High Performance Nutrition

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Mahidol University

6th World Congress of Racket Sport Science
## Nutritional challenges for racket sports

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# Carbohydrate intake recommendations during exercise

<table>
<thead>
<tr>
<th>Duration of exercise</th>
<th>Amount of carbohydrate needed</th>
<th>Recommended type of carbohydrate</th>
<th>Additional recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–75 minutes</td>
<td>Small amounts or mouth rinse</td>
<td>Single or multiple transportable carbohydrates</td>
<td>Nutritional training recommended</td>
</tr>
<tr>
<td>1–2 hours</td>
<td>30 g/hour</td>
<td>Single or multiple transportable carbohydrates</td>
<td>Nutritional training recommended</td>
</tr>
<tr>
<td>2–3 hours</td>
<td>60 g/hour</td>
<td>Single or multiple transportable carbohydrates</td>
<td>Nutritional training highly recommended</td>
</tr>
<tr>
<td>&gt; 2.5 hours</td>
<td>90 g/hour</td>
<td>ONLY multiple transportable carbohydrates</td>
<td>Nutritional training essential</td>
</tr>
</tbody>
</table>
Carbohydrate & the brain

- Studies showed performance improvement with CHO ingestion during high intensity exercise <1h
  - normal blood glucose, enough glycogen storage

- Potential role of CHO & central nervous system
  - brain sensing CHO presence via receptors in mouth & oral space

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Mouth rinsing options
What does the evidence say?

Effects of carbohydrate mouth rinse on endurance performance

Consistent performance benefits with carbohydrate mouth rinse

Most studies are around 1h exercise and most (not all) in fasted state. Effects seems smaller when fed.

Time to exhaustion (TTE) usually exaggerates differences
Practical recommendations

• CHO rinsing for ~5-10s ➔ HI endurance performance of 30-70min

• Maybe beneficial for athletes with GI discomfort

• Potentially useful strategy for weight management
  – ↓ perception of effort and/or higher exercise intensities without the intake of additional calories

• Must practice rinsing during training
  – disruptions to breathing and/or concentration (Gam et al., 2013).

• Consume a high-CHO meal 2-3h before exercise & ingest/rinse small volumes of a CHO-containing solution periodically throughout HI endurance exercise
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Hydration issues in racket sports

- Indoor vs Outdoor
- Rules dictate opportunities to drink
  - Between games & sets
- Tennis has “extreme heat” policy
  - Players can generally access fluids kept at the side of the court or in close proximity
  - Matches can span from brief (~15 min) to long (~6 h)
  - Competition is usually conducted over a series of rounds, either on the same day or over a number of days, causing a potential carryover of fluid deficits between matches
Limited hydration data in the literature

• Sweat rates appear to differ according to the caliber of the athlete
  – Elite and sub-elite players = ~1,000–2,000 ml/h
  – Recreational players = ~600–800 ml/h
• Mean BM changes over a match were 0-1% BM but wide standard deviation
  – So some lost >2% BM and some gain weight (over-drank)
• Mean fluid intakes of ~800–1,500 ml/h were reported, with some individuals, including professional women players, consuming ~2,000 ml/h.
• Many players started a match with mild dehydration (mean USG >1.020)
  – Pronounced when they were required to play two matches in a day
Practical recommendations

- Start collecting own data, particularly during tournaments with extreme conditions
  - Substantial fluid losses in some players in these situations particularly during tournaments when incomplete recovery from the previous match may have occurred

- What information to collect?
  - Urine specific gravity (morning sample)
  - Body weight before & after training/match (sweat rate)
  - Monitor \textit{amounts} of fluid consumed
  - Monitor \textit{types} of fluid consumed
    - Intention to consume other ingredients found in drink influences hydration practices

- Consider trialing “ice slushie” as a pre-cooling method
The role of glycerol

- No longer on the WADA-banned substances list
- Due to its osmotic properties, glycerol can be used in combination with excess fluid to cause fluid retention and hyperhydration ("plasma expander")
  - By inducing an osmotic gradient that enhances renal water reabsorption
- Advantageous in situations in which dehydration may negatively affect performance
  - Negate heat stress & in extreme conditions
- Dose = 1.0–1.2 g glycerol/kg BM + ~25ml/kg fluid
Glycerol & sports performance

- Improvements to performance include increased endurance time to exhaustion by up to 24%, or a 5% increase in power or work
  - Thermoregulatory and cardiovascular changes from increased plasma volume and sweat rates, as well as reduced core temperature and ratings of perceived exertion
- Some studies have found no performance benefits during either prolonged exercise or specific skill and agility tests
  - ?racket sports
- Potential side effects
  - Weight gain, nausea, gastrointestinal discomfort, dizziness & headaches
- Watch this space!
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The role immunonutrition
Figure 1. A schematic of the way that the gut microbiota may contribute to sporting performance. The microbiota exerts strong influence over the immune system, which in turn is also dependent on nutrient status and metabolism, to reduce the risk of infection. Specific microbial species produce short chain fatty acids that act as fuel for colonocytes along with other nutrients that exert an anti-inflammatory influence on immune system and energy for exercise. Digestion of starches and the liberation of energy via the microbiota may impact on metabolism and subsequent energy for exercise. The response of the microbiota to dietary macronutrients further suggests that changes in the composition of microbial species to high protein or high carbohydrate diets may have direct implications for exercise metabolism.
Probiotics

The Difference Between Probiotics and Prebiotics

This is your gut (intestines)

Probiotics

- Probiotics are alive!
- Usually bacteria or yeast
- Aid digestion & other health benefits
- **Good sources are:**
  - Yogurt, kefir, buttermilk, aged cheese, sauerkraut, kimchi, sourdough bread, miso, tempeh, kombucha, beer, wine

Prebiotics

- Prebiotics are a form of fiber
- Serve as food for probiotics!
- **Good sources are:**
  - Chicory root, Jerusalem artichoke and dandelions
- **Foods you'll actually eat:**
  - Garlic, leeks, onions, whole wheat, fruits, vegetables, legumes

- Probiotics = live lactic acid bacteria (capsule, powder or selected dairy products)
- Compliment the normal GI flora by enhancing gut immunity against GIT infection

Want to know what's in your food?
Get the Fooducate APP

www.fooducate.com

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## What does the literature say?

### Table 1: Effect of probiotic supplementation on upper respiratory symptoms (URS) in athletic cohorts ranging from healthy active individuals through to elite athletes

<table>
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<tr>
<th>References</th>
<th>Study design and participants</th>
<th>Intervention</th>
<th>Impact on URS</th>
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<tbody>
<tr>
<td>Clancy et al. [119]</td>
<td>Double-blind placebo-controlled trial of 18 healthy and nine fatigued recreational athletes over 4 weeks</td>
<td>Probiotic (<em>Lactobacillus acidophilus</em> LAFT1-L10 strain) daily</td>
<td>Reversal of defect in IFN-γ secretion from T cells (viral control mechanism)</td>
</tr>
<tr>
<td>Cox et al. [120]</td>
<td>Double-blind placebo-controlled trial of 20 healthy, elite male distance runners over 16 weeks</td>
<td>Probiotic (<em>Lactobacillus fermentum</em> VRI-003 strain) daily</td>
<td>Reduced incidence of URS by 50% and reduced severity of symptoms and trend for higher IFN-γ secretion from T cells (p = 0.07)</td>
</tr>
<tr>
<td>Gleeson et al. [79]</td>
<td>Double-blind placebo-controlled trial of 84 endurance athletes over 16 weeks</td>
<td>Probiotic (<em>Lactobacillus casei</em> Shirotai strain) daily</td>
<td>Reduced the number of URS episodes by ~50%; higher S IgA level in those taking probiotics</td>
</tr>
<tr>
<td>Haywood et al. [86]</td>
<td>Single-blind, placebo-controlled, double-arm crossover trial of 30 rugby players, 4 weeks per treatment separated by a 4-week washout</td>
<td>Probiotic (<em>Lactobacillus gasseri, Bifidobacterium longum, Bifidobacterium bifidum</em> strains) daily</td>
<td>No difference in the incidence of URS</td>
</tr>
<tr>
<td>West et al. [87]</td>
<td>Double-blind placebo-controlled trial of 88 well-trained recreational cyclists over 11 weeks</td>
<td>Probiotic (<em>Lactobacillus fermentum</em> VRI-003 strain) daily</td>
<td>No significant effects on URS; reduction of LRI in male cyclists by a factor of 0.31 but a 2.2-fold increase in LRI in female cyclists</td>
</tr>
<tr>
<td>Gleeson et al. [76]</td>
<td>Double-blind placebo-controlled trial of 54 endurance athletes over 16 weeks</td>
<td>Probiotic (<em>Lactobacillus salivarius</em> strain) daily</td>
<td>No difference in the incidence of URS</td>
</tr>
<tr>
<td>Kekkonen et al. [75]</td>
<td>Double-blind placebo-controlled trial of 141 marathon runners over 3 months</td>
<td>Probiotic (<em>Lactobacillus rhamnosus</em> GG strain) daily</td>
<td>No difference in the incidence of URS</td>
</tr>
<tr>
<td>West et al. [88]</td>
<td>Double-blind placebo-controlled trial of 465 physically active individuals for 150 days</td>
<td>Probiotics (<em>Bifidobacterium animalis</em> subsp. <em>lactis</em> Bi-04) daily or <em>Lactobacillus acidophilus</em> NCFM and <em>Bifidobacterium animalis</em> subsp. <em>lactis</em> Bi-07 daily</td>
<td>Bl-04 associated with a significant 27% reduction in the risk of URS compared with placebo</td>
</tr>
</tbody>
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*IFN* interferon, *LRI* lower respiratory illness, *S IgA* salivary immunoglobulin A

6th World Congress of Racket Sport Science  Colbey et al. 2018
Proposed mechanisms of action for enhancing immune function in the GI & respiratory tract with probiotics

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<tr>
<th>Proposed mechanisms</th>
<th>References</th>
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<tbody>
<tr>
<td>Enhanced epithelial cell barrier function</td>
<td>Lambrecht et al. (2012)</td>
</tr>
<tr>
<td>Modified macrophage/lymphocyte cytokine secretion</td>
<td>Clancy et al. (2006)</td>
</tr>
<tr>
<td>Antibacterial effects of colonisation</td>
<td>Strober (2011)</td>
</tr>
<tr>
<td>Upregulation of antimicrobial peptides and antioxidant compound/enzyme production</td>
<td>Martarelli et al. (2011)</td>
</tr>
<tr>
<td>Induction of regulatory T-cells</td>
<td>Liu et al. (2010)</td>
</tr>
<tr>
<td>Augmentation of communication between immune system and commensal microbiota</td>
<td>Otczyk and Cripps (2010), Lefrançois and</td>
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<td></td>
<td>Puddington (2006)</td>
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<tr>
<td>Involvement of short-chain fatty acids in Treg cell homeostasis</td>
<td>Geukenig et al. (2013)</td>
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</table>

Figure 2. Schematic diagram of the mucosal immune system. Interaction with environmental antigens (A) the microbiota, microbial metabolites, antimicrobial proteins (AMPs) (C) and dendritic processes (B) provide the mucosal immune system with multiple transient activation signals. Antigen invasion is prevented via the mucus layer, its constituent components and ciliated airway cells. T and B cell subsets (D) provide multiple, but highly plastic cell differentiation programs. TLR, toll-like receptor; NF-kb, nuclear factor – kappa beta; TGF-b, transforming growth factor beta; IL, interleukin; Th, T-helper; CD, cluster of differentiation cells; IgA, immunoglobulin A.

Practical information for athletes

- Dietary modification should be addressed to improve gut health and immune function before supplementation is considered, particularly in relation to increasing the diversity of the microbiota with *dietary fibre*.

- Some probiotic supplements have an evidence base for reducing URS and GI symptoms in athletic cohorts. Dosages in commercial applications are consistent with the dosage used in research trials. Consuming greater amounts than recommended should be approached with caution and trialled before travel and competition.

- *Carbohydrate* intake *pre-exercise* and *during* exercise moderates the exercise-induced immune response, which may be important during heavy training periods or prolonged exercise.

- *Adequate energy intake* is coming to the fore as a strong predictor of greater susceptibility to illness and impaired immune function. Meeting the energy demands of exercise is important for good health.
Speedy recovery

- Challenging in multiple events, prolonged training, ≥2 sessions/d
- Poor attention to nutrition recovery ➔ compromise performance at next training session or competition
- RE-ality:
  - Fatigue, loss of appetite, post-exercise commitments, post-competition activities

To repair damaged muscle & stimulate muscle protein synthesis
Consume 20 to 25g of high quality protein soon after exercise.

REFUEL

Consume carbohydrate-rich food (rice, noodle, bread, fruits and milk) after exercise.

REPAIR

Fluid and electrolyte replacement
Drink 100-150% of fluid loss after exercise with water, milk, soup, sports drink or fruit juice.

REHYDRATE

Incorporate key vitamins and minerals with plenty of colourful fruits and vegetables.

REVITALISE
Vitamin D (calciferols)

- Not technically a vitamin, more like a hormone
- Essential for maintaining normal calcium metabolism
  - increasing intestinal calcium absorption

Holick 2007
Other functions of vitamin D

- Non-calcium actions
- Regulates the expression of >1,000 genes in a variety of tissues
- Muscle repair & remodeling
- Muscle function
- Innate & acquired immunity
- Cardiac structure & function

Holick 2007
Positive correlations of 25(OH)D with improved VO\textsubscript{2}\text{max}
<table>
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<tr>
<th>Author</th>
<th>Reference #</th>
<th>Population</th>
<th>Subjects/Specimens</th>
<th>Type of Study</th>
<th>Intervention</th>
<th>Duration</th>
<th>Results</th>
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<tr>
<td>Ceglia et al. 2013</td>
<td>[55]</td>
<td>Elderly</td>
<td>21 Mobility-Limited Women (age 2.65) with 25(OH)D levels of 225 to 60 nmol/L</td>
<td>Intervention - RCT - Placebo + Double Blind</td>
<td>4000 IU/Day of Vitamin D or Placebo</td>
<td>4 Months</td>
<td>Vitamin D3 supplementation ↑ intramyonuclear VDR concentration by 30% and increased muscle fiber size by 10% in older, mobility-limited, vitamin D- insufficient women.</td>
</tr>
<tr>
<td>Close et al. 2013</td>
<td>[56]</td>
<td>Athletes</td>
<td>10 Male Professional Soccer Players</td>
<td>Correlation + Intervention - RCT</td>
<td>5000 IU/Day of Vitamin D3 or Placebo</td>
<td>8 Weeks</td>
<td>Vitamin D vs Placebo: (1) ↑ Serum 25 hydroxyvitamin D (2) ↑ in Vertical Jump (3) Faster 10 m sprint times</td>
</tr>
<tr>
<td>Close et al. 2013</td>
<td>[10]</td>
<td>Athletes</td>
<td>30 Club-Level Athletes from UK</td>
<td>Intervention - RCT</td>
<td>Three Groups: Placebo, 20,000 IU/Week, or 40,000 IU/week of Oral Vitamin D3</td>
<td>12 Weeks</td>
<td>Both 20,000 IU and 40,000 IU of Vitamin D3 ↑ 25(OH)D over &gt; 50 nmol/L, but had no effect on any performance measurement</td>
</tr>
<tr>
<td>Fitzgerald et al. 2014</td>
<td>[41]</td>
<td>Athletes</td>
<td>52 Caucasian Competitive Ice Hockey Players (age 20.1 ± 1.5) (V02max 54.6 ± 4.3)</td>
<td>Cross-sectional</td>
<td>Performance Testing: Maximal Oxygen Uptake (V02peak), Max Heart Rate (HR), Peak RER, Total Exercise Time</td>
<td>1 Month</td>
<td>All Athletes had 25(OH)D Levels £65.0 ng/mL, 37.7% of the Athletes had 25(OH)D levels of &lt; 32 ng/mL &amp; 25(OH) D status was not significantly associated with any parameter measured</td>
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<td>Forney et al. 2014</td>
<td>[42]</td>
<td>Active College Students</td>
<td>39 Physically Active College Students (20 Males, 19 Females)</td>
<td>Correlation</td>
<td>25(OH)D Levels of 20.97 ± 1.97 ng/mL (N = 20) or 44.15 ± 2.17 ng/mL (N = 19) - Primary Outcomes: BMI, % Body Fat, Resting Metabolic Rate, Maximal Oxygen Uptake (V02max), Power Output (Watts), and Muscle Strength</td>
<td>14 Days</td>
<td>Significant positive relationship seen between V02max and 25(OH)D &amp; Significant negative relationship seen between BMI and 25(OH)D</td>
</tr>
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Dahlquist 2015
Risk factors for Vitamin D deficiency

- Indoor environment
- Extensive clothing cover
- Excess sun avoidance (shade, sunscreen)
- Air pollution
- Exposure through glass
- Dark skin pigmentation
- Malabsorptive syndromes
- Obesity
- Hepatic/renal failure
- Exclusive breastfeeding
- Pregnancy
- Aging

Risk factors for low serum 25(OH)D levels

- Inadequate sun exposure
- Low ambient UV radiation level

Physiologic factors

- Low vitamin D intake

Medication: antiseizure drugs, rifampin antiretroviral treatment, glucocorticoids

- High-latitude location
- Winter season
- Outside peak UV radiation times (10 AM to 3 PM)
- No or low vitamin D supplements
- Low vitamin D diet without fortified food
- Lactose intolerance
- Socioeconomic status

http://www.mayoclinicproceedings.org/article/S0025-6196(13)00404-7/fulltext
So what to do?

Is sunlight exposure (35% of body or arms and legs) limited to <20 min per day and/or do your athletes reside <30° or >60° North?

Yes

No

Is your athlete(s) dark skinned?

Yes

No

Can you test 25(OH)D?

Yes

No

Can you test bioavailable/free 25(OH)D?

Yes

No

Is free 25(OH)D < 2 ng.ml⁻¹?

Yes

No

Is 25(OH)D < 75 nmol.L⁻¹?

Yes

No

Consider 2000-4000 IU vitamin D₃/day from a reputable company

Likely no need to supplement

Owens et al. 2018
Take home message

Get the basics right

Systematic & evidence-based approach

Be practical & realistic
Thank you