinase and lactate dehydrogenase responses”. *J Strength Cond Res* 2011; 25(5): 1339-45
38. Kafkas ME. “The effect of strength exercises at different angular velocities on muscular LDH and CK.” *Isokinetics and Exercise Science* 2014; 22(1): 63-8
39. Rodrigues BM, Dantas E, de Salles BF, Miranda H, Koch AJ, Willardson JM, Simão R. “Creatine Kinase and Lactate Dehydrogenase Responses After Upper-Body Resistance Exercise With Different Rest Intervals”. *Journal of Strength & Conditioning Research* 2010; 24 (6): 1657-62
40. Horita T, Komi PV, Nicol C, Kyröläinen H. “Effect of exhausting stretch-shortening cycle exercise on the time course of mechanical behaviour in the drop jump: possible role of muscle damage”. *European Journal of Applied Physiology and Occupation Physiology* 1999; 79: 160-7
41. Schantz PG. “Plasticity of Human Skeletal Muscle with Special Reference to Effects of Physical Training on Enzyme Levels”. *Acta Physiol Scand Suppl* 1986; 558:1-62
42. Clarkson PM, Thompson HS. “Antioxidants: What Role Do They Play in Physical Activity and Health?”. *American Journal of Clinical Nutrition* 2000;72: 637-46
43. Schott HC, Hinchcliff KW. “Fluids, electrolytes, and bicarbonate”. *Vet Clin North Am Equine Pract* 1993; 9(3):577-604
44. Artioli GG, Gualano B, Coelho DF, Benatti FB, Gailey AW, Lancha AH Jr. “Does sodium-bicarbonate ingestion improve simulated judo performance?”. Int *J Sport Nutr Exerc Metab* 2007; 17(2): 206-17
45. Bruce, R.A. (1972) *Multi-stage treadmill test of maximal and sub maximal exercise. Exercise Testing and Training of apparently Health Individuals: A handbook for physicians*.
46. Cohen J, “Statistical Power Analysis for Behavioral Sciences”. 2thed. New York, *Academic Press*; 1977. P. 19-20.
47. Park I, Schutz RW: “An introduction to latent growth models: analysis of repeated measures physical performance data”. *Res Q Exerc Sport* 2005; 76(2):176–192.
48. Cohen J: “A power primer”. *Psychol Bull* 1992; 112(1):155–159.
49. Minasian V, Eslami M, SabaghLangrodi M. “The effect of the bicarbonate supplement on anaerobic power on the football player.” *Sport Biosciences Journal* 2012; 16: 5-19

50. Mc Naughton LR & Thompson D. "Acute versus chronic sodium bicarbonate ingestion and anaerobic work and power output". *J Spots Med Phy Fithess* 2001; 41(4): 436-62
51. Feng D, Rusell PT, et al. "Effect of shortterm aspirin use on C - reactive protein". *Journal of Thrombosis and Thrombolysis* 2000; 9: 37-41
52. Church TS, Barlow CE, Earnest CP, Kampert EL, Priest SN. "Association between cardiorespiratory fitness and C-reactive protein in men". *Arterioscler. Thromb. Vasc. Biology* 2000; 22: 869-76
53. Stauffer BL, Hoetzer GL, Smith DT, DeSouza CA. "Plasma C-reactive protein is not elevated in physically active postmenopausal women taking hormone replacement therapy". *Apple Physiology* 2004; 96: 143-8
54. Scharhag J, Meyer T, Gabriel HW, Schlick B, Faude O, Kindermann W. "Does prolonged cycling of moderate intensity affect immune cell function?" *Br J Sports Med* 2005; 39: 171-7
55. Collins P, Ford I, Croal B, Ball D, et al. "Homeostasis, inflammation and renal function following exercise in patients with intermittent claudication on statin and aspirin therapy". *Thrombosis Journal* 2006; 4: 1-8