Sports Pharmacy

SPORTSRXNEWS
DECODING THE SCIENCE OF ELITE HUMAN PERFORMANCE

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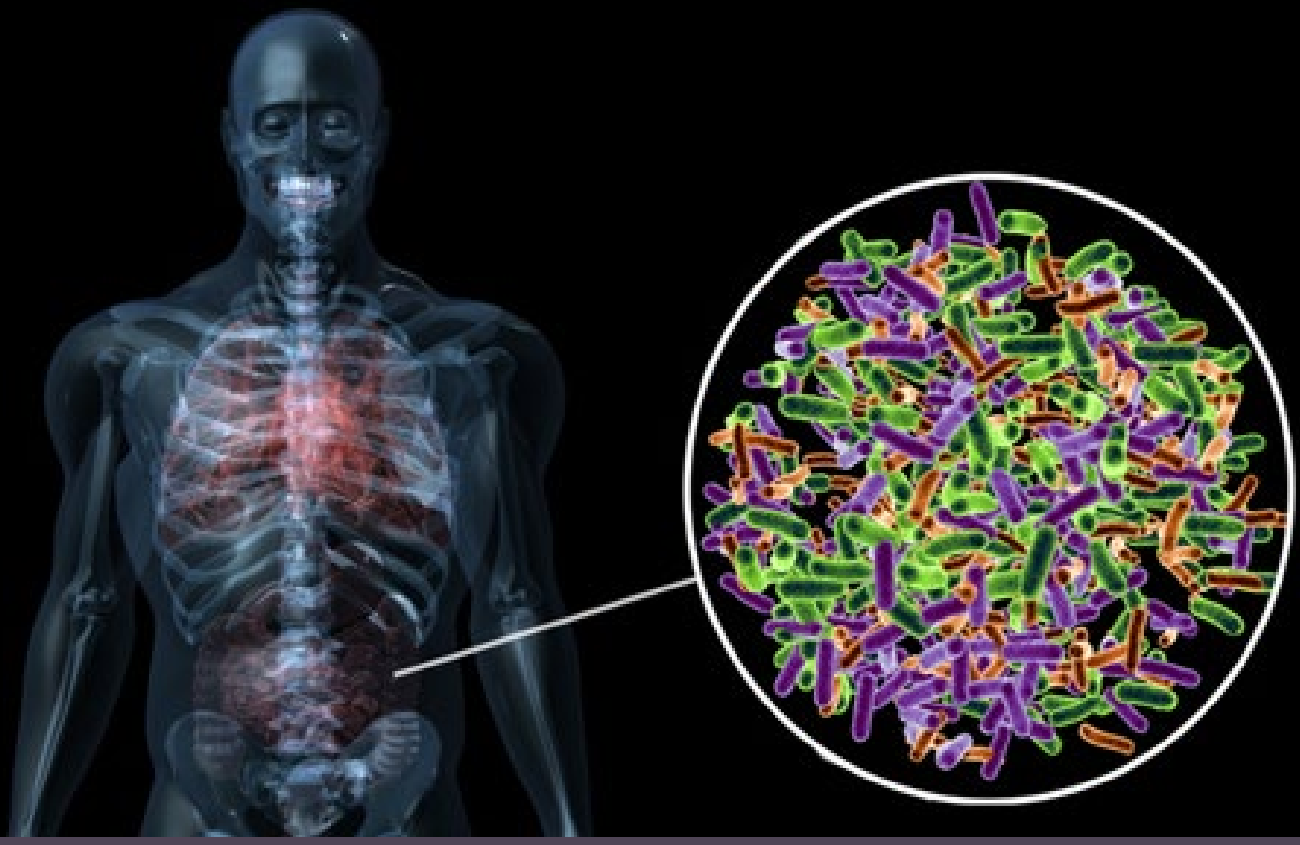
THE ATHLETE MICROBIOME



The Athlete's Gut Microbiome

A Bacterial Solution to Runners Trots?

Stress and the Gastrointestinal Track

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MISSION STATEMENT

THE PURPOSE

Brandon K. Welch, Pharm.D.
Founder of Pharmacy Athlete

The Sports Pharmacy magazine exists to empower a community of pharmacist professionals to optimize their impact through disseminating evidence-based knowledge and applied science on sports performance supplements and nutrition. Pharmacists can be pivotal players in the arena of sports. They are poised to help intersect biochemistry with biomechanics and real-life science with athletic performance. Our patient athletes rely on results and we are here to deliver them in real-time.

> Where Pharmacists merge Metabolic Health with Peak Human-Performance
>
> Brandon K. Welch, PharmD.

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Wellness is the Future of Pharmacy.

More than ever, the importance of restorative sleep, mental well-being, intentional movement, a healthy diet, recovery, and stress management has come to the forefront of our lives.

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Marissa Brooks, PharmD, MBA
NASM-CWC

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Brandon Welch, PharmD
NASM-CWC (Expected December 2022)

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The Athlete's Gut Microbiome:

The Unseen Powerhouse Influencing Health and Performance

By Dr. Brandon Welch, Pharm.D., M.S.(c)
Human Performance Specialist

AUTHOR BIO:

Dr. Brandon K. Welch is an experienced licensed wellness pharmacist that holds his doctorate in pharmacy from the University of South Florida and his bachelor degree in biomedical sciences with a focus in biochemistry. He is the wellness pharmacist for Baptist Health where he works collaboratively with the Miami Dolphin's and Florida Panther's team physician to help enhance athletic performance and reduce risk of illness. His passion in connecting metabolic health with human performance led him to pursue his Master's degree in physiology and kinesiology with a concentration in human performance and athletic development. His expertise lies in functional training, metabolic health, sports nutrition, sports medicine, and sleep therapy. He utilizes science based medicine and literature to help maximize his clients training performance and daily lifestyle. He's worked with several clients, helping them lose weight, improve performance, improve their sleep cycle, muscle building, and appropriate nutrient supplementing.

Introduction

Picture the human gut as a lively city, home to microorganisms crucial to our health, including **vitamin absorption, digestion, and immunity**. Recent research hints at a symbiotic relationship between physical activity and this gut microbiome, raising the exciting prospect of **enhancing athletic performance by tweaking it**. This review uncovers current evidence and potential future developments in this burgeoning field.

Diving into the Microbiome

Our gut houses about 40 trillion microbial cells, our gut microbiome. Advanced technologies reveal these micro-dwellers as diligent workers, aiding in digestion, immune defense, and more. Research on the human microbiome has surged over the last decade, illustrating that our diet, age, and medications influence it.

The gut microbiome's adaptability presents a golden opportunity for **boosting health and performance**. While it's generally stable, specific triggers can cause drastic shifts impacting our health.

Athletes have now entered this microbial scene. There's growing interest in the potential role of the gut microbiome **in improving athletic performance**. Although we lack a solid playbook for athlete-specific microbiome modifications, the future holds promise for tapping into the power of the gut microbiome in sports science.

Exercise, the Gut, and Microbiome: A Delicate Balance

The impact of exercise on gut health swings both ways. While moderate exercise can enhance gut health and reduce inflammation, **intense and prolonged** activity may cause **negative effects**. For example, endurance athletes often report gut issues during intense sessions, leading some to abandon races. Conversely, inactive individuals have been found to have higher serum endotoxin levels than trained athletes, underscoring the positive influence of exercise on gut health.

Intense exercise can lead to 'intestinal ischaemia,' which increases **gut inflammation and permeability**, potentially causing severe issues. But new evidence also implicates the gut microbiome in these problems. Specifically, some studies suggest that consuming probiotics before a race can help athletes avoid gut discomfort and infections. As we understand this relationship better, harnessing the gut microbiome could become a critical part of sports nutrition.

The Interplay of Microbiome, Respiratory Illnesses, and Inflammation

Elite athletes' intense training can unfortunately make them more prone to upper respiratory tract infections (URTIs) and gastrointestinal problems, which can disrupt training and performance. Here's where probiotics come in – they're not just great for gut health but can also help **safeguard against URTIs** through immune modulation. Certain strains of probiotics, for example, have **significantly reduced URTIs** in marathon runners.

Likewise, intense workouts can result in chronic systemic inflammation, causing gastrointestinal discomfort and more. Probiotics again show promise in managing this inflammation, improving health,

> Constant monitoring enables early detection of detrimental changes and subsequent adjustments.

and potentially **enhancing performance**. Additionally, they could cut down the need for regular anti-inflammatory medications, which can harm the gut microbiome.

So, incorporating specific probiotics into athletes' routines could be a powerful strategy for combating URTIs and inflammation, thereby boosting performance.

The Dance Between Gut Health and Athletic Performance

Athletes' gut microbiomes are quite unique. They're not only more diverse, but they're also enriched with health-promoting bacteria, which can help predict and shape their performance. Various types of sports may influence the gut microbiome differently, with those that require more cardiovascular fitness, like long-distance running, showing a higher abundance of beneficial bacteria.

Understanding Gut Microbiome and Athletic Performance: A Focus on Pro-, Pre-, and Synbiotics

The gut microbiome, with its multitude of microorganisms, plays a critical role in our health and has exciting implications for athletic performance. These insights make gut-altering substances like pro-, pre-, and synbiotics a fascinating prospect for sports nutrition.

Probiotics, beneficial bacteria mainly from the Bifidobacterium and Lactobacillus genera, have gained popularity due to their potential to balance gut microbiota, ward off harmful organisms, and stimulate gut immunity. Interestingly, some research has also linked them with enhanced athletic performance, such as **improved running endurance and increased swimming endurance and grip strength in mice**.

Alongside probiotics, fermented foods, rich in lactic acid bacteria, are gaining attention for promoting a healthy gut microbiome. Preliminary findings suggest they may also **aid athletes by reducing post-exercise immune suppression**.

Prebiotics, which act as food for our beneficial gut bacteria, can help steer our microbiome's health. Although research on their effects on athletic performance is scant, early results are promising, particularly for synbiotics (a blend of probiotics and prebiotics). For instance, they have been linked to **significant reductions in toxic endotoxins levels in triathlon runners**.

Polyphenols, a type of prebiotic, have been highlighted for their antioxidant and anti-inflammatory properties. Some studies suggest they may enhance athletic performance by **aiding muscle recovery, reducing fatigue, and decreasing lactate production**.

In conclusion, while more research is needed, the potential impact of pro-, pre-, and synbiotics on athletic performance offers intriguing possibilities for sports nutrition,

further underscoring the key role of the gut microbiome.

Emerging research has also spotlighted some fascinating findings. For instance, **certain probiotics found in fermented cabbage have been linked to improved grip strength and endurance in mice**. In marathon runners, a type of bacteria that metabolizes lactate, a compound that builds up during intense exercise, was found in greater quantities.

The gut microbiome also plays a crucial role in energy production, mainly through short-chain fatty acids (SCFAs). These not only serve as an energy source but also help maintain gut health and regulate the immune system. They're found in higher levels in athletes and are believed to enhance carbohydrate uptake and fat metabolism.

Finally, the gut microbiome plays a part in **muscle building and maintenance**, notably through its role in protein metabolism. It can boost the availability of amino acids and influence muscle metabolism through certain nutrient-sensitive pathways. So, all in all, the gut microbiome and athletic performance are intricately connected, with future research promising to unlock even more insights for maximizing athletic performance through nutrition and gut health management.

Monitoring the Microbiome Over Time

The gut microbiome, similar to a bustling city, is a dynamic entity. Its monitoring over time allows us to understand how lifestyle changes affect it, which can inform healthier decisions. While some companies offer **microbiome profiling**, few explore longitudinal trends. A one-time snapshot of the gut microbiome gives limited insights, much like a photo of a city at noon doesn't represent its different phases. Long-term monitoring, however, can uncover patterns related to recurring conditions like IBD or changes caused by diet modifications and gastrointestinal surgery.

Antibiotics serve as a perfect example of the value of long-term monitoring. They can disrupt gut health, favoring harmful bacteria like Clostridioides difficile. This shift may take **up to six months to reverse**, with some bacterial strains potentially going extinct, which is crucial information for athletes requiring such treatments.

The gut microbiome's stability over time also bears significance. A healthy microbiome remains relatively stable, while drastic fluctuations may hint at diseases or health issues. Athletes with stable gut microbiomes have shown better performance improvement after dietary changes. Moreover, athletes experiencing gut distress before travel exhibited more microbiome instability.

Regular microbiome monitoring can be especially beneficial for athletes. Seasonal lifestyle and dietary changes could significantly alter their microbiome, impacting performance. Constant monitoring enables early detection of detrimental changes and subsequent adjustments. Although athletes' unique lifestyle can negatively affect the gut microbiome, targeted pro-/prebiotic mixes could help rectify imbalances. However, more research is required to formulate effective strategies.

In essence, long-term microbiome monitoring can offer crucial insights into gut health, particularly for athletes, assisting in identifying and remedying negative changes to improve performance.

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The State of Microbiome Testing

By Dr. Kristal Potter, Capt, USAF, BSC, PharmD.

AUTHOR BIO:

Dr. Kristal Potter received her B.S. in Neuroscience from Florida Atlantic University and her Pharm.D. from the University of South Florida Taneja College of Pharmacy. After graduating she served as a pharmacist in the United States Air Force at Cannon Air Force Base, where she was the Pharmacy and Therapeutics Committee Chair and championed several patient education programs. She is passionate about holistic approaches to healthcare and inspiring the next generation of pharmacy leaders. Dr. Potter currently serves as an Assistant Professor at the Larkin University College of Pharmacy and as an Air Force Reserve Pharmacist for Davis-Monthan Air Force Base.

The Microbiome

Your gut microbiome is about as unique as your fingerprint. The collection of bacterial, archaeal, fungal, viral, and protozoal species that make up our microbiome is a culmination of so many factors.[1] It's influenced by our diets, exercise regimens, genetics, and medications (just to name a few). Recent advances in DNA sequencing have allowed us to better understand the makeup of our microbiome and our symbiotic relationship with it. You can find out what's in your microbiome with some simple testing…but just how affordable, reliable, and useful are these tests?

Microbiome Testing

Direct-to-consumer (DTC) tests of the microbiome are currently flooding the market, with new ones sprouting up frequently. The process is fairly simple; patients take a sample of their stool using a provided fecal swab and then mail it back for sequencing.[2] This collection process is similar to other companies who sequence the human genome, like 23andMe and Ancestry. The 5 most *popular* microbiome testing companies in the United States are summarized in the "Microbiome Test Comparisons" table. The biggest differences between microbiome tests are how they sequence the microbiome genome and what services are provided after testing.

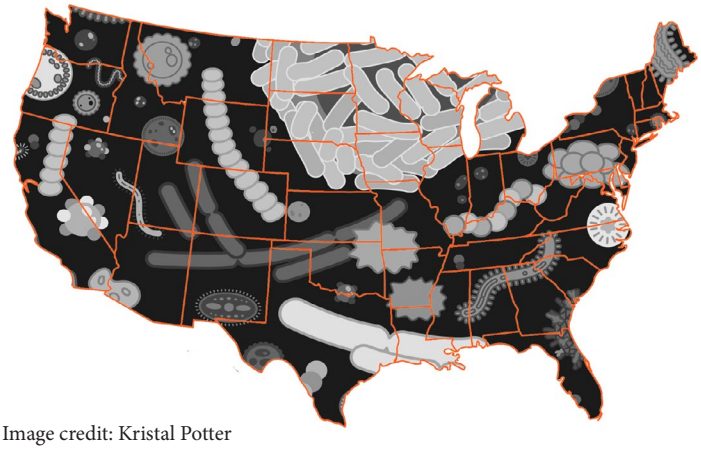

Image credit: Kristal Potter

Microbiome Test Comparisons

Company	Cost	Turnaround Time	Sequencing	Counseling Available
BIOHM[3]	$129	4-6 weeks	RNA	Available with Registered Dietician for additional fee
Floré[4]	$299	1-3 weeks	DNA	Available with Flore Care Scientist (microbiologists)
Ombre[5]	$100	2-4 weeks	RNA	Report only
Thorne[6]	$198	5-6 weeks	DNA	Available for additional fee
VIOME[7]	$179	2-3 weeks	RNA	Report only

*Companies listed in alphabetical order. Sports Pharmacy does not endorse, support, or have partnerships with any of these companies. The statements made by these companies have NOT been evaluated or approved by the FDA. All costs, testing methods, and turnaround times were verified on respective company website as of May 2023.

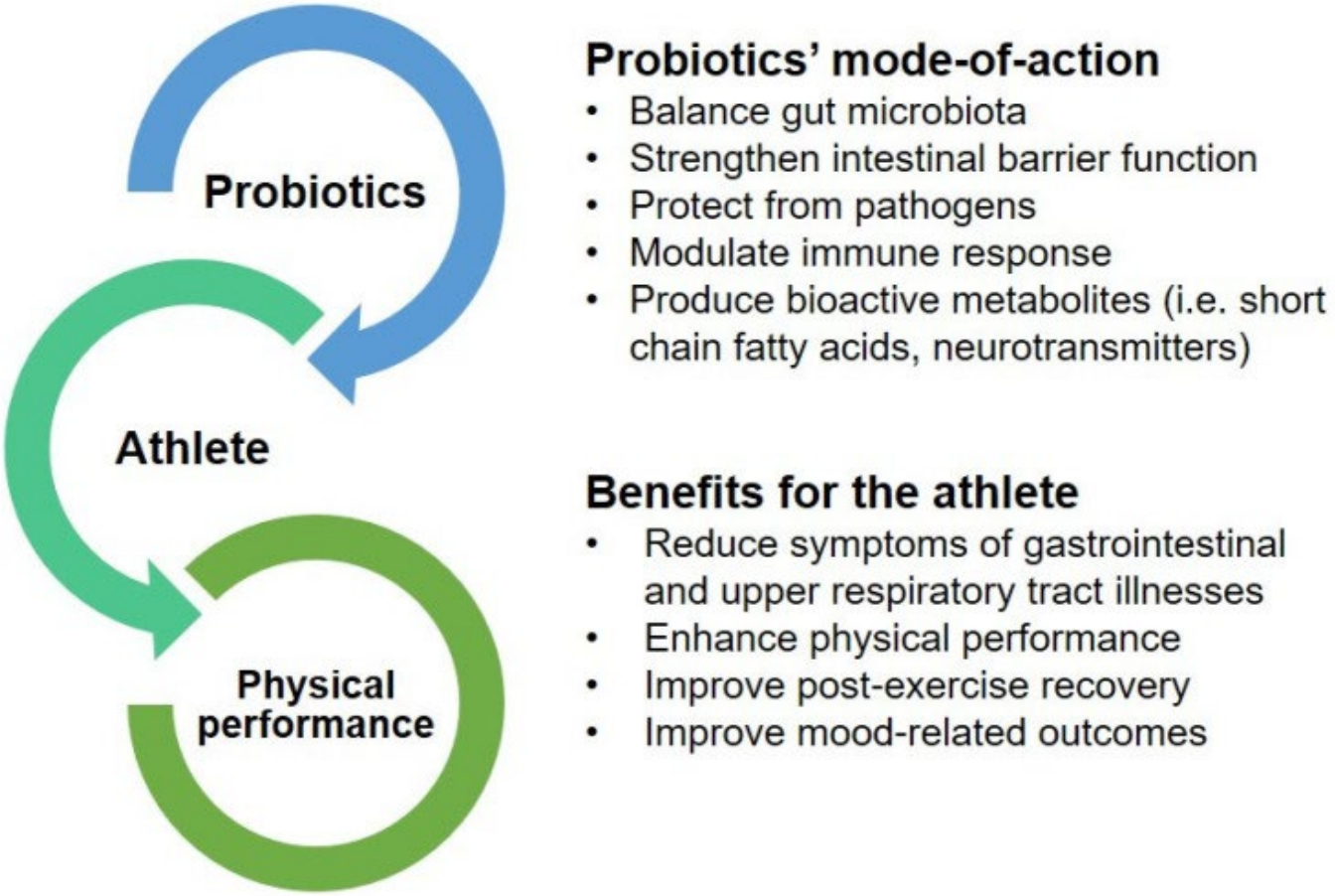

Image credit: Marttinen M, Ala-Jaakkola R, Laitila A, Lehtinen MJ. Gut Microbiota, Probiotics and Physical Performance in Athletes and Physically Active Individuals. Nutrients. 2020;12(10):2936. Published 2020 Sep 25. doi:10.3390/nu12102936

Microbiome Sequencing

Microbiome tests produce their results via metatranscriptomics or metagenomics. Metagenomic tests identifies the DNA of ALL microorganisms present in a sample.[8] On the other hand, metatranscriptomic tests look at the RNA that microorganisms are producing. [9] The advantage of this type of testing is that it will elucidate microorganisms that are active (as evident by their expression of RNA), not just microorganisms that are merely present. The disadvantage of this type of testing is that the results can be influenced by recent meals more than metagenomic tests.

Recommendations and Counseling

Some companies offer counseling services to guide patients through the interpretation of their results.[3,4,6] They may also offer recommendations on dietary changes and prebiotics/probiotics. All of these companies also provide and recommend their own personalized line of supplements to correct whatever imbalances are found. As you can imagine, this can introduce an undeniable amount of perceived (or perhaps real) bias into their testing validity and supplement recommendations. Some microbiome tests claim they are covered by health insurance or patients can use their HSA or FSA accounts.[7]

Testing Process

A lot of the companies offering DTC microbiome testing also have mixed consumer reviews. Consumers seem to enjoy the glimpse into their microbiome, as limited as it is. However, complaints arise about the customer

Image credit:
knowyourDNA.com

> Testing can be a fun informational snapshot of a patient's microbiome, but without actionable clinical implications it doesn't provide much benefit.

service and quality of testing these companies provide. Consumers are also wanting structured medical guidance and interpretation of their results. Most companies are failing to integrate nutrition counseling and clinical recommendations because the science isn't there yet. The shortcomings of microbiome testing could be due in part to the novelty of the tests and the minimal oversight and regulation of these types of tests. We can hope that over time if demand for quality testing continues to rise, the field will become more regulated.

Interpreting Results

The United States National Institutes of Health (NIH)

launched the Human Microbiome Project (HMP) in 2007 to improve the understanding of the microbiome's involvement in human health and diseases.[10] It concluded in 2016 with over data from over 200 healthy volunteers and almost 5,000 samples. Projects like the HMP and others contribute to our understanding of the mapping of a normal microbiome in healthy humans. It allows us to compare new samples to established reference databases and use their boundaries and variations for comparison.

Further research still needs to be done on what an ideal microbiome makeup looks like. We do have an idea of what strains are beneficial and what strains can be detrimental, but not enough data to make strong evidence-based recommendations. We also need more research on what quantities should be aimed for. DTC microbiome testing does not provide precise qualitative results, but instead uses relative phrasing like low or high.

Future Implications

If we pinpoint specific deviances in a patient's microbiome that are implicated in certain disease states or ailments (IBS, diarrhea, constipation, gas, bloating, etc.) we can provide specific probiotics to correct these imbalances.[11,12] These recommendations can even go beyond targeting issues in the gastrointestinal tract. Microbiome imbalances have been linked to anxiety, depression, autism, ADHD, Alzheimer's, and more.[13,14,15,16] Some studies have even shown success in modulating serotonin levels with supplementation of strain specific probiotics.[17] Optimizing the microbiome can also enhance performance for athletes.[18]

The promises of microbiome testing and its use for personalized medicine are ambitiously endless. Testing results can guide clinicians on probiotic recommendations, diet adjustments, drug interactions, and overall lifestyle modifications. One day microbiome testing may have as much significance as pharmacogenomic testing, but we're not quite there yet. Testing can be a fun informational snapshot of a patient's microbiome, but without actionable clinical implications it doesn't provide much benefit.

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Postbiotics:

When Corpses & Bacterial Poop Matter!

By Sean Casey, RD, CSCS

AUTHORS BIO:

Sean Casey RD CSCS is a registered dietitian, movement coach and member of the Evolve Wellness Science Team at Hometown Pharmacy of Wisconsin. He specializes in sports nutrition, nutraceuticals, and proactive care.

Quick Hit Summary:

Postbiotics are a 'rising star' in the gut microbiome world – from both a research perspective as well as consumer marketplace. Postbiotics refers to inanimate microorganisms (i.e. "corpses") and/or metabolites (i.e. "poop") obtained from microorganisms which provide health benefits to the host. Examples of postbiotics include inactivated bacterial strains or cellular components, beta-glucans, short chain fatty acids, vitamins such as Vitamin K2, various b-vitamins and more which have a positive effect on human health. Collectively, postbiotics have been shown to improve immune function, mood, metabolic health, bone structure and many other physiological processes.

Postbiotics – The New Kid on the Microbiome Block!

Within the health, wellness and physical performance field, few topics have gained as much attention during the last year as the gut microbiome - And rightfully so! The gut is pretty dang important; it's a jack of all trades and master of MANY as evidenced by containing 70-80% of your immune system, playing the role of the '2nd brain' and being responsible for absorbing EVERY nutrient that you eat.[1,2]

As it relates to supporting a healthy gut, many consumers are familiar with probiotics, live microoganisms which support one's microbiome such as bacterial and yeast strains as well as prebiotics, the food which is eaten by said microorganisms.

Within the last few years however, a new buzzword has made its way onto the microbiome block from both a clinical research and consumer product perspective – "postbiotics". According to The International Scientific Association of Probiotics and Prebiotics (ISAPP), postbiotics refers to:

"…preparation of inanimate microorganisms and/or their components that confers a health benefit on the host…" [3]

Additionally,

"… Effective postbiotics must contain inactivated microbial cells or cell components, with or without metabolites, that contribute to observed health benefits..." [3]

In layperson lingo, postbiotics refers to killed off microorganisms (i.e. "corpses"), cellular components of said corpses or metabolites (i.e. "poop") produced by bacterial strains which provide health benefits to those who consume them.

Postbiotics can include everything from dead bacterial strains to byproducts produced by bacteria such as short chain fatty acids, beta glucan and even essential micronutrients such as B-vitamins and the bone supporting vitamin K2.[3,4]

With that being said, time to buckle up, turn on your inquisitive mind and explore the exciting world of postbiotics – starting first with food sources before diving into condition specific uses!

Please pass the postbiotic dish!

A large number of foods may contribute to postbiotics within the body. For instance, fermented foods such as sauerkraut, yogurt, kombucha and pickled vegetables are produced with the assistance of microorganisms which leave behind of a trail of potential healthy metabolites.[4]

Additionally, foods containing prebiotic fibers can be fermented by bacteria producing postbiotic metabolites such as short chain fatty acids (SCFA).[5] To date,

> By increasing one's postbiotic load, we may be able to better optimize our mood, immune, bone and cardiometabolic function.

research indicates that SCFA may positively influence everything from brain health to cardiometabolic function![6,7]

Foods rich in polyphenol antioxidants have postbiotic potential too, through production of SCFA production as well as other beneficial metabolites.[8-10]

If only there was a food high in antioxidants and prebiotic fibers … Hmmm – fruits and veggies anyone?!

Between vitamins, minerals, antioxidants, and fodder for probiotics to feed on, it's no wonder that high intakes of veggies and fruits are associated with so many health and performance outcomes!

Priming the Immune System via Postbiotics

A significant amount of research has examined the effects of postbiotics on Immune function. For instance, various researchers have studied the inactivated Lactococcus lactis JCM 5805 strain and its ability to modulate the immune system. Based on research to date, its mechanism of action appears to be related to its ability to activate plasmacytoid dendritic cells (pDC) which regulate both branches of the immune system – innate and acquired immunity. When consumed in doses of 100 billion cells, L lactis JCM 5805, researchers have observed positive effects on immune function in adolescents, office workers and male athletes; the latter which trained on average, trained for ~ 22 hrs/wk.[11-13]

Looking more at the metabolite side of the postbiotic equation, various groups have examined the immune effects of ***β***-1,3/1,6-Glucans, which are fermentation byproducts made from Saccharomyces cerevisiae.

For instance, 500 mg of EpiCor®, a commercially available postbiotic which consists of ***β***-1,3/1,6-Glucans, polyphenols, vitamins and minerals derived from Saccharomyces cerevisiae, has been shown to significantly reduce seasonal allergy symptoms vs. placebo (25% reduction in mean number of days with congestion) when consumed for 6 weeks.[14] Additional research suggests Epicor® may also reduce cold and flu symptoms too.[15]

Various studies have shown that 250 mg of purified of ***β***-1,3/1,6-Glucans (Wellmune®) obtained from Saccharomyces cerevisiae to be especially beneficial in endurance athletes as it relates to upper respiratory track infections (URTI). In a group of 202 healthy marathon runners, those who consumed 250 mg of Wellmune® vs. placebo for 45 days pre and post marathon saw a 10% decrease in total days with URTI symptoms as well as a 19% reduction in severity of symptoms.[16]

Postbiotics – A natural 'Therapist' for the brain?

Postbiotics also appear to influence brain function & stress. As aforementioned, SCFA's, which are derived from the fermentation of prebiotic fibers, appears to play a key role in this process.[7] In a recently published study, researchers found that 5g of partially hydrolyzed guar gum, a specific type of prebiotic fiber, positively influenced both quality of sleep as well as motivation scores in healthy Japanese adults. [17]

As it relates to mental health and wellness, the aforementioned Wellmune®, has been shown to support mood in both marathon athletes as well as stressed women when consumed in doses of 250mg/d for a duration of 4-12 weeks.[18, 19]

Postbiotics – Powering a healthy cardiometabolic system?

Along with supporting immune and mental health, postbiotics may also contribute to overall cardiometabolic function. These beneficial effects may be the result of

metabolites produced from the fermentation of prebiotic fibers, antioxidants and/or ingestion of inactivated bacterial strains.

With respect to bacterial strains, in one small pilot study, involving 32 overweight or obese participants, researchers examined the effects of ingesting a placebo, living *Akkermansia muciniphila* (10^10 cells) or pasteurized *Akkermansia muciniphila* for 3 months.[20] Upon conclusion of the study, it was found that consuming pasteurized *A. muciniphila* significantly improved insulin sensitivity (+28%) and decreased total cholesterol (-8.68%) while improving markers of liver function and inflammation.

Wrapping Things Up

As discussed in this article, and in this issue of Sports Pharmacy as a whole, maximizing one's microbiome is key for health, wellness and performance. Many variables affect microbiome function, including the consumption of postbiotics (aka bacterial 'corpses' & 'poop') or food's which serve as postbiotic precursors.

By increasing one's postbiotic load, we may be able to better optimize our mood, immune, bone and cardiometabolic function.

Thus, whether it's sauerkraut on a brat, a kombucha drink or two, fruit, veggies or other targeted postbiotics, bon appétit!

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A Bacterial Solution to Runners Trots?

A Common Shackle in Running Performance

By Dr. Matthew Liaw, Pharm.D.

AUTHOR BIO:

Matthew Liaw is a pharmacist with ten years of service to Navajo people at Crownpoint Healthcare. He is also an amateur distance runner specializing in the 10k, half-marathon, and marathon. As a pharmacist, he has led a medication error subcommittee, run a pain management clinic, and led an antimicrobial stewardship program. The runner in him is a scientist who enjoys repeating physiology trials to see how valid they are for his training. Some of his favorite moments at the UNM physiology lab include testing how shoes affect running economy, testing the impact of an extended interval block, and comparing methods of body fat testing. His dream is to bring his expertise in pharmacy and passion for running together and become a sports pharmacist.

One of the biggest concerns for endurance athletes is the possibility of gastrointestinal issues during training and competition. Marathoners sometimes call this runner's trots, runner's diarrhea, or runner's colitis. Past surveys found that as many as sixty-eight percent of distance runners stopped to have a bowel movement during training, and twelve percent had to stop during competition (Sullivan,Wong, 1992). Most strategies dealing with this issue involve dietary changes and meal time changes. The increased interest in human microbiota and probiotics has encouraged some research into the possibility of probiotics improving the symptoms of endurance athletes. These probiotics often contain a combinations of the following strains of bacteria: Lactobacillus acidophilus (CUL60), L.acidophilus (CUL21), Bifidobacterium bifidum (CUL20), and/or Bifidobacterium animalis (CUL34).

Why do GI issues happen in runners? There are many theories because of the broadness of symptoms. Biomechanically, running for a human is closer to the physics of a bouncing ball than a single plane of movement. This causes movement in the gut during exercise. If running nutrition is improperly planned, the athlete can encounter indigestion when their intestines cannot process the ingested nutrients. Failure to consume sufficient water along with concentrated carbohydrates can cause GI distress. Carbohydrate solutions of 8% or more of carbohydrates reduce gastric emptying. On a hot day, increased body temperature and/or dehydration reduces gastric emptying. GI distress can also be caused by stress as hormones like epinephrine reduce blood flow to the GI. Gender affects gastric emptying as well. Women typically have slower emptying than men and have been found to be more prone to GI complaints (Jeukendrup,Gleeson 2019). These causes make managing GI problems difficult for suffering runners.

A Microscopic Solution?

How can a probiotic containing Lactobacillus and Bifidobacterium help with some of these symptoms? In theory, the bacterium could help improve the digestion of nutrients not absorbed into the small intestine. One study found a minor improvement in glucose absorption in cyclists (Pugh, et al. 2020). If the distress is caused by heat, there is one study that suggested probiotics improved performance in heat (Shing, et al. 2014). Unfortunately, there are many variables that confound conclusive evidence.

Because the study of this subject is new, there is little consistency between studies. For example, the study on probiotic effect on heat performance used 45 billion CFU instead of 25 billion from most other studies and also included Streptococcus strains along with Lactobacillus and Bifidobacterium. Most probiotic studies have small sample sizes typically around 20-30 people. In addition, the factors causing GI symptoms can come from many different sources which makes it difficult to determine

> If one wants to try probiotics but prefers not to use pills, fermented foods like yogurt and fermented vegetables contain healthy strains and quantities of bacterium.

why a probiotic worked or did not work. A simple matter of having more men in a study can decrease the chances of GI distress. This makes further study all the more important to demonstrate consistent results from the protocols established.

Based on available research, there is a possibility a probiotic mix of Lactobacillus acidophilus (CUL60), L.acidophilus (CUL21), Bifidobacterium bifidum (CUL20), and Bifidobacterium animalis (CUL34) can reduce GI symptoms in endurance runners. Three studies were found with one of study having been performed on cyclists instead of runners. All three studies used a dose of 25 billion CFUs. The first study by Pugh and colleagues tested 28 days of probiotics leading up to a marathon. They found that supplementation reduced the number of symptoms and the number of symptomatic days during training. When assessing the effects during the marathon, there was little difference between placebo and probiotic in the first two-thirds of the race but a trend towards significance in the final third of the race (Pugh, et al. 2019). Because it did not reach significance, additional study is warranted. A few questions need to be considered. Did the best-practices nutrition plan improve GI symptoms or was it the probiotic? The study also had 20 male subjects and 4 females. Could results be more significant if more women participated? Was any caffeine ingested? Pugh and colleagues also performed another study on male cyclists to determine if the mixture increased carbohydrate metabolism. They detected an increase in carbohydrate absorption, but did not find any differences in markers of GI symptoms (Pugh, et al 2020). This could be attributed to using cyclists instead of runners. The third study studied long distance runners who used the probiotic for 3 months. The team by Schreiber and colleagues found no significance in the symptom of regurgitation, a trending decrease in diarrhea, and a trending decrease in constipation. The authors acknowledged that the study with 66 participants was still limited in size and also pointed out that the diverse microbiomes of individuals is a

confounder (Schreiber, et al. 2021).

One study researched the impact of a probiotic on inflammatory markers and GI symptoms. A 45 billion CFU mix of Lactobacillus, Bifidobacterium, and Streptococcus strains was tested on 27 elite male cyclists. No differences in performance or inflammatory markers were found between the two groups. They did find a lower incidence of GI symptoms during the training period for the probiotic group. These symptoms include nausea, belching and vomiting (Smarkusz-Zarzecka, et al. 2022). This study sounds promising for elite athletes, but additional work is needed in runners.

Final Thoughts

The studies available to guide probiotic use in athletes is limited. However, it is a promising field. Current work suggests a probiotic blend may be beneficial in reducing GI symptoms during training and competition for runners. The best strains and dose for this task still need to be determined, and is a subject for future study. It could be beneficial to take fecal samples and determine how the athlete microflora changes with a probiotic. It would take much work to develop a protocol accounting for all the confounders. These issues with current research make clear recommendations difficult.

Considering the available information, a probiotic has the potential to be beneficial to an athlete's health. Because of the lack of clear results, it is best for athletes to experiment and see if a probiotic capsule can help with GI issues. The adverse effects are typically mild, but if GI issues worsen it may be advisable to go without a probiotic. Available information suggests trying doses of 25 billion CFU or more for several weeks. If one wants to try probiotics but prefers not to use pills, fermented foods like yogurt and fermented vegetables contain healthy strains and quantities of bacterium. Although the jury is out, probiotics can be a safe and healthy supplement to one's diet.

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Stress and the Gastrointestinal Track

By Dr. Jessica Beal-Stahl, Pharm.D.

AUTHOR BIO:

Jessica Beal-Stahl, PharmD, is the founder of The Athlete's Pharmacist company, tying her passions of athletics and pharmacy together where she works privately with clients to improve their performance in sport and life. She received her Doctorate of Pharmacy from Mercer University in 2009 and has been practicing as a Director of Clinical Services at Hobbs Pharmacy in Merritt Island, Florida, since graduation. Jessica also knows what it's like to be a high-level athlete, having played D1 volleyball, medaled internationally in Olympic weightlifting, and set at 41 years old a world record in Olympic Weighting for snatch in her age/weight class. She holds additional certifications in Integrative Medicine, Nutrigenomics, and Sports Nutrition.

Quick HIT Summary

Ever had to make a "gut-wrenching" decision under pressure or so anxious that you had "butterflies in your stomach?" If so, then you know that stress can affect your digestive system.

Only recently have we begun appreciating the human gastrointestinal tract's complexity and roles in physiology and pathophysiology. Although diet is well known to modulate the composition of the gut microbiota, numerous studies suggest that stress and exercise can also alter gut microbial communities and gastrointestinal tract health.

Background on the Gastrointestinal Track

Sandwiched between our epithelial cells that line the gastrointestinal (GI) tract, esophagus to the rectum, is a complex network of nerves and neurons that oversees all gastrointestinal processes, managing blood flow, muscle contractions, and the release of digestive fluids. This complex system of nerves is known as the enteric nervous system (ENS) or the "second brain." It communicates directly to the central nervous system via neurotransmitters such as serotonin and dopamine. More neurons reside in the gut than in the entire spinal cord.[1]

Gut Microbiome

Humans have more bacterial cells—a lot more—than human cells.[2] We are filled with microbes, which form microbiomes on our skin, GI tract, lungs, eyes, and reproductive systems. These microbes can perform many functions that can't be performed by our human cells. In short, you can consider them 'our besties' - at least the good ones!

The GI tract microbiome is massively complex, and its residents vary enormously from person to person. It can weigh up to 2kgs and are imperative to host digestion, metabolic function, and resistance to infection.[3]

Picture a bustling New York City on a weekday morning; the sidewalks, roads, and transit all flooded with people rushing to work or appointments. Now imagine that on a microscopic level, and you have an idea of what the microbiome community looks like inside our bodies; trillions of microorganisms work in what is known as the gut microbiome.[4]

"Fight or Flight"

Stress is a ubiquitous condition that affects all people. Stress can be mental or physical, perceived, or actual stress. All stress shows short and long-term effects on the functions of the GI tract.

Anytime you experience stress, the sympathetic nervous system, "fight or flight," becomes activated. Once upon a time, the fight-or-flight response helped our ancestors to avoid being a lion's dinner. While few of us must worry about fleeing lions anymore, the physiological response remains and is triggered in response to any threatening situation or stimuli, from a job interview to before a big game.

When you encounter a situation perceived

> Research suggests the link between our microbiome and stress is bi-directional, with evidence indicating that our gut microbiota mediates the stress response

as stressful, the hypothalamic-pituitary-adrenal (HPA) axis sets in motion a cascade of biochemical reactions and hormones that stimulate adrenal glands and release cortisol, epinephrine, and norepinephrine. Not only do these stress hormones affect how we respond to stress, but all other parts of the body. The focus of this article concerns the reciprocal effects on the digestive system.[5]

Changes in GI motility

When the main stress hormones fly around the body, our heart rate and blood pressure increase, as do our breathing and blood glucose levels. Interestingly, our digestive activity also decreased or changed.

Cortisol aids in moving blood flow toward the brain, large muscles, and limbs rather than the digestive tract. Therefore, our body is not concerned with digestion and suppresses it in this mode. For some, this can mean digestive processes stop; for others, it results in an urgent emptying of the bowels.

Due to cortisol shunting the blood from your digestive tract to your brain and muscles, blood flow decreases GI tract mobility. This often leads to constipation, bloating, gas, acid reflux, and/or stomach pains. In turn, one can get more stressed, leading to more cortisol release creating a vicious cycle.

Some people experience the opposite, speeding up the gut's motility and causing food to move too fast through your digestive system leading to diarrhea. As a result, your ability to absorb nutrients decreases, causing nutrient deficiencies and decreased energy for your body to function efficiently.

Increase in intestinal permeability

The endothelial cells that line the GI tract allow digested food particles and nutrients to pass through them into the bloodstream and function as a barrier, prohibiting the passage of toxins, antigens, and harmful bacteria from entering the gut lumen.

In a state of stress, the production of corticotropin-releasing hormone by the hypothalamus directly affects the intestinal lining junctions between these cells, increasing permeability and allowing pathogens and other substances to pass into the bloodstream.[5] When this happens, your immune system becomes triggered to identify and destroy these "foreign invaders" and preserve your health, consequently resulting in inflammation and irritation of the mucosal lining.[5,6]

Animal studies found stress can make the gut and intestines more permeable, activating immune and pro-inflammatory responses which trigger additional stress hormones to be released.[7]

A study of soldiers undergoing an intense cross-country ski trip demonstrated that physical exertion increased intestinal permeability and inflammation.[8] A disruption to the gut microbiome may have partly caused the change in intestinal permeability. Participants experienced a decrease in certain bacteria associated with inflammation and immune regulation, such as *Faecalibacterium* and *Roseburia,* with a simultaneous increase in potentially pathogenic bacterial species.[8]

Changes in gastrointestinal secretions

Multiple changes in GI secretion have been reported during a prolonged state of stress:

- Stress causes the gut to produce less mucus, the protective layer which coats the gastrointestinal tract walls.
- Stress slows saliva production and reduces the enzymes that break down food, which leads to impaired digestion and increasing indigestion.
- Stress causes brain changes that turn up pain receptors, making you physically more sensitive to slight increases in acid levels. Additionally, increased cortisol production decreases prostaglandins, which protect your stomach from acid, causing increased GI sensitivity. A double whammy!
- Stress alters cytokine secretion. Mast cells are essential effectors of the brain-gut axis that translate the stress signals into releasing a wide range of neurotransmitters and pro-inflammatory cytokines.[9,10]

Adverse effects on intestinal microbiota

Altered gut motility and changes in GI secretions change the weather in your gut, allowing robust pathological bacteria to reproduce at the expense of beneficial microbes.

Observation studies have shown that psychological stress is associated with an altered microbiome in humans, though a cause-and-effect relationship has not been established.[11] Despite this, researchers postulate numerous plausible mechanisms by which stress may disrupt microbiome diversity, both directly and indirectly:

- Exposure to stress can trigger comfort eating and cravings for ultra-processed food high in sugar, fat, and salt leading to gut dysbiosis.[12]
- Stress impacts catecholamine levels and may cause shifts in microbial colonization patterns.[13] Thus, leading to HPA activation and altered autonomic nervous system response.[14]
- Serotonin, dopamine, and catecholamines are active in the brain and the gut and regulate blood flow and influence gut motility, nutrient absorption, the immune system, and the microbiome. Stress-mediated changes, like changes in the level of catecholamines, may shift the microbial colonization patterns of the intestine and alter one's susceptibility to infection.[13]

Research suggests the link between our microbiome and stress is bi-directional, with evidence indicating that our gut microbiota

> Chronic stress promotes local and systemic inflammation and disrupts the normal balance of microbes within the gut, compromising many immune processes and natural cross-talk.

mediates the stress response.[15] The gut microbiota is also thought to influence serotonin production.

Scientists have found that people with stress-associated conditions, such as depression and anxiety, have gut microbiomes that differ from healthy people. A 2018 review found that depressed people had increased levels of bacteria that are associated with poor health, such as those from the *Proteobacteria phylum* and the *Eggerthella* genus, while beneficial bacteria, such as those from the *Prevotella*, *Ruminoccus*, and *Coprococcus* genera are decreased compared to healthy controls.[16]

Another study assessing the interplay between the microbiome and mood disorders found that 65% of participants experienced increased psychological distress, correlated with an increased abundance of *Proteobacteria*.[17]

Down-regulates the immune system

There is extensive interaction between the body's immune system and bacteria in the gut which houses 70-80% of our immune system.

Chronic stress promotes local and systemic inflammation and disrupts the normal balance of microbes within the gut, compromising many immune processes and natural cross-talk. The disruption of this dialogue between the immune system and microbiome affects the latter's composition by promoting the growth of certain bacterial strains at the expense of others.[18]

Just as stress affects the gut and microbiota by mobilizing neural and hormonal pathways, the reverse is true; these pathways work in both directions.

Wrapping things up

Every day we are discovering more about how vital the health of our microbiota is to our overall health, including mental health. In our modern societies, where stress is present every day, and an unbalanced diet has already weakened the symbiosis between ourselves and our microbiota, understanding how the latter reacts to stress and modulates our biological responses is crucial.

There is much yet to learn about the effects of stress on the GI tract. Yet, it's been proven that transforming the body's response to stress may lead to a healthier GI tract, overall resilience, and, thus, positive health outcomes.

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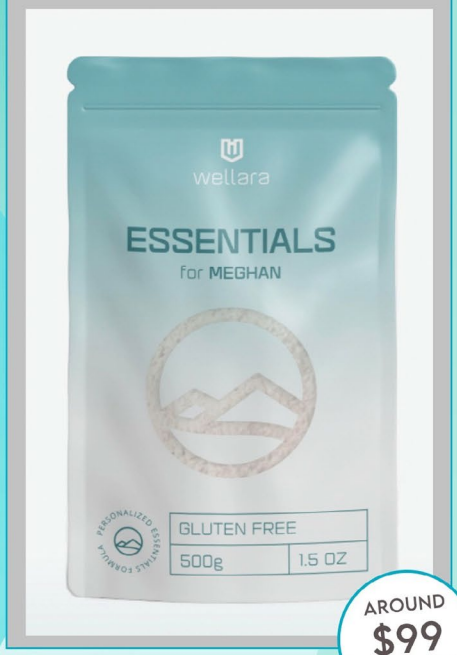

AROUND $99 A MONTH

BLEND OF 42+ ESSENTIAL NUTRIENTS THAT SUPPORT*:

MUSCLE RECOVERY
ENERGY
METABOLISM
FOCUS, COGNITION & STRESS MANAGMENT
SLEEP
IMMUNITY

SAY "NO" TO MORE PILLS

GET THE BEST MEDICINE RIGHT AWAY
FOOD & ESSENTIAL NUTRIENTS!

SHIPS ANYWHERE IN THE USA!

SCAN QR CODE TO GET YOUR OWN CUSTOMIZABLE ESSENTIAL NUTRIENT BLEND & PERSONALIZED MEAL PLAN!

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