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Effect of Sodium Bicarbonate on the Sportive Performance

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ABSTRACT

Background: Does the use of Sodium Bicarbonate have any effects on the performance improvement? If any, how much does it have? The fact that athletes can maintain their performance depends on the changes of blood's acid-base balance. In sportive achievements, seconds, even split seconds have great importance for the records to be broken. **Objectives:** Therefore, the use of ergogenic substances has always been a center of interest for athletes, trainers and sport scientists. We can come across studies in which the subjects were orally given salts which provided alkalosis years ago. In 1926, the first reported researches were the controlled laboratory studies of Rozani, Dening *et al*. (1931, 1937) which are called "Denning Mixture" today. Researches increased in 1980's, like Sutton (1981), Wilkes (1983), Costil (1984), McKenzie (1986), Bovissou (1988). **Results**: However these studies were carried out on sedanteries and with a limited number of subjects, and were criticised hereby. **Conclusion**: In this study, published articles were examined. As the result of the examination, it is the common view of the researchers that the use of sodium bicarbonate affects anaerobic performance positively.

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INTRODUCTION

As sportive achievements are the center of interest not only for athletes but also for states, politicians, companies and interest groups, we cannot see them only as part of sports. Thus, it is the reality accepted by the experts that the use of legal or illegal ergogenic substances in sports is unpreventable. Since athletes' health is ignored and only the success is put ahead, these substances are used. Performance improvement depends on factors such as genetic structure, training programs, nutrition, conscious and life style. However it is true that ergogenic substance use has also positive effects. The ergogenic substances used should not have any negative effects on the organism. In this respect, within the lights of analysed articles, such questions as whether the use of sodium bicarbonate has any effects on performance, if any, how much it affects and whether it causes any damage to the organism were tried to be examined.

Before starting to examine the articles, let's introduce with these chemicals that are used: Sodium (Na), Bicarbonate (HCO3) and Sodium Bicarbonate (NaHCO3).

Sodium (Na):

Sodium (Na) is an alkali ion which has functions such as liquid exchange in many parts of body, exchange of nutrient and waste in and outside of cells, and regulation of electrical difference in and outside of cells. The duty of sodium in the body is the regulation of liquid in and outside of all body cells, hearth rhythm, transmission of nerve stimulation and muscle contraction, balance of circulatory system, activation of enzymes. Symptoms of lack of sodium are weakness, neurosis, indifference, low intention and muscle cramps. Among these duties, its functions on body's acid base balance play an important role [58]. There are 1300-1500 grams of sodium in an adult body. 40% of it is in the bones, %50 of it is in extracellular liquids and %10 of it is inside cells. Kidneys are the mechanisms which have the upmost control over sodium [17,18,64].

Bicarbonate (HCO3):

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Bicarbonate is an organic compound. It is produced in blood cells and pancreas in the body. It is released depending on the body's need. Its major duty is to stabilize the body's acid base balance. Therefore, bicarbonate is an alkali ion. It forms carbonic acid (H_2CO_3) by associating with hydrogen ions which cause body to move to acidic media and the effect of sodium tries to take away this acidity [51].

Compound of Sodium Bicarbonate:

Sodium acts as a transporter. Bicarbonate ions forms carbonic acid by associating with extra hydrogen ions which cause acidosis in the body. Then, it dissociates from hydrogen ion by being transported to the kidneys with the help of sodium [24]. Beside its combining and transporting features, sodium's function here is to get mostly absorbed by kidneys and sent back for circulation. Along with sodium, bicarbonate is also absorbed here. In this formation, sodium prevents wasting of bicarbonate ions in a sense and therefore, it is used for preventing lactic acid accumulation in blood cells which causes feeling of tiredness. In this context, sodium bicarbonate ($NaHCO_3$) is accepted as one of the ergogens which are free to use [15,36,43,58].

Use of Sodium Bicarbonate:

Sodium bicarbonate is accepted as a medicine and it has two means of use. It is used both by injection or orally. This kind of use may cause gastrointestinal complaints like vomiting, diarrhea, dyspepsia and besides, inappetence, headache and myalgia. It is recommended to be taken with plenty of liquid or fruit juice. The followings should be taken into consideration while using sodium bicarbonate:

- It should not be used with milk and dairy products
- It should be taken at least 1-2 hours after taking another medicine
- Those who are suspected to have appendicitis should not use it
- It should not be used for a long term
- It should be used for 2 weeks at most [41].

It was found out that taking 300 mg/kg body mass bicarbonate daily delayed fatigue and improved the performance in the maximal exercises lastin 1-7 minutes (Guyton, 1986, Alpay, 2014, Williams, 1995).

Denning *et al*. [17,18] examined its effects on the performance on the high speed treadmill (58 mile/hour): The $NaHCO_3$ group were given a dosage of 10 g for 2 days. they did not give any substance to the control group. They did not use placebo group. They examined the acid base balance by taking samples after exercise and maximal exercise. They observed 15-20 minutes extension in the experimental group. In their second study they examined the effects of pre-exercise metabolic alkalosis on the length of exercise. They used 2 subjects. They used 2 subjects. The first subject exercised on treadmill 14 times within 6 weeks and the second subject exercised on cycle ergometer. They did not use the control group in both subjects during the exercise. 1. subject was orally given 20gr. $NaHCO_3$ and Na citrate for 3 days before the exercise. This mixture was given to the subjects in 3 portions after having a meal. The subjects did 8 control and 4 experimental exercises. The researchers found out an approximately 100% increase **1** in the pre-exercise metabolic alkalosis compared to the control group. While the average race duration was 16.1, the race duration of the subject given alkali substance was recorded as 21 minutes for 3 days. A 4.9-minute increase or 30% increase was recorded.

In their research Johnson and Black, Atterbom and Margaria investigated the effects of glucose and some blood alkalizers given to harriers in the competition period, the effects of pre-exercise metabolic alkalosis on the anaerobic performance and the effects of alkalosis on the performance and the Hla production in intense exercises. 17 high school students at the ages 16-19 participated in the experiment. During the season, athletes ran a distance of 1.5 miles. Weather conditions were variable in each run. The subjects were allocated to 4 groups. They were not informed about the aim of the study and what substance they were given before the race. The subject group were given “Denning Mixture” and the placebo group were orally given 10 gr lactose capsules. At the end of the study, no significant difference were observed in the performances of both the groups that took ergogenic aid and the placebo group.

The study of Atterbom was comprised of 7 subjects at the ages 20-25 who are students in the department of physical education and sports. Bicycle ergometer test was used at 5000-feet (1524m) elevation. Average exercise load was 1800 kgm/min. The test was repeated two times for each subject. In the first one, subjects were given $NaHCO_3$ and in the second one they were given placebo. Exercise duration were approximately 2.5-3 minutes. The dosage of $NaHCO_3$ was 0.18 gr/kg body mass. The absorption time of $NaHCO_3$ was arranged accordingly to the maximum resting base levels of the subjects. It is stated that oral ingestion of $NaHCO_3$ did not have any significant effect on performance.

In his study, Margaria investigated the effect of alkalosis to the performance in intensive exercises. 12 male subjects at the ages 21-33 participated in the study. 4 of them were elites, 4 of them were normal and 4 of them had no sports experience. They exercised in treadmill at a speed of 16km/hour at 10% incline. The placebo group and the alkalosis group were given 3.24 g of substance three times before the test. The alkali mixture given was composed of 0.81 g HCO_3, 2.43 g Na citrate ve K citrate. At the end of maximal exercise no significant change was observed in the performances and Hla production of alkalosis group [9,28,19].

Webster *et al* [56] examined the effects of bicarbonate use on fatigue in the resistance aerobic exercises performed until getting fatigue. They found out that NaHCO3 had no effect in such exercises. Heck *et al*. [31] detected that while sodium bicarbonate use affects the low-volume performances in exercises with stable intensity, it does not have a positive effect on the performances in long-time aerobic exercises [38,63].

In his study on 8 trained swimmers (5 sprinters, 3 long distance swimmers) Simmons researched the effects of alkali substance use in the exercise on the performance and in his study on 8 trained long distance swimmers, Wilkes examined the effects of pre-exercise metabolic alkalosis on the race duration in 800 meters. The swimming durations of the subjects were recorded for 5 weeks. 3 of the sprinters were the experimental group and 2 of them were the control group. 2 of the long distance swimmers were the experimental group and 1 of them were control group. All swimming tests started with warming up 200 yards. The sprinter subjects swam 100 yards and long distance swimmers swam 400 yards for 5 times, the first one of which was preliminary test and four times were as final tests. The experimental group were given alkali substance and the control group were given placebo two days before the test swimming. Alkali compound included 0.715g Na citrate, 0.50 g NaHCO3 and 0.215 g K citrate, and 1.43 g saccharose was given as placebo.

The study of Wilkes was comprised of control groups who took alkali substance (NaHCO3), who took placebo (CaCO3) and who did not take any substance. In the experiment and placebo trials, subjects were given 300 mg/kg two hours before the test. As the result of research, running duration of alkalosis group subjects was 2.9 min. shorter and correspondingly, the lactic acid and H+ concentration were higher than control placebo group. He states its reason as the increase of anaerobic energy use. It can be said that NaHCO3 ingestion provides ergogenic contribution to the speeds of middle distance athletes in 800-meter run [33,7].

Vitor, *et al* We investigated the effect of beta-alanine (BA) alone (study A) and in combination with sodium bicarbonate (SB) (study B) on 100- and 200-m swimming performance. In study A, 16 swimmers were assigned to receive either BA (3.2 g·day−1 for 1 week and 6.4 g·day−1 for 4 weeks) or placebo (PL; dextrose) . At baseline and after 5 weeks of supplementation, 100- and 200-m races were completed. In study B, 14 were assigned to receive either BA (3.2 g·day−1 for 1 week and 6.4 g·day−1 for 3 weeks) or PL. Time trials were performed once before and twice after supplementation (with PL and SB), in a crossover fashion, providing 4 conditions: PL-PL, PL-SB, BA-PL, and BA-SB. In study A, BA supplementation improved 100- and 200-m time-trial performance by 2.1%) and 2.0% respectively. In study B, 200-m time-trial performance improved in all conditions, compared with presupplementation, except the PL-PL condition (PL-SB, +2.3%; BA-PL, +1.5%; BA-SB, +2.13%. BA-SB was not different from BA-PL but the probability of a positive effect was 78.5%. In the 100-m time-trial, only a within-group effect for SB was observed in the PL-SB and BA-SB conditions.

Antti A, *et al* This study examined the effect of simultaneous supplementation of extracellular buffer sodium bicarbonate (SB) and intracellular buffer beta-alanine (BA) on maximal sprint swimming. : Thirteen competitive male swimmers completed 4 different treatments (placebo [PL], SB, BA + PL, and BA + SB) in a crossover procedure. PL or SB supplementation (0.3 g/kg body weight) was ingested 60 min before two maximal 100-m freestyle swims that were performed with a passive recovery of 12-min between each swim. Because of the known long washout period for carnosine, four weeks of BA supplementation (4.8 g per day) was started after the first week of PL or SB supplementation and performance testing. The first maximal swims were similar, but the increase in time of the secon versus the first 100-m swimming time was 1.5 s more in PL than in SB. Blood pH values were significantly greater in the SB and in the BA + SB groups compared to the PL and BA + PL values. There were no differences in peak blood lactate between the treatments [33,39,7,56]. At the end of the study, it was found out that there was a significant enhancement in the performances of the sprinters who used alkali substance in comparison with the sprinters who were placebo group.

Jones examined the effects of metabolic alkalosis and metabolic acidosis on the biochemical and cardiovascular response during males' exercise. 5 subjects were exposed to 3 different exercises in 3 weeks. The subjects exercised three times with 33%, 66% and 95% of their capacities on a random cycle ergometer. 3 hours before each test, the placebo group was given 0.3 g/kg body mass CaCO3 and the subject group was orally given ammonium chloride NH4CL (acidosis) and NaHCO3 (alkalosis).The exercise continued 20 minutes from the slow tempo to the maximum. At the end of the study, when exercise durations of acidosis and alkalosis groups were compared with control groups, utmost decrease was observed in the acidosis group (270 sec - 160 sec) and an increase (438 sec) was observed in the alkalosis group's duration. No significant increase was observed in cardiovascular variables. In all loads, the venous blood lactate levels were high in acidosis group and low in alkalosis group. The pH and HCO3 changes in the blood affected the exercise metabolism and reduced the resistance to the exercise.

In their study Sutton, Costil and Kowalchuck investigated the effects of acidosis and alkalosis taken before the exercise. They orally gave 5 male subjects 3 different substances: CaCO3 (control group), NH4Cl (acidosis) and NaHCO3 (alkalosis). The experiment was made for 8 days within 6 weeks. On the exercise days, 3 hours before the exercise the subjects were given totally 0.3 g/kg control, acidosis and alkalosis substances every 15 minutes. The subjects with 33% of V02 max exercised 20 minutes and at the end of 20 min the load was increased to 66% and then to 95%. In the end, the resistance to 95% load was the highest in alkalosis group

(5.44 min), low in acidosis group (3.13 min) and midlevel in control group (4.56 min). As a result, plasma lactate levels increased in acidosis media after exercise. When compared to control and alkalosis groups, this situation was observed to be related to the prevention of muscle glycolysis and accordingly the decrease of lactic acid excretion in muscles.

Costil carried out his study on 10 male and 1 female subjects. He investigated the effects of 0.2 g/kg NaHC03 and placebo NaCl solutions taken one hour before the exercise on the performance at five 1-min exercises with 125% V02 max. Fifth test continued till the subject was exhausted and the duration was recorded. The blood pH and HCO3 levels of NaHCO3 group were higher than the placebo group. The difference between two groups was 42%. The H+ and lactic acid levels measured during the each exercise and the recovery proved to be lower in NaHCO3 group. The use of NaHCO3 pursuant to increasing performance acted as a powerful buffer. When the pH level in vastus lateralis muscle was measured before the exercise, the pH level of NaHCO3 group proved to be lower than the placebo group. As a result, it was stated that H+ concentration in the blood and the muscle stemming from NaHCO3 use affects the performance directly during the repeated heavy exercises.

In his study Kowalchuck compared the performances of 6 subjects till they got fatigue in 3 exercises by increasing their load 100 kgm/min every minute. The control group was orally given CaCO3, the experimental group was given NH4Cl (metabolic acidosis) and NaHCO3 (metabolic alkalosis). When the control, the alkalosis and the acidosis groups were compared at the lowest load (kgm/min), the plasma lactic acid concentration of the acidosis group proved to be low during the exercise and resting. Even though the lactic acid secretion decreased in the acidosis group, the increase in the H+ concentration were the same in all groups. As a consequence, it was found out that the changes in acid base balance affected the maximum power [49,4,55].

McLaren, McKenzie, Pfeffzerle, Goldfinch and Gao examined the effects of NaHCO3 use on the maximal exercise performance. 7 subjects exercised on a cycle ergometer with 100% VO2 max until they got exhausted. The subjects were given a dosage of 0.25 g/kg NaHCO3 and placebo before the exercise. The Hla level of NaHCO3 group was high on the point of fatigue and 5 minutes after the exercise but not before the exercise and right after the exercise. As a result, a 21-minute increase was recorded in the exercise duration (326 sec in the NaHCO3 group and 285 sec in the placebo group). In his study on 6 male subjects, McKenzie investigated the effects of the artificially increased alkalosis level with two different dosages in 3 experimental trials on maximal exercise performance. In the study, the subjects made 60-second cycle exercises 6 times and every 60 seconds with 125% VO2 max. Group 1 were given a placebo solution, group 2 were given 0.15 g/kg NaHCO3 and group 3 were orally given 0.30 g/kg NaHCO3. Each of 6 exercises continued till the number of pedal revolutions was decreased to 50 revolutions per minute. At the end, in all circumstances there were changes in the pre-exercise pH and HCO3 levels.

In the production of Alkalosis groups, it was observed an increase of 121 kJ in the Group I, 133 kJ in the Group II, 133.5 kJ in the Group III. Though, there wasn't any differences between Group I and Group II during fatigue period of the 6 studies, it was seen a significant increase compared to the Placebo Group. Consequently, as the increase in HCO3 level affects metabolism of energy in the interval exercises, the period of working and fatigue increased. Pfeffzerle researched the effects of alkalosis on the performances of trained and untrained subjects who do high level exercises: Subjects were separated 3 groups as control, placebo and alkalosis (0.3 g/kg HCO3) with the method of double-blind. Subjects were done sub maximal exercise with 100 % of VO2 max training. PH levels of trained group were low at first, but after alkalosis, their blood HLA values were higher compared to the untrained group. Working period after alkalosis was longer in trained group than in untrained group. Fatigue period of trained group rose from 56.3 sec. to 62,7 sec. after taking HCO3, but this rise wasn't observed in the untrained group. As a result, the performances of trained athletes in the alkalosis were better than the performances of untrained subjects. Goldfinch esearched the effects of 6 trained male subjects who continually run 400 m on the 400 m race time in the state of control, alkalosis (NaHCO3) and placebo (CaCO3): Each subject ran 400 m 3 times in 7 days and in the first running, control test was made without giving any substance. In the other two tests, subjects was given 400 mg/kg NaHCO3 (alkalosis group) and 250 ml water based energy drink (placebo group) an hour ago before the test. It was observed a significant increase before exercises in the pH, HCO3 and base levels of the group which had taken NaHCO3, compared to the control and placebo groups. The running speed of NaHCO3 group was significantly higher than the other two groups. After exercises, the pH, HCO3 and base levels of alkalosis group was observed to be lower than the other two groups. As a consequence, taking NaHCO3 was understood to increase performance as an ergogenic aid. Because with taking NaHCO3, H+ ions are thrown out of cells in the working tissues and intracellular pH value decreases. With this decrease, extracellular buffering is done and fatigue is delayed. Gao researched the effects of bicarbonate (NaHCO3) on exercise performance in his study: 5 different tests were made to 10 male swimmers. Each test included 2 min. interval and 100 yard freestyle. 2 tests were done with taking NaHCO3, 2 tests were done with taking placebo and 1 test was done without taking any substance. Subjects took 17 mmol NaCl (placebo) and 300 ml citric acid including 2.9 mmol NaHCO3/kg an hour ago before each test. Blood pH, standard bicarbonate and base levels were measured. There wasn't a significant difference between placebo and the group which hadn't taken drink in terms of performance and blood parameter. Taking bicarbonate ensured a significant increase of 4. and 5. sprint performances. Furthermore, after exercises a significant increase was observed in the blood lactate, pH standard bicarbonate and base levels of the group taking bicarbonate. Consequently, it was understood that with taking NaHCO3 during repetitive loadings before exercises and removing H+ from the working muscles delayed fatigue and by this way performance increased [34,42,46,25,27].

Lavender, Tiryaki and Pierce found out the sodium bicarbonate to increase performance in interval exercises: 15 male and 8 female subjects at the ages of 21.4 + 2.3 participated in this study. Each subject was made 6 tests including 10 sec. sprint, ten times at 50 sec. intervals. While three of the subjects took NaHCO3 300 mg/kg, three of them took placebo 8 g NaCL. Highest powers and average power generation of the subjects were measured every ten seconds. In comparison with placebo group, values of bicarbonate group were high in 8 tests of 10. The difference between power values of bicarbonate and placebo groups significantly increased when the number of repetition increased. As a consequence, during short time sprint exercises done after taking sodium bicarbonate, power generation increases.

Tiryaki researched the effects of sodium bicarbonate and sodium citrate on 600 m running performance in the study done on 11 athletes and 4 trained athletes: Subjects took the substances of bicarbonate, sodium citrate and placebo 2.5 hours ago before the test. The dosage of taken substances was 0.3 g/kg. At the end of this study, a significant increase was observed in H+, base and HCO3 levels of the subjects before and after taking alkali substance. Before and after exercises, a significant increase was observed in HLA level and 600m running period of the subjects decreased from 124.7 to 118.7.

In order to research the effects of bicarbonate on performance, Babalık, McNaughton and Price & Cripps measured the effects of short time high level exercises on power output by using Wingate protocol. For measuring the effect of sodium bicarbonate to 100 % of VO2 max work done on the cycle ergometer individually, 25 male athletes participated in the Wingate test, 13 male athletes participated in 600 m running test and 20 male athletes participated in the test as subjects. At the end of Wingate test, a significant difference was seen in powers shown in first 5 sec. compared to control group. There was an important difference in blood lactate concentration values at the end of exercises, but heart rate didn't change. At the end of 600 m running, there was no difference in running time and heart rate in 3 tests. McNaughton researched the effects of NaHCO3 on anaerobic performance period in his study, done on 9 male athletes: The subjects were given control, placebo (CaCO3 500 mg/kg) and 5 different doses NaHCO3 (100, 200, 300, 400 and 500 mg/kg). The subjects did the work in maximum 300 mg/kg and there wasn't a significant increase in more than this amount. After taking all doses except 100 mg/kg muscle pH, alkalosis was reached and blood level increased.

McNaughton, in his study done on 4 subjects, researched the effects of NaHCO3 (O.3 mg/kg) taking as ergogenic aid, on 10, 30, 120 and 240 sec. anaerobic exercises done on the cycle ergometer: Blood samples were taken 90 minutes ago before taking NaHO3 and shortly after the exercise and pH, base excess, bicarbonate and lactate levels were measured. Total work done during tests and the highest power was tried to be determined. At the end of the research, blood bicarbonate level was above control and placebo values, blood lactate level increased in the bicarbonate test and pH levels decreased in all of the placebo and control tests. As a result, although there wasn't any ergogenic benefit of NaHCO3 taking in this dose in 10 and 30 minutes' studies, blood HCO3 levels were above control and placebo groups after taking NaHCO3.

This study examined the effects of combined glucose and sodium bicarbonate ingestion prior to intermittent exercise. Nine males (mean +s age 25.4 +6.6 years, body mass 78.8 +12.0 kg, maximal oxygen uptake (V_ O2max) 47.0+7 ml kg min71) undertook 4 645 min intermittent cycling trials including 15 6 10 s sprints one hour after ingesting placebo (PLA), glucose (CHO), sodium bicarbonate (NaHCO3) or a combined CHO and NaHCO3 solution (COMB). Post ingestion blood pH were greater for NaHCO3 and COMB when compared to PLA and CHO, remaining elevated throughout exercise (main effect for trial; Gastrointestinal distress was lower during COMB compared to NaHCO3 at 15 min post-ingestion. No differences were observed for sprint performance between trials. Consequently, it was understood that there was a positive effect of loading bicarbonate in the laboratory conditions on maximal and submaximal exercise performances, but it didn't affect the performance in the field conditions [8,47].

Webster and Amelia, *et al*, researched the effects of 300 mg/kg NaHCO3 and placebo taken 105 min ago before endurance exercises: 6 trained male subjects were used. There were 12 sets in the test and depending upon fatigue and desire of the subject, 4. and 5. sets were tested on the leg press with maximum 70% loading. Also, lactate concentration in the venous blood, blood gas and acid-base parameters were examined. At the end of analyses, levels of resting pH and HCO3 significantly increased. After each set, a regular decrease was observed in the acid-base situation of both groups. But there was more alkali in the NaHCO3 group than in placebo group. Blood lactate concentration, each arterio and venous blood samples were taken before taking resting substance and in 2, 6, 10, 14, 18 and 22 minutes of the exercise. Samples were taken after each exercises and for each of blood samples, arterio-venous difference was determined. It was observed that taking NaHCO3 increased arterial bicarbonate, pH levels and power-speed performance during resting. Furthermore, the arterio-venous difference was high during exercises in NaHCO3 group. Consequently, the increase of performance can be connected to taking NaHCO3 and decreasing of arterio-venous.

The aim of this study was to determine the effect and reliability of acute and chronic sodium bicarbonate ingestion for 2000-m rowing ergometer performance (watts) and blood bicarbonate concentration. In a crossover study, 7 well-trained rowers performed paired 2000-m rowing ergometer trials under 3 double-blinded conditions: (1) 0.3 grams per kilogram of body mass (g/kg BM) acute bicarbonate; (2) 0.5 g/ kg BM daily chronic bicarbonate for 3 d; and (3) calcium carbonate placebo, in semi-counterbalanced order

Specifically, in a randomised and counterbalanced order, participants ingested solutions 8 providing either 75 g carbohydrate (sucrose) 45 min before exercise (Study A; n=10) or 2x0.2 g·kg-1 9 sodium bicarbonate (NaHCO3) 90 and 20 min before exercise (Study B; n=7), each relative to appropriate placebos (H2O and 2x0.14 g·kg-1 10 NaCl, respectively). Heart rate, sweatrate, pedometer count and perceived exertion did not systematically differ between the 60- min basketball simulation test and competitive basketball, with a strong positive correlation in heart rate response. Pre-exercise carbohydrate ingestion resulted in marked hypoglycaemia throughout the first quarter, coincident with impaired sprinting and lay-up shooting performance (8.5/11 versus 10.3/11 baskets. However, ingestion of either carbohydrate or sodium bicarbonate ingestion prior to exercise offset fatigue such that sprinting performance was maintained into the final quarter relative to placebo, although neither translated into improved skilled (lay-up shooting) performance [38,5,1].

In his study, Granier researched the effects of taking NaHCO3 on lactate amount and performance during intense leg exercise: 7 subjects were given placebo and NaHCO3 (2 mEq/min) and they were subjected power-speed test with double-blind method. The power generation in both test was high in NaHCO3 group. In the low-level exercise, there wasn't an important difference between two groups in terms of plasma lactate concentration. But in the high level exercise, lactate level increased more quickly in the NaHCO3 test.

Vertibsky and Zoladz researched the effects of taking NaHCO3 on fatigue and recovery of quadriceps femoris muscle after maximum exercise: 6 subjects participated in the research. They were subjected to 3 different loadings on cycle ergometer. They took NaHCO3 an hour ago before exercise. As a result, the highest power generation in quadriceps femoris muscle was observed in the test which was taken NaHCO3 and fatigue of the group which took NaHCO3 decreased and their recovery became more quickly. Zoladz made two test to male non-smoker subjects at the ages of 22.4 + 1.8. These test included 40% and 87% VO2 max, 70 period/min and 20 minutes' resting time. In the first exercise, 250 mg/kg NaHCO3 was given 1.5 hours ago before control and second exercise. Venous blood pH and HCO3 values were significantly high in the low level exercise where NaHCO3 was taken and in the high level exercise. At the end of the set, a regular increase was observed, but there wasn't an important difference between the two groups. In his study where he examined the activity of ergogenic aids, Applegate found out that taking sodium bicarbonate increased performance 1-7 min. high level exercises. The changes of blood's acid-base situation affects healthy athletes to keep their performances in high level exercises. If acid- base balance decreases, performance can increase [29,57,65].

Ching-Lin Wu *et al*, The aim of this study was to investigate the effect of NaHCO3 supplementation on skilled tennis performance after a simulated match. After given fasting blood samples,the participants consumed NaHCO3 (0.3 g kg-1 body mass) or placebo (NaCl, 0.209 g kg-1, , equal amount of sodium) in 250 ml water.A standard breakfast (1.5 g. kg-1 carbohydrate, including white bread, jam, and glucose drink) was ingested 20 min after the drink consumption. A 100 ml drink containing 0.1 g. kg-1 NaHCO3 or 0.07 g. kg-1 NaCl was ingested after the third game in the simulated match. Gabriel, *et al*, We examined the isolated and combined effects of beta-alanine (BA) and sodium bicarbonate (SB) on high-intensity intermittent upper-body performance in judo and jiu-jitsu competitors . 37 athletes were assigned to one of four groups: (1) placebo (PL)?PL; (2) BA?PL; (3) PL?SB or (4) BA?SB. BA or dextrose (placebo) (6.4 g day-1) was ingested for 4 weeks and 500 mg kg-1 BM of SB or calcium carbonate (placebo) was ingested for 7 days during the 4th week Before and after 4 weeks of supplementation, the athletes completed four 30-s upper-body Wingate tests, separated by 3 min. Blood lactate was determined at rest, immediately after and 5 min after the 4th exercise bout, with perceived exertion reported immediately after the 4th bout. BA and SB alone increased the total work done in ?7 and 8 %, respectively The co-ingestion resulted in an additive effect.

Daniel, *et al*l The purpose of this study was to investigate the effects of pre-exercise alkalosis on the physiological stress response to high-intensity exercise. Seven physically active males (age 22 ± 3 years, height 1.82 ± 0.06 m, mass 81.3 ± 8.4 kg and peak power output 300 ± 22 W) performed a repeated sprint cycle exercise following a dose of 0.3 g kg-1 body mass of sodium bicarbonate (NaHCO3 (BICARB), or a placebo of 0.045 g kg-1 body mass of sodium chloride (PLAC). Monocyte-expressed heat shock protein 72 (HSP72) and plasma thiobarbituric acid reactive substances (TBARS) were significantly attenuated in BICARB compared to PLAC, however total anti-oxidant capacity, the ratio of oxidised to total glutathione, cortisol, interleukin 6 and interleukin 8 were not significantly induced by the exercise [11,23].

Discussion:

Experts classify ergogenic aids as mechanics or biomechanics, psychological, physiological, pharmacological and nutritional aids [59,60,53]. In order to enhance performance, athletes frequently use nutritional supplements or practices as ergogenic aids. Although, there are nutritional information that vitamins and minerals don't increase performance, athletes generally consume them. Because they believe those vitamins and minerals to increase their performance [59,60,53,50,10,3]. Alkalizer agents are also claimed to be ergogenic aids. Before and after competitions, they are taken after meals. Lactate acid occurs after intense exercises. It is claimed that alkalizer agents increase pH in the beginning of exercises and athletes can tolerate higher valued lactate acid. Using buffer substance buffers lactate acid that occurs during exercises, so fatigue can be delayed [62,13,20,35,48]. Buffers are watery systems that tend to resist pH changes when low level acid (H+) or (OH-) base is added. "Sodium Bicarbonate Buffering System" is the most important system that removes accumulated hydrogen of body from the environment. With increasing of NaHCO3 level in the intracellular and extracellular environment, hydrogen ions are removed from the environment. Researchers claimed that loading NaHCO3 outside for the purpose of raising bicarbonate level occurred in the body during exercises, will be useful. However, in the first studies, clear results couldn't be obtained due to time of taking bicarbonate, its amount, exercise period, intensity of the exercise and individual variability [22,26,34,42]. Only the substances of "Creatine, cafein, (if it is above 12µ/ml in the urinary, it is accepted as doping), phosphate salts, sodium bicarbonate, sodium citrate", among nutritional supplements that are not doping, are proved to affect athletes' performances positively [32].

According to the researchers, sodium bicarbonate decreases lactate acid level and increases anaerobic performance. They also state that as a side effect, the problems about digestive system can be faced. In the researches, it has been observed that use of NaHCO3 affects performance of athletes positively. When the effect of sodium bicarbonate (NaHCO3) on high level exercise performance was examined, it was observed that sodium bicarbonate taken before intense exercise significantly increase anaerobic performance and it was suggested that NaHCO3 could be used as an effective ergogenic aid [12,47].

Ching *et al*., Antti *et al*., Afman *et al*., Amelia *et al*., Tobias *et al*., Yamaguchi *et al*. and Daniel *et al*. carried out some studies regarding the effects of NaHCO3 use on performance. In the studies conducted in the field of anaerobic exercise, tennis, swimming, basketball and rowing ergometer the researchers found out that Sodium Bicarbonate ingestion had positive effects on performance [11,39,1,5,23,52].

Besides, the studies of Lambert, Ball & Maughan, Price & Cripps, Campos and Painelli *et al*., *et al*. concluded with different results. They did not find out a significant difference between the SB and placebo groups. In short, SB proved not to improve performance, however, it still had some positive impacts on reducing stress during the exercise trials [47,55].

Matson researched the effect of taking sodium bicarbonate on anaerobic performance. He examined 35 researches in his study. Many researchers have researched the effects of metabolic alkalosis that increases with taking of sodium bicarbonate. In 19 of all these researches, positive effect of sodium bicarbonate was stated. However, in 16 researches it was stated that there was no positive effect of sodium bicarbonate. Matson expressed this effect to be relevant to the significant increase in pH, but partially it was related to the significant decrease in pH. Consequently, he stated alkalosis not to affect performance. Because, the number of the subjects and the dosage were low [40].

In this study, 46 article were examined. While 39 researchers stated sodium bicarbonate to have positive effect on performance, 7 researchers asserted sodium bicarbonate not to have an effect on performance. That there were not a suitable procedure and sufficient subjects can be the reason of this, as Matson stated.

Summary:

In order to enhance performance, researchers have made many experimental studies where buffering substances, given before exercise, were used. The changes of blood's acid-base situation affects healthy athletes to keep their performances in high level exercises. Especially, it is stated to have positive effects on performances such as in weight trainings, 100m-400m sprints, interval exercises and high level trainings.

As a consequence; in this study and examined researchers, it is concluded that sodium bicarbonate contributes to balancing blood and intramuscular pH and inreasing performance in case of using it as a supplement.

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