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Understanding the Link between Exercise and the Gut Microbiome: Is there a role for Prebiotics?

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Disclosures

- **Avid Exerciser (College Soccer All-American, triathlete, Muay Thai, Gold belt karate)**
- **GI Issues: Gastritis, IBD and lacking a gall bladder since 2015**
- **Aunt Denise and Uncle Peter had major battles with colon cancer**
- **Spencer, my Muay Thai Kru, has Crohn's, Jen karate partner has ulcerative colitis**
- **Many of my students have or know family who has GI issues**

- **EXERICSE AND GUT HEALTH IS A PASSION… A PERSONAL PASSION FOR US!**

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TALK OUTLINE

- EXECISE AND GUT MICROBIOME
- CONSIDERATIONS FOR EXERCISERS/ATHLETE
  - GI DISTRESS
  - LEAKY GUT
  - IMMUNE FUNCTION
- SOLUTIONS: Prebiotics or Probiotics
  - QUICK REMINDER
  - PREBIOTICS
  - MECHANISMS OF ACTION
  - EXERCISE IMPLICATIONS

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EXERCISE AND GUT MICROBIOME

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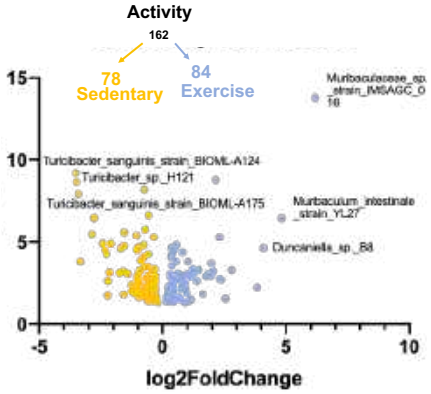
Exercise Enhances Taxa that are Distinct from Sedentary Animals



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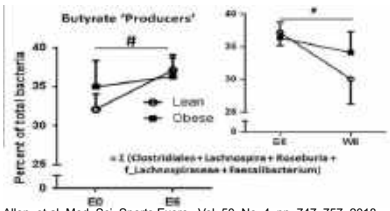
Exercise increases abundance of butyrate producing microbes and butyrate

Microbes enhanced by Exercise.

Fecalibacterium prausnitzii
Roseburia Intestinalis
Allobaculum
Allobaculum spp
Blautia spp
Allobaculum spp 104
Lactobacillus spp
Corprococcus spp
Oscillibacter spp
Clostridium spp

Campbell et al., PLoS ONE, 2016



Allen, et al. Med. Sci. Sports Exerc., Vol. 50, No. 4, pp. 747–757, 2018.

Table I. Organic Acid Concentrations in the Cecal Contents of the Control and Exercise Groups

	Control	Exercise
	(μmol/g of cecal contents)	
Succinate	1.31 ± 0.25	0.65 ± 0.19
Lactate	1.74 ± 0.30	1.39 ± 0.33
Acetate	41.7 ± 3.44	43.9 ± 2.94
Propionate	15.2 ± 0.75	16.6 ± 0.76
n-Butyrate	4.87 ± 0.41	8.14 ± 1.36*

Matsumoto et al. Biosci. Biotechnol. Biochem., 72 (2), 572–576, 2008

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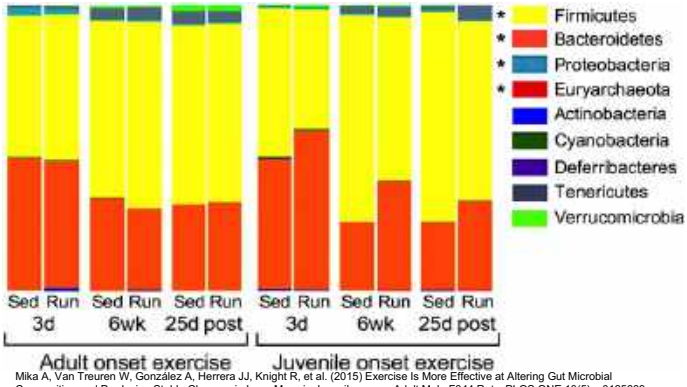
Effects of Age and Exercise on Gut Microbiota



Mika A, Van Treuren W, González A, Herrera JJ, Knight R, et al. (2015) Exercise Is More Effective at Altering Gut Microbial Composition and Producing Stable Changes in Lean Mass in Juvenile versus Adult Male F344 Rats. PLOS ONE 10(5): e0125889. https://doi.org/10.1371/journal.pone.0125889
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0125889

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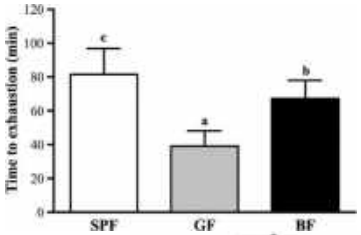
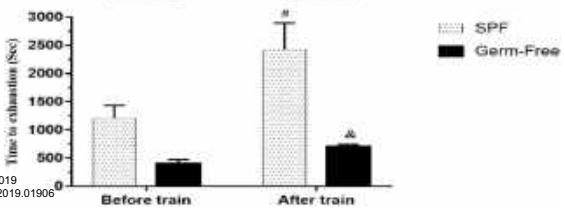
Intact Microbiota needed for Exercise Tolerance



Hsu et al., 2015. J Strength Cond Res; 29(2):552-558.



Front. Microbiol., 20 August 2019
https://doi.org/10.3389/fmicb.2019.01906

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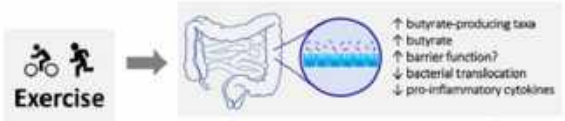
Summary on Exercise Microbiome



Exercise does NOT always alter diversity

Exercise must be done in order to see beneficial changes to gut microbiota

Exercise can alter the microbiota in young and old animals; however, it seems that the impacts are more robust when animals are younger

Intact gut microbiome required for exercise

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CONSIDERATIONS FOR THE EXERCISERS/ATHLETES

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Gastrointestinal (GI) Distress

- Bloating
- Cramping
- Abdominal Distention
- Pain

Depending on methods anywhere from 30-90% of endurance athletes complain of GI issues related to exercise. Complaints include: nausea, vomiting, abdominal angina, and bloody diarrhea.

This can influence not only performance but recovery

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Leaky Gut
What Influences Barrier Function?

- Physiologic Mechanism
  - Membrane and ions
    - Glucose and protein
    - Promote passive paracellular flux of ions, water and nutrients soon after meal
    - Expression of transporters
      - Na+/H+ antiporter
      - Sodium-glucose trans
      - Chloride channels
      - Na+/K+ ATPase
- Pathologic Mechanism
  - Enteric pathogens
  - Basolateral inflammatory cytokines
    - Protein kinase C
    - Mitogen activated protein kinase
    - Rho GTPase
    - Micro-RNAs

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PREBIOTICS AND GUT FUNCTION

- **Positive Impacts**
  - Exert Influence on GALT (gut-associated lymphoid tissue)
  - Bacteria that flourish with prebiotic foods produce short chain fatty acids (SCFA) like butyrate that promotes colonocyte proliferation and differentiation
  - SCFA also interact with leukocytes
  - SCFA enable modulation of mucin production (mucus has sugars that feed the good microbes, cyclic relationship)
  - Prebiotics interact with CHO receptors of pathogens, inhibiting their enhancement on epithelial cells.

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SOLUTIONS?

PREBIOTICS OR PROBIOTICS

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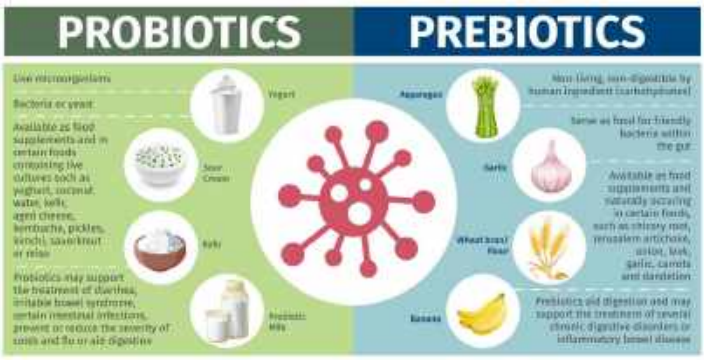
Modulating factors of gut microbiota: Prebiotics versus Probiotics



Probiotics MUST BE alive for them to work

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REMINDER: Exercise and the Microbiome

- General Findings
  - Increase in butyrate concentrations
  - Increase in [BCoAT] (enzyme to make butyrate)
  - Increase in certain microbes, many of which produce butyrate
    - Faecalibacterium
    - Prevotella
    - Roseburia
    - Lachnospira
    - Sometimes Akkermansia and Veillonella

Most commonly studied probiotics are: Lactobacillus and Bifidobacterium

WHY DO I MENTION THIS ALL??

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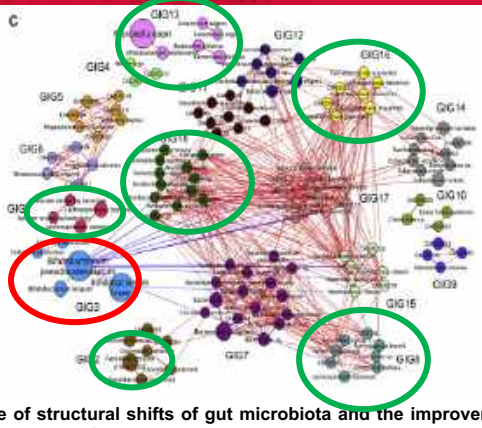
GENOME INTERACTION GROUPS



Concordance of structural shifts of gut microbiota and the improvement of the host metabolic health. Genome interaction groups interaction network. Highlight the importance of probiotic microbes and microbes known to be increased with exercise (red circles)., Zhang et al., EBioMedicine, 2015 Aug; 2(8): 968–984.

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PREBIOTICS: FEED THE BUGS!

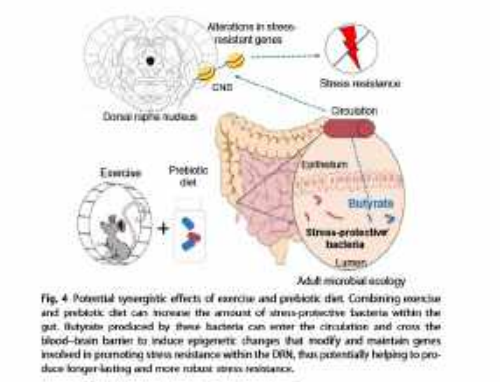

Fig. 4 Potential synergistic effects of exercise and prebiotic diet. Combining exercise and prebiotic diet can increase the amount of stress-protective bacteria within the gut. Butyrate produced by these bacteria can enter the circulation and cross the blood–brain barrier to induce epigenetic changes that modify and maintain genes involved in promoting stress resistance within the DRN, thus potentially helping to produce longer-lasting and more robust stress resistance.

Mika et al., 2016, Exercise and Prebiotics Produce Stress Resistance: Converging Impacts on Stress-Protective and Butyrate-Producing Gut Bacteria. Chapter 8

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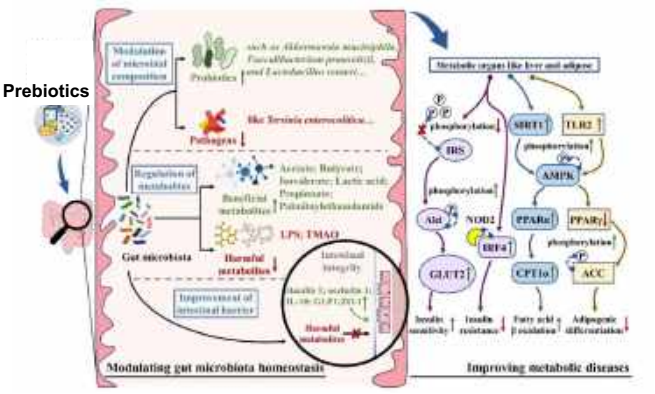
MECHANISMS OF ACTION



Li et al., Nutrients **2021**, 13, 3211.

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WHY IS THIS RELEVANT?

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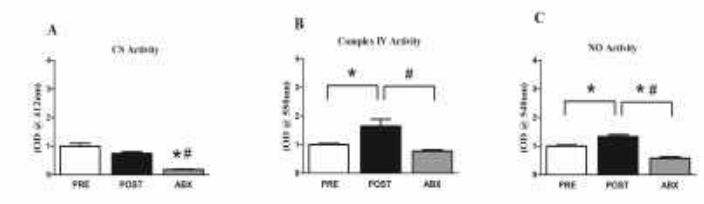
Mitochondrial Oxidative Function



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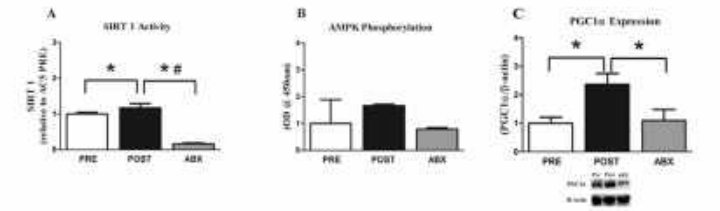
Mitochondrial Biogenesis



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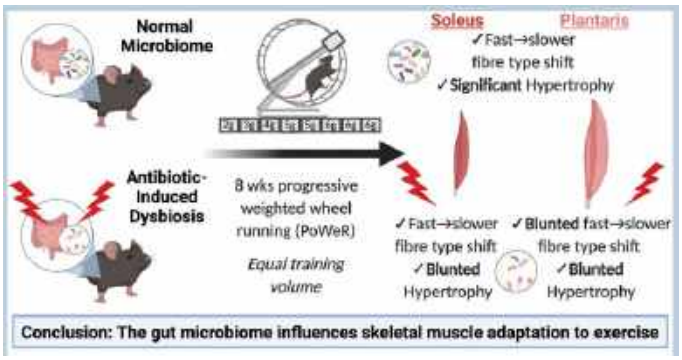
Muscle Hypertrophy



Fast-twitch plantaris (PLA) versus Slow-twitch soleus (Sol)

Valentino et al. J Physiol 599.21 (2021) pp 4845–4863

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TAKEAWAY POINTS

- **SUMMARY**
  - **Prebiotics are functional foods that feed the bacteria present in the gut and have greater potential for influencing all populations of microbes not just a few. Evidence for nutritional strategies for improving performance are well known and include many prebiotic foods already.**
  - **Prebiotic diets and exercise can improve health throughout the life span, and the adaptations in gut bacteria as well as the central nervous system and behavior produced by exercise training and prebiotics are well documented at all ages.**
  - **Exercising individuals have several gut considerations, which can be aided by prebiotics.**
  - **Exercise is disrupted including aspects of mitochondrial function and hypertrophy, critical training adaptations that are linked to good metabolic health.**

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  - Lee Kerkhof, PhD
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