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Analysis of the use of Sodium Bicarbonate for the performance of surfing athletes

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Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

Purpose: Surfing is a sport in which the intensity and duration of training varies. Therefore, strategies that contribute to muscle attenuation may be efficient to improve surfers' performance. **Objective:** The aim of this study was to investigate the effectiveness of sodium bicarbonate on surfers' performance. **Methods:** Eighteen male volunteer surf athletes participated in the study, in which they were instructed to perform up to twenty shots of twenty meters of paddling under their own surfboard in a swimming pool. The method was carried out twice, with an interval of 72 hours between them, being randomized between previous supplementation of sodium bicarbonate diluted in water, alternating with placebo containing sodium chloride and water. The blood lactate (Bla) was collected immediately before and after the rowing tests. **Results:** The longest twenty-meter paddling shot time in the placebo group was 13.08 seconds (Bla 13.7 mg/dL after exercise) and the shortest was 9.89 seconds (Bla 15.1 mg/dL). On the day of bicarbonate ingestion, the longest time was 12.5 seconds (Bla14 mG/dL) and the shortest time was 9.1 seconds (Bla 15.5 mg/dL). **Conclusions**: The study showed that the administration of sodium bicarbonate positively affected the performance of surfers, resulting in a maximum improvement in paddle time and an increase in blood lactate.

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Keywords: Surfing athletes, blood lactate, performance.

Introduction

Surfing is becoming increasingly popular on beaches around the world, which means that the number of participants in this sport is steadily increasing [1]. With the inclusion of surfing in the 2020 Olympics, attention to professional surfing has increased, and more research has been conducted on the physical characteristics of competitive surfing athletes and the corresponding strategies to improve performance in this sport [2]. Surfing involves intermittent training runs that vary in intensity and duration [3]. The surfer's locomotion during training is done by paddling in a prone position on the board until they reach the wave of their choice. Once surfers enter the wave, they stand up, accelerate to the unbroken portion of the wave, and begin a series of maneuvers until the wave is completely over. The surfer's approach to the wave is strongly influenced by environmental conditions and variables such as wave formation, size and frequency, ocean currents and changes in tide levels [4]. In this way, the way the athlete presents himself on the wave and the intensity of his paddling during training is variable and also depends on the external conditions. However, most of the time the surfer paddles with moderate intensity combined with short periods of high intensity to get on the wave. In this way, both aerobic and anaerobic metabolism are engaged during surfing [5].

Since it is very difficult to evaluate a surfer's performance in the ocean, the use of stimuli similar to those required in surfing is intensively studied and evaluated to explore mechanisms that favor the surfer athlete's performance. Thus, the anaerobic stimulus can be evidenced by the parameters of performance, such as paddling in short periods of time observed in the practice of surfing to complete the entry into the waves [6].

In situations of anaerobic activity, the production of adenosine triphosphate (ATP) occurs without the presence of oxygen via the phosphagenic and glycolytic systems. In the glycolytic system, ATP production occurs through the breakdown of glucose to pyruvate and then to lactic acid. And when this is produced excessively, it is converted to lactate and leads to an accumulation of H+ ions, resulting in acidosis of the environment. The consequences of acidosis are seen in changes in the blood PH, i.e. acid-base balance, and this homeostatic imbalance is potentially detrimental in terms of athletic performance, as it affects muscle contractility and ATP production. [7] In a study by Borgonovo-Santos et al [8], it was found that the surfer is fatigued shortly after the first paddle sprint cycle during surf training, even with the rest breaks available, and this may negatively affect subsequent surf cycles. Therefore, finding mechanisms to reduce the effects of acid-base imbalance during anaerobic activities could be an excellent means to improve surfers' performance during their training. Given the lack of studies investigating the performance of surfing athletes, the present study investigated the metabolic response (BLA) of high performance surfers by administering sodium bicarbonate.

Methodology

After signing the free informed consent form, eighteen male volunteer surf athletes between the ages of 16 and 20 participated in this study. All athletes were administered a sodium bicarbonate solution (0.5 g/kg) 40 minutes before the practical test in the swimming pool. 72 hours later, the same method was alternated with a solution containing sodium chloride and water (placebo) in a randomized cross-over procedure. The placebo had the same properties as the intervention substance, so the participants could not tell them apart, only the researcher knew about it, which marked the study as single blind. There were no casualties in the study. The study was approved by the Ethics and Research Committee of the Universidade Metropolitana de Santos - CAAE: 50876221.9.0000.5509. Upon arrival at the test site, subjects had their blood lactate measured before and after exercise (Roche, model BM -Lactate) and underwent a progressive paddle test in the pool on their own surfboard.

They were instructed to perform a stroke at a maximum speed of 20 meters to determine the time to be observed as a basis for continuing the test.

The athlete then rested for 2 minutes and was instructed to perform up to 20 strokes 20 meters apart at 80% of their maximum speed. The test was stopped if the subject deviated 2 seconds from the maximum time achieved twice in a row or if he completed the idealized 20 shots of the test. At the end of each test, blood samples were collected from the distal phalanx of the finger of the hand (random selection of the finger) for analysis of blood lactate concentration.

The values of blood lactate and the time of the sets at maximum speed can be seen in Table 1 and Table 2.

Results

Maximal time and blood lactate levels (BLA) were measured before and after placebo (Table 1) and bicarbonate (Table 2) ingestion. The mean and standard deviation of the groups and the results are shown in Table 3. The longest time in the placebo group was 13.08 seconds (Bla 13.7 mg/dL after exercise) and the shortest time was 9.89 seconds (Bla 15.1 mg/dL). On the day of bicarbonate intake, the longest time was 12.5 seconds (Bla14 mG/dL) and the shortest was 9.1 seconds (Bla 15.5mg/dL).

The bicarbonate group had an advantage in the results analyzed, with a higher mean value in mg/dL of Bla and a shorter maximum time, i.e. a higher speed in performing the rowing strokes. The values obtained in the study for each continuous variable were ordered and described using the mean and standard deviation. To compare two sample populations, Student's t-test was used, with a significance level for $p < 0.05$.

Table 1. Description of the maximum time taken (in seconds) and lactate values before and after the test on the day when placebo (sodium chloride) was administered, for the volunteer athletes

Placebo			
Athletes male	**Maximum Time (seconds)**	**Lactate pré (mg/dL)**	**Lactate pós (mg/dL)**
01	10,98	3,9	18,4
02	10,95	3,8	16,7
03	10,45	4,1	12,4
04	10,25	2,0	15,2
05	11,96	2,3	11,7
06	10,65	2,8	7,5
07	9,89	1,9	15,1
08	10,49	2,6	12,7
09	13,08	1,5	13,7
10	10,26	3,5	15,7
11	10,80	3,8	16,4
12	10,82	3,3	16,4
13	11,08	2,3	14,7
14	11,78	2,5	15,5
15	11,73	3,5	17,3
16	11,5	1,6	19,7
17	11,76	1,9	15,1
18	9,58	2,2	15,2

Table 2. Description of the maximum time taken (in seconds) and lactate values before and after the test on the day that sodium bicarbonate was administered, for the volunteer athletes

Sodium Bicarbonate			
Athletes	**Maximum time**	**Lactate pre**	**Lactate pos**
01	10,83	1,7	19,6
02	10,43	1,9	17,9
03	10,35	2,9	15,9
04	10,14	1,1	15,5
05	12,3	1,0	12,2
06	10,2	2,1	13,3
07	9,98	2,2	16
08	10,04	2,4	10,1
09	12,5	1,5	14,0
10	10,18	4,7	21
11	10,40	3,3	16,4
12	10,76	3,3	19,6
13	11,38	2,1	16,4
14	10,80	2,5	15,7
15	11,35	5,4	20
16	10,63	4,3	15,7
17	12,29	4,9	21,7
18	9,10	5	15,5

Table 3. Description, by Student's t-test, of the mean and standard deviation of lactate values; maximum time; and number of doses in relation to the use of bicarbonate and sodium chloride (placebo). The level of significance accepted was p≤0.05.

Evaluation	Bicarbonate	Placebo	P value
Lactate	16,43 ± 3,1	14,83±2,7	0,04
Maximum time	10,68±0,8	10,88±0,6	0,05
Shots	16,35±5,2	16,35±5,2	

Discussion

The buffer system of carbonic acid (bicarbonate ion) consists of a weak acid (H_2CO_3) and the bicarbonate anion (HCO_3^-) as a conjugate base, which acts by the following reaction:

$H^+ + HCO_3^- \leftrightharpoons H_2CO_3 \leftrightharpoons H2O + CO2$

Studies have shown that hyperacidity negatively affects muscle activity and that HCO3- can help buffer the accelerated release of hydrogen ions associated with this intense anaerobic activity, thereby reducing hyperacidity. [9] An evaluation of amateur surfers [10] found that training aimed at improving aerobic performance increased athlete performance, even when that training was performed out of the ocean. The action of bicarbonate in the blood (HCO3-) is part of the acid-based homeostatic bicarbonate buffering system, which is important for regulating blood pH concentration and supporting metabolic functions. [11]

Assigned participants underwent testing and a relevant difference in lactate concentration was noted (p=0.04), showing a higher mean for the group using bicarbonate and a lower mean maximum time for the bicarbonate group compared to placebo (p=0.05). During the study, some episodes of diarrhoea were noted as an adverse effect with the use of sodium bicarbonate.

During exercise, submaximal performance is linked to oxygen consumption, which is part of the oxidative metabolism that provides energy to the body. Lactate is part of the anaerobic threshold, anaerobic glycolysis. The end product of this glycolysis is pyruvate, which is converted to acetyl-coenzyme A and participates in the Krebs cycle and cellular respiration. When energy demands are high, as in exercise, the accumulation of pyruvate is converted to lactate by the enzyme lactate dehydrogenase (LDH), which recycles nicotinamide adenine dinucleotide (NAD) and promotes the maintenance of glycolysis to provide energy. [12]

The additional buffering capacity of HCO3, derived from an exogenous form, resulted in an increase in blood lactate after exercise, presumably caused by increased efflux of H+, [13] suggesting that the buffering function was exerted in the expected manner. In surfing, the athlete paddles during moments of high intensity, when the muscles of the upper limbs are heavily used. [10] During activities that require high intensity muscular effort, acidosis may occur more frequently, which promotes a decrease in the athlete's performance. [14] The athlete is likely to experience a decrease in blood lactate.

In the study participants who ingested bicarbonate after performing the shots, the release of lactate was delayed longer compared to the placebo. This shows that the release of lactic acid was delayed, reducing its negative effects on the muscles of the athletes, suggesting the effectiveness of taking sodium bicarbonate as a buffering system.

Therefore, evaluating agents that aid in buffering muscle acidosis could provide potential benefits. Many buffering agents have been studied (sodium citrate, sodium phosphate, sodium lactate), but the evidence continues to support sodium bicarbonate (NaHCO3) as the most consistently effective agent for improving athletic performance. [15]

Conclusions

Administration of sodium bicarbonate had a positive effect on the performance of surfing athletes, resulting in a maximal improvement in paddle test time and a prolongation of the delay time of lactate release in the blood.

Declarations

Competing interests

The authors declare no conflict of interest.

Contributorship

Taliê Hanada wrote the manuscript, researched and designed; Kamilla Mayr wrote the manuscript; Rafael Knack reviewed the content; Renata Knack reviewed the content; Dilmar Guedes reviewed the data; Claudio Scorcine performed the statistical analysis and Rodrigo Pereira interpreted the results.

Acknowledgements

None.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Ethical approval information

The study was approved by the Ethics and Research Committee of the Universidade Metropolitana de Santos - CAAE: 50876221.9.0000.5509.

Patient involvement

Yes.

References

1. ^*Minghelli B, Paulino S, Graça S, et al. Time-motion analysis of competitive surfers: Portuguese championship. Revista da Associacao Medica Brasileira (1992), 65(6), 810-817. https://doi.org/10.1590/1806-9282.65.6.810*
2. ^*Langenberg L. C.,Vieira G., Heitkamp S. E., et al. The Surfer's Shoulder: A Systematic Review of Current Literature and Potential Pathophysiological Explanations of Chronic Shoulder Complaints in Wave Surfers. Sports medicine -*

open.2021,7(1), 2. https://doi.org/10.1186/s40798-020-00289-0

3. ^*Farley O. R., Abbiss C. R.,Sheppard J. M. Performance Analysis of Surfing: A Review. Journal of strength and conditioning research. 2017; 31(1), 260-271. https://doi.org/10.1519/JSC.0000000000001442*
4. ^*Barlow M. J., Findlay M., Gresty K, et al. Anthropometric variables and their relationship to performance and ability in male surfers. European journal of sport science.2014; 14 Suppl 1, S171–S177. https://doi.org/10.1080/17461391.2012.666268*
5. ^*Farley O. R, Harris N. K, Kilding, A. E.Physiological demands of competitive surfing. Journal of strength and conditioning research. 2012; 26(7), 1887-1896. https://doi.org/10.1519/JSC.0b013e3182392c4b*
6. ^*Farley O, Harris N. K, Kilding, A. E.Anaerobic and aerobic fitness profiling of competitive surfers. Journal of strength and conditioning research.2012; 26(8), 2243-2248. https://doi.org/10.1519/JSC.0b013e31823a3c81*
7. ^*Calvo J.L, Xu H, Mon-López D. et al. Effect of sodium bicarbonate contribution on energy metabolism during exercise: a systematic review and meta-analysis. J Int Soc Sports Nutr 18, 11 (2021). https://doi.org/10.1186/s12970-021-00410-y*
8. ^*Borgonovo-Santos M, Zacca R, Fernandes R. J.The impact of a single surfing paddling cycle on fatigue and energy cost. Scientific reports. 2021;11(1), 4566. https://doi.org/10.1038/s41598-021-83900-y*
9. ^*Wang J, Qiu J, Yi L, Hou Z, Benardot D, Cao W. Effect of sodium bicarbonate ingestion during 6 weeks of HIIT on anaerobic performance of college students. J Int Soc Sports Nutr. 2019 Apr 15;16(1):18. doi: 10.1186/s12970-019-0285-8.*
10. [a, b]*Godoy DF, Cadore EL, Feitosa WG, et al. Oxygen Uptake of Wave Surfers and Complementary Parameters in Front Crawl and Surfing-Paddling Tests. J Strength Cond Res. 2019 Jul 31. doi: 10.1519/JSC.0000000000003205.*
11. ^*Hadzic M, Eckstein ML, Schugardt M. The Impact of Sodium Bicarbonate on Performance in Response to Exercise Duration in Athletes: A Systematic Review. J Sports Sci Med. 2019;18(2):271-281.*
12. ^*Benetti M, Santos R, Carvalho T.Cinética de lactato em diferentes intensidades de exercícios e concentrações de oxigênio. Revista Brasileira de Medicina do Esporte [online]. 2000, v. 6, n. 2 [Acessado 27 Julho 2021], pp. 50-56. doi: https://doi.org/10.1590/S1517-86922000000200004*
13. ^*Hadzic M, Eckstein ML, Schugardt M. The Impact of Sodium Bicarbonate on Performance in Response to Exercise Duration in Athletes: A Systematic Review. J Sports Sci Med. 2019;18(2):271-281.*
14. ^*Macnaughton LS, Wardle SL, Witard OC, et al. The response of muscle protein synthesis following whole-body resistance exercise is greater following 40 g than 20 g of ingested whey protein. Physiol Rep. 2016 Aug;4(15):e12893. doi: 10.14814/phy2.12893.*
15. ^*Siegler JC, Marshall PW, Bishop D, et al. Mechanistic Insights into the Efficacy of Sodium Bicarbonate Supplementation to Improve Athletic Performance. Sports Med Open. 2016 Dec;2(1):41. doi: 10.1186/s40798-016-0065-9.*