Effects of the Amount of Dietary Nitrates Consumption on Endurance Performance
膳食補充硝酸鹽對新加坡休閒運動員的耐力運動表現的影響

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Abstract

The current study examined the effects of dietary nitrates consumption on endurance performance of recreational athletes in Singapore. The consumption of dietary nitrates has been shown to reduce whole body oxygen cost of submaximal exercise and enhance tolerance to high intensity exercise. Beetroot, which is concentrated in dietary nitrates, is a popular natural food that has been associated with enhancement of endurance performance. Majority of studies on the effects of beetroot consumption on endurance performance have been carried out using 500ml of beetroot juice. To make the juice more palatable, and hence encourage consumption by the young athletes, this study used 250ml of beetroot juice, mixed with 250ml of apple and orange juice. 23 subjects (10 males and 13 females aged between 12 and 24) were recruited for the study. Subjects performed the Multi-stage Fitness Test (MST) on two separate days after consuming 500ml of Apple and Orange (AO, Control Group) juice or Apple, Beetroot and Orange (ABO, Experimental Group) juice. The VO2 max obtained from both tests were compared using a Paired Sample t-test. Paired Sampled t-test ($t = -0.08$, $p < 0.05$) showed that there was no significant difference between the VO2 max of the experiment group and the VO2 max of the control group. Results of the present study suggests that 250ml of beetroot juice combined with 250ml of apple and orange juice did not result in significant differences in endurance performance.

摘 要

本文旨在探討膳食補充硝酸鹽如何影響新加坡休閒運動員的耐力運動表現。過去研究顯示在日常飲食內攝取膳食硝酸鹽，可以降低亞極量運動的氧價，並增強對激烈運動的耐受力。由於甜菜根高含硝酸鹽，眾人深信食用甜菜根是能提升耐力運動的表現。多數研究在實驗內利用500毫升的甜菜根汁來探測它對耐力表現。為了鼓勵年輕運動員飲用甜菜根汁，本研究混合了250毫升的甜菜汁及250毫升的蘋果和橙汁。23名12歲至24歲的休閒運動員（10名男性與13名女性）參與本研究。實驗在分別兩天喝了500毫升蘋果與橙汁（控制組）或500毫升蘋果，橙與紅甜菜根汁（實驗組）之後，進行了多階段體能測試(Multi-stage Fitness Test 短稱 MST）。實驗採用相似樣本T鑒定法比較從這兩次MST測試到的最大攝氧量。相似樣本T鑒定（$t=-0.08$, $p<0.05$）顯示控制組與實驗組的VO2 max之間沒有顯著的差異。因此，本研究顯示250毫升甜菜根加入250毫升蘋果和橙混合汁對耐力運動表現沒有顯著的影響。

Introduction

Consumption of dietary nitrates has been shown to reduce whole body oxygen cost of submaximal exercise and enhance tolerance to high intensity exercise (Bailey et al., 2009). According to Jones (2014), consumption of nitrates, which is concentrated in green leafy vegetables and beetroot, could have positive effects on the mitochondria within our cells, reducing the oxygen cost during exercise. This means that with higher nitrate

concentration in the body system, the same amount of muscular force can now be generated using less oxygen, improving muscle efficiency and allowing athletes to exercise at a higher power output.

Beetroot is one of the more popular natural foods considered to help athletic performance. In a study by Lansley et al. (2011), nine competitive male cyclists consumed 500ml of beetroot juice which contained approximately 6.2mmol of nitrates before a cycling time trial displayed an improvement in cycling economy. The study indicated that the physiological effects of beetroot juice consumption was due to the nitrate content in beetroot.

In a study conducted by Wyle et al. (2013), the dose-response relationship between the volume of beetroot juice consumed and the physiological effects elicited was investigated, using 70ml, 140ml and 280ml of concentrated beetroot juice. The study concluded that consumption of beetroot juice containing approximately 5-8mmol of inorganic nitrate, induced an increase in plasma nitrite concentration, reduced blood pressure, and may positively affect the physiological responses to exercise.

However, there were several studies which produced contradicting results. A study by Cermak et al. (2012) on the effect of beetroot juice with positive results was conducted in physically active people or recreational athletes, but failed on competitive athletes. Well-trained athletes demonstrate increased endothelial function, vascular control, greater blood flow in muscles and are more metabolically efficient (reduced consumption of oxygen for a given workload). Since the ergogenic effects of dietary nitrates consumption are primarily induced by enhancing metabolic efficiency, there is a possibility that there is less room for further improvement of exercise oxygen cost and performance in athletes (Zafeiridis A, 2014).

While the consumption of beetroot juice have been found to enhance performance, there is a general perception that the taste of beetroot juice, by itself, is unpalatable, especially to younger athletes. To circumvent the problem, one possible solution could be to blend other fruits with beetroot. The extant literature suggests that an amount of 500ml of pure beetroot juice could bring about enhanced endurance performance. To add additional fruit juice to the recommended quantity of beetroot juice would mean consuming a large amount of fruit juice prior to physical activity. In this study, we experimented with a beverage that contained 250ml of beetroot juice and 250ml of apple and orange juice.

We hypothesized that our concoction of fruit juice containing beetroot, apple, and orange would enhance endurance performance of recreational athletes in Singapore.

Would athletes still be able to reap the same benefits consuming a reduced amount of beetroot juice at 250ml?

This study sets out to replicate the investigation of the effects of dietary nitrates consumption on endurance performance on the Singaporean recreational athletes, but with a reduced amount of beetroot.

Methodology

Subjects

A total of 23 subjects (10 male and 13 female aged between 12 and 24) performed the Multi-stage Fitness Test (MST) on two separate days after consuming 500ml of Apple and Orange (AO, Control Group) juice or 500ml of Apple, Beetroot and Orange (ABO, Experimental Group) juice.

11 subjects drank ABO juice while 12 subjects drank AO juice on the first day of the test. There was a crossover on the second day of the test and the 11 subjects drank AO juice while the 12 subjects drank ABO juice. The two tests were conducted with a 2-day rest in between to facilitate recovery, as suggested by Rhea et al., (2003).

Subjects consumed the juice 2.5 hours before performing the MST, as research has shown that peak nitrate levels occur 2-3 hours after consumption (Wylie et al., 2013).

Multi-stage Fitness Test (MST)

The MST is a maximal test used to evaluate cardiovascular fitness and measure one's VO2 max. The test consists of 23 levels, with each level lasting approximately 1 minute. Each level comprises of a series

of 20-meter shuttles where the starting speed is 8.5km/hr and increases by 0.5km/hr at each level (Leger and Lambert, 1982). Maximal oxygen uptake (VO2 max) is the measurement of the highest rate of oxygen consumption during maximal exercise. It is an indicator of one's maximal ability to utilise oxygen in the aerobic production of energy (Southard and Pugh, 2004).

Subjects ran back and forth between the 20-meter shuttles, in time with the beep sounds from an online MST audio file downloaded from Topend Sports. Each successful run of the 20 meter distance was a completion of the shuttle. Subjects were informed if they did not reach the end of the shuttle line in time once. The test was terminated when they were unable to follow the set pace of the "beeps" for two successive shuttles, and/or stopped voluntarily. The number of stages and levels completed by the subject was recorded (Aziz et al., 2005). The subjects' VO2 max was then calculated using an online calculator developed by Topend Sports from the published tables in Ramsbottom et al. (1988). The subject's results and VO2 max calculated from the two tests were then compared.

Results

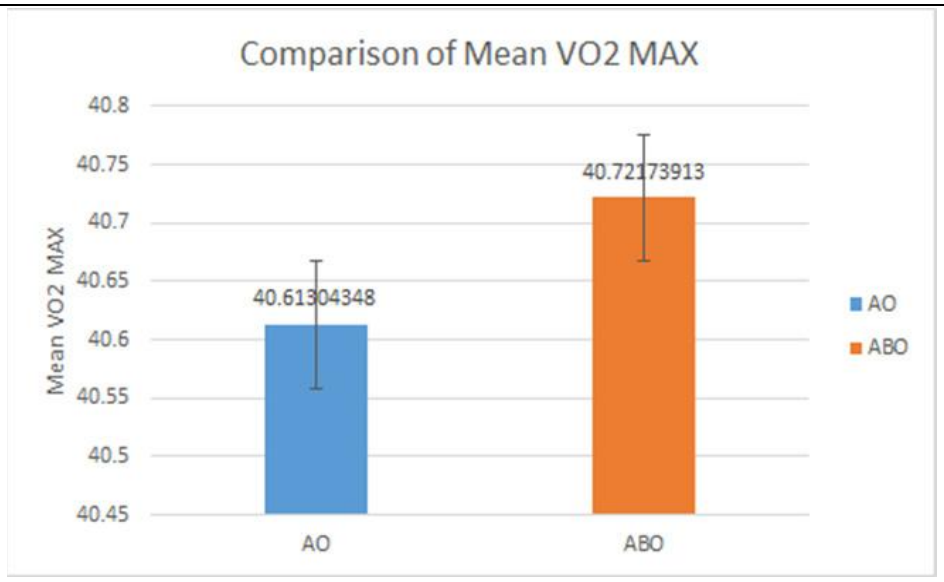

Figure 1. shows the comparison between the mean VO2 max of the control and experimental group.

Paired Sample t-test:
$t = -0.08$ ($p < 0.05$)

Paired Sampled t-test ($t = -0.08$, $p < 0.05$) shows that there is no significant difference between the VO2 max of the experiment group (mean = 40.72 ml/kg/min, SD = 12.73) and the VO2 max of the control group (mean= 40.61 ml/kg/min, SD = 13.75).

Discussion

The results show that there is no significant difference between the VO2 max of the experiment group consuming Apple, Beetroot, Orange juice and the control group consuming Apple and Orange juice. The reduced amount of beetroot in this study fails to deliver the result of enhanced endurance performance.

A possible reason for this study's failure to deliver the result of enhanced endurance performance may be due to the amount of nitrates in 250ml of beetroot juice which may be insufficient (<5mmol of nitrates) to induce ergogenic effects dietary nitrates consumption does. The supplementation of 250ml of beetroot juice, with 250ml other fruit juices, does not give the same outcome as studies using 500ml of beetroot juice.

Suggestion for future research

1. What the subjects do in terms of training and their diet during the two days between the two MSTs might have an impact on the findings of the study. There may be a need to better control the activity and diet of the subjects in future studies.

2. The Multi-stage Fitness Test is a maximal test and the results could be affected by the level of motivation of the subjects. Ways to enhance motivation should be considered.

3. Future research could explore the effects of endurance performance with increasing amounts of beetroot. (300ml, 350ml, 400ml etc.)

Conclusion

Consuming 250ml of beetroot juice (dietary nitrates) 2.5 hours before a beep test does not enhance the endurance performance of the Singaporean recreational athletes. The reduction in the amount of beetroot juice, and the corresponding reduction in the inorganic nitrate in the juice failed to induce the positive physiological responses to exercise that 500ml of beetroot juice have been found to provide.

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