

# Effect of sodium bicarbonate supplementation before exhaustive activity on physiological parameters of fatigue in conscripts: A study in Sanandaj, Iran

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## ABSTRACT

**Purpose:** To investigate the effects of sodium bicarbonate (NaHCO<sub>3</sub>) on exhaustive activity and physiological parameters of fatigue in conscripts.

**Materials and Methods:** Thirty conscripts did Wingate test in two groups: sodium bicarbonate group (treatment) and placebo (control) group. In both groups, sodium bicarbonate (0.3 g/kg of body mass) or placebo was ingested 60 minutes before the training in 250 mL solution. Blood sample was collected before and after doing Wingate test. All parameters were compared using two-way analysis of variance (ANOVA), followed by Tukey's post-hoc test. Significance level was set at .05.

**Results:** After sodium bicarbonate supplementation, the La Anion in Wingate test was significantly higher in the treatment group than the control group ( $17.93 \pm 3.8$  mmol/L vs  $15.67 \pm 3.29$  mmol/L  $P < .01$ ). Sodium bicarbonate supplementation had no significant effect on heart rate in both groups.

**Conclusion:** Sodium bicarbonate improves conscripts' performance by increasing glycolytic capacity but does not improve fatigue indicators.

**Keywords:** Conscript; sodium bicarbonate supplementation; lactate; PH; exercise.

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## INTRODUCTION

Success in intense training depends on activity type and recovery consisting of both aerobic and anaerobic activities.<sup>1-4</sup> People participating in daily events and amateur and professional sports gain more self-satisfaction and social acceptability.<sup>5,6</sup> So they try to show their best performance. Such people can prevent the occurrence of several problems due to intense exercise. Regarding causes of fatigue, researches have focused on the factors such as energy pathway (ATP-pc, glycolysis and aerobic oxidation), the accumulation of by-products of metabolism, nervous system, and impaired contractile mechanisms. It has been suggested that in intense activity, increased lactic acid itself can be a cause of fatigue. But lactic acid is decomposed and converted to lactate and hydrogen ions, leading to aggregation and loss of

muscle cell PH.<sup>7,8</sup> Incremental increase in hydrogen ions decreases in intracellular pH, leading to fatigue in most sports.<sup>9</sup> Increased proton buffering can delay fatigue by improved use of energy substrates and the work done to preserve muscle contraction.

Compared to continuous training of the same energy expenditure, intense activity needs carbohydrate and lactate metabolism.<sup>5,6</sup> Increased carbohydrate metabolism can induce production of lactic acid and the dissociation into hydrogen ions (H<sup>+</sup>) and lactate, decreasing the pH of the blood.<sup>7-9</sup> Reduced pH causes the encumbrance of calcium ions delivered from the sarcoplasmic reticulum, the coupling of actin and myosin, and the activity of phosphofructokinase. These factors lead to downfall force production during performance.<sup>10-13</sup>

Sodium bicarbonate ( $\text{NaHCO}_3$ ) supplementation can help in reducing fatigue during drilling efforts<sup>2,14-16</sup> by reducing pH of the blood.<sup>16,17</sup> Thus, aside from inconsistent findings about its ergogenic effects,<sup>3,18-21</sup> sodium bicarbonate has been used to increase performance in several sports.<sup>22</sup> Lindh and colleague<sup>14</sup> confirmed that 300 mg/kg supplementation of sodium bicarbonate can increase 200 Meter performance in experienced swimmers due to the increase in buffering capacity. The advantage of sodium bicarbonate on intense exercise was recently indicated. Siegler and Gleadall-Siddal<sup>21</sup> have suggested that consumption of sodium bicarbonate in rigorous drilling sessions for swimmers can improve the quality of their drilling performance.

If sodium bicarbonate can help in maintaining or even soothing the forfeiture in important parameters during intense training, it would be reasonable to conclude that conscripts would benefit from this nutritional strategy. However, to the authors' knowledge, no study has evaluated the effect of sodium bicarbonate on activity parameters in intense performance in conscripts.

Thus, the aim of the present study was to evaluate the effect of sodium bicarbonate supplementation on the chemical and mechanical parameters of physiological responses and intense activity of conscripts.

## MATERIALS AND METHODS

Thirty conscripts of a garrison in Sanandaj city, Iran, participated in this study. They were randomly assigned into two 15-member groups: control (placebo) group (mean age  $20.58 \pm 3.25$  years old, body mass index  $21.57 \pm 2.67$  kg/m<sup>2</sup>) and treatment (sodium bicarbonate) group (mean age  $20.35 \pm 3.65$  years old, body mass index  $21.61 \pm 2.74$  kg/m<sup>2</sup>). The participants were instructed to avoid any high-intensity exercise during the testing sessions and to continue their nutritional habits. Before their participation, each participant signed an informed consent and completed medical screening. Individuals who had health problems and disorders of the cardiovascular and respiratory were excluded.

### Sodium Bicarbonate Supplement Ingestion

Sodium bicarbonate supplement (alkalosis) in the form of white powder was bought from Pars Azmoon Company (Tehran, Iran). This supplement was used with dosage of 0.03 g per kilogram of body weight<sup>18-19</sup> 60 minutes before the performance test. Placebo was pure water (250 mL), ingested 60 minutes before the performance test. The volunteers had not eaten or drunk for 12 hours before the test.<sup>10</sup>

### Chronic Supplementation

Chronic supplementation involved a four day loading period with sodium bicarbonate. Each subsequent day of the chronic loading period involved supplementation with 0.3 g per kilogram of body mass. On the day 5, the participants ingested no supplement and carried out the performance test. Previous studies have shown that the five day loading period followed by no supplementation on the day of the performance test may induce pre-exercise alkalosis sufficiently while allowing time for any gastrointestinal discomfort that may affect performance to be alleviated.

### Performance Test

The performance test was a high-intensity test on a 'Monark 824E' cycle ergometer (Monark Exercise, Farberg, Sweden). The cycle ergometer recorded various forms of power output and was automatically calibrated by the patented self-regulating braking system. Wingate test was set at a 7.5% body mass resistance for each participant.

Mean power output (MPO) was recorded for all participants. MPO was also expressed relative to body mass (relative MPO). Total work was calculated as the sum of the MPO for each Wingate and the duration of the Wingate (10 seconds). Fatigue index was also calculated for each performance as the MPO minus the minimum power output, expressed as a percentage of the MPO.<sup>13</sup>

### Blood Sampling

There were two blood sampling phases: five minutes before the test and 60 minutes after test. In both loading, the blood samples were poured into lab tubes containing heparin. The blood samples were immediately sent to a laboratory for analysis.

### Biochemical Measurements

Five milliliters of blood were obtained from the vein of forearm of each participant. Lactate was measured with an enzymatic method by a lactate kit (Pars Azmoon, Tehran, Iran), bicarbonate by a bicarbonate kit (ABL5 Radiometer, Copenhagen, Denmark) and pH by a pH meter instrument (I-STAT Abbott Laboratories, USA).

### Heart Rate

Heart rate was measured throughout each test and recorded at similar intervals to pretest, posttest and after one hour of performing the test. Heart rate was recorded using a wireless polar heart rate monitor (Polar Vantage NV™ Polar, Port Washington, NY).

## Statistical Analysis

Statistical analysis was done using statistical package for social sciences (SPSS) software version 16. Data were tested for normal distribution using the Kolmogorov–Smirnov test and were normally distributed. They were presented as means  $\pm$  standard deviation. One-way repeated measures of analysis of variance (ANOVA) were used to investigate the differences in all the dependent variables at all the time points. Where a difference was found, it was investigated using a least significant difference post hoc test. The level of significance was set at  $P < .05$ .

## RESULTS

Bicarbonate concentration was greater in treatment group than placebo group at all the time points. The peak blood  $[\text{HCO}_3^-]$  (30.3 mmol/L) and the greatest change in  $[\text{HCO}_3^-]$  from baseline (6.6 mmol/L) were recorded after ingestion.  $\text{StdHCO}_3^-$  levels were significantly greater with chronic sodium bicarbonate supplementation for all time points after ingestion compared to control group ( $P < 0.01$ ). Following ingestion, blood pH was significantly higher in treatment group at all the time points for sodium bicarbonate group compared to control group ( $P < 0.05$ ).

### Lactate

Baseline lactate levels were within the normal ranges before supplementation for all participants (0.8–1.8 mmol/L) with no significant differences between the two groups ( $P = 1.000$ ). Following chronic sodium bicarbonate supplementation, blood lactate concentrations were found to be significantly greater than the control group after the Wingate test only. Following the Wingate test, sodium bicarbonate ingestion resulted in a mean blood lactate concentration of  $12.71 \pm 2.13$  mmol/L, which was significantly higher than the control group (mean blood lactate concentration of  $4.3 \pm 1.21$  mmol/L).

### Mean Power Output

MPO was analyzed for each Wingate performance with significant differences observed between groups in Wingate test. The greatest MPO was observed during

Wingate in chronic supplement loading ( $P = .01$ ).

### Fatigue Index

No significant differences were found for fatigue index in the Wingate test between the two groups ( $P = 1.000$ ). Fatigue index was calculated as  $27.2 \pm 2.2$  and  $27.5 \pm 1.65$  for control and sodium bicarbonate groups, respectively.

### Heart Rate

No significant differences were found between the two groups regarding the heart rate after the Wingate test ( $P = .15$ ). Heart rates were 173 and 177 for sodium bicarbonate and placebo groups, respectively.

## DISCUSSION

The primary finding was that sodium bicarbonate supplementation has an ergogenic effect on conscripts' Wingate test performance. Sodium bicarbonate supplementation leads to increased buffering capacity without a change in heart rate at the end of physical activity.

Although sodium bicarbonate possesses an ergogenic effect lasting one to ten minutes,<sup>14–19</sup> the present study found improvement in the performance of Wingate test after sodium bicarbonate consumption. This is in agreement with Lindh and colleagues<sup>14</sup> study in which they reported a single effort of 200 m performance improvement in elite athletes. Their elite athletes also seemed to present greater anaerobic capacity that allows for a higher level of acidosis and, therefore, benefit from sodium bicarbonate more than non-elite athletes.

Siegler and Gleadall-Siddall<sup>21</sup> studied the effect of sodium bicarbonate consumption in trained swimmers following eight sets of 25 Meter with a five seconds pause, and detected a reduction in the total time of the performance (placebo:  $163.2 \pm 25.6$  seconds, sodium bicarbonate:  $159.4 \pm 25.4$  seconds). Thus, the elimination of noisome components could have influenced their participants' improvement in performance. In the present study, significant difference was seen after sodium bicarbonate consumption in performance which is consistent with results of Siegler and Gleadall-Siddall<sup>21</sup> and Lindh and colleagues.<sup>14</sup> Technical and competitive improvement of the participants can be seen in their performance. This improvement was seen in the performance of those who had supplemented sodium bicarbonate.

Regarding pH alterations, sodium bicarbonate loading was effective in changing pH and the concentration of bicarbonate ion same as other studies.<sup>18,21,23</sup> The

**Table 1.** Physical characteristics of the studied participants.

	Sodium Bicarbonate Group	Placebo Group
Age (years old)	$20.58 \pm 3.25$	$20.35 \pm 3.65$
Height (cm)	$175.33 \pm 2.48$	$175.42 \pm 2.35$
Weight (kg)	$64.43 \pm 1.34$	$64.53 \pm 1.23$
Body mass index (kg/m <sup>2</sup> )	$21.57 \pm 2.67$	$21.61 \pm 2.74$

lactate concentration was significantly higher at the end of the last 100 m effort (placebo:  $15.67 \pm 3.29$  mmol·l<sup>-1</sup> and sodium bicarbonate:  $17.93 \pm 3.80$  mmol·l<sup>-1</sup> ( $P = .03$ )).

The increase in lactate concentration was reported by several studies.<sup>6,18,28</sup> Some hypotheses may explain the higher values of lactate concentration on sodium bicarbonate. The first one is related to the fact that the elimination of lactate is increased when the extracellular pH increases, so lactate depletion from muscle increases with the sodium bicarbonate supplementation.<sup>12-15</sup> The second relates to the higher glycolytic activity and anaerobic energy production due to a better internal environment, which would increase performance. However, this hypothesis was confirmed in our study since there was significant difference in the Wingate test after sodium bicarbonate consumption. The protocol used in the present study consisted of Wingate test to improve the tolerance to acidosis. So besides achieving the goal of training, sodium bicarbonate allowed for a higher production of [La<sup>-</sup>] without a decrease in the performance.

The MPO was used to estimate performance improvement during exercise because of the close relationship between MPO and physiological markers related to intensity (such as heart rate and blood lactate).<sup>9-17</sup> The present study found significant difference between the values of MPO in sodium bicarbonate. Jones and colleagues<sup>26</sup> found no difference in MPO when studying the legs, with higher lactate concentration in sodium bicarbonate after a set of intense exercise, which is in agreement with the present study. Numerous studies have shown elevated lactate concentration after sodium bicarbonate supplementation.<sup>6,18,23</sup> So, it seems that despite the change in MPO, sodium bicarbonate increased the production capacity and the lactate tolerance. Therefore, the ergogenic effect may be beneficial in training that is aimed at increasing tolerance or [La<sup>-</sup>] production.

No differences were found on the effect of sodium bicarbonate on heart rate. Although the majority of the researches involving sodium bicarbonate supplementation demonstrate fluctuation in the acid-base balance inducing a state of alkalosis, this condition does not always translate into an enhanced performance. Horswill and colleagues found no significant improvement in the total work performed in a two-minute cycling sprint with sodium bicarbonate supplementation.<sup>13</sup> In another study, no improvements were recorded, either for work performed or power output, following 90 seconds of maximal cycling exercise by untrained men.<sup>14</sup>

The lack of significant findings in certain studies

may also be a result of factors such as sample size, participant characteristics, sodium bicarbonate dosages and insufficient durations and intensities of exercise. The exact reasons for these conflicting results are unclear but may in part be due to inadequate exploitation of the maximum buffering capacity through insufficient duration or intensity of exercise, thereby limiting the ergogenic benefits.<sup>11</sup> In addition, there appears to be a highly individual response to sodium bicarbonate ingestion, which may be partially accounted for by the gastrointestinal side effects associated with sodium bicarbonate ingestion.

Another explanation for the lack of performance enhancement with sodium bicarbonate supplementation in some previous studies has been the use of untrained participants. Plasma pH and [HCO<sub>3</sub><sup>-</sup>] measured before the Wingate test in the present study was comparable to those reported by Lindh and colleagues.<sup>16</sup> From these results it appears that 0.3 g/kg of body mass of sodium bicarbonate was sufficient to induce metabolic alkalosis in conscripts. In support of this data, previous research has showed a significantly higher alkalinity in trained men<sup>16</sup> and elite women athletes.<sup>5</sup> This finding is widely supported in the related literature, particularly in investigations involving high intensity exercise with a heavy reliance on anaerobic metabolism.<sup>10,13,17,18</sup>

An increase in the activity of the lactate/H<sup>+</sup> cotransporter, promoting an increased efflux of lactate from the muscle cells, is purported to be the mechanism underpinning the increased post-exercise lactate concentrations observed with sodium bicarbonate ingestion in chronic loading.<sup>10-16</sup> However, the sample size used in the current study was higher than the average of  $8 \pm 2$  participants observed in a review of research involving sodium bicarbonate ingestion.<sup>11</sup> Sodium bicarbonate loading may have additional buffering effects in more participants with enhanced intracellular buffering mechanisms.<sup>20</sup> Regarding performance, sodium bicarbonate ingestion resulted in no significant difference between trials for participants. However, significant differences in performance in chronic loading were observed. Previous studies have reported improved short-duration high-intensity cycling performance after chronic loading of sodium bicarbonate.<sup>8,16,18</sup>

## CONCLUSION

Sodium bicarbonate supplementation improves performance and its parameters. But it does not improve fatigue indicators. The change in conscripts' performance after sodium bicarbonate supplementation can prolong

the duration of their activity or result in technical improvement in their performance.

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