High Performance Nutrition

Alisa Nana, PhD
College of Sports Science & Technology
Mahidol University

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Nutritional challenges for racket sports

Tennis	Badminton	Table tennis

Training nutrition

Body composition manipulation

Hydration

Eating & drinking during a game

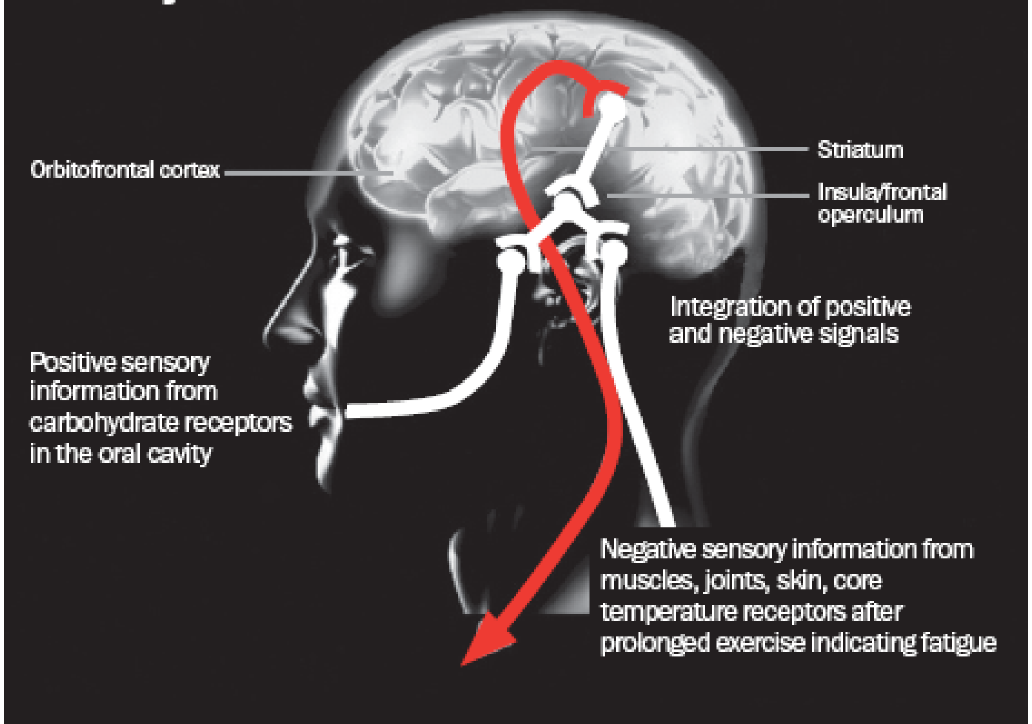
Recovery

Carbohydrate intake recommendations during exercise

Duration of exercise	Amount of carbohydrate needed	Recommended type of carbohydrate	Additional recommendation
30–75 minutes	Small amounts or mouth rinse	Single or multiple transportable carbohydrates	Nutritional training recommended
1–2 hours	30 g/hour	Single or multiple transportable carbohydrates	Nutritional training recommended
2–3 hours	60 g/hour	Single or multiple transportable carbohydrates	Nutritional training highly recommended
> 2.5 hours	90 g/hour	**ONLY multiple transportable** carbohydrates	Nutritional training essential

Carbohydrate & the brain

Figure 1: A simplified model of the actions of a carbohydrate mouth rinse

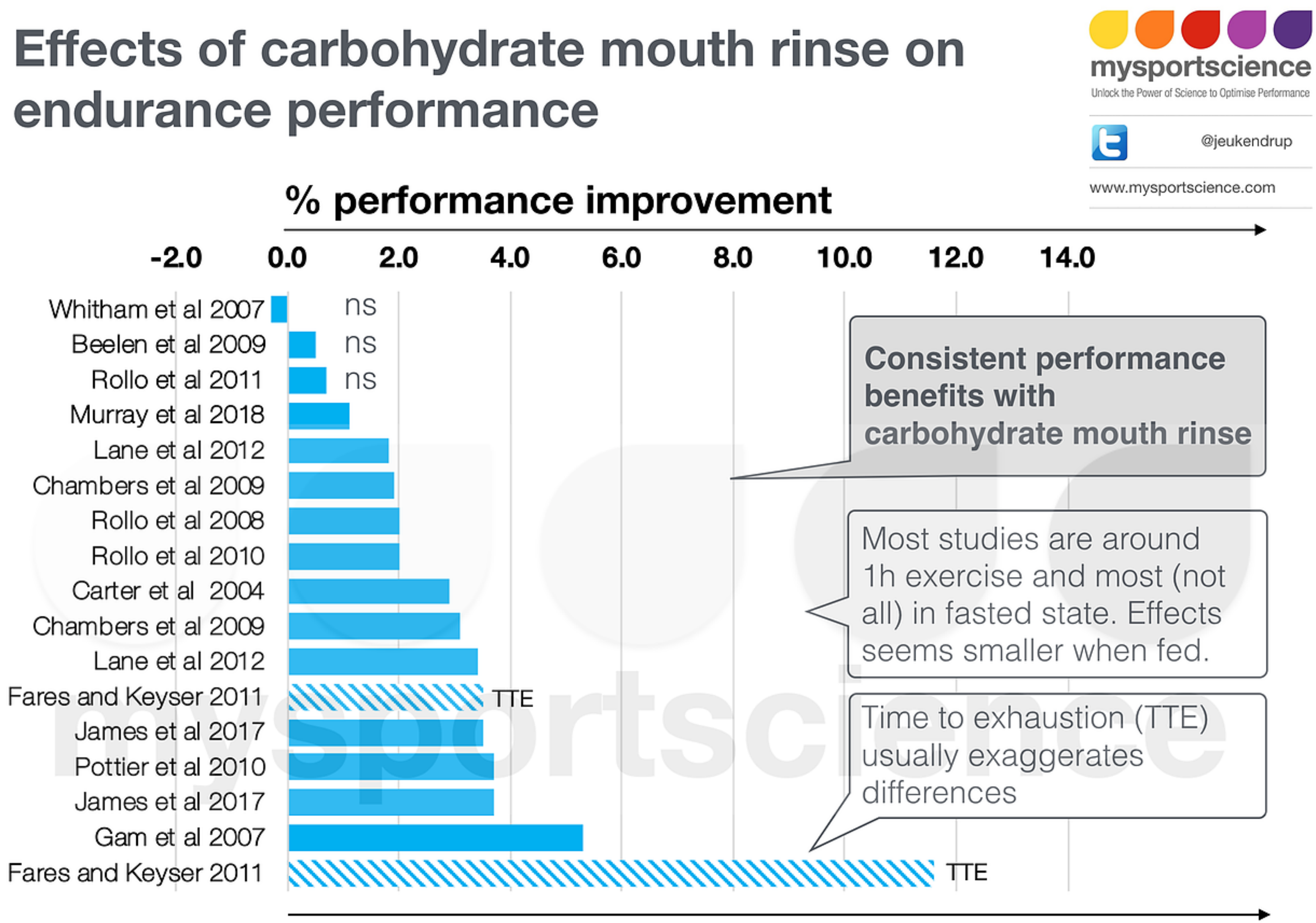


Carbohydrate receptors in the mouth send positive signals to three main areas in the brain (insula/frontal operculum, the orbitofrontal cortex and the striatum). These signals are integrated with negative signals from the periphery and an appropriate motor output is generated.

- 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

Mouth rinsing options

What does the evidence say?



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

 Garth & Burke 2013.

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 *amounts* of fluid consumed
  - Monitor *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!

Van Rosendal et al. 2009

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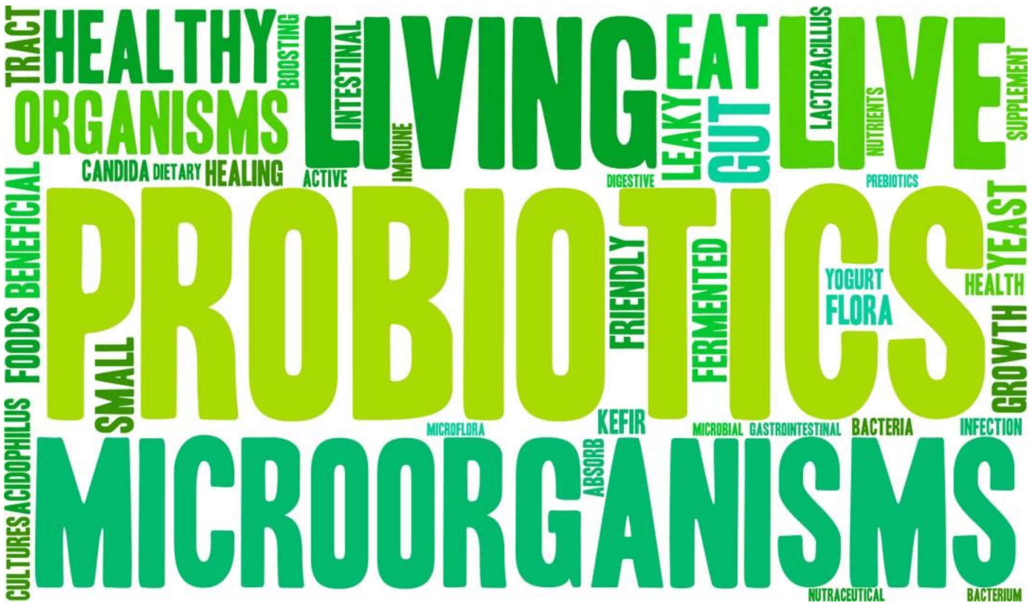
The role immunonutrition



Gut microbiota & sports performance

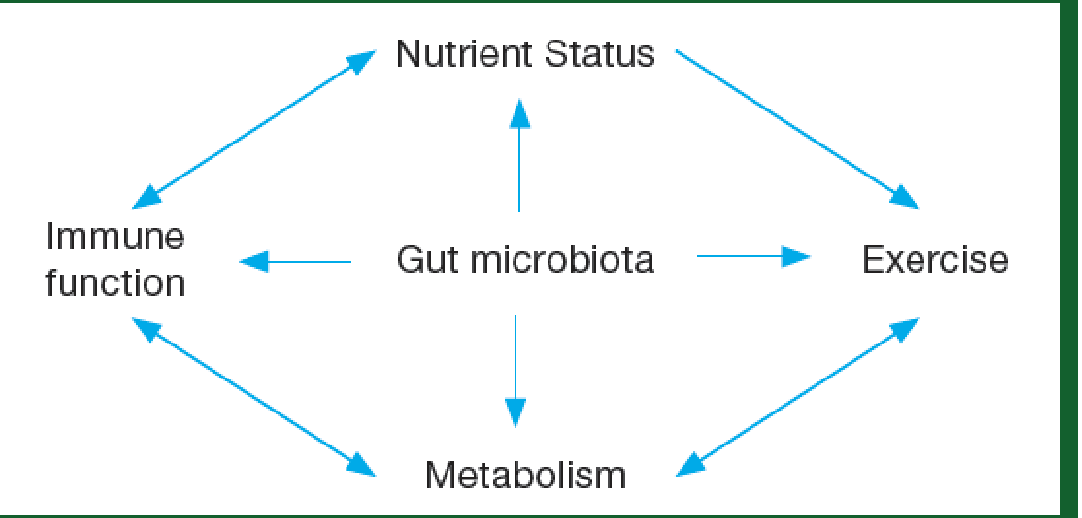
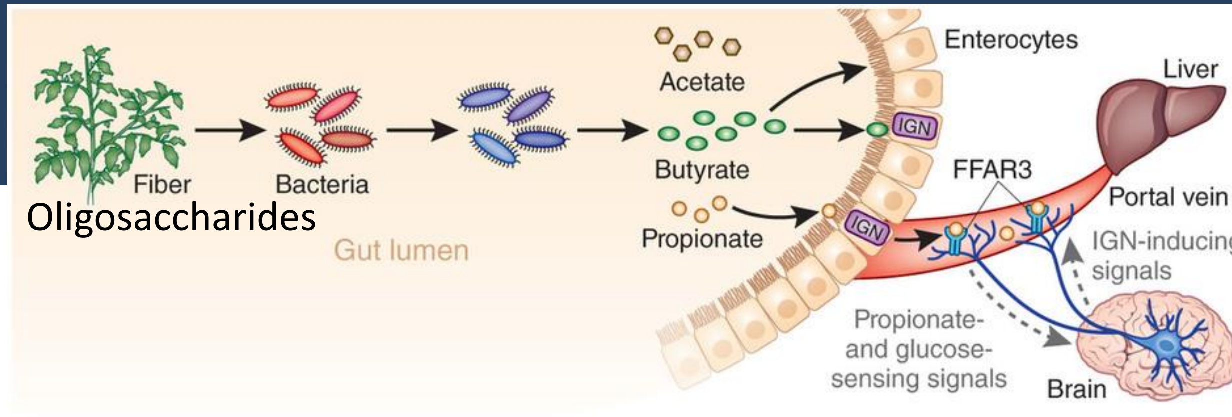
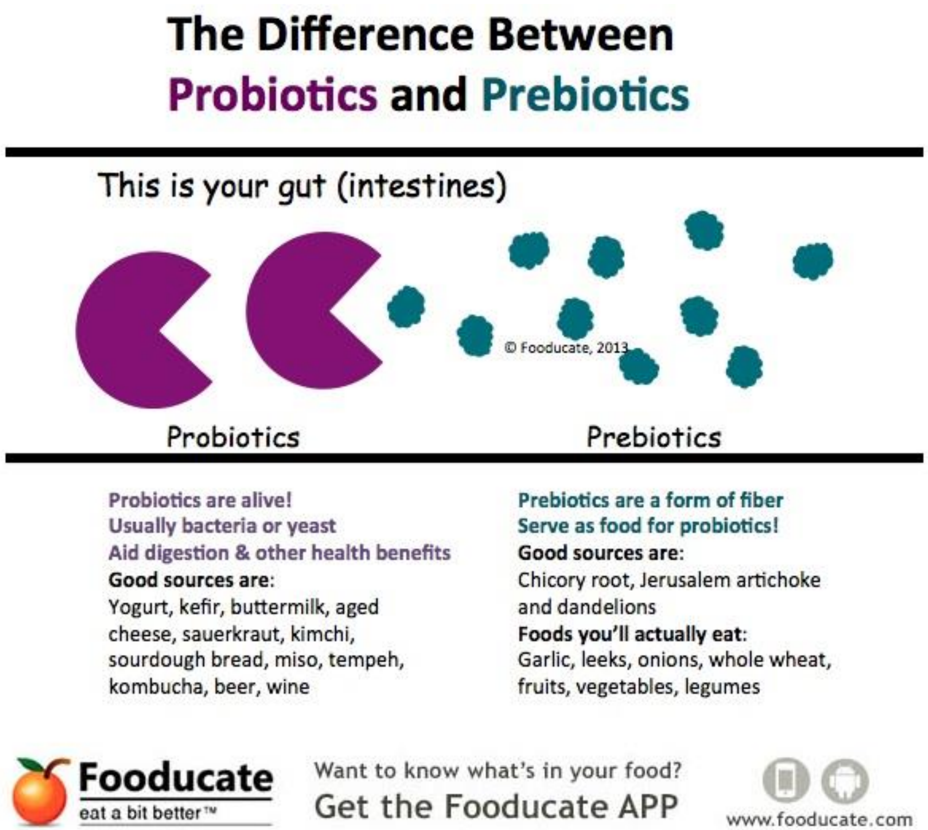


Figure 1. A schematic of the way that the gut microbiota may contribute to sporting performance. The microbiota exerts strong influence over the immune system, which in turn is also dependent on nutrient status and metabolism, to reduce the risk of infection. Specific microbial species produce short 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.

West et al. Sports Science Exchange. Vol 28. #179. 2017

Probiotics





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

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

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

IFN interferon, *LRI* lower respiratory illness, *SIgA* salivary immunoglobulin A

Colbey et al. 2018

Proposed mechanisms of action for enhancing immune function in the GI & respiratory tract with probiotics

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

Pyne 2015

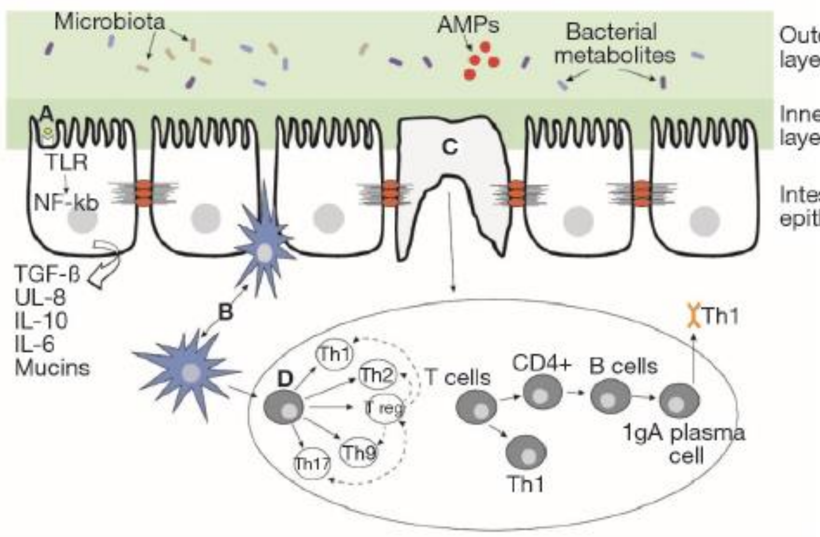


Figure 2. Schematic diagram of the mucosal immune system. Interaction with environmental antigens (A) the microbiota, microbial metabolites, antimicrobial proteins (AMPs) (C) and dendritic processes (B) provide the mucosal immune system with multiple transient activation signals. Antigen invasion is 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, immunoglobin A.

West et al. Sports Science Exchange. Vol 28. #179. 2017

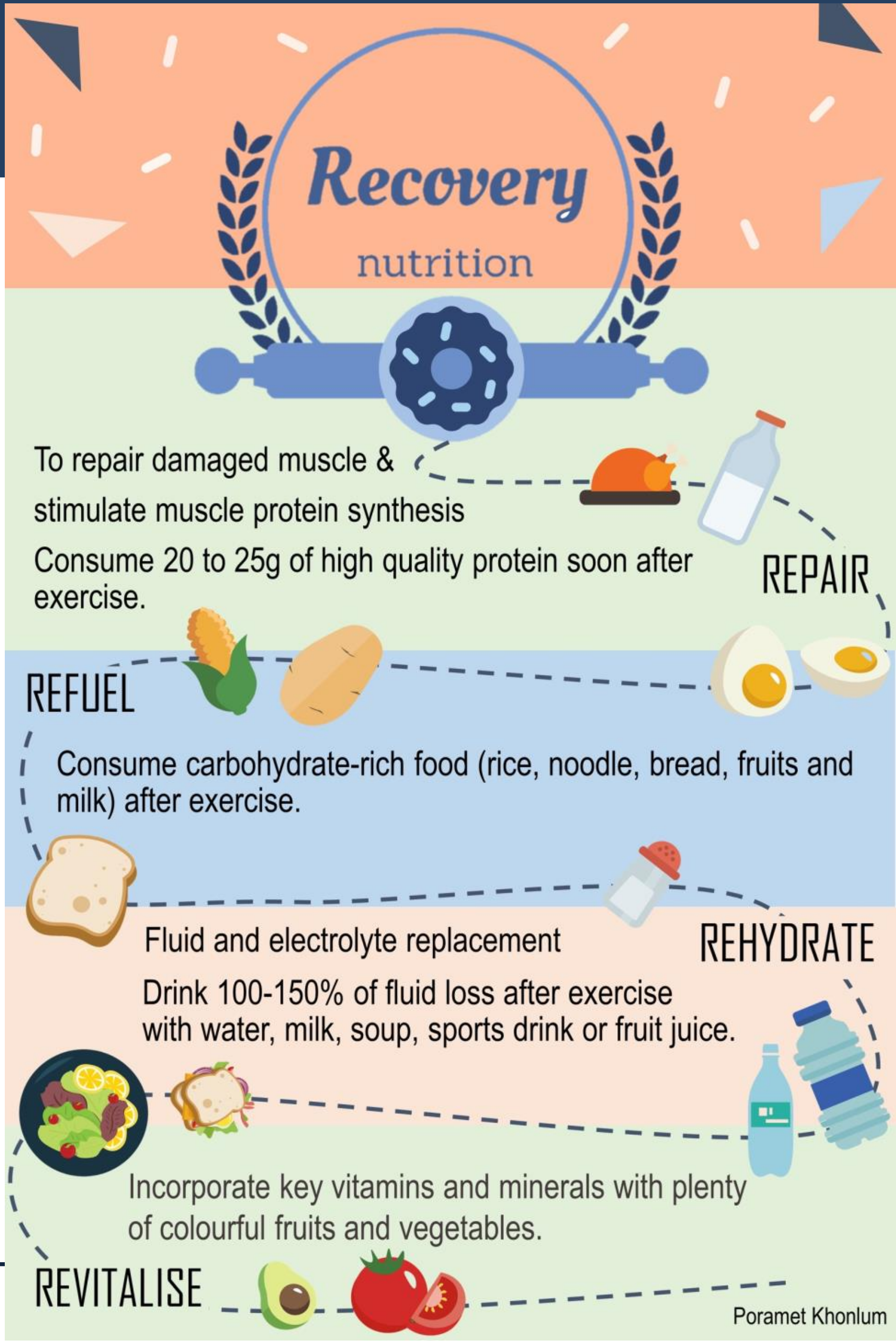
Practical information for athletes

- 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.

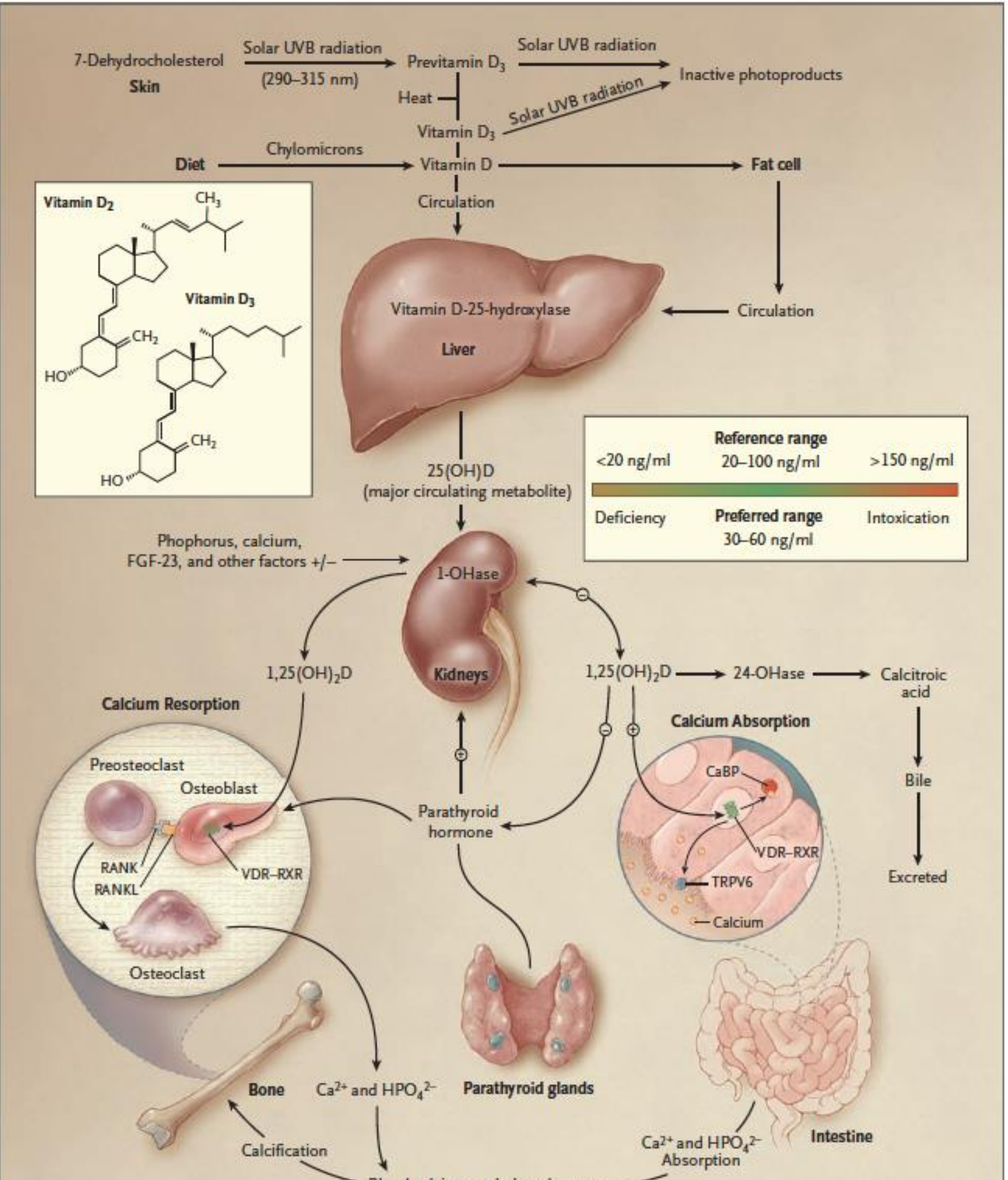
West et al. Sports Science Exchange. Vol 28. #179. 2017

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



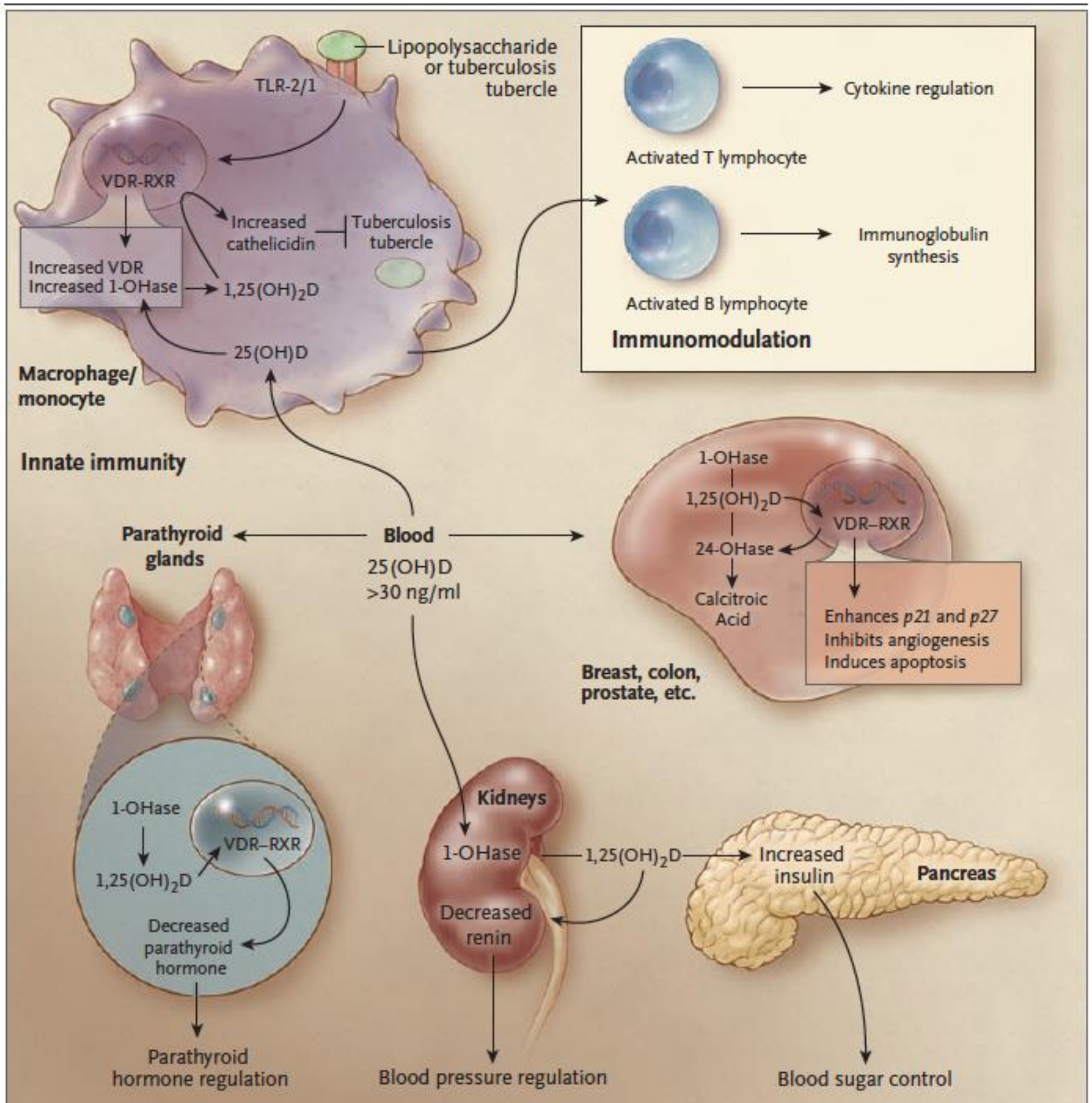
Vitamin D (calciferols)



Holick 2007

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

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

Table 1 Vitamin D correlation and intervention studies on Maximal Oxygen Uptake (VO2max)

Author	Reference #	Population	Subjects/Specimens	Type of study	Intervention	Duration	Results
Gregory et al. 2013	[37]	Healthy adults	213 Healthy Male (*N* = 104) and Female (*N* = 109) Adults (44.8 ± 16.4)	Correlation	3 Groups: Deficient (<50 nmol/L, *N* = 16), Insufficient (>50nmol/L, but < 75 nmol/L, *N* = 57), Sufficient (>75 nmol/L, *N* = 140)	6 Months	Aerobic Fitness Not Affected by 25(OH)D Levels
Mowry, Costello & Heelan 2007	[38]	Mixed females	59 Non-Trained Females (age 16to 24; 19.86 ± 2.13), 55 Caucasian and 4 Asian (V02max of 39.10 ± 7.18 mL/kg/min)	Correlation	Serum 25(OH)D Levels of 46.19 ± 20.14 ng/mL	-	Significant positive association with V02max and 25(OH)D Levels & Significant inverse association with body fat and both V02 max and 25(OH)D
Ardestani et al. 2011	[39]	Healthy adults	200 Healthy Adults (age 40 ± 14.4), Male (*N* = 92) and Female (*N* = 108) (V02max of 40 ± 9.1 and 30 ± 8.5, respectively)	Correlation	Serum 25(OH)D levels of 34 ± 13.3 ng/mL	-	25(OH)D concentrations are positively (*p* =0.05) related to V02max & Significant Interaction between 25(OH)D and Self- Reported Hours of Moderate to Vigorous Physical Activity (Higher 25(OH)D = Higher Activity)
Koundourakis et al. 2014	[40]	Athletes	67 Caucasian Male Professional Soccer Players (age 25.6 ± 6.2)	Correlation	Performance Testing: Squat Jump (SJ), Countermovement Jump (CMJ), 10 (10 m) and 20 m(20 m)sprint, Maximal Oxygen Uptake (V02max), and anthropometry	6 Weeks (Pre Off-Sea onto Post Off-Season)	Significant correlations between 25(OH)D and ALL performance parameters for both PRE and POST experimental sessions
Fitzgerald et al. 2014	[41]	Athletes	52 Caucasian Competitive Ice Hockey Players (age 20.1 ± 1.5) (V02max 54.6 ± 4.3)	Cross-sectional	Performance Testing: Maximal Oxygen Uptake (V02peak), Max Heart Rate (HR), Peak RER, Total Exercise Time	1 Month Recruiting Phase During Off-Season (May to June)	All Athletes had 25(OH)D Levels <. 65.0 ng/mL, 37.7 % of the Athletes had 25(OH)D levels of < 32 ng/mL & 25(OH)D status was not significantly associated with any parameter measured
Forney et al. 2014	[42]	Active College Students	39 Physically Active College Students (20 Males, 19 Females)	Correlation	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	-	Significant positive relationship seen between V02max and 25(OH)D & Significant negative relationship seen between BMI and 25(OH)D
Jastrzebski 2014	[43]	Athletes	14 Elite Lightweight Rowers	Intervention - RCT	6000 IU/day of Vita min D3 vs Placebo in 25(OH)D sufficient athletes (>30 ng/mL)	8 Weeks	Vitamin D vs Placebo: Significant ↑ in V02max (12.1 % and 10.3 %, respectively) and 25(OH)D concentrations by 400 % (~120 ng/mL)

Positive correlations of 25(OH)D with improved VO_{2max}

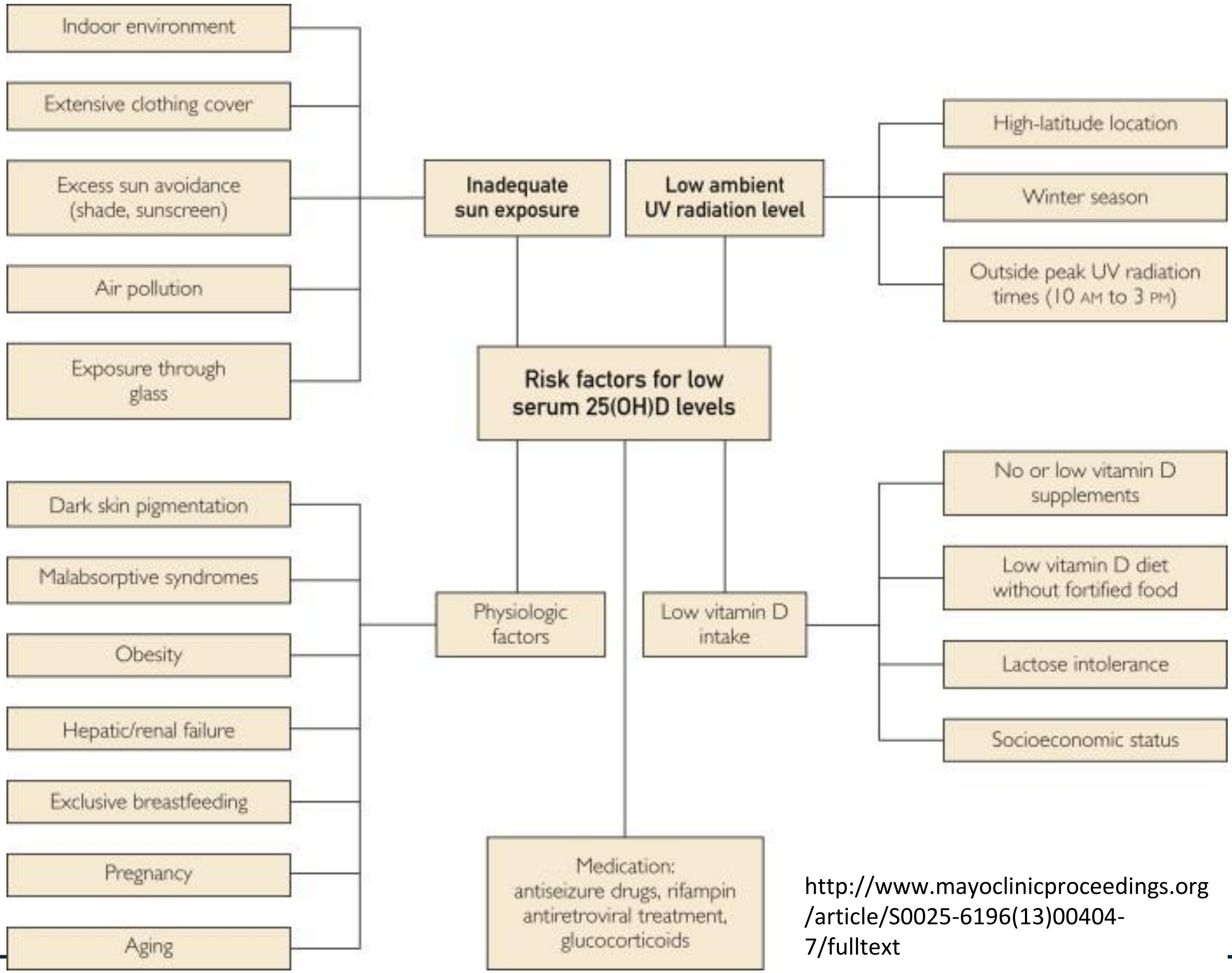
Dahlquist 2015

Table 3 Vitamin D correlation and intervention studies on force & power production

Author	Reference #	Population	Subjects/ Specimens	Type of Study	Intervention	Duration	Results
Ceglia et al. 2013	[55]	Elderly	21 Mobility-Limited Women (age ≥ 65) with 25(OH)D levels of ≥25 to 60 nmol/L	Intervention - RCT-Placebo + Double Blind	4000 IU/Day of Vitamin D or Placebo	4 Months	Vitamin D3 supplementation ↑ intramyonuclear VDR concentration by 30 % and increased muscle fiber size by 10 % in older, mobility-limited, vitamin D- insufficient women.
Close et al. 2013	[56]	Athletes	10 Male Professional Soccer Players	Correlation + Intervention - RCT	5000 IU/Day of Vitamin D3 or Placebo	8 Weeks	Vitamin D vs Placebo: (1) ↑ Serum 25 hydroxyvitamin D (2) ↑ in Vertical Jump (3) Faster 10 m sprint times
Close et al. 2013	[10]	Athletes	30 Club-Level Athletes from UK	Intervention - RCT	Three Groups: Placebo, 20,000IU/Week, or 40,000 IU/ week of Oral Vitamin D3 (Performance Testing: 1-RM Bench Press, 1-RM Leg Press and Vertical Jump)	12 Weeks	Both 20,000 IU and 40,000 IU of Vitamin D3 ↑ 25(OH)D over > 50 nmol/L, but had no effect on any performance measurement
Fitzgeral et al. 2014	[41]	Athletes	52 Caucasian Competitive Ice Hockey Players (age 20.1 ± 1.5) (V02max 54.6 ± 4.3)	Cross-sectional	Performance Testing: Maximal Oxygen Uptake (V02peak), Max Heart Rate (HR), Peak RER, Total Exercise Time	1 Month Recruiting Phase During Off-Season (May to June)	All Athletes had 25(OH)D Levels £65.0 ng/mL, 37.7 % of the Athletes had 25(OH)D levels of < 32 ng/mL & 25(OH) D status was not significantly associated with any parameter measured
Forney et al. 2014	[42]	Active College Students	39 Phyiscally Active College Students(20 Males, 19 Females)	Correlation	25(0H)D Levels of 20.97 ± 1.97 ng/mL (*N* = 20) or44.15 ± 2.17 ng/mL (*N* = 19)- Primary Outcomes: BMI, % Body Fat, Resting Metabolic Rate, Maximal Oxygen Uptake (V02max), Power Output (Watts), and Muscle Strength	14 Days	Significant positive relationship seen between V02max and 25(OH)D & Significant negative relationship seen between BMI and 25(OH)D

Dahlquist 2015

Risk factors for Vitamin D deficiency



http://www.mayoclinicproceedings.org/article/S0025-6196(13)00404-7/fulltext

So what to do?

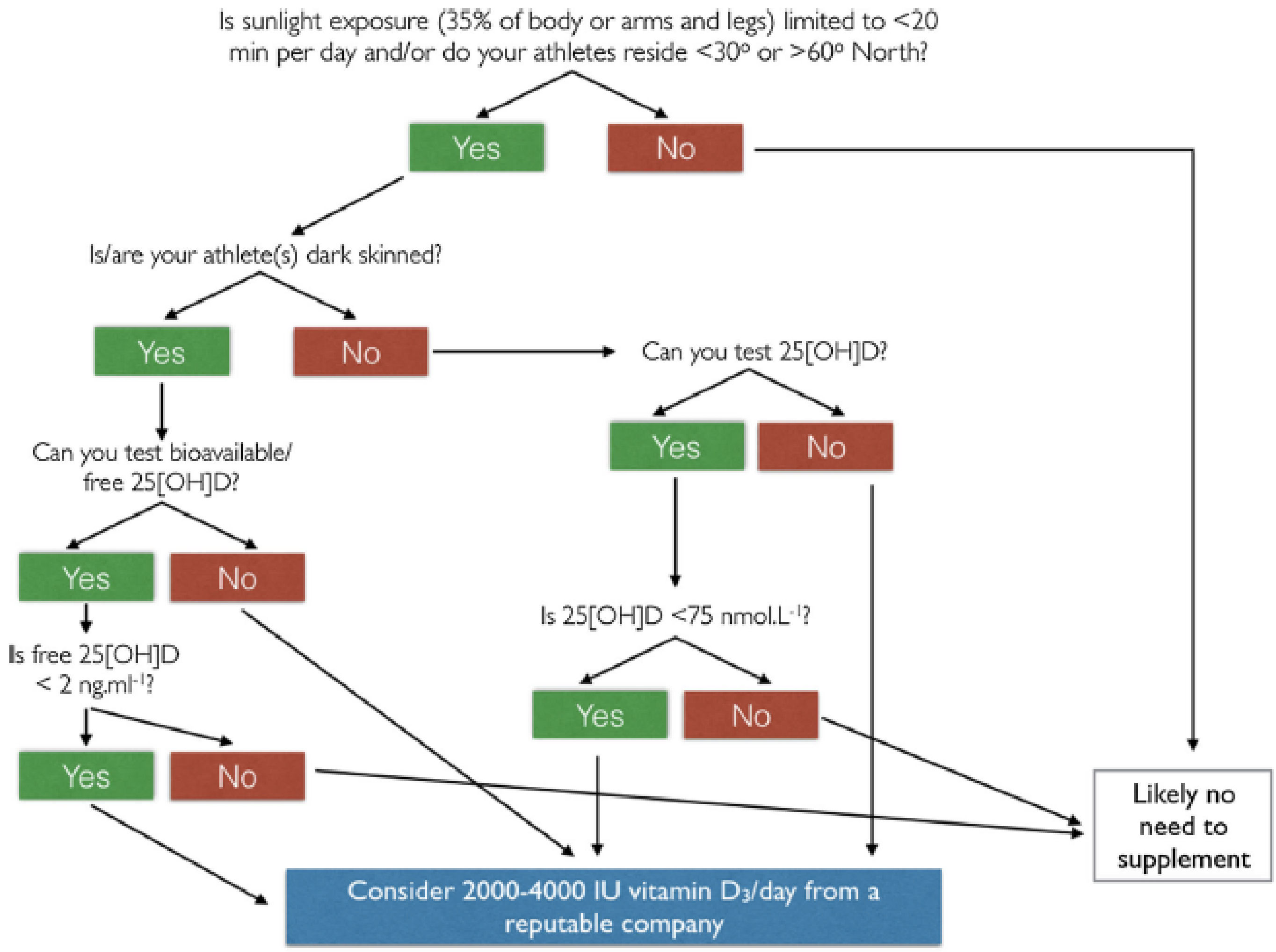


Fig. 5 Vitamin D supplementation decision tree for use with athletes Owens et al. 2018

Take home message

Get the basics right

Systematic & evidence-based approach

Be practical & realistic

Thank you