Nitrate Supplementation and Exercise Performance

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Nitrate and Exercise

Several recent studies have addressed the influence of dietary nitrate supplementation on the physiological responses to exercise. Larsen et al. [1] first showed that 3 days of sodium nitrate supplementation (0.1 mmol/kg per day) reduced resting blood pressure and the O_2 cost of sub-maximal cycle exercise. Subsequently, our research group reported that enhancing NO bioavailability through supplementation of the diet with a natural foodstuff (nitrate-rich beetroot juice; table 1) reduces resting blood pressure and the O_2 cost of exercise and improves exercise performance [2–5]. In our first study on this topic [2], we found that 4–6 days of dietary nitrate supplementation (0.5 l of beetroot juice per day containing ~ 6 mmol nitrate) reduced the 'steady-state' O_2 cost of sub-maximal cycle exercise by 5% and extended the time to exhaustion during high-intensity cycling by 16% (fig. 1). These effects were highly surprising given that the O_2 cost of submaximal exercise has been considered to be essentially fixed. We and others have subsequently confirmed these findings in other populations and with different exercise modalities.

Applications

The positive effects of nitrate supplementation on the O_2 cost of submaximal exercise can be manifest acutely (i.e. 2.5 h following a 6-mmol nitrate 'bolus'), and this effect can be maintained for at least 15 days if supplementation at the same daily dose is continued [3]. Because beetroot juice contains compounds other than nitrate that might also be bioactive, we have developed a nitrate-depleted beetroot juice as a placebo. We found that nitrate-depleted beetroot juice had no physiological effects relative to a control condition whereas nitrate-rich beetroot juice

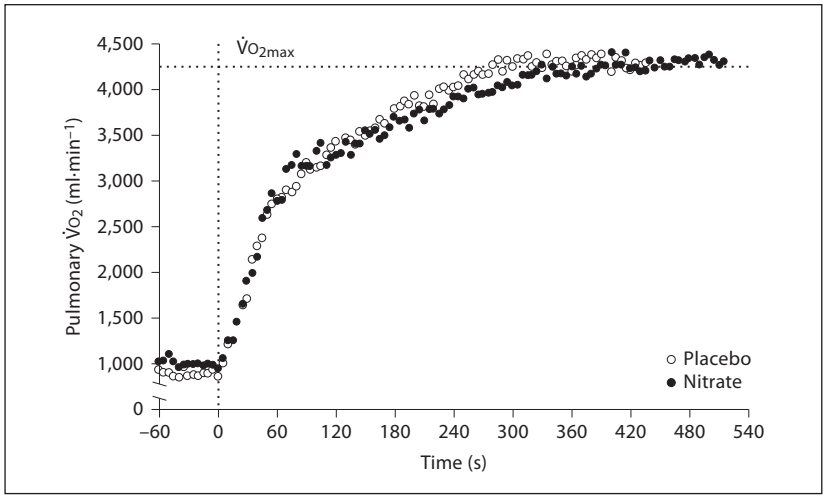

Fig. 1. Pulmonary oxygen uptake ($\dot{V}o_2$) for a representative individual during severe-intensity cycle exercise continued until the limit of tolerance following nitrate (beetroot juice) and placebo supplementation. The dotted vertical line represents the abrupt imposition of the work rate from a baseline of 'unloaded' cycling. The dotted horizontal line represents the $\dot{V}o_{2max}$ of the representative individual. Note the reduced $\dot{V}o_2$ 'slow component', delayed attainment of the $\dot{V}o_{2max}$ and longer time to exhaustion following nitrate supplementation.

Table 1. Nitrate content (mg/100 g fresh weight) of selected vegetables

Nitrate content	Vegetable
Very high (>250)	beetroot, spinach, lettuce, rocket, celery, cress, chervil
High (100–250)	celeriac, fennel, leek, endive, parsley
Medium (50–100)	cabbage, savoy cabbage, turnip, dill
Low (20–50)	broccoli, carrot, cauliflower, cucumber, pumpkin
Very low (<20)	asparagus, aubergine, onion, mushroom, pea, pepper, potato, sweet potato, tomato

reduced the O_2 cost of both walking and running, and extended the time to exhaustion by 15% [4]. These results confirm that nitrate is the key bioactive component of beetroot juice, though it cannot be discounted that other components (such as antioxidants and polyphenols) facilitate the bioconversion of nitrate to NO. Most recently, we have investigated the influence of acute dietary nitrate supplementation on 4-km and 16.1-km time trial performance in competitive cyclists [5]. We found that cyclists were able to produce a greater power output for the same rate of

pulmonary O_2 uptake, resulting in a 2.7% reduction in the time to complete both time trial distances.

Practical Recommendations

The available evidence indicates that dietary supplementation with 5–7 mmol nitrate (approximately 0.1 mmol/kg body mass) results in a significant increase in plasma nitrite and associated physiological effects including a lower resting blood pressure, reduced pulmonary O_2 uptake during sub-maximal exercise and enhanced exercise tolerance or performance [2–5]. This 'dose' of nitrate can readily be achieved through the consumption of 0.5 l of beetroot juice (or an equivalent high-nitrate foodstuff). Following a 5–6 mmol 'bolus' of nitrate, plasma nitrite typically peaks within 2–3 h and remains elevated for a further 6–9 h before declining towards baseline. Therefore, it is recommended that nitrate is consumed approximately 3 h prior to competition or training. A daily dose of a high-nitrate supplement is required if plasma nitrite is to remain elevated. It is presently unclear if, and in what ways, sustained dietary nitrate supplementation might impact upon adaptations to training. There is the possibility that uncontrolled high doses of nitrate salts might be harmful to health. In contrast, natural sources of nitrate are likely to promote health. For this reason, it is recommended that athletes wishing to explore possible ergogenic effects of nitrate supplementation employ a natural, rather than pharmacological, approach.

References

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