Dietary nitrate and exercise

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The beneficial effects of a vegetable-rich diet upon cardiovascular health and longevity are well established and have been partly attributed to the high inorganic nitrate content of foods such as spinach, lettuce and beetroot. Research has also suggested that supplementation with nitrate-rich beetroot juice can result in improvements in exercise performance. The aim of this article is to summarise recent findings and to discuss the practicalities and implications of nitrate ingestion.

Nitric oxide is an important physiological signalling molecule which is known to influence an array of biological processes and is essential for normal physiological functioning. It can be synthesised endogenously via the ‘classical’ oxygen-dependent L-arginine-NO synthase (NOS) pathway and also via the oxygen-independent reduction of nitrate to nitrite and subsequently, nitric oxide. Ingested inorganic nitrate is concentrated in the saliva and converted to nitrite by facultative anaerobic bacteria in the oral cavity. Once swallowed, some nitrite is further reduced to nitric oxide in the acidic environment of the stomach, whilst the remainder is absorbed, increasing the concentration of plasma nitrite ([NO$_3^-$]) and the bioavailability of nitric oxide. That antibacterial mouthwash can markedly attenuate the effects of nitrate ingestion on the increase in plasma [NO$_3^-$] and the reduction in resting blood pressure highlights the importance of the enterosalivary system in nitric oxide generation via the nitrate-nitrite reduction pathway. Supplementation with beetroot juice has been consistently found to reduce systolic blood pressure and positively affect the physiological responses to exercise in young, normotensive, recreationally active individuals (1, 2). In 2009, Bailey et al. (3) reported that 6 days of beetroot juice supplementation resulted in a significant reduction in steady state pulmonary oxygen uptake (VO$_2$) during moderate-intensity constant-work-rate cycling exercise. These results are remarkable as the VO$_2$-work rate relationship has traditionally been considered to be independent of age, health status, and aerobic fitness (4). Similar reductions in steady state VO$_2$ were also evident just 2.5 hours post ingestion of a single ‘bolus’ of beetroot juice (2). Vanhatalo et al. (2) found that the improved exercise efficiency during moderate-intensity cycle exercise was maintained when supplementation was...
Message from the President

Hello PINES Members!

Spring has sprung or harvest is settling in most places around the PINES world. This month’s featured article is all about beets and along with it there is a bit on beets as part of Sustainable PINES, a new addition to PINES NEWS! Thanks to World Beet Expert Andy Jones and his team for an excellent update on beets and exercise performance.

This PINES News also covers a newly launched conference that was held in Newcastle upon Tyne in the England in December, 2012. The International Sport and Exercise Nutrition Conference (ISENC) was a highlight for many of us who attended. The sessions were well organized and aligned along two tracks and are summarized here by Kathryn Brown, Senior Performance Nutritionist, Sport Wales. Thank you Kathryn for this great contribution.

We also have two global contributions from China and Hong Kong on recent advances in sports nutrition. Please submit your global updates to info@pinesnutrition.org. We need to know all of the great work you are doing in your regions and identify where PINES needs to provide support.

Finally, I would like to give you some PINES updates. At ACSM 2013, which is less than 2 months away, we are holding our famous PINES session as a Pre-Conference on Tuesday, May 28th from 16:00-18:00 on “Training and Nutrient Interactions”, followed immediately by the Annual PINES Reception. This year we are discussing the topic of the “Male Triad” with star moderator Dave Martin, Australian Institute of Sport and three women speakers (Burke, Manore, and Meyer) competing in a scientific debate. Please join us and register at www.pinesnutrition.org. The reception is partially supported by Powerbar and Nestle Nutrition Institute but still needs your gracious support. The purpose of the reception is for PINES members to network, obtain scientific updates, meet and toast to health, performance and friendships, and enjoy some good local food and beer!

We also have elections this year. PINES will post election ballots in the next few weeks for president and vice president along with several officers and co-officers We have been a stellar board but need you to step up and get involved!

It has been an honor for me to serve as your PINES president for many years but I too need to be replaced! I will continue to support the mission of PINES through giving my service to PINES where it will be most needed. I am also looking forward to new horizons to engage in food and sustainability!

Nanna Meyer, President

Dietary nitrate and exercise (continue)

continued for 15 days, indicating that extended beetroot juice supplementation does not provide any greater improvements in efficiency but that tolerance to the supplementation does not occur, at least over a 15 day period. Reductions in VO₂ have also been reported in two-legged knee extensor exercise (1) and treadmill walking and running (5). In contrast, no reduction in VO₂ was reported when subjects ingested beetroot juice that had been depleted of nitrate using an ion-exchange resin (5). This suggests that it is the high nitrate content of the beetroot that is responsible for the elicited physiological effects. However, it is important to note that beetroot juice contains a number of antioxidants and polyphenols, therefore, the possibility of nitrate working synergistically with one or more of these compounds to facilitate the reduction of nitrate to nitrite and nitric oxide, cannot be ignored (6). Plasma [NO₂⁻] has been reported to correlate with exercise tolerance in healthy humans (7). Consistent with this, several studies have demonstrated that when beetroot juice supplementation results in a significant elevation in plasma [NO₂⁻], there is an associated enhancement in exercise tolerance and/or performance in physically active individuals. More specifically, time to exhaustion during severe-intensity constant-work-rate cycling exercise (3), two-legged knee-extensor exercise (1), and severe-intensity treadmill running (5), was improved by 16%, 25% and 15%, respectively. Furthermore, incremental single-legged knee-extensor (5) and cycling (2) exercise performance improved as a result of beetroot juice supplementation. Hopkins et al. (8) have suggested that a ~20% improvement in time to exhaustion is likely to result in a ~ 1-2 % improvement in exercise performance. These predictions have been supported by Lansley et al. (9) who noted a 2.7 % reduction in the time to complete both a 4.0 and 16.1 km cycle time trial after an acute dose of beetroot juice, and Cermak et al. (10) who recorded a 1.2 % reduction in time to complete a 10 km cycle time trial following 6 days of beetroot juice supplementation. More recently, a 4.2 % improvement in performance during the Yo-Yo Intermittent Recovery 1 test, which mimics the high-intensity
Dietary nitrate and exercise (continue)

intermittent exercise undertaken by team sports players, has been reported (11). In addition, a 0.4% improvement in repeated maximal 500 m rowing ergometer repetitions has been reported (12). The mechanisms underlying the effects of nitrate supplementation remain debated but include a reduced ATP cost of muscle force production (3), an improved mitochondrial efficiency (13), increased muscle blood flow with preferential distribution to Type II muscle fibres (14) and changes in intracellular calcium handling leading to increased force production by Type II muscle fibres (15).

It is noteworthy that recent studies have indicated that acute beetroot juice supplementation may be less effective as an ergogenic aid in highly-trained endurance athletes (16, 17). This may be due to the low-intensity and long duration of the exercise protocols used in those studies (16, 17). Also, in comparison to less trained individuals, endurance athletes tend to have higher baseline plasma [NO₃⁻] values, greater training-related NOS activity, a higher proportion of type muscle fibres and greater mitochondrial and capillary density, all of which may reduce the potential benefits of nitrate supplementation (17).

Historically, exposure to nitrate has been considered hazardous to health due to a potential increased risk of gastric cancer. Today, dietary nitrate is being reconsidered as an essential nutrient which positively affects physiological functions and benefits human cardiovascular health and exercise performance (18).

Dietary nitrate, specifically beetroot juice, has emerged as a promising new ergogenic aid to sports performance. However, this area of research is still in its infancy and many questions remain unanswered. Future studies are likely to shed light on the dose-response relationship and optimal supplementation regimens, the interaction of beetroot juice with training status and exercise intensity and duration, and the influence of beetroot juice in non-athletic (elderly and clinical) populations. Watch this space!

Andy Jones is professor in applied physiology and Head of Sport and Health Sciences at the University of Exeter, United Kingdom. From 2nd left to right, James Kelly, Sinead McDonagh and Lee Wylie, current PhD students of Dr. Jones.

References
Feedback on The International Sports and Exercise Nutrition Conference, Newcastle, England reported by Kathryn Brown

The International Sports and Exercise Nutrition Conference 2012 was held at Northumbria University in December 2012. The full packed 3-day programme identified two main themes – one focused on sport and performance issues and one on physical activity and health. Professor Ron Maughan introduced the conference with a fascinating history of sports nutrition at the Olympic Games from 1908-2012. A great mix of practical and research focused sessions followed. The summary below highlights some key messages:

Focus on quality not just quantity

Nigel Mitchell (Head of nutrition, Team Sky) gave a fantastic insight into the Team Sky nutrition approach during the Tour de France. For success it is critical to understand the demands of the event. The demands of the Tour de France are phenomenal – riders competing in varying conditions ranging from a snow storm to 40 degrees with mean daily energy requirements of 4000-9000kcal and fluid requirements as high as ≤10L! Nigel highlighted that understanding the demands is the easy part but for Team Sky it’s the implementation and attainment of strategies which is key:

1. Maintain performance – with sufficient fluids & fuel
2. Promote recovery to ensure daily recovery
3. Prevent weight loss and especially lean tissue mass
4. Promote health & well being

To achieve the above the Team Sky approach isn’t just about providing calories but to provide the nutrients needed for health and performance. To do this Nigel emphasised it was key to ensure the basics are covered all the time with a big emphasis on quality – highlighted by the use of a bespoke olive oil pressed in Italy and using fruit & vegetable juices at meal times to increase nutrient density without adding ‘bulk’ to meals.

Sleep Low - Withholding carbohydrate in recovery?

Professor John Hawley, RMIT, presented research demonstrating that training adaptations can be enhanced to a greater extent when a portion of workouts are undertaken with low muscle glycogen and/or low exogenous glucose availability as opposed to undertaking all workouts with normal glycogen stores. He reported that commencing endurance exercise with low muscle glycogen stores leads to an increase in the maximal activities of selected enzymes involved in carbohydrate metabolism (including AMPK, GLUT4, hexokinase and PDH) and amplifies the expression of the major transcriptional factor for mitochondrial biogenesis, PGC-1α. A practical limitation to this model is that subjects often self-select lower power outputs when exercising in a low glycogen state which may be counter intuitive for elite athlete preparation. A new model which may enable athletes to maintain training quality may be to undertake a high-intensity quality workout in the evening, withhold carbohydrate in recovery and ‘sleep low.’ Investigations are currently taking place so watch this space!

Consider a cocktail approach

Dr David Nieman, Appalachian State University, discussed the role of nutritional agents in attenuating immune changes and inflammation following intensive exercise. Athletes should consume adequate energy, carbohydrate and protein and avoid deficiencies of micronutrients to maintain immune health. Evidence also suggests that some nutritional supplements, including flavonoids such as quercetin and lactobacillus probiotics may enhance immune function and reduce illness rates in exercise stressed athletes. Some have questioned whether immunonutritional support interferes with important signalling mechanisms for training adaptations but Dr Nieman suggested that nutritional supplements only partially block exercise-induced immune dysfunction, inflammation and oxidative stress and are therefore likely to just ‘take the edge off’ but not blunt signalling. Whereas early studies focused on large doses of vitamin and mineral supplements, a new hypothesis suggests that the “pharma” approach is not as effective as a “cocktail” approach. This may be due to the diversity of the immune system or that the primary target of the immune
Cocktail Approach continued...

supplements should be the non-specific innate immune system. Quercetin supplementation when combined with other polyphenols and food components (e.g. green tea extract, isoquercetin, and fish oil), substantially reduces exercise-induced inflammation and oxidative stress with chronic augmentation of innate immune function.

Focus on vitamin D

Vitamin D plays an important role in calcium regulation and bone health and emerging evidence suggests that it has potential to impact the health and performance of athletes due to its roles in immunity, inflammatory modulation and skeletal muscle function. Dr Enette Larson-Meyer, University of Wyoming updated on the current research around vitamin D deficiency in athletic populations highlighting that athletes fail to meet dietary recommendations of vitamin D. In athletes supplementation with 5000IU/day for 8 weeks improved 10m sprint times and vertical jump performances.

It is important to assess the vitamin D status in athletes and assessment should follow an A, B, C, D, E approach:

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<tbody>
<tr>
<td>A</td>
<td>Anthropometry</td>
<td>e.g. height, weight, BMI, body fat</td>
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<tr>
<td>B</td>
<td>Biochemical</td>
<td>Serum 25(OH) Vitamin D – several times per year Others for a more complete assessment include: Alkaline phosphatase, serum calcium, serum phosphorous)</td>
</tr>
<tr>
<td>C</td>
<td>Clinical</td>
<td>History, physical exam, bone density, medications</td>
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<tr>
<td>D</td>
<td>Diet</td>
<td>e.g. Vitamin D, Calcium, Fat content, phosphate, magnesium</td>
</tr>
<tr>
<td>E</td>
<td>Environment</td>
<td>e.g. Training regimen, latitude, altitude, climate, clothing, sunscreen use &amp; type, sun exposure, tanning bed use</td>
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Table 1. A, B, C, D, E for vitamin D assessment

Recommendations can be individualised following assessment. Athletes should meet vitamin D requirements through regular supplementation, sensible sun exposure or a combination of both. Clinical practice guidelines of the Endocrine Society recommend a maintenance dose of 1500-2000 IU/day and if deficiency is identified (<50nmol/l) to treat with 50000 IU/wk for at least 8wks followed by maintenance therapy.

Update on inadvertent doping through meat consumption

Over the past few years increasing numbers of dietary supplements containing undeclared doping substances have been detected. As well as updating on the risk of nutritional supplements Dr Hans Geyer, German Sport University Cologne, also updated on the risk that some meat products may be connected with doping risk. Recent investigations have shown that the doping substance clenbuterol is misused in some countries as a growth promoter in cattle feeding, with the great extent of this problem in China and Mexico. In 2011 analysis of urine samples of 28 travellers (between 15th Sept 2010, and 15th Jan 2011) travelling from China to Germany, resulted in findings of low concentrations of clenbuterol in 22/28 urine samples. In the 2011 U17 FIFA World Cup in Mexico, positive clenbuterol findings were identified in 52% of samples (109/208) across all 3 cities where competitions were held (range of positive tests 16-89%). Players from 19/24 teams tested positive for clenbuterol and in 4 of those teams all players had positive tests. One of the most important factors playing a role in identifying clenbuterol in subjects is the sensitivity of the test.

The International Sports and Exercise Nutrition Conference is back on the books for December 2013! As soon as we know more we will let you know the location and date!
Sports nutrition is a new and growing career in China with an increased demand by professionals and athletes since the 2008 Beijing Olympic Games. Training courses in sports nutrition are presented by private organizations and universities, whilst some are presented through collaboration with relevant government departments. Currently there is no unique registration body for sports nutritionists/dietitians in China and Hong Kong. Dietitians, nutritionists, coaches, athletes and students with a major in sports and exercise, and physical education teachers are all eligible to enroll in the existing sports nutrition courses. Dietitians in Hong Kong who are interested in sports nutrition can either further studies through their own registration bodies or complete the IOC Diploma in Sports Nutrition.

By Daphne (Mei-yi) Wu, MSc, IOC Grad Dip Sport Nutr, State Registered Dietitian, PhD Candidate, University of Exeter, UK.

In Hong Kong, providing scientific support to elite athletes is one of the most important mandates of the Hong Kong Sports Institute (HKSI). The department of Sports Science and Physical Education at the Chinese University of Hong Kong has developed a close collaboration with the researchers of HKSI in the area of sports nutrition and exercise physiology. The Sport Nutrition Unit at the HKSI is responsible for monitoring the nutritional status and body composition of elite athletes. Their caloric intake, as well as their macro- and micro-nutrient consumption is carefully monitored in order to complement their training load, depending on their competition schedule. The Sport Nutrition Unit also works closely with their catering department to ensure a tasty variety of food choices are provided, which include optimal nutrients for training, competition and recovery. In addition to individual counselling, the Unit also provides lectures and athlete education to ensure that competitors at different levels will learn about the importance of nutrition in training and competition. Lastly, the Chinese University of Hong Kong has made tremendous efforts in ensuring the quality of the sports nutrition course in their postgraduate programmes. Over the years, they have invited many renowned speakers to join the teaching team, such as our Adjunct Professors, Dr Ron Maughan and Dr Susan Shireffs from the UK and other academics from China, Taiwan and Australia.

In mainland China, Sports Nutrition has also become a topic of particular interest to both the general population and to professional athletes. Nutritional support for full-time athletes is usually conducted by researchers or specialists working within the professional sport teams. Some sport teams also get support from universities or specialised regional sports institutes. For sports teams at national level, the related staff will be trained by the Centre for Sports Nutrition at the National Institute of Sport Medicine. There are also different levels of training and athlete education on the topic of sports nutrition that are organized by different national associations, such as the China Sports Nutrition & Food Society (CSNFS) as well as various university departments with a research focus on sports nutrition.

By Stephen H. Wong, PhD, FACSM Department of Sports Science and Physical Education The Chinese University of Hong Kong

Sustainable PINES: a note on beets

Beets, also called Beta Vulgaris, were first known by the Romans but the root wasn’t cultivated until much later. The Germans were first to integrate beets into their diet and the Swiss made the first beet root juice (Biotha), which is still available as one of the few brands around the world. Beets are rich in phytonutrients and folate, but recently beets have become new staples for athletes and active individuals due to their high nitrate content and the reported health and performance benefits. While we are most familiar with purple beets, there are many other kinds, all similar in nitrate content. Nitrate content in beets is dependent on the soil and this can vary by region and season. Growing your own beets isn’t difficult at all. In fact, you can grow them from spring to fall and in succession, trying out the various types! Beets are still best if organically and locally grown, and these you can buy at your local farmer’s market!
Feedback on The International Sports and Exercise Nutrition Conference (continue)

Carbohydrate during exercise – how much and what kind? (continue)

Transporter SGLT1 but when additional carbohydrates are ingested that are absorbed by other transporters (e.g. fructose uses GLUT5) the rate of carbohydrate oxidation is increased. New guidelines of carbohydrate ingestion have been suggested: Recommendations are not based on body weight as body weight doesn’t affect exogenous carbohydrate oxidation – it’s limited by the absorption of the carbohydrate.

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<thead>
<tr>
<th>Duration of exercise</th>
<th>Carbohydrate recommendation</th>
<th>Type of carbohydrate</th>
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<tr>
<td>&lt;30mins</td>
<td>No Carbohydrate</td>
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<tr>
<td>30-75mins</td>
<td>Very small amounts/ mouth rinse</td>
<td>Most forms</td>
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<tr>
<td>1-2hr</td>
<td>Small amount - up to 30g/hr</td>
<td>Any type</td>
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<tr>
<td>2-3hr</td>
<td>Moderate amounts – up to 60g/hr</td>
<td>Carbohydrate that is oxidised easily (e.g. glucose)</td>
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<tr>
<td>&gt;2.5hr</td>
<td>Large amounts – up to 90g/hr</td>
<td>Only multiple carbohydrate sources (e.g. glucose combined with fructose)</td>
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By Kathryn Brown,
Senior Performance Nutritionist, Sport Wales

If you are going to a conference and would like to summarize it for PINES
please email it to info@pinesnutrition.org