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Probiotics for Athletic Health & Performance

Dr. Ralf Jäger, FISSN, CISSN, MBA

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The views expressed on the following slides by Dr. Jaeger are his own and do not reflect the views of Lonza.

Sports Nutrition: Athletes Have Different Nutritional Goals

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Different Athletes, Different Nutritional Goals

- Body Weight
  - Gain
  - Lose
  - Maintain
- Muscle
  - Increase LBM
  - Increase Strength
  - Increase Power
  - Increase Endurance
- Mind
  - Increase Focus
  - Increase Concentration
  - Increase Alertness

Stacy Lewis
LPGA Professional

Ben Pakulski
Professional Bodybuilder

You & Me
Recreational Athletes

Sports Nutrition: One Common Goal: INCREASE PERFORMANCE

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HOWEVER, athletes have ONE common goal

- Increase Performance through nutrition
  - **Ergogenic supplements** are defined as ingredients that have been shown to significantly enhance exercise performance (e.g., helps you run faster, lift more weight, …)
  - Nutritional practices that help prepare individuals to train and/or enhance recovery from exercise should also be viewed as ergogenic (enhancing performance in the long run).

- Commonly used nutrients
  - **Hydration** (water, electrolytes, betaine, glycerol, …)
  - **Lean Body Mass-Strength-Power** (protein, BCAA, creatine, HMB, ATP, PA, …)
  - **Endurance** (beta-alanine, nitrates, choline, astaxanthin, …)
  - **Mental performance** (PS, creatine, caffeine, aGPC, L-theanine, …)
  - **Immune health** (probiotics, beta-glucan, …)
  - **Recovery** (probiotics, PS, protein, …)

Reference: Jäger: **Ergogenic Sport Supplements.** In *Sports Nutrition & Performance Enhancing Supplements*. Antonio J, Smith-Ryan A (Eds). Linus Publications, Deer Park New York **2013**, ISBN 978-1607973393.

The Gut

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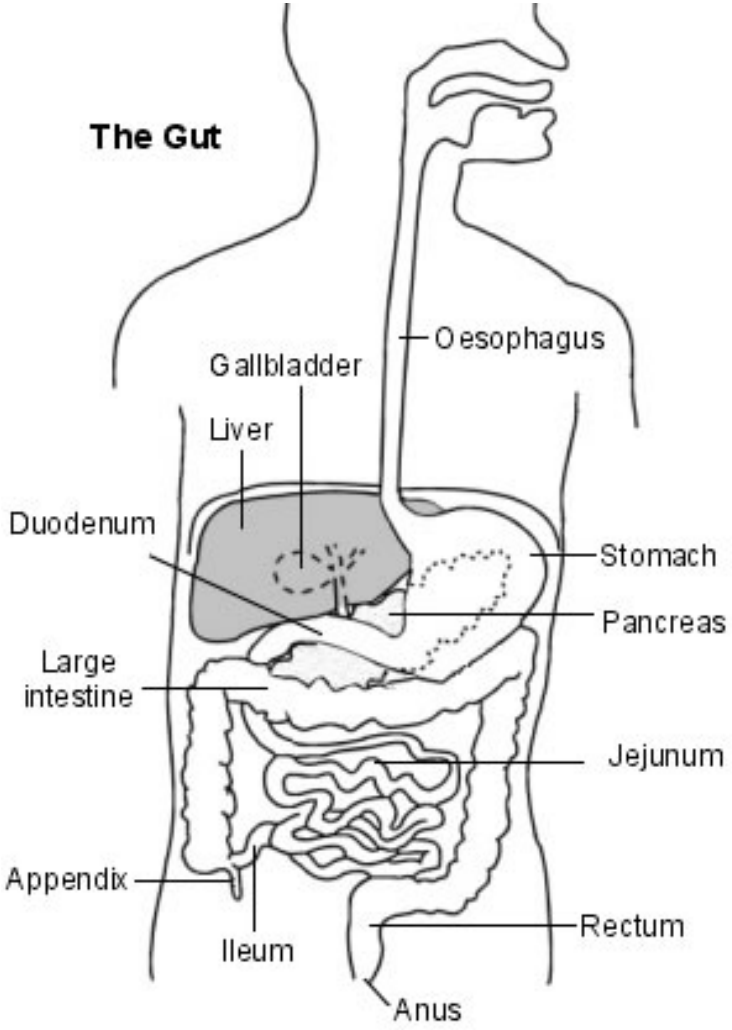
- The gastrointestinal tract is a long tube that starts in your mouth and ends at the anus.
- Its main function is to process/absorb food (300 m^2 surface).
- 70-80% of your immune system is located in your digestive system.
- Largest hormone producing organ (>30 hormones).
- Nervous organ.
  - 100 million nerve cells
  - complex interaction with the brain, skin, muscle, …
- Disorders of the gut include
  - Constipation/Diarrhea
  - Irritable bowel syndrome (IBS)
  - Obesity and related metabolic disorders
  - Exercise-induced leaky gut
  - …



Gut Bacteria

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- In your body there are 20x more bacteria than human cells.
- We excrete our own weight in fecal bacteria annually.
- Some cause disorder, most are benign, some are positive for health.
- Gut problems are the most common complains during practitioner visits.

Microflora of the Stomach and Small Intestine

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STOMACH

- Transit time ca. 30-60 minutes
- Low pH
- Colonizers need to invade the mucosal layer
- Numbers are low
- *Helicobacter pylori*, usually harmless, however, they are responsible for the majority of ulcers and gastritis

SMALL INTESTINE

- Transit time 2-4 hours
- The organ is a long narrow tube
- Bile salts and pancreatic secretions affect colonization by the indigenous flora
- Typical number are around 1 million per mL content. Varies jejunum to ileum

Microflora of the Large Intestine

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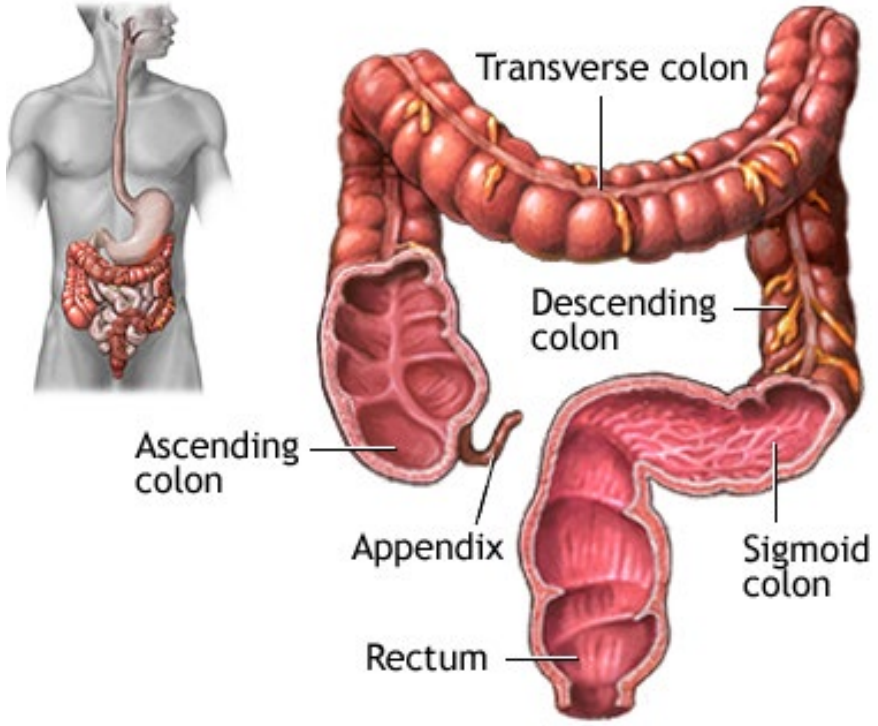
LARGE INTESTINE

- Typical transit time ca. 24-72 hours
- 150cm in length
- THE most heavily colonized organ in the human body
- Up to 1,000 species
- 99% of bacteria come from 30-40 species
- Most of the bacteria in your body (1,000,000,000,000,000) are here
- Antimicrobial intake, stress, poor diet and living conditions all affect the flora composition



Factors Influencing the Gut Microbiota

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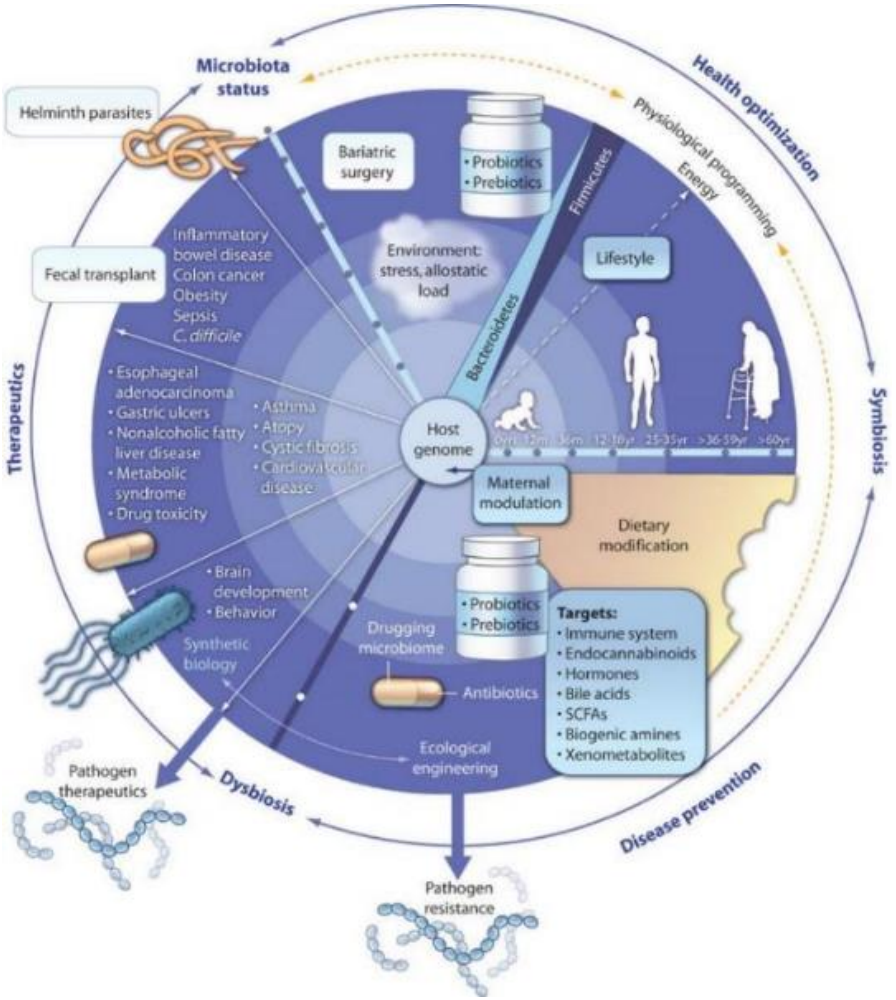
LIFE (aging)

- Birth (vaginal vs. caesarian)
- Breastfed vs. bottle
- Age-related decline in bifidobacteria

LIFESTYLE

- Smoking, Alcohol
- Stress
- **Diet**
- Pets
- **EXERCISE**

vs.



THERAPEUTICS

- Antibiotics
- Fecal transplants
- …

DIETARY MODIFICATION

- **Probiotics**
- Prebiotics
- Synbiotics
- Postbiotics
- Immunobiotics
- Fermented Foods

Gut Microbiota of Athletes is Different

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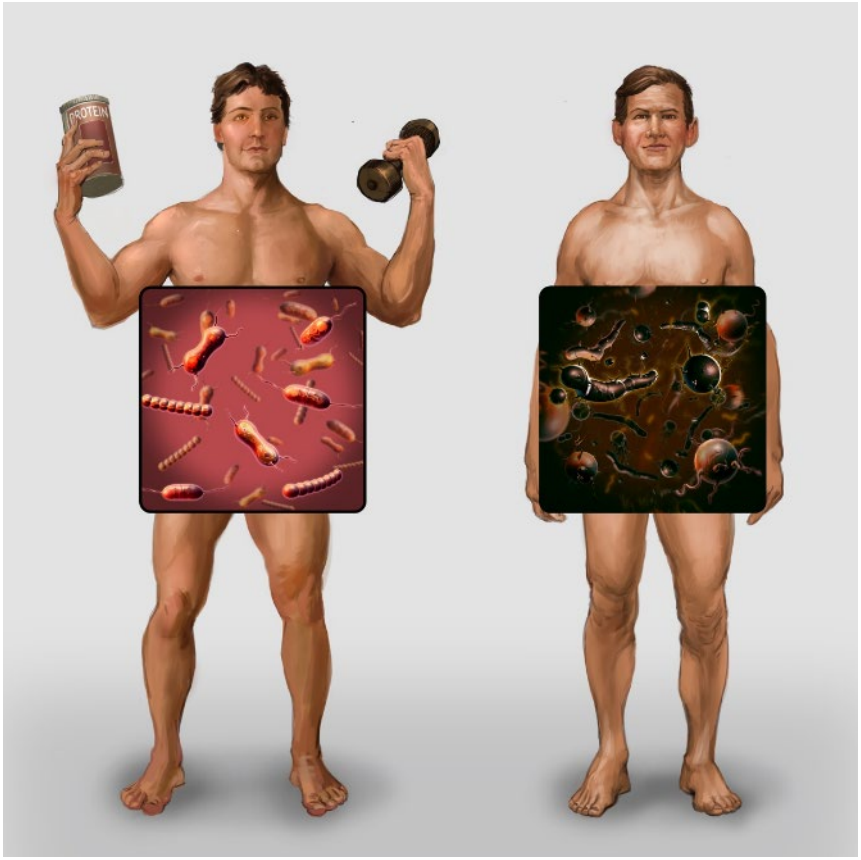
- Athletes have a more diverse gut microbiota
  - Subjects:
    40 professional athletes (BMI = 29) from an international rugby team compared with two groups of healthy male controls from the Cork region of Ireland (BMI ≤ 25, or BMI > 28).

  - Results & Conclusion:
    - Athletes also had a far higher diversity of gut bacteria
    - High protein intake, as well as high levels of creatinine kinase, positively correlated with bacterial diversity, suggesting that **both diet and exercise are drivers of biodiversity.**



Reference: Clarke *et al.* **Exercise and associated dietary extremes impact on gut microbial diversity.** *Gut* **2014**, *63(12)*:1913-1920.

Probiotics

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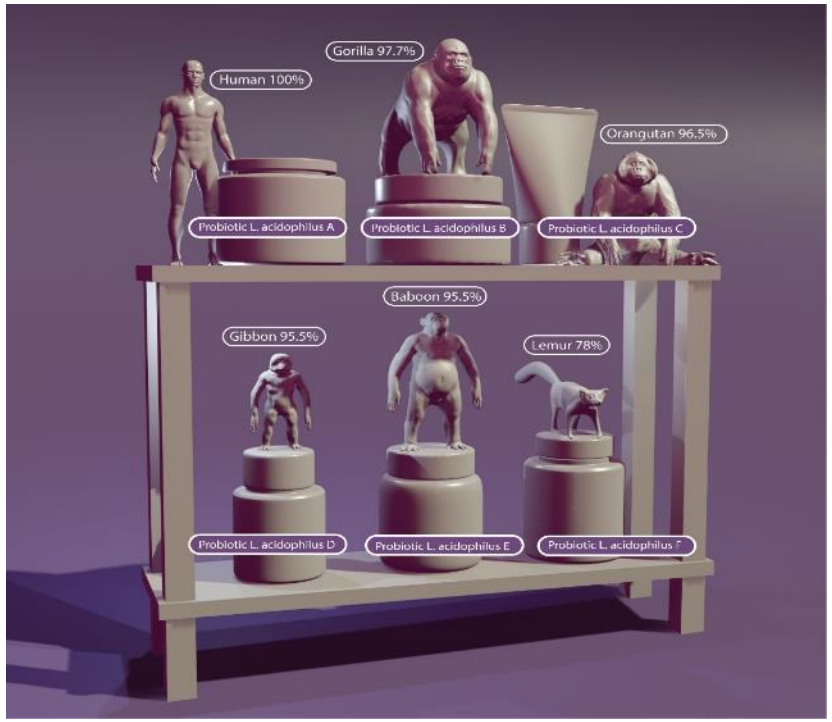
- Live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO 2001)
- Nomenclature: gene and species and a strain identifying name: e.g. *Lactobacillus rhamnosus* GG
- **Health benefits** of probiotics are **STRAIN SPECIFIC** and dose dependent!
- Three fundamental strategies to improve gut health

I. Add more good guys

II. Add fertilizer, so the good guys can grow

III. Kill the bad guys



Reference: Jäger *et al.*: **International Society of Sports Nutrition Position Stand: Probiotics.** *J Int Soc Sports Nutr* **2019**, 16:62.

Condition Specific Probiotics

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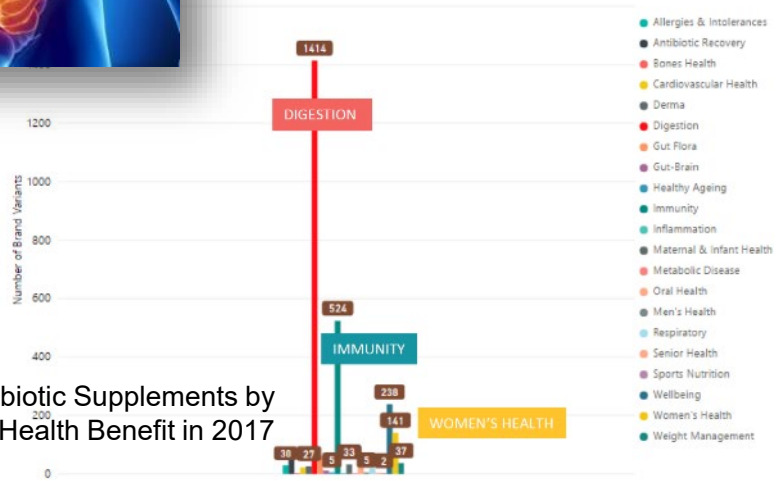
Established **Emerging**



Leading Probiotic Supplements by Health Benefit in 2017

Gut-Muscle-Axis

Allergies

Anxiety/Depression

Weight Management

Anti-Aging

Asthma

Oral Health

Skin Health

Neuropsychiatric Disorders

Potential Sport Specific Benefits of Probiotics

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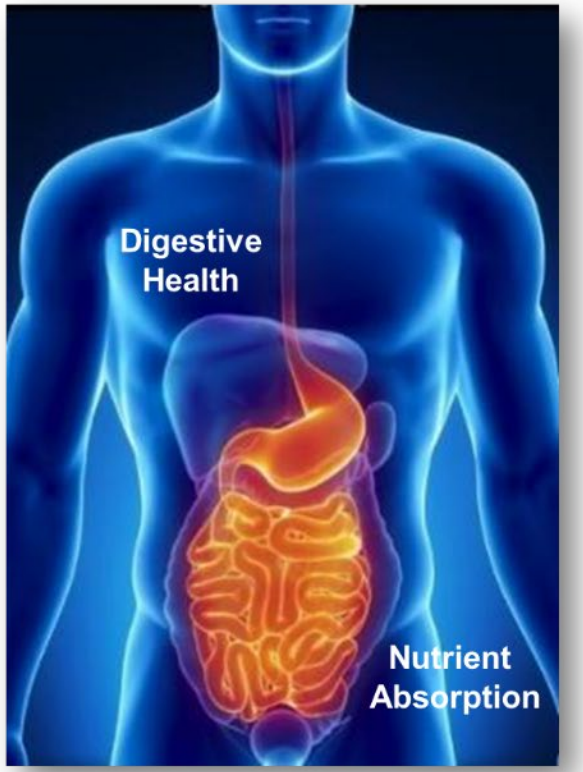
- Someone going to the gym is <u>twice as likely</u> to take probiotics
- Do probiotics have sport specific benefits? Performance benefits?



The Problem: Exercise Compromises Immune Health in Athletes

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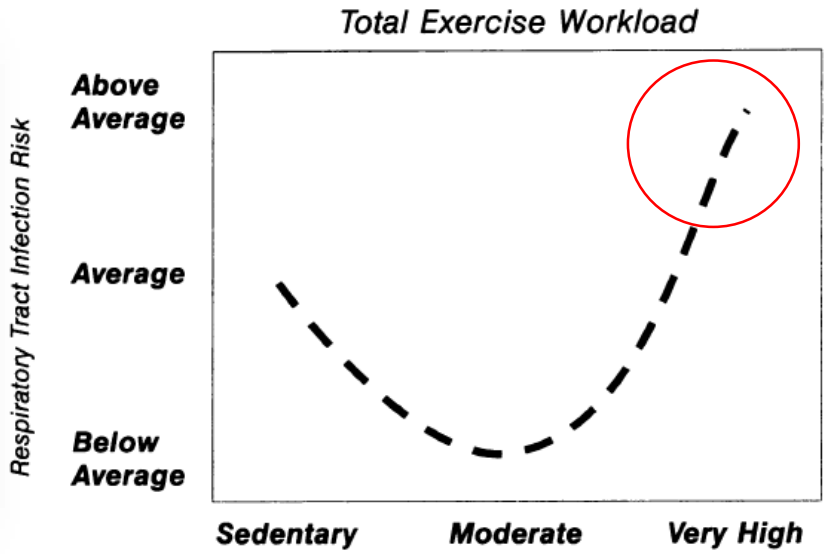

- Infection risk and exercise workload follow a J-Shape
  - Moderate intensity exercise reduces infection risk
  - High intensity exercise increases infection risk

- **Immune suppression in athletes worsens by**
  - Psychological stress
  - Foreign travel
  - Disturbed sleep
  - Environmental extremes
  - Bad diet
  - Exposure to large crowds
  - Increases exposure to pathogens due to elevated breathing during exercise
  - Exercise-induced leaky gut
  - …

Immune Health is a Real Problem for Athletes

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- Out of 11,274 athletes at the 2016 Rio de Janeiro Summer Olympics
  - 5.4% reported an illness (651) over the 17-day period
  - 47% of illnesses were URTI, 21% GI related
  - 18% of illnesses resulted in time lost

- Out of 2,914 athletes at the 2018 PyeongChang Winer Olympics
  - 9.4% reported an illness (279) over the 17-day period
  - 70% of illnesses were URTI, women suffered 61% more illnesses than men
  - 30% of illnesses resulted in time lost

- Chrissie Wellington

  2007: Ironman World Champion Hawai'i
  2008: Ironman World Champion Hawai'i
  2009: Ironman World Champion Hawai'i
  2010: Missed event due to an infection
  2011: Ironman World Champion Hawai'i

- Faris Al-Sultan

  2005: Ironman World Champion Hawai'i
  2007: Missed event due to an infection

References: T. Soligard *et al.* **Sports injury and illness incidence in the Rio de Janeiro 2016 Olympic Summer Games: A prospective study of 11274 athletes from 207 countries.** *Br J Sports Med* **2017**, 51(17):1265-1271; T. Soligard *et al.* **Sports injury and illness incidence in the PyeongChang 2018 Olympic Winter Games: a prospective study of 2914 athletes from 92 countries.** *Br J Sports Med* **2019**, 53(17):1085-1092.

Probiotic Studies on Immune Health in Athletes

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Reference	Subjects	Supplementation	Exercise	Performance Benefit	Immune or GI Benefit
Kekkonen et al (2007)	Non-elite Marathon runners (n=141)	L. rhamnosus (LGG), milk-based drink, 4×10^{10} CFU per day for 12 weeks	Running (3-month training & 2003 Helsinki City Marathon)	Not assessed	No effect on respiratory infections or GI episodes, however, shortened GI stress post marathon.
Tiollier et al (2007)	French commandos cadets (n=47)	L. casei, milk-based drink during training	3-week training followed by a 5-day combat course.	Not assessed	No effect on respiratory tract infections
Cox et al (2010)	Elite male distance runners (n=20)	1.2×10^{10} CFU L. fermentum VRI 003 per day for 4 months	Running (4-month of winter training)	No changes in running performance	Significant reduction in respiratory episodes and severity.
Gleeson et al (2011)	Recreationally active endurance athletes (n=84)	L. casei Shirota (LGG), 1.3×10^{11} CFU per day for 16 weeks	Running (4-month of winter training, normal training load)	Not assessed	Significant reduction in respiratory infections.
West et al (2011)	Competitive cyclists (n=80)	L. fermentum 1×10^{9} CFU per day for 11 weeks	Cycling (winter training, normal training load)	No effect on peak power or VO_2 max	Significant reduction in respiratory infections (duration and severity) in males. No effect in females.

Probiotic Studies on Immune Health in Athletes

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Reference	Subjects	Supplementation	Exercise	Performance Benefit	Immune or GI Benefit
Gleeson et al (2012)	Highly active individuals (n=66)	L. salivarious, 2×10^{10} CFU per day for 16 weeks	4-months of spring training (endurance-based physical activities)	Not assessed	No effect on frequency. severity and duration of respiratory infections.
Salarkia et al (2013)	Females endurance swimmer (n=46)	Multi-strain probiotic yoghurt 4×10^{10} CFU per day for 8 weeks	Swimming	Increase in aerobic fitness. No effect on swim times.	Significant reduction in respiratory and ear infections . No effect on GI episodes.
West et al (2014)	Active individuals (n=465)	L. lactis BI-04 2×10^{10} CFU, or LA NCFM and B. lactis BI-07 5×10^{9} CFU/d for 150 days	Normal activity load (approx. 6 hours per week)	Not assessed	BI-04 reduced URTI frequency. BI-07+LA NCFM showed no effect.
Haywood et al (2014)	Highly-trained rugby union players (n=30)	L. gasseri 2.6×10^{12} CFU, B. bifidum and B. longum 0.2×10^{12} CFU/d for 4 weeks	Normal training load	Not assessed	Significant reduction in respiratory infections and GI episodes. No effect on severity.
Strasser et al (2016)	Trained athletes (n=33)	B. bifidum W23, B. lactis W51, E. faecium W54, L. acidophilus W22, L. brevis W63, and L. lactis W58 $1x10^{10}$ CFU/d for 12 weeks	Winter training	No improvement in athletic performance	Limited exercise-induced drops in tryptophan levels and reduced the incidence of URTI

Probiotic Studies on Immune Health in Athletes

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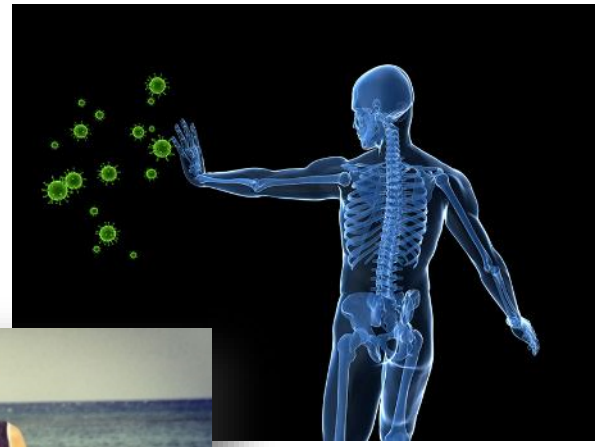
- 20 highly-trained male distance runners
  - Competing in events from 800m to marathon
  - Mean training mileage approx. 100km per week
  - 1.2×10^{10} CFU *L. fermentum* VRI 003 per day for 4 months
- 4-month period of winter training
  - Probiotic administration reduced the number of days with URTI symptoms by more than half (30 days vs. 72 days)
  - Illness severity was lower during probiotic administration
  - No difference in running performance measures were observed



Source: Cox *et al.* **Oral administration of the probiotic *Lactobacillus fermentum* VRI-003 and mucosal immunity in endurance athletes.** *Br J Sports Med* **2010**, 44:222–226.

Validated Probiotic Strains for Immune Health in Athletes

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The following 7 strains/species have been shown to improve immune health in athletes, reducing the episodes, severity or duration of exercise-induced infections:

1) *L. fermentum* VRI-003 (PCC): 1.2 × 10^{10} CFU
2) *L. casei* Shirota (LcS): 6.5 × 10^{9} CFU twice daily
3) *L. delbrueckii bulgaricus*, *B. bifidum*, and *S. salivarus thermophilus:* 4 × 10^{10} CFU (as yogurt drink)
4) *B. animalis subsp. lactis* BI-04: 2 × 10^{10} CFU
5) *L. gasseri* 2.6 × 10^{9} CFU, *B. bifidum* 0.2 × 10^{9}, and *B. longum* 0.2 × 10^{9} CFU
6) *B. bifidum* W23, *B. lactis* W51, *E. faecium* W54, *L. acidophilus* W22, *L. brevis* W63, *L. lactis* W58: 1 × 10^{10} CFU
7) *L. helveticus* Lafti L10: 2 × 10^{10} CFU

4 strains can be recommended

Jäger et al. Journal of the International Society of Sports Nutrition (2019) 16:62
https://doi.org/10.1186/s12970-019-0329-0

Journal of the International Society of Sports Nutrition

REVIEW Open Access

International Society of Sports Nutrition Position Stand: Probiotics

Ralf Jäger[1*], Alex E. Mohr[2], Katie C. Carpenter[3], Chad M. Kerksick[4], Martin Purpura[1], Adel Moussa[5], Jeremy R. Townsend[6], Manfred Lamprecht[7], Nicholas P. West[8], Katherine Black[9], Michael Gleeson[10], David B. Pyne[11], Shawn D. Wells[12], Shawn M. Arent[13], Abbie E. Smith-Ryan[14], Richard B. Kreider[15], Bill I. Campbell[16], Laurent Bannock[17], Jonathan Scheiman[18], Craig J. Wissent[19], Marco Pane[20], Douglas S. Kalman[21], Jamie N. Pugh[22], Jessica A. ter Haar[23] and Jose Antonio[24]

Abstract

Position statement: The International Society of Sports Nutrition (ISSN) provides an objective and critical review of the mechanisms and use of probiotic supplementation to optimize the health, performance, and recovery of athletes. Based on the current available literature, the conclusions of the ISSN are as follows:

1) Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO).
2) Probiotic administration has been linked to a multitude of health benefits, with gut and immune health being the most researched applications.
3) Despite the existence of shared, core mechanisms for probiotic function, health benefits of probiotics are strain- and dose-dependent.
4) Athletes have varying gut microbiota compositions that appear to reflect the activity level of the host in comparison to sedentary people, with the differences linked primarily to the volume of exercise and amount of protein consumption. Whether differences in gut microbiota composition affect probiotic efficacy is unknown.
5) The main function of the gut is to digest food and absorb nutrients. In athletic populations, certain probiotics strains can increase absorption of key nutrients such as amino acids from protein, and affect the pharmacology and physiological properties of multiple food components.
6) Immune depression in athletes worsens with excessive training load, psychological stress, disturbed sleep, and environmental extremes, all of which can contribute to an increased risk of respiratory tract infections. In certain situations, including exposure to crowds, foreign travel and poor hygiene at home, and training or competition venues, athletes' exposure to pathogens may be elevated leading to increased rates of infections. Approximately 70% of the immune system is located in the gut and probiotic supplementation has been shown to promote a healthy immune response. In an athletic population, specific probiotic strains can reduce the number of episodes, severity and duration of upper respiratory tract infections.

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* Correspondence: ralf.jaeger@ingenovo.com
This position stand is dedicated to the late Dr. Mike Greenwood who made significant contributions to the development of the ISSN and JISSN. This position stand has been adopted by the Austrian Society of Sports Nutrition (Österreichische Gesellschaft für Sporternährung (ÖGSE)).Submitted to the ISSN Research Committee for consideration as a Position Stand of the Society.October 31, 2019
[1]Ingenovo LLC, Milwaukee, WI, USA
Full list of author information is available at the end of the article

The Problem: Exercise-induced intestinal barrier dysfunction

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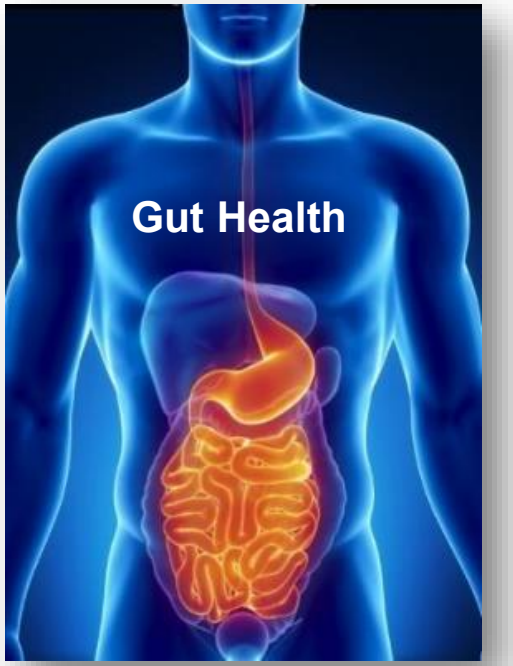
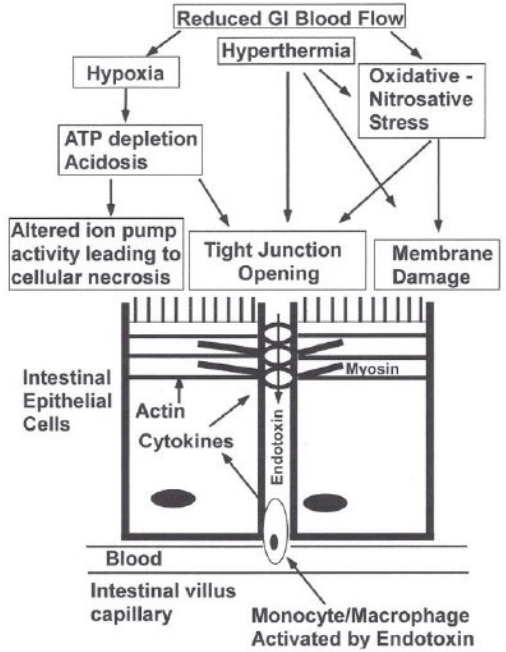


- 80% of blood from the GI transferred to muscle
- Change of tight junctions' structure
- Leaky gut: increased permeability of intestinal wall (mainly paracellular)
- Pathogens/toxins enter blood stream
- Consequences: inflammation, intestinal complains, obstipation, sleep disorders, reduced recovery and performance, allergies, autoimmune disorders, susceptibility to infectious diseases, …



Validated Probiotic Strains for Gut Health in Athletes

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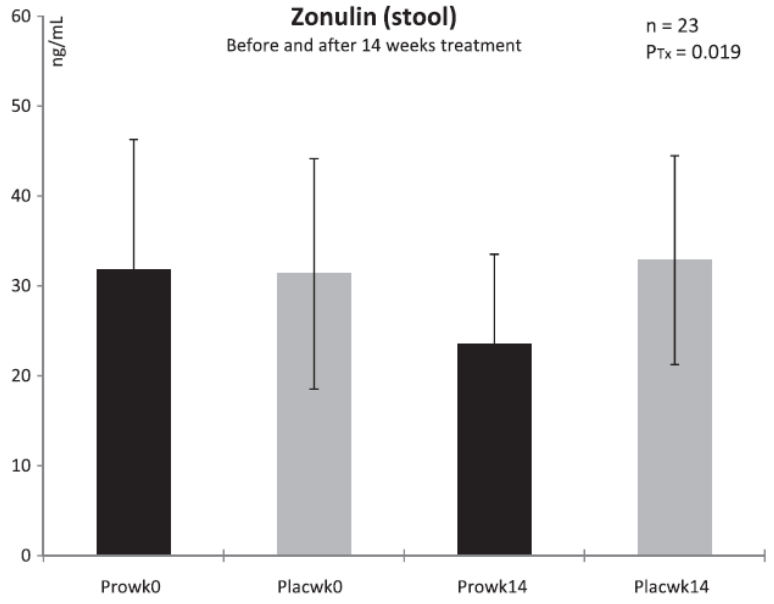
- 23 trained males, 14 week supplementation with multi-strain probiotic
- Results: Improved intestinal permeability (reduction in zonulin), reduction in inflammation, however, no performance benefits



The following 3 strains/species have been shown to improve gut health in athletes

1) *L. rhamnosus* GG at 4 × 10^{10} CFU in form of a milk-based drink

2) *B. bifidum* W23, *B. lactis* W51, *E. faecium* W54, *L. acidophilus* W22, *L. brevis* W63, and *L. lactis* W58, at 1 × 10^{10} CFU

3) *L. salivarius* (UCC118) (unknown dose).


Jäger et al. Journal of the International Society of Sports Nutrition (2019) 16:62
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(Continued on next page)

BMC

Reference: Lampbrecht *et al.* **Probiotic supplementation affects markers of intestinal barrier, oxidation, and inflammation in trained men; a randomized, double-blinded, placebo-controlled trial.** *J Int Soc Sports Nutr* **2012**, 9:45

Can Probiotic Increase Athletic Performance?

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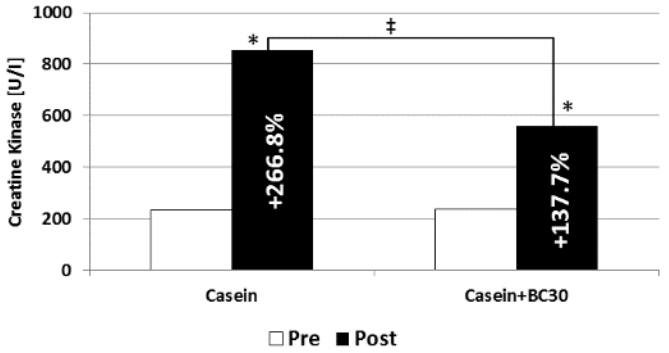
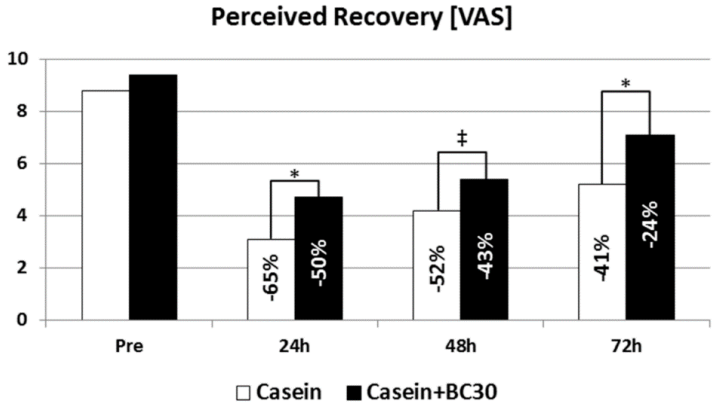
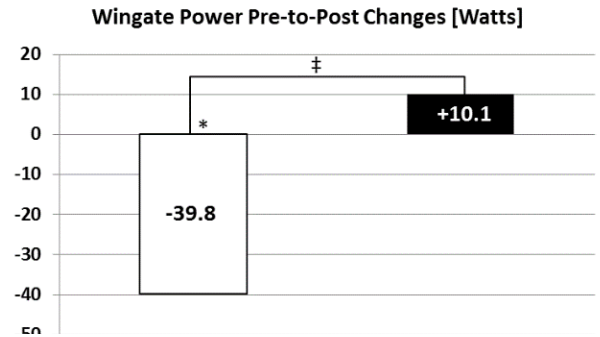
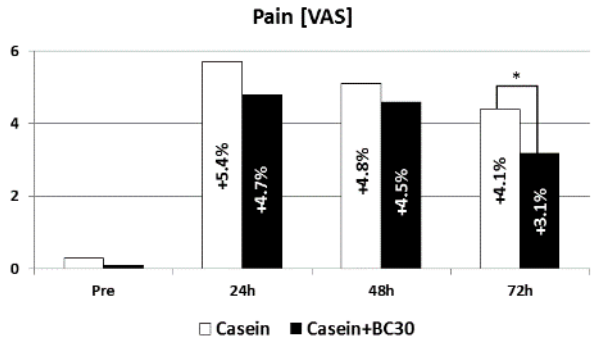
Probiotic (BC30) + Protein (casein)

- Subjects:
  29 recreationally trained males
- Supplement:
  20g of casein or 20g of casein plus *Bacillus coagulans* GBI-30, 6086 (BC30), 1 billion CFU, 2 weeks.
- Exercise:
  Damaging Single-Leg Exercise









Reference: Jäger *et al.*: **Probiotic Bacillus coagulans GBI-30, 6086 reduces exercise-induced muscle damage and increases recovery.** *PeerJ* **2016**, 4:e2276.

Can Probiotic Increase Athletic Performance?

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- Daily ingestion of encapsulated probiotics containing 5 bn live cells of *B. breve* BR03 (DSMZ 16604) and 5 bn live cells of *S. thermophilus* FP4 (DSMZ 18616) or placebo for 3 weeks, 3 week washout period.
- Muscle-damaging elbow flexor exercise: 5 sets of 10 maximal eccentric (forced lengthening) contractions at a speed of 30°•sec^{-1}.

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TCU
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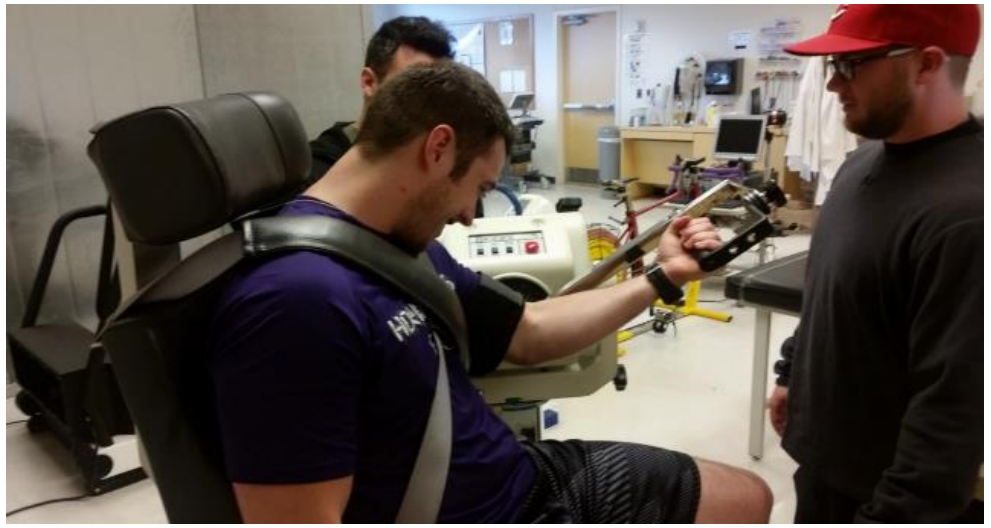

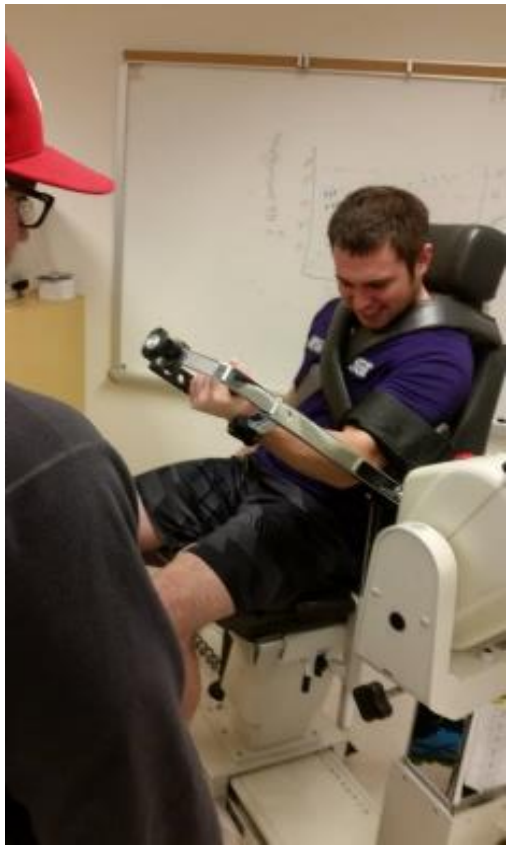

Reference: Jäger *et al.*: **Probiotic supplementation attenuates performance decrements and inflammation following muscle damaging exercise.** *Nutrients* **2016**, 8:642

Can Probiotic Increase Athletic Performance?

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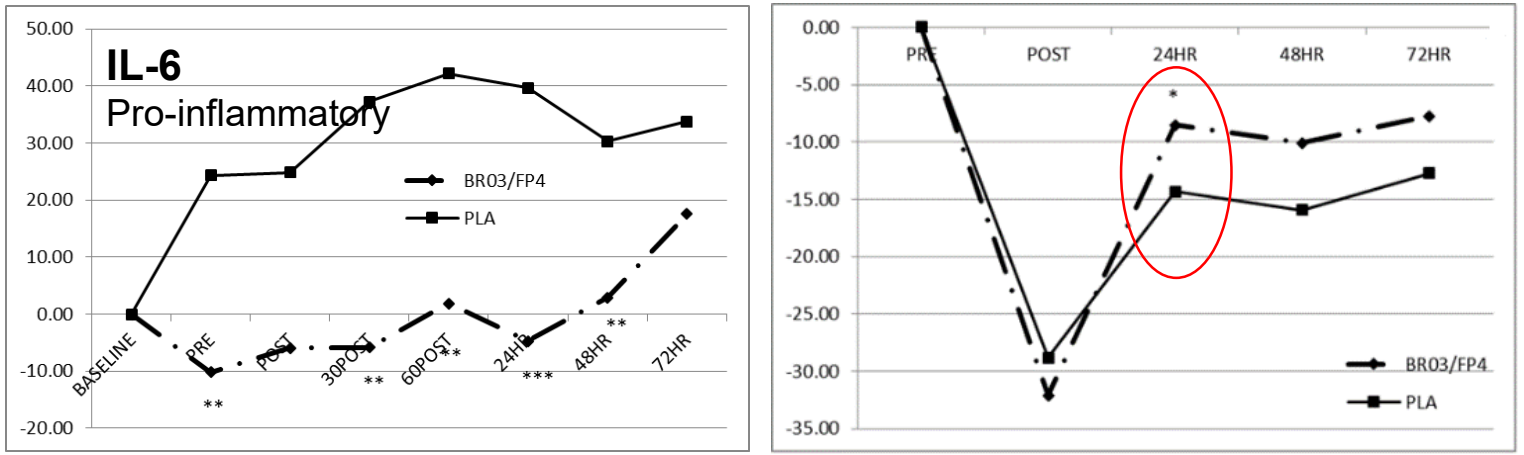
Capsules & Health Ingredients

- Muscle-damaging exercise reduced performance by ~30% (Isometric Peak Torque).
- Probiotics attenuated the performance decrement compared to placebo.
- Probiotics lowered baseline (-10%, vs. +24%) and post-exercise inflammation (-8%, vs. +25%)



- **Probiotic supplementation improved range-of-motion (relaxed arm angle) 24 (+2.4%) and 48 hours (1.9%) after exercise.**

Reference: Jäger *et al.*: **Probiotic supplementation attenuates performance decrements and inflammation following muscle damaging exercise.** *Nutrients* **2016**, 8:642

Can Probiotic Increase Athletic Performance?

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Performance, Immune & Gut Health

- Subjects:
  Young (13.8 ±1.8 years) female endurance swimmer
- Supplement:
  L. acidophilus SPP, *L. delbrueckii bulgaricus*, *B. bifidum*, *S. salivarus thermnophilus* yoghurt at 4×10^{10} CFU per day for 8 weeks. Yoghurt without probiotics was used as control.

- **Performance**
  - Probiotic administration reduced 400m swim time by 3.9 seconds (control -0.5s, p=0.22)
  - **Probiotic significantly increase aerobic fitness (VO_2max, 0.56 vs. 0.01, p<0.05)**

EPISODES	Probiotic	Control	P-value
Digestive Disorders	0.9±0.8	1.6±0.8	0.06
Respiratory Infections	**0.9±0.8**	**1.4±0.6**	**< 0.01**
DURATION	**Probiotic**	**Control**	**P-value**
Rhinitis	3.2±2.5	4.3±3.0	0.27
Fever	0.5±0.7	1.0±0.9	0.15
Sore Throat	0.8±0.9	1.8±1.7	0.08
Cough	2.0±2.4	2.9±3.3	0.35
Dyspnea	**2.4±2.6**	**4.4±2.8**	**< 0.05**
Ear Pain	**0.5±0.9**	**1.6±1.7**	**< 0.01**
DURATION	**Probiotic**	**Control**	**P-value**
Diarrhea	1.0±1.5	1.2±1.3	0.39
Vomiting	0.8±0.9	1.0±1.5	0.98
Stomach Ache	1.4±1.3	2.0±1.1	0.10

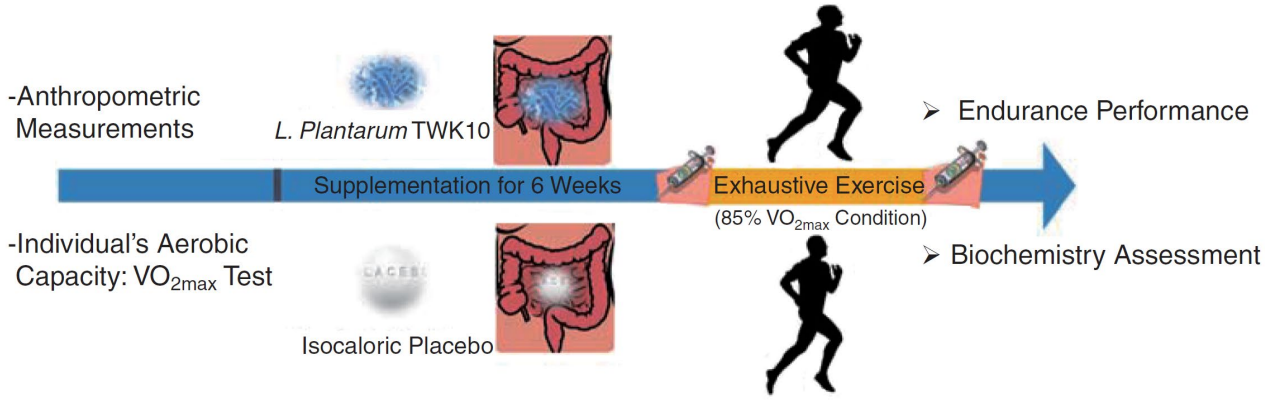
Reference: Salarkia *et al*. **Effects of probiotic yogurt on performance, respiratory and digestive systems of young adult female endurance swimmers: a randomized controlled trial.** *MJIRI* **2013**, 27(3):141-146

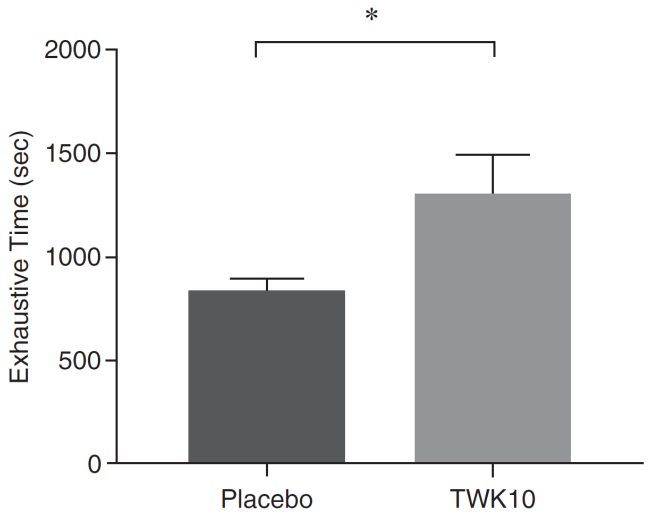
Studies Show That TWK10® Increases Athletic Performance

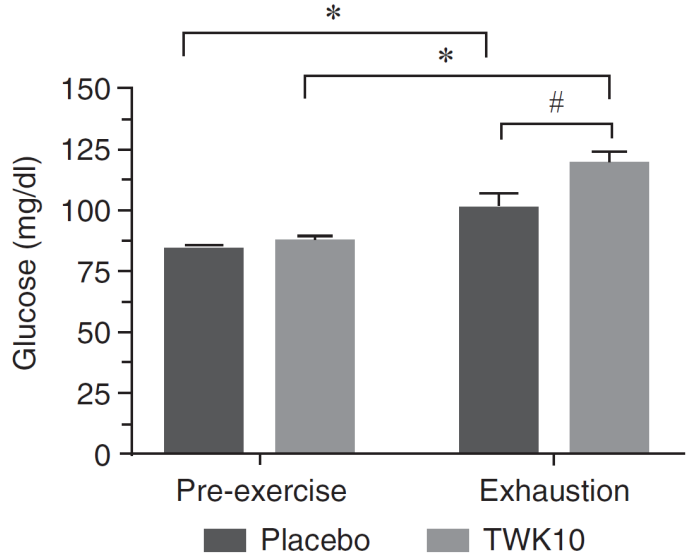
Lonza
Capsules & Health Ingredients

- Lactobacillus plantarum TWK10
  1×10^{11} CFU/day for 6 weeks
- Increased open-ended endurance performance (time-to-exhaustion) by 58% over placebo.
- Proposed mechanism: better energy utilization.

TWK10™







Reference: Huang *et al*. **Effect of *Lactobacillus Plantarum* TWK10 on Improving Endurance Performance in Humans.** *Chin J Physiol* **2018**, 61(3):163-170.

Validated Probiotic Strains for Athletic Performance

Lonza
Capsules & Health Ingredients

1) *B. coagulans* GBI-30, 6086 (BC30) at 1 × 10^9 CFU has beneficial effects in combination with protein on exercise recovery.

2) Encapsulated *B. breve* BR03 in combination with *S. thermophilus* FP4 at 5 × 10^9 CFU each has beneficial effects on exercise recovery and performance following muscle-damaging exercise.

3) *L. delbrueckii ssp. bulgaricus* at 1 × 10^5 CFU can increase VO_2max and aerobic power.

4) *L. acidophilus* SPP, *L. delbrueckii bulgaricus*, *B. bifidum*, and *S. salivarus thermophilus* at 4 × 10^{10} CFU administered in form of a yogurt drink can increase VO_2max.

5) *L. plantarum* TWK10 at 1 × 10^{10} CFU has been shown to increase endurance performance.

6) *L. acidophilus*, *L. rhamnosus*, *L. casei*, *L. plantarum*, *L. fermentum*, *B. lactis*, *B. breve*, *B. bifidum* and *S. thermophilus* at 4.5 × 10^{10} CFU can increase run time to fatigue in the heat.

TWK10™

Jäger et al. Journal of the International Society of Sports Nutrition (2019) 16:62
https://doi.org/10.1186/s12970-019-0329-0

Journal of the International Society of Sports Nutrition

REVIEW Open Access

International Society of Sports Nutrition Position Stand: Probiotics

Ralf Jäger[1*], Alex F. Mohr[2], Katie C. Carpenter[3], Chad M. Kerksick[4], Martin Purpura[1], Adel Moussa[5], Jeremy R. Townsend[6], Manfred Lamprecht[7], Nicholas P. West[8], Katherine Black[9], Michael Gleeson[10], David B. Pyne[11], Shawn D. Wells[12], Shawn M. Arent[13], Abbie E. Smith-Ryan[14], Richard B. Kreider[15], Bill I. Campbell[16], Laurent Bannock[17], Jonathan Scheiman[18], Craig J. Wissent[19], Marco Pane[20], Douglas S. Kalman[21], Jamie N. Pugh[22], Jessica A. ter Haar[23] and Jose Antonio[24]

Abstract

Position statement: The International Society of Sports Nutrition (ISSN) provides an objective and critical review of the mechanisms and use of probiotic supplementation to optimize the health, performance, and recovery of athletes. Based on the current available literature, the conclusions of the ISSN are as follows:

1) Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO).
2) Probiotic administration has been linked to a multitude of health benefits, with gut and immune health being the most researched applications.
3) Despite the existence of shared, core mechanisms for probiotic function, health benefits of probiotics are strain- and dose-dependent.
4) Athletes have varying gut microbiota compositions that appear to reflect the activity level of the host in comparison to sedentary people, with the differences linked primarily to the volume of exercise and amount of protein consumption. Whether differences in gut microbiota composition affect probiotic efficacy is unknown.
5) The main function of the gut is to digest food and absorb nutrients. In athletic populations, certain probiotics strains can increase absorption of key nutrients such as amino acids from protein, and affect the pharmacology and physiological properties of multiple food components.
6) Immune depression in athletes worsens with excessive training load, psychological stress, disturbed sleep, and environmental extremes, all of which can contribute to an increased risk of respiratory tract infections. In certain situations, including exposure to crowds, foreign travel and poor hygiene at home, and training or competition venues, athletes' exposure to pathogens may be elevated leading to increased rates of infections. Approximately 70% of the immune system is located in the gut and probiotic supplementation has been shown to promote a healthy immune response. In an athletic population, specific probiotic strains can reduce the number of episodes, severity and duration of upper respiratory tract infections.

(Continued on next page)

Probiotics and Nutrient Absorption

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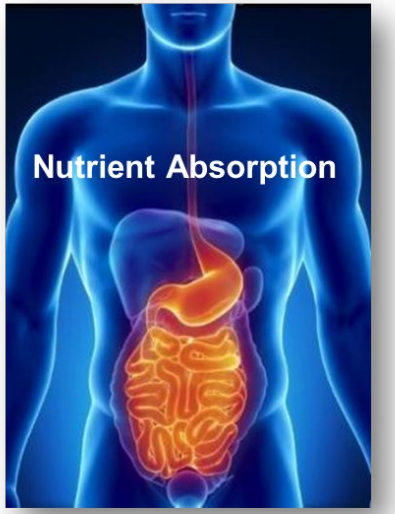
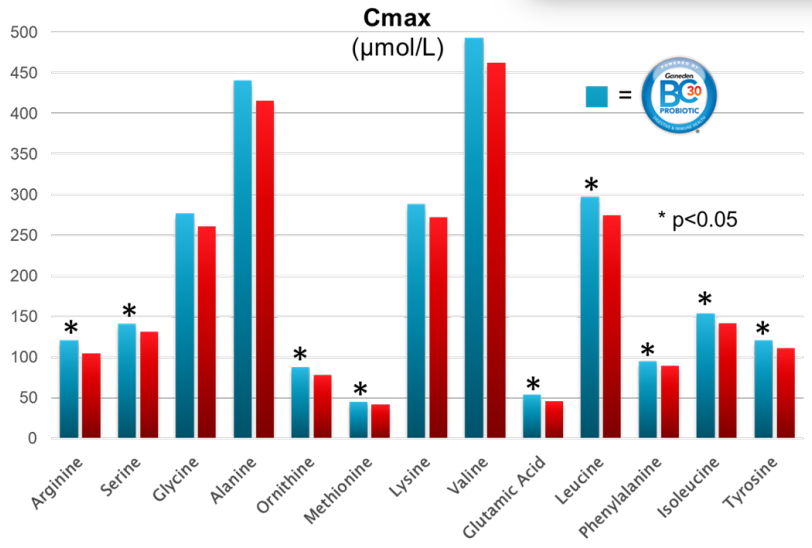
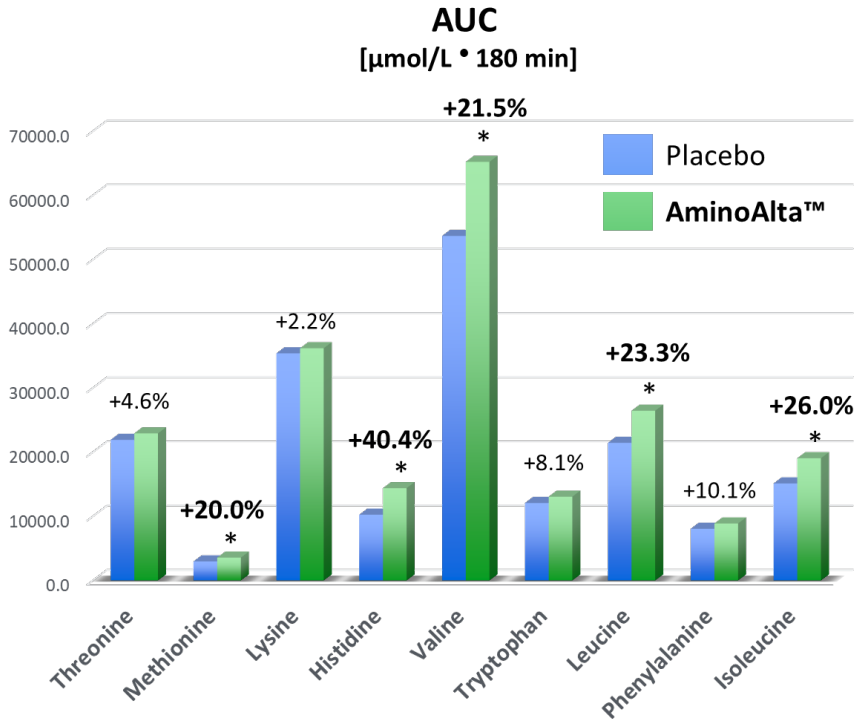
- Probiotics can increase nutrient absorption
- Plant Protein
  - Leucine (+23.3%)
  - Total BCAAs (+22.8%)
  - Total EAA (+16.0%)
- Animal Protein
- Iron







Reference: Jäger, *et al.* **Probiotic administration increases amino acid absorption from plant protein – A placebo-controlled, randomized, double-blind, multicenter, crossover study.** *Probiotics Antimicrob Proteins* **2020**, 10.1007/s12602-020-09656-5.

Future Research Directions

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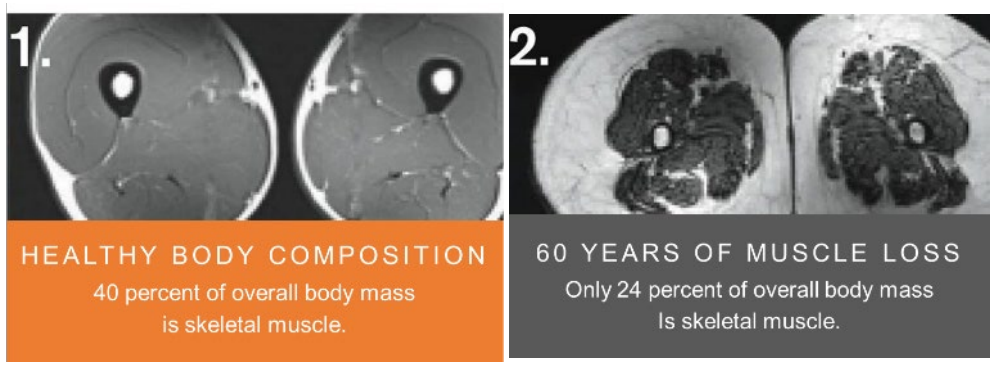
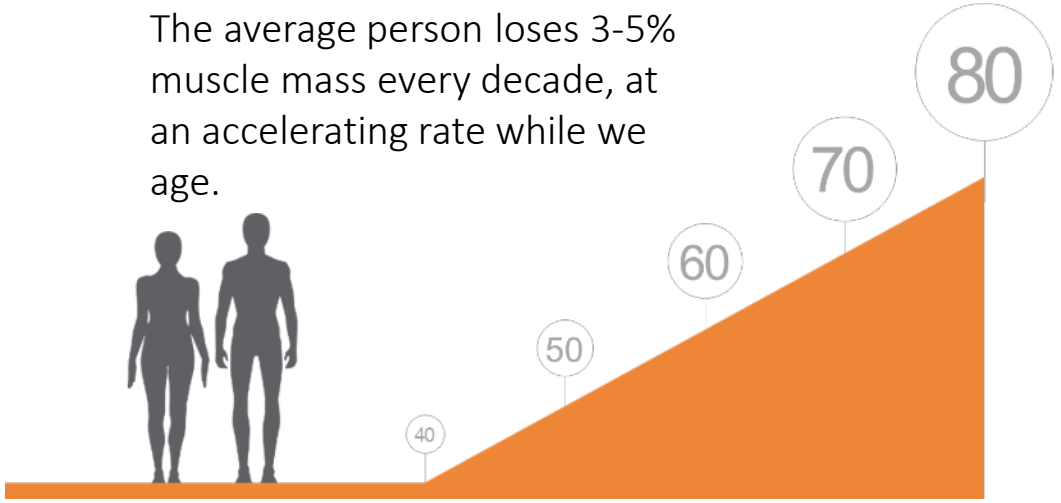
- Probiotics have been linked to numerous benefits relevant for athletes
  - Normalize age related drops in testosterone levels: body composition, sarcopenia
  - Increase neurotransmitter synthesis (acetylcholine): endurance, explosiveness
  - Reduce cortisol levels: body composition
  - Improve mood, reduce anxiety: performance
  - Reduce lactic acid: endurance
  - Reduce baseline inflammation = reduction in body fat
  - Increase muscle mass = strength, performance
  - …



The average person loses 3-5% muscle mass every decade, at an accelerating rate while we age.



Reference: Jäger *et al.*: **International Society of Sports Nutrition Position Stand: Probiotics.** *J. Int Soc Sports Nutr* **2019**, 16:62.

Probiotics - Athletes

Lonza

Capsules & Health Ingredients

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Journal of the International Society of Sports Nutrition

REVIEW Open Access

International Society of Sports Nutrition Position Stand: Probiotics

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(Continued on next page)

* Correspondence: ralf.jaeger@increnovo.com
This position stand is dedicated to the late Dr. Mike Greenwood who made significant contributions to the development of the ISSN and JISSN. This position stand has been adopted by the Austrian Society of Sports Nutrition (Österreichische Gesellschaft für Sporternährung (ÖGSE)).Submitted to the ISSN Research Committee for consideration as a Position Stand of the Society.October 31, 2019
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Journal of the International Society of Sports Nutrition

REVIEW Open Access

The athletic gut microbiota

Alex E. Mohr[1*], Ralf Jäger[2], Katie C. Carpenter[3], Chad M. Kerksick[4], Martin Purpura[2], Jeremy R. Townsend[5], Nicholas P. West[6], Katherine Black[7], Michael Gleeson[8], David B. Pyne[9], Shawn D. Wells[10], Shawn M. Arent[11], Richard B. Kreider[12], Bill I. Campbell[13], Laurent Bannock[14], Jonathan Scheiman[15], Craig J. Wissent[16], Marco Pane[17], Douglas S. Kalman[18], Jamie N. Pugh[19], Carmen P. Ortega-Santos[1], Jessica A. ter Haar[20], Paul J. Arciero[21] and Jose Antonio[22]

Abstract

The microorganisms in the gastrointestinal tract play a significant role in nutrient uptake, vitamin synthesis, energy harvest, inflammatory modulation, and host immune response, collectively contributing to human health. Important factors such as age, birth method, antibiotic use, and diet have been established as formative factors that shape the gut microbiota. Yet, less described is the role that exercise plays, particularly how associated factors and stressors, such as sport/exercise-specific diet, environment, and their interactions, may influence the gut microbiota. In particular, high-level athletes offer remarkable physiology and metabolism (including muscular strength/power, aerobic capacity, energy expenditure, and heat production) compared to sedentary individuals, and provide unique insight in gut microbiota research. In addition, the gut microbiota with its ability to harvest energy, modulate the immune system, and influence gastrointestinal health, likely plays an important role in athlete health, wellbeing, and sports performance. Therefore, understanding the mechanisms in which the gut microbiota could play in the role of influencing athletic performance is of considerable interest to athletes who work to improve their results in competition as well as reduce recovery time during training. Ultimately this research is expected to extend beyond athletics as understanding optimal fitness has applications for overall health and wellness in larger communities. Therefore, the purpose of this narrative review is to summarize current knowledge of the athletic gut microbiota and the factors that shape it. Exercise, associated dietary factors, and the athletic classification promote a more "health-associated" gut microbiota. Such features include a higher abundance of health-promoting bacterial species, increased microbial diversity, functional metabolic capacity, and microbial-associated metabolites, stimulation of bacterial abundance that can modulate mucosal immunity, and improved gastrointestinal barrier function.

Keywords: Athletes, Gut microbiome, Microbial ecology, Gut health, Sports nutrition, Sport performance, Exercise, Physical activity, Metagenome, Short-chain fatty acids

Introduction

The human gut microbiota contains thousands of different bacterial taxa as well as various archaea, eukaryotic microbes and viruses, more than three million genes, and harbors an enormous metabolic capacity [1, 2]. The microorganisms in the gastrointestinal (GI) tract play a role in nutrient uptake, vitamin synthesis, energy harvest, inflammatory modulation, and host immune response [3, 4]. In turn, numerous intrinsic and extrinsic factors can affect the gut microbiota which results in a complex gut ecosystem that is highly dynamic and individual [5, 6]. Important factors such as age, birth delivery route, antibiotic use, and diet can shape the gut microbiota [7–10]. The role that exercise plays, in particular the associated factors and stressors, such as sport/exercise-specific diet [11], environment [12], and their interactions, on the gut microbiota have been less well

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REVIEW

OPEN

CURRENT OPINION

Recent advances in clinical probiotic research for sport

Ralf Jäger[a], Alex E. Mohr[b], and Jamie N. Pugh[c]

Purpose of review
This is a review of the most up-to-date research on the effectiveness of probiotic supplementation for outcomes related to athletes and physical activity. The focus is on clinical research incorporating exercise and/or physically active participants on the nutritional effectiveness of single and multistrain preparations.

Recent findings
Findings of the included clinical studies support the notion that certain probiotics could play important roles in maintaining normal physiology and energy production during exercise which may lead to performance-improvement and antifatigue effects, improve exercise-induced gastrointestinal symptoms and permeability, stimulate/modulate of the immune system, and improve the ability to digest, absorb, and metabolize macro and micronutrients important to exercise performance and recovery/health status of those physically active.

Summary
The current body of literature highlights the specificity of probiotic strain/dose and potential mechanisms of action for application in sport. These novel findings open new areas research, potential use for human health, and reinforce the potential role for probiotic's in exercise performance. While encouraging, more well designed studies of probiotic supplementation in various sport applications are warranted.

Keywords
exercise, gut microbiome, physical activity, probiotic, sport

INTRODUCTION

In humans, the effects of probiotics in relation to exercise has been less described in comparison with clinical conditions and sedentary populations, and even less so when considering athletic populations. However, the body of probiotic research in physically active individuals and competitive athletes is expanding, including investigations in gastrointestinal health, exercise performance, recovery, physical fatigue, immunity, and body composition [1▪▪]. Probiotic preparations comprise live microorganisms that, when administered in adequate amounts, confer a health benefit on the host [2]. The beneficial effect of probiotic supplementation profoundly relies on strain, dose, duration, form, and host physiology as well as the target population and the outcome of interest [3]. As such, recommendations for probiotics should consider all of these factors and benefits from specific studies should not lead to general conclusions for all probiotic products.

Probiotics are available commercially in capsule or tablet forms, as powder sachets, in the form of liquids, and in specific foods such as yogurt and nutrition bars. Commonly used probiotic strains for the application of exercise include *Lactobacillus*, *Bifidobacterium*, and *Bacillus* genera, however, new microbiome research and technological advances are identifying potential next-generation probiotic candidates [4]. In the context of exercise, and especially athletes, the present body of literature suggests their microbiota has several key differences in comparison with other populations, likely driven, in part, by exercise and diet [5▪]. These characteristics may influence the effects of probiotics on the

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Thank you

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