Effects of a Fruit and Vegetable Sports Drink on Hydration and Oxidative Stress Recovery of Brazilian Professional Athletes

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Introduction

A healthy hydration status for athletes is the condition of healthy individuals who maintain their water balance at a relatively consistent level across exercise sessions, while a dehydration state, caused by a decrease of a 1% to 2% of body weight may cause poor performance and represents a risk to health. However, long before a risk to one's health is posed, dehydration can impair athletic performance [1,2].

Research examining the efficacy of sports beverages indicates that their intake results in better fluid balance restoration, following exercise in comparison to water [3]. For this reason, various products have been developed to, purportedly, enhance athletic performance to a greater extent than water alone [4-6].

Another recurring concern among athletes is the increased production of reactive oxygen species (ROS) induced by exercise [7], which can have adverse effects on performance and muscle recovery.

It is well known that excessive physical activity produces excess levels of ROS, especially in professional athletes after aerobic or anaerobic strenuous exercise, increasing oxidative stress biomarkers in blood and tissues [7-9]. Additionally, sex, age, and food intake directly affect ROS production and the balance between ROS and the antioxidant system capacity to preserve or restore homeostasis [10-13].

To ultra-endurance athletes, oxidative damage may persist for 1-month post-exercise, depending on the biomarker assessed. For these, it has been reported that reduced glutathione (GSH) levels remain depleted in blood after 28 days post-race [14]. Furthermore, the increase in the levels of inflammatory cytokines (IL-6), lactate production, associated with a decrease of both antioxidant capacity and renal function has also been observed [8].

The Electro Sensor Complex (ESC) has been used over the past decade as a method to assess, through sensors placed on the skin, biochemical data and body composition measurements, providing physiological data. It is a fast (less than 3 minutes), cost-effective and non-invasive method widely used in medical practice around the world. It is a method approved by the Food and Drug Administration (FDA-US) and the National Health Surveillance Agency (Anvisa-Brazil) [15-17].

The consumption of sports drinks has become widespread both for recreational and professional athletes because of their proposed energetic effects, and their ability to replenish electrolytes and prevent dehydration [18]. In this context, a natural sports drink may be an effective way to promote adequate water intake, electrolyte replacement and the additional benefit of providing dietary antioxidants whose positive effect on physical activity after recovery is still unclear and divides opinion in literature [19,20].

Thus, the objective of this pilot study was to evaluate the effect of a natural sports drink, made from whole fruit and vegetables (edible and non-edible parts), in hydration and oxidative stress markers, using a non-invasive method of detection in Brazilian jiu-jitsu and athletics sportsmen.

Materials and Methods

Beverage preparation

The following species of fruits were used: Sweet orange (Citrus sinensis), passion fruit (Passiflora edulis) and watermelon (Citrullus lanatus). The following species of vegetables were used: lettuce (Lactuca sativa), courgette (Cucurbita pepo), carrot (Daucus carota), spinach (Spinacea oleracea), mint (Mentha s.p.), tara (Colocasia esculenta), cucumber (Cucumis sativus) and rocket (Eruca sativa) [4].

Keywords: Bioactive compounds; Dehydration; Supplement; Oxidative Stress

Abstract

This pilot project aimed to investigate the hydration and recovery from oxidative stress in athletes from different sports, after hydration with water or with a natural sports drink made of fruit and vegetables, in addition to the supplementation effects caused by this drink, using the Electro Sensor Complex. The consumption of the natural sports drink provided all the athletes with better hydration levels when compared to hydration with water. To athletics practitioners, body mass loss (BML) was significantly lower after the consumption of the natural sports drink, ranging from -1.1 ± 0.4 (%) after supplementation and -1.77 ± 0.5 (%), without supplementation. The effects on the recovery from oxidative stress showed a significant difference in interstitial free-radical levels and cortisol for athletics practitioners as a result of the consumption of the natural sports drink. The consumption of the natural sports drink resulted in better responses regarding hydration and oxidative stress recovery of the athletes when compared to water intake.

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All vegetable species were purchased in a local market in the city of Rio de Janeiro (Brazil), in January 2015.

The concentrated juice was prepared, as previously reported [4], using the whole fruits and vegetables, and kept at -18°C in plastic bags after pasteurization (60°C for 60 min). The final formulation of concentrated natural sports drink is described in table 1.

Finally, to prepare the natural sports drink (NSD) water was added using the proportion 1:2 of frozen concentrated juice, followed by the addition of natural green colorant (Chlorophyll), mint flavoring, xanthan gum (0.3%, w/w) and sodium citrate (0.1%, w/w) as previously reported [21].

The upper limit of carbohydrate concentration was established at around 8% (w/v) and the interval of sodium content 460–1,150 mg L⁻¹ based on the suitable concentration for isotonic drinks [22].

Participants

A randomized pilot study was conducted on six healthy, non-smoking jiu-jitsu (n=3) and athletics practitioners (n=3) in Rio de Janeiro, Brazil, according to the guidelines laid down in the Declaration of Helsinki. All procedures were approved by the Ethics Committee of the Federal University of the State of Rio de Janeiro (CAS number: 0009.0.313.00008). All athletes were training for upcoming competitions when the experiment was performed and had not used supplements with antioxidants in the six months prior the intervention. Before the trials, all participants were informed about the aims of the study, potential risks and benefits, and how the intervention would be carried out. All participants signed an authorization form.

Procedure

To ensure a correct evaluation of the hydration status, the athletes received no orientation on pre-exercise hydration. At all steps, the athletes performed 60 minutes of aerobic exercises, with brief moments of anaerobic activity specific to their sports, considering competition preparation. There was no intervention into how the activities were usually carried out. Thus, intervention into the hydration of athletes was performed considering only the actual needs of each athlete for each sport during the training session. Immediately before and after each training, they were analyzed using the Electro Sensor Complex [15]. The interval between sessions was 5 to 7 days.

To supplementation assess, each athlete received two individual doses of the NSD (200 ml=1 dose) and was instructed to consume one in the morning and the other one in the evening for 5 days before trials.

Protocols: Control Assay (A): During exercise, they consumed water, freely, whenever they felt thirsty.

Hydration with an isotonic drink (NSD) without supplementation (B): During exercise, they consumed 3 ml.kg⁻¹ of isotonic drink every 15 minutes.

(C): Hydration with water after 5 days of supplementation with the sports drink (NSD). During exercise, they consumed 3 ml.kg⁻¹ of water every 15 minutes.

(D): Hydration with an isotonic drink (NSD) after 5 days of supplementation with the same sports drink. During exercise, they consumed 3 ml.kg⁻¹ of isotonic drink every 15 minutes.

All measures were obtained using the Electro Sensor Complex to assess: (1) body composition: Body mass index (BMI), fat body mass (FBM), lean body mass (LBM), total body water (TBW), intracellular body water (IBW), extracellular body water (EBW) using ES-BC (Electro Sensor-Body Composition); (2) biochemistry parameters: electrolytes – sodium (Na); potassium (K), chloride (Cl), phosphorus (P), magnesium (Mg) and free ions of calcium (Ca); Oxidative stress biomarkers - Nitric oxide (NO·), peroxynitrite (ONOO⁻) ; Leptin, lactic acid and cortisol using ES-GS (Electro Interstitial Scan-Galvanic Skin ); (3) Systemic Vascular Resistance (SVR), stroke volume (SV), cardiac output (CO), blood volume (BV), Systolic blood pressure (SBP) and Diastolic blood pressure (DBP) using EIS (Electro Interstitial Scan) [16].

The percentage changes were calculated according to the formula $\left(\frac{B-A}{A} \times 100\right)$ where, A was obtained before practice and B after practice.

Statistical analysis

The statistical program ASSISTAT 7.7 beta was used for the statistical analyses in addition to the ANOVA (Tukey’s test). P<0.05 was considered significant in all analyses.

Results and Discussion

Body composition and hydration status

In the present study, we initially evaluated the body composition of all athletes. All measures were taken before and after a regular practice day, before the competition. Therefore, the average age and height (means ± SD) of athletes and jiu-jitsu sportmen were 22.0 ± 3.41, 38.33 ± 2.14 (years) and 1.66 ± 0.05, 1.77 ± 0.08 (m), respectively. Their body characteristics (mean ± SD) can be found in table 2. All athletes were considered eutrophic according to their BMI, and the average total body water content was 60.04 ± 3.95 and 67.68 ± 1.09 (%) for jiu-jitsu and athletic practitioners, respectively, indicating that they were all normally hydrated before the trials, and this status was maintained across all protocols.

Percentage of body mass (BM) loss in the control assay was -2.3 ± 0.6 for athletics practitioners, while no BM loss was observed in jiu-jitsu athletes. Although there was no difference in body composition among protocols, a significantly smaller body weight loss when rehydrated with the NSD (B) and supplemented with the NSD followed by hydration with water (C) and the NSD (D) was observed for athletics practitioners, as in table 3.

Regarding jiu-jitsu athletes, only supplementation (C and D) ensured rehydration, although in this sport the athletes seem to present a lower loss in body water through sweat when compared to athletics.

During practice, jiu-jitsu athletes showed a higher loss of electrolytes which hydration with water was not able to replace, as shown in table 4. It was found that rehydration with the NSD (B) promoted a positive percentage change for all electrolytes, except for phosphorus (-7.14 ± 1.23%), ensuring an adequate electrolyte replacement. The effects of supplementation were also observed, where chlorine was the exception (-18.88 ± 2.0%; %) in that it presented a higher loss after supplementation (D) than the one seen in rehydration with water after supplementation.

Table 1: Final concentration of fruits and vegetables in concentrated natural sports drink.

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Amount (g.L⁻¹)</th>
<th>Fruits</th>
<th>Amount (g.L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mint</td>
<td>20</td>
<td>Orange</td>
<td>110</td>
</tr>
<tr>
<td>Rocket</td>
<td>20</td>
<td>Passion fruit</td>
<td>190</td>
</tr>
<tr>
<td>Lettuce</td>
<td>55</td>
<td>Watermelon</td>
<td>220</td>
</tr>
<tr>
<td>Spinach</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taro</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Courgette</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>130</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

shown in Table 5, jiu-jitsu athletes presented an increase in lactic acid of -9.67 ± 1.39 (A) and a better response was observed only after supplementation (D) - this was not, however, better than rehydration with water (20.0 ± 1.73; %) and the NSD (30.0 ± 2.99 b -2.3 ± 0.6 a). A decrease was observed only after supplementation (C and D). This effect on performance [24].

It has been reported that severe hyperthermia may be more common in high-intensity, short duration exercise, when thermal equilibrium is less likely to be achieved, especially in hot humid environments where water body loss is increased. In this study, however, all athletes were euhydrated and their body water losses during exercise were not characteristic of dehydration. Likewise, it is important to know the initial hydration status of these athletes, given the possibility that a fluid deficit incurred before exercise can increase physiological strain and reduce performance, although this effect has not been reported in all studies of the area [24].

In this study, the athletics practitioners present an average dehydration of -2.3% of body weight, after hydration with water (A), and smaller losses in the following protocols. A similar body weight loss (>2%) has been reported as enough to compromise physiologic function and negatively influence performance [25]. It has also been reported, however, that a body mass reduction of more than 2% has no significant effect on sprint performance, suggesting that sprinting would be "easier" with a lower body mass [2]. Despite this, to prevent excessive dehydration (>2% body weight loss), it is also necessary to minimize electrolyte imbalance [26], as well as strength and power losses that seem to be related to alterations in total body water. These alterations affect certain aspects, which are yet to be determined, of strength generation, which in turn may cause an adverse effect on performance [24].

Biochemical markers
As shown in Table 5, jiu-jitsu athletes presented an increase in lactic acid when hydrated with water (20.0 ± 1.73; %) and the NSD (30.0 ± 2.99 b). A decrease was observed only after supplementation (C and D). This differed from the behavior observed in athletics practitioners, when a better response was observed only after supplementation (D) - this was not, however, better than rehydration with water (A) - with a reduction in lactic acid of -9.67 ± 1.39 (A) and a better response was observed only after supplementation (D) - this was not, however, better than rehydration with water (A) - with a reduction in lactic acid of -9.67 ± 1.39 (A).
All acid-base indicators and nitric oxide (NO) of jiu-jitsu athletes and athletics practitioners presented a better response after protocols B and C (-19.97 ± 0.57; %). A significant reduction was observed in superoxide, hydrogen peroxide, hydroxyl radical and peroxynitrite radical after supplementation (D), as shown in table 5.

Jiu-jitsu athletes presented a higher production of leptin in all protocols except with supplementation (D), where the percentage changes were significantly lower. A greater change was observed in athletics practitioners with an increase of 41.86 ± 1.15 (%) after rehydration with NSD (B).

Interstitial production of cortisol was higher in athletics practitioners than jiu-jitsu athletes. Cortisol changes were only significant after supplementation protocols, presenting a percentage increase (3.96 ± 1.15; %) similar to water intake in jiu-jitsu athletes. For athletes practitioners, all interventions made with the NSD caused a lower increase in cortisol levels (30.03 ± 1.15; %).

It is well known that fruit and vegetables are the main source of antioxidant compounds in human diets [25-28]. Among them, phenolic compounds seem to play a major role in the prevention of oxidative stress-related diseases. In this study, no significant differences were observed in the antioxidant status between protocols A and D.

Table 4: Athletes cardiac parameters before and after exercise, and interstitial electrolytes percentage changes after hydration with different protocols

<table>
<thead>
<tr>
<th>Cardiac parameters</th>
<th>Pre-exercise</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVR1 (SRU)*</td>
<td>1323.50 ± 179.73a</td>
<td>1120.10 ± 116.06d</td>
<td>1197.10 ± 86.22b</td>
<td>1105.53 ± 139.76e</td>
<td>1130.86 ± 19.33c</td>
</tr>
<tr>
<td>SV2 (ml/beat)</td>
<td>89.16 ± 18.64a</td>
<td>77.36 ± 17.50c</td>
<td>69.53 ± 7.00c</td>
<td>72.7 ± 15.05d</td>
<td>78.9 ± 15.95b</td>
</tr>
<tr>
<td>CO3 (L/min)</td>
<td>6.13 ± 1.00d</td>
<td>6.80 ± 1.08bc</td>
<td>6.9 ± 0.75ab</td>
<td>6.96 ± 0.91a</td>
<td>6.73 ± 0.46c</td>
</tr>
<tr>
<td>BV4 (L)</td>
<td>5.065 ± 0.56d</td>
<td>5.39 ± 0.73a</td>
<td>5.30 ± 0.63a</td>
<td>5.29 ± 0.61b</td>
<td>5.26 ± 0.58b</td>
</tr>
<tr>
<td>SBP5 (mmHg)</td>
<td>138.25 ± 11.78b</td>
<td>128.33 ± 8.50e</td>
<td>142.33 ± 17.03a</td>
<td>131.0 ± 5.29d</td>
<td>134.0 ± 1.73c</td>
</tr>
<tr>
<td>DBP6 (mmHg)</td>
<td>80.66 ± 8.70b</td>
<td>77.33 ± 8.50c</td>
<td>84.33 ± 18.02a</td>
<td>77.0 ± 5.56d</td>
<td>75.66 ± 10.41e</td>
</tr>
<tr>
<td>Na and Ca (%)</td>
<td>-12.5 ± 2.16c</td>
<td>22.22 ± 3.84a</td>
<td>13.13 ± 4.83b</td>
<td>-12.5 ± 2.16c</td>
<td>29.09 ± 3.00a</td>
</tr>
<tr>
<td>K and Mg (%)</td>
<td>-12.5 ± 2.16c</td>
<td>0 ± 0b</td>
<td>-7.14 ± 1.23c</td>
<td>20.88 ± 2.00c</td>
<td>13.13 ± 4.83b</td>
</tr>
<tr>
<td>Cl (%)</td>
<td>-8.33 ± 1.44b</td>
<td>6.66 ± 1.15a</td>
<td>8.33 ± 1.44a</td>
<td>-8.33 ± 1.44a</td>
<td>-8.33 ± 1.44a</td>
</tr>
<tr>
<td>P (%)</td>
<td>12.5 ± 2.16a</td>
<td>-7.14 ± 1.23b</td>
<td>12.85 ± 4.22a</td>
<td>12.5 ± 2.16a</td>
<td>12.5 ± 2.16a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Jiu-Jitsu (n=3)</th>
<th>Athletics (n=3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-15.01 ± 0.57a</td>
<td>-19.97 ± 0.57b</td>
</tr>
<tr>
<td>O&lt;sub&gt;2&lt;/sub&gt;</td>
<td>6.93 ± 0.57b</td>
<td>10.35 ± 0.57a</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;2&lt;/sub&gt;</td>
<td>6.93 ± 0.57b</td>
<td>10.35 ± 0.57a</td>
</tr>
<tr>
<td>OH&lt;sup&gt;·&lt;/sup&gt;</td>
<td>-0.77 ± 0.57b</td>
<td>10.35 ± 0.58a</td>
</tr>
<tr>
<td>ONOO&lt;sup&gt;-&lt;/sup&gt;</td>
<td>-3.77 ± 0.57b</td>
<td>10.35 ± 0.58a</td>
</tr>
<tr>
<td>Leptin</td>
<td>22.16 ± 1.15a</td>
<td>22.16 ± 1.15a</td>
</tr>
<tr>
<td>Cortisol</td>
<td>3.96 ± 1.15b</td>
<td>12.0 ± 1.15a</td>
</tr>
</tbody>
</table>

Table 5: Biochemical markers percentage changes after rehydration following different protocols.

<sup>1</sup>Nitric oxide (NO·); <sup>2</sup>Superoxide (O<sub>2</sub>·); <sup>3</sup>Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>); <sup>4</sup>Hydroxyl radical (OH·); <sup>5</sup>Peroxynitrite (ONOO·).

Different letters in the same line mean significant difference (p<0.05). Mean ± SD obtained from triplicate.

(B, C, and D) on the stroke volume of athletics practitioners that, despite not having reached the standard average (120.45 ± 5.37), was significantly higher than after rehydration with water (A). The same effect was observed in jiu-jitsu athletes, only after supplementation with the sports drink (D).

Cardiac output, blood volume, and blood pressure were significantly different at all steps for both sports. However this difference was not relevant since rehydration with water caused similar effects.

It is also known that dehydration affects cardiovascular functions by causing a decrease in blood and plasma volumes, as well as in the stroke volume, which reduces cardiac output and impairs overall endurance capacity [36]. Thereby, an effective hydration protocol can influence the behavior of cardiac parameters, as observed by Moreno et al. [37], who studied the influence of hydration with water in cardiorespiratory parameters in 31 healthy young male volunteers. Thus, it is possible that hydration and supplementation with a NSD (C and D) had a positive effect on athletics practitioners’ hydration status which could impact performance.

Based on these results, we conclude that the natural sports drink was able to improve the hydration of all athletes at different levels, regarding their needs during exercise. Also, supplementation has a positive effect on stress markers, causing a reduction in radical and cortisol levels. These findings may benefit the sporting community who should consider this natural sports drink as a supplement and as a dietary intervention that could improve health and performance. Moreover, it is important to emphasize that no side effects were observed or reported by participants in this pilot study.

Acknowledgments

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