



THE ATHLETE GUT: GASTROINTESTINAL FUNCTION, FUELING TOLERANCE, AND THE EMERGING ROLE OF THE MICROBIOME

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KEY POINTS

- Exercise-related stressors such as high training load, intensity, heat, dehydration, and reduced gut blood flow can challenge GI function, fueling tolerance, and symptom control.
- Exercise-induced GI changes are often transient, but they may affect intestinal permeability, motility, nutrient absorption, and tolerance during training or competition.
- The gut microbiome and its metabolites may influence the gut barrier, immunity, metabolism, and gut–brain signaling, but direct effects on athletic performance remain uncertain.
- Athlete strategies should align performance fueling and gut health by individualizing intake, timing, recovery, and evidence-based microbiome-targeted approaches.

INTRODUCTION

The gastrointestinal (GI) tract, or gut, is increasingly recognized as central to well-being with physiological effects extending far beyond the gut. Our guts are host to trillions of microorganisms, their genes, and metabolites. This collection of microbes and their environment have come to be known as the “gut microbiome” (Berg et al., 2020). The gut microbiome not only influences nutrient absorption and digestive symptoms, but metabolic signaling, immunity, and even brain function. It is well-established that our gut microbiome is shaped by a variety of lifestyle factors including geographical location, diet, genetics, early life exposures, medication intake, stress, and exercise (Gabriel & Ferguson, 2023). While diet is arguably the most studied of these factors, research is emerging on how exercise impacts the gut microbiome.

Regular physical activity and athletic training have been associated with differences in gut microbial composition and function, although findings vary by population, diet, training modality, exercise intensity, and analytical method. Exercise also affects gastrointestinal physiology, but the direction and magnitude of these effects depend on exercise intensity, duration, environmental conditions, hydration, and individual tolerance (Bi & Triadafilopoulos, 2003; Dziewiecka et al., 2022; Ghaffar et al., 2024; Hoseini et al., 2026; Hawley et al., 2025). Training and competition put unique stress on the gut. Intense or prolonged exercise can transiently disrupt GI function and provoke symptoms, particularly under conditions of heat, dehydration, or inadequate fueling. With repeated practice of an appropriate individualized fueling and hydration strategy, some athletes can improve tolerance during exercise, a process commonly described as “gut training.” This should be distinguished from exercise-associated changes in the gut microbiome, whose direction, functional relevance, and contribution to performance remain less certain.

Emerging research suggests a potential bidirectional relationship between exercise and the gut microbiome. Microbial metabolites may participate in metabolic, immune, and neural signaling relevant to exercise adaptation and recovery, but whether these pathways meaningfully improve athletic performance in humans remains uncertain (Clauss et al., 2021; Hughes & Holscher, 2021; Wu et al., 2026).

Therefore, “gut health” is more than just a buzzword for athletes. Gut health encompasses “a state of normal gastrointestinal function without active gastrointestinal disease and gut-related symptoms that affect quality of life” (Marco et al., 2026). Maintaining GI function and tolerance is particularly important because GI symptoms or impaired fueling tolerance can interfere with planned intake during training and competition.

This Sports Science Exchange (SSE) article frames the gut as a critical organ system that links diet, physiology, and training to set the stage for exploring how exercise and nutrition interventions can support gut health to improve athletic performance, recovery, and resilience.

EXERCISE-RELATED GI STRESS, ADAPTATION, AND PERFORMANCE

Exercise Stress and GI Responses

Training load, exercise intensity, environmental heat, dehydration, and reduced oxygen availability can each act as systemic stressors that influence GI function. Mechanistically, these stressors converge during more intense or prolonged exercise, when sympathetic activation redirects blood flow toward contracting muscle, skin, heart, and lungs and away from the splanchnic circulation. The resulting reduction in GI blood flow may affect motility, epithelial integrity, and nutrient and fluid absorption, particularly when exercise is prolonged, performed in

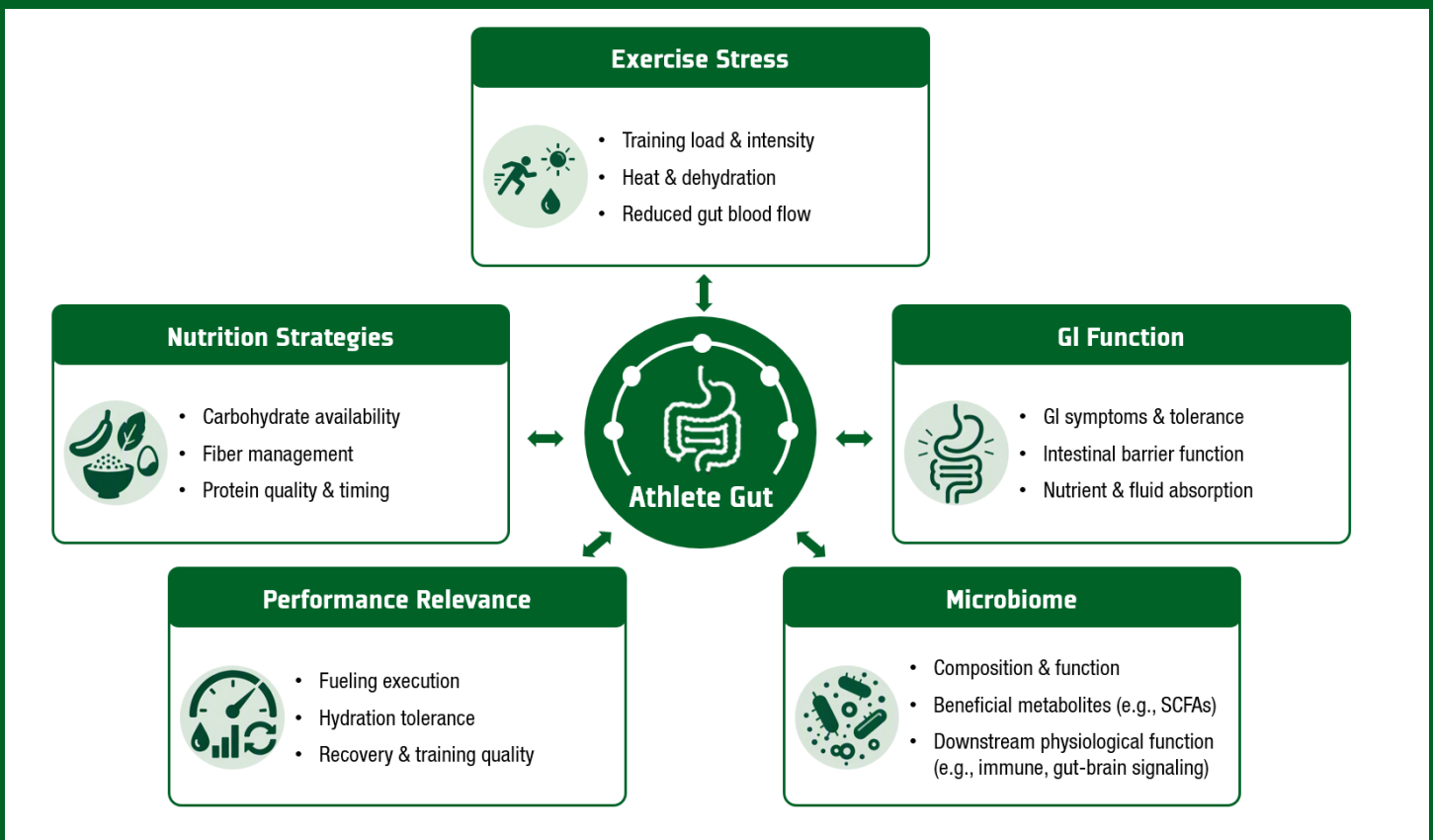


FIGURE 1. Interactions among exercise stress, gastrointestinal function, microbiome, performance, and nutrition. GI, gastrointestinal; SCFAs, short-chain fatty acids.

the heat, or combined with inadequate hydration or fueling (Ribichini et al., 2023).

As these circulatory and absorptive challenges increase, they can contribute to the GI symptoms commonly reported by athletes, especially during endurance events, repeated high-intensity efforts, and sports performed in hot environments. Symptoms may include nausea, abdominal discomfort, bloating, reflux, urgency, or diarrhea, although reported frequency varies widely across sports, environments, measurement methods, and athlete populations. In higher-stress conditions, the same physiological strain may also coincide with transient changes in intestinal epithelial integrity and permeability, along with altered gastric emptying, intestinal transit, and nutrient absorption (Ribichini et al., 2023).

These responses are further modified by environmental and hydration-related factors. Heat exposure can increase thermal and circulatory strain, and recent human work shows that exercise intensity and hyperthermia can influence markers of epithelial injury (Alhadad et al., 2026). At the same time, baseline microbiota or barrier measures alone do not reliably identify who will develop exertional heat illness (Gould et al., 2026). Dehydration may amplify physiological strain by reducing circulating blood volume, and hypoxic exposure may add stress in

some environments (Ribichini et al., 2023). Together, these findings support evaluating GI risk in context—integrating exercise demands, environment, hydration, fueling, symptoms, and recovery rather than relying on a single biomarker or microbiome profile (Alhadad et al., 2026; Gould et al., 2026; Ribichini et al., 2023).

Adaptation and Performance Relevance

The response to exercise-related GI stress is therefore dynamic rather than uniformly harmful or beneficial. With repeated exposure, appropriate fueling, hydration, and recovery, some athletes may improve GI tolerance through training adaptation and deliberate gut training (Martinez et al., 2023). Conversely, when heavy training is paired with insufficient fueling, dehydration, heat stress, or inadequate recovery, GI and barrier stress may persist rather than resolve through adaptation (Ribichini et al., 2023). This distinction is important because GI function becomes most performance-relevant when physiological disruption interferes with fueling or hydration execution. Nausea, urgency, abdominal discomfort, or reflux may cause athletes to reduce intake, change pacing, or stop exercise, while altered motility or absorption may make planned carbohydrate and fluid strategies less effective (Martinez et al., 2023; Ribichini et al., 2023).

Over time, repeated disruptions can extend beyond the affected session. Persistent symptoms or poor fueling tolerance may reduce training

quality, compromise recovery nutrition, disrupt hydration planning, and reduce confidence in competition fueling plans. Viewed through this lens, GI health is best understood as a foundation for consistently executing fueling, hydration, and recovery strategies across training and competition rather than as an isolated performance target (Martinez et al., 2023; Ribichini et al., 2023).

GUT MICROBIOTA, BARRIER FUNCTION, AND METABOLITES

The functional consequences of exercise-related GI stress provide a useful entry point for considering the gut microbiota, intestinal barrier, and microbial metabolite signaling as interconnected components of athlete gut health. The gut microbiota refers to the microorganisms that inhabit the gastrointestinal tract, whereas the gut microbiome includes these organisms, their genes, metabolites, and surrounding environment. Because this ecosystem is shaped by diet, geography, genetics, medication use, stress, and exercise, microbial composition, diversity, and functional capacity can vary widely among individuals (Berg et al., 2020; Gabriel & Ferguson, 2023). It is important to note that differences in microbial diversity or composition should not be assumed to represent improved gut health or enhanced performance without accompanying functional or clinical outcomes.

Within this variable ecosystem, diet is especially relevant because it supplies substrates for microbial metabolism, where microbial products can influence epithelial, immune, metabolic, and neural signaling (Fontana et al., 2023; Patel et al., 2024). Active adults and athletes often, though not uniformly, show differences in microbial diversity, taxonomic composition, or predicted metabolic capacity compared with less active groups (Carlone et al., 2025b; Fontana et al., 2023; Mancin et al., 2024). A recent matched analysis of junior and senior elite athletes further showed that microbiome patterns differed by age and athletic status, reinforcing that there is no single “athletic” microbiome and that cross-sectional findings should not be interpreted as causal performance effects (Lenz et al., 2026; Mancin et al., 2024).

Barrier Function and Permeability

A key physiological link between exercise stress, diet, and microbial signaling is the intestinal barrier, which provides a functional interface between the gut lumen and circulation by regulating the movement of nutrients, water, microbial products, and other compounds. Exercise-related increases in intestinal permeability are generally transient, but the magnitude of change can increase with prolonged high-intensity exercise, heat stress, dehydration, inadequate fueling, and insufficient recovery (Ribichini et al., 2023).

Importantly, barrier responses do not occur in isolation; they are modified by surrounding context, including medication use such as nonsteroidal anti-inflammatory drugs (NSAIDs), recent dietary intake, hydration status, environmental conditions, and recovery. For this reason, while “leaky gut” can physiologically refer to increased intestinal permeability, the term should be used cautiously because it is often interpreted as a distinct clinical condition rather than a measurable and context-

dependent feature of intestinal barrier function (Ribichini et al., 2023).

Microbial Metabolites and Host Signaling

Alongside barrier-mediated effects, microbial metabolites provide another biologically plausible pathway through which diet and the microbiota may influence host physiology. Short-chain fatty acids (SCFAs), produced through fermentation of dietary fiber, can support epithelial integrity and participate in immune and metabolic signaling (Fontana et al., 2023; Patel et al., 2024). These effects are biologically relevant, but metabolite production depends on diet, microbial function, training context, and host factors, which limit broad performance claims (Fontana et al., 2023; Patel et al., 2024).

Extending beyond local effects at the intestinal epithelium, gut-derived signals may also interact with immune, metabolic, energy-regulatory, and neural systems. The microbiota–gut–brain axis may be relevant to perceived exertion, stress response, fatigue, and cognition. However, mechanistic evidence linking exercise intensity, epithelial regulation, immune function, and microbiota dysbiosis is still developing, and much of the evidence comes from preclinical or non-athlete populations. Direct performance effects in athletes have not been established (Carlone et al., 2025a; Hoseini et al., 2026; Xia et al., 2024).

INTER-INDIVIDUAL VARIABILITY

At the individual athlete level, interactions among training, nutrition, environment, and host factors can shape both GI tolerance and measured microbiome outcomes. Training status, habitual diet, recent dietary intake, environmental conditions, hydration, medication use, illness, recovery state, baseline GI symptoms, and prior experience with fueling may influence individual responses (Mancin et al., 2024; Ribichini et al., 2023). In parallel, baseline microbial composition and analytical methods introduce additional variability, making it difficult to compare findings across studies or translate group-level results directly to individual athletes (Mancin et al., 2024).

The variability described across microbial composition, barrier responses, metabolite production, and host signaling is central to interpreting microbiome-targeted interventions. Recent literature suggests that certain probiotics may influence inflammatory, microbiome, recovery, or performance-related outcomes, but existing trials are often small, heterogeneous, and at variable risk of bias (Aykut et al., 2024; Mahmoudi Shirkoohi et al., 2025). Accordingly, certain probiotics may be considered for defined GI or immune outcomes of interest, but effects should be interpreted as strain-, ingredient-, outcome-, and context-specific rather than broadly performance enhancing (Aykut et al., 2024; Mahmoudi Shirkoohi et al., 2025; Porepp et al., 2024; Teglas & Radak, 2025).

Consequently, interpretation should shift from isolated measurements toward longitudinal, athlete-specific patterns. No single microbiome profile, fueling strategy, or microbiome-targeted approach can be assumed to work for every athlete. Instead, intervention design and evaluation should integrate symptom history, training load, diet,

environment, product characteristics, and repeated observations to distinguish meaningful individual responses from normal biological and methodological variation (Mancin et al., 2024).

BALANCING PERFORMANCE FUELING AND GUT HEALTH

For athletes, performance fueling and gut health are interdependent rather than competing priorities. The aim is to meet energy and nutrient needs for training, recovery, and competition while preserving GI comfort, microbial substrate availability, and dietary variety. Practical strategies should therefore align nutrient timing, food selection, and tolerance-building approaches so athletes can execute fueling plans without unnecessarily restricting foods that support overall health (Mancin et al., 2025; Martinez et al., 2023; Ribichini et al., 2023; Thomas et al., 2016).

Carbohydrates

Carbohydrates are a primary nutrition priority around training, competition, and recovery because they support contracting muscle fuel availability and post-exercise glycogen restoration (Morton et al., 2026; Thomas et al., 2016). Evidence supports individualizing carbohydrate type, amount, format, and timing. Although some trained endurance athletes may tolerate intakes above traditional targets, the efficacy and GI tolerability of very high intake rates remain context-dependent and should be tested progressively in training before competition (Martinez et al., 2023; Morton et al., 2026). For this reason, carbohydrate recommendations are typically calculated utilizing body mass-based targets, intake rates, timing relative to exercise and recovery, environmental conditions, and athlete tolerance, with guidance often expressed as g/kg and/or g/kg/h (Morton et al., 2026; Thomas et al., 2016).

Once these fueling targets are established, the practical challenge becomes selecting carbohydrate strategies that can be absorbed and tolerated under exercise stress. This distinction between fueling capacity and GI tolerance is especially important when adjusting carbohydrate choices around sessions with different symptom risk (Martinez et al., 2023; Ribichini et al., 2023). For example, lower-fiber, lower-residue foods may reduce symptoms before high-risk sessions (Martinez et al., 2023; Ribichini et al., 2023). Rapidly available carbohydrate sources are commonly used during exercise because they can support carbohydrate delivery and may be easier to tolerate when practiced and appropriately dosed (Martinez et al., 2023; Morton et al., 2026). However, because fiber-containing carbohydrate foods also provide fermentable substrate for microbial metabolism, lower-fiber strategies should be used strategically rather than chronically (Mancin et al., 2025). This approach supports performance by improving the likelihood that athletes can execute planned carbohydrate intake during key sessions or competitions, while preserving varied, fiber-rich carbohydrate foods during lower-risk windows (Mancin et al., 2025; Martinez et al., 2023; Ribichini et al., 2023).

If symptoms persist despite these timing and tolerance strategies, more targeted carbohydrate-related modifications may be appropriate. These

may include reducing specific triggers, such as gluten-containing foods in athletes with celiac disease or non-celiac gluten/wheat sensitivity diagnosed or managed with appropriate clinical guidance, or using a short-term, targeted low fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) approach, under professional guidance with structured reintroduction as appropriate. Recent guidance emphasizes that FODMAP manipulation should be driven by symptom severity, and exercise demands rather than used as a routine default. This approach may help manage severe exercise-associated GI symptoms but has not been consistently demonstrated to improve performance (Scrivin et al., 2026). Approaches should therefore be individualized and paired with food substitutions to preserve overall carbohydrate adequacy, fiber intake, and diet quality (Ribichini et al., 2023; Patel et al., 2024).

Fiber

Within carbohydrate strategies, fiber becomes a key modulator of the balance between GI comfort, microbial substrate availability, and overall diet quality. Current sports nutrition guidance does not provide athlete-specific fiber targets separate from general dietary recommendations; therefore, fiber intake is typically guided by general adult targets of ~25–38 g/day, or about 14 g/1,000 kcal, and individualized according to energy needs, training demands, GI tolerance, and timing relative to exercise (Fang et al., 2026; Institute of Medicine, 2005; Mancin et al., 2025; Thomas et al., 2016). For athletes, fiber recommendations should not be viewed only through the lens of total daily intake, but also through the type of fiber consumed, its fermentability, timing relative to exercise, baseline tolerance, and the training or competition context (Fang et al., 2026; Mancin et al., 2025). Fiber-containing foods contribute carbohydrates, micronutrients, phytochemicals, and fermentable substrates that may support microbial diversity, SCFA production, epithelial integrity, and immune- and metabolic-signaling pathways (Fontana et al., 2023; Hughes & Holscher, 2021; Mancin et al., 2025; Patel et al., 2024). However, these potential benefits must be balanced against acute GI tolerance, especially when exercise stress, heat, dehydration, high intensity, or pre-existing symptoms increase the likelihood of bloating, cramping, urgency, or discomfort (Mancin et al., 2025; Ribichini et al., 2023).

This balance requires distinguishing between habitual fiber intake and short-term fiber manipulation around high-risk sessions. Across the training week, varied fiber-rich foods such as whole grains, legumes, fruits, vegetables, nuts, and seeds can help maintain diet quality and provide substrates for saccharolytic fermentation, including SCFA-producing pathways (Fontana et al., 2023; Hughes & Holscher, 2021; Mancin et al., 2025; Patel et al., 2024). In contrast, immediately before or during sessions with high GI risk—such as long-duration exercise, high-intensity intervals, competition in the heat, or events where bathroom access is limited—lower-fiber or lower-residue choices may improve comfort and reduce symptoms (Mancin et al., 2025; Martinez et al., 2023; Ribichini et al., 2023). Fiber type, dose, and fermentability should also be considered because highly fermentable fibers and FODMAP-containing foods may worsen symptoms in some athletes

when consumed close to exercise, particularly in those with a history of exercise-associated GI complaints (Scriven et al., 2026; Mancin et al., 2025).

In practice, this means fiber intake should be periodized rather than static. Higher-fiber meals and snacks are often best emphasized farther from demanding sessions, during recovery meals, or on lower-risk training days, while lower-fiber carbohydrate sources may be more appropriate in the hours before hard sessions or competition (Mancin et al., 2025; Martinez et al., 2023; Ribichini et al., 2023). Individualization remains essential because athletes differ in habitual intake, microbiome function, symptom history, energy needs, food preferences, and sport demands (Fang et al., 2026; Mancin et al., 2024; Mancin et al., 2025). Rather than removing broad categories of foods indefinitely, the goal is to adjust timing, portion size, and specific triggers so athletes can meet fueling goals while preserving carbohydrate availability, microbial substrate availability, diet quality, and the ability to execute nutrition plans consistently (Mancin et al., 2025; Ribichini et al., 2023; Scriven et al., 2026).

Protein

As with carbohydrates, protein recommendations should balance performance and recovery needs with consideration of GI tolerance and the broader dietary pattern. Sports nutrition guidance emphasizes adequate total daily protein distributed across the day, with the specific target individualized according to training goals, energy availability, sport demands, and timing relative to exercise (Jäger et al., 2017). Although the dietary reference intake (DRI) for protein in adults is 0.8 g/kg/day, athlete recommendations are typically higher, generally ranging from 1.2–2.0 g/kg/day, or ~1.5–2.5 times the sedentary adult recommendation, to support muscle protein synthesis, lean mass maintenance, training adaptation, and recovery (Thomas et al., 2016).

From a gut health perspective, the implications of higher protein intake depend largely on what accompanies it in the total diet. This context becomes especially important when high protein intake occurs alongside low carbohydrate or low fiber intake, which may increase reliance on colonic protein fermentation (Patel et al., 2024). In this setting, microbial by-products such as ammonia, sulfides, phenolic compounds, indoles, and branched-chain fatty acids may increase (Patel et al., 2024). Some of these compounds have been associated with potentially unfavorable epithelial or metabolic effects, although their physiological significance depends on concentration, overall dietary pattern, microbial metabolism, and host context (Patel et al., 2024).

Therefore, protein guidance should continue to prioritize performance and recovery needs while also considering the overall dietary pattern. Practical recommendations should emphasize adequate total protein intake and distribution across the day (Jäger et al., 2017; Thomas et al., 2016) without displacing carbohydrates and fiber needed for fueling execution and microbial substrate availability. Pairing protein-rich meals with fiber-containing foods when tolerated may be especially

relevant when animal-based proteins are emphasized. This is because adequate fiber influences gut microbial composition and function, as well as saccharolytic fermentation and may limit a shift toward greater proteolytic fermentation and its associated metabolites when protein intake is high. This approach links performance and gut-health goals by supporting repair and adaptation while maintaining the carbohydrate and fiber patterns needed for training quality, GI resilience, and overall diet quality in athletes (Fontana et al., 2023; Mancin et al., 2025; Patel et al., 2024).

Fat

Dietary fat is an important contributor to total energy intake, essential fatty acid provision, absorption of fat-soluble vitamins, and overall diet quality, but its timing and dose require consideration when GI tolerance is a priority. Unlike carbohydrate and protein, fat is not typically emphasized as an acute fuel during higher-intensity exercise because oxidation rates are lower and performance fueling recommendations prioritize carbohydrate availability around key sessions (Morton et al., 2026; Thomas et al., 2016). From a GI perspective, higher-fat meals may be digested more slowly and increase feelings of fullness, which may be useful in some daily eating patterns but less desirable close to training or competition when rapid digestion, carbohydrate delivery, and comfort are priorities (Martinez et al., 2023; Ribichini et al., 2023).

In the context of gut health, the relevance of fat depends on the broader dietary pattern rather than fat intake alone. Dietary patterns in which high fat intake displaces carbohydrate- and fiber-containing foods may reduce microbial substrate availability and shift the balance away from saccharolytic fermentation, whereas dietary patterns that include adequate carbohydrate, fiber, and varied plant foods can better support microbial diversity and SCFA-producing pathways (Fontana et al., 2023; Hughes & Holscher, 2021; Mancin et al., 2025; Patel et al., 2024). Therefore, practical fat guidance for athletes should focus less on isolating fat as harmful or beneficial and more on whether fat choices, amounts, and timing complement fueling goals, fiber intake, micronutrient adequacy, and GI comfort.

In practice, fat intake should be periodized around training demands and individualized to the athlete's energy needs, preferences, symptom history, and sport context. For many athletes, fat intake commonly falls within ~20%–35% of total energy intake, with very low-fat diets generally not recommended because they may limit essential fatty acid intake, fat-soluble vitamin absorption, and overall dietary variety (Thomas et al., 2016). Higher-fat meals may be better tolerated farther from high-intensity or prolonged sessions, while lower-fat, carbohydrate-focused choices may be preferable in the hours before exercise or during events when GI symptoms, heat stress, or limited gut tolerance are concerns (Martinez et al., 2023; Ribichini et al., 2023; Thomas et al., 2016). This approach preserves fat's role in daily energy and nutrient adequacy while helping athletes prioritize carbohydrate delivery, GI comfort, and fueling execution during key sessions.

TABLE 1. Gut considerations, nutrition implications, and practical strategies for athlete fueling.

Nutrient	Gut Considerations	Nutrition Implications	Practical Strategies
Carbohydrates	- Tolerance depends on type, amount, and format^{18,21} - Timing and gut training influence symptoms^{18,21} - Lower-fiber choices may improve high-risk session tolerance^{17,18,21}	- Primary fuel for training, competition, and recovery^{19,23} - Use daily g/kg/day and during-exercise g/h targets^{19,23} - Preserve carbohydrate adequacy during GI-focused changes^{19,21,23}	- Practice planned intake in training^{18,19} - Use rapidly available options during key sessions^{18,19} - Use lower-fiber options strategically, not chronically^{17,18,21}
Fiber	- Supports microbial substrate availability^{7,11,17,20} - Promotes SCFA-producing pathways^{11,20} - Tolerance depends on type, dose, timing, and symptoms^{17,21,22}	- Use ~25–38 g/day as a starting point¹² - Use ~14 g/1,000 kcal as an energy-scaled guide¹² - Individualize to energy needs, training demands, and tolerance^{6,17,23}	- Emphasize fiber-rich foods during lower-risk windows^{7,11,17,20} - Reduce fiber before high-risk sessions if needed^{17,18,21} - Avoid unnecessary long-term fiber restriction^{17,21,22}
Protein	- Gut effects depend on the dietary pattern²⁰ - Proteolytic fermentation risk may increase if carbohydrate or fiber is displaced²⁰	- Supports recovery, adaptation, and lean mass maintenance^{3,23} - Target ~1.2–2.0 g/kg/day for many athletes²³ - Distribute intake across the day¹³	- Pair protein-rich meals with fiber-containing foods^{7,17,20} - Avoid displacing carbohydrate and fiber^{17,20,23} - Adjust pairings based on tolerance^{17,20}
Fat	- Timing may influence fullness^{18,21} - Dose may influence GI comfort^{18,21} - Effects depend on the broader dietary pattern²⁰	- Contributes to energy and nutrient adequacy²³ - Commonly ~20%–35% of energy for many athletes²³ - Avoid very low-fat diets that limit essential fatty acids, fat-soluble vitamins, or variety²³	- Individualize to energy needs, diet pattern, and training goals²³ - Place higher-fat meals farther from demanding sessions if needed^{18,21} - Avoid displacing carbohydrate and fiber with poorly timed intake^{17,20,23}

GI, gastrointestinal; SCFA, short-chain fatty acids.

To conclude, TABLE 1 synthesizes carbohydrates, fiber, protein, and fat considerations by linking their roles in fueling, GI tolerance, and microbial substrate availability with relevant nutrition implications and practical strategies.

PRACTICAL APPLICATIONS

- Build fueling tolerance by testing type, amount, timing, and format under conditions that reflect competition demands.
- Support gut health alongside performance goals by emphasizing dietary variety and fiber-rich foods during lower-risk periods while adjusting fiber before sessions with greater symptom risk.
- Consider microbiome-targeted interventions only when evidence matches the ingredient, dose, duration, population, and intended outcome.
- Individualize decisions by tracking symptoms, fueling tolerance, training quality, recovery, and environmental context over time rather than relying on isolated microbiome profiles or single biomarkers as performance indicators.

SUMMARY

Training and competition can place meaningful stress on the GI system, with implications for nutrient and fluid absorption, immune regulation, gut barrier integrity, and performance sustainability. Current evidence points to a dynamic relationship among exercise, gut physiology, and the gut microbiota. Consistent training, adequate fueling, and diverse dietary patterns may support microbial composition and function while strengthening gut resilience. In contrast, prolonged high-intensity exercise, heat stress, dehydration, inadequate fueling, and insufficient recovery can increase GI disruption and compromise fueling tolerance.

Although microbiome-targeted strategies and gut–brain interactions represent promising areas of investigation, current evidence linking

specific microbiome profiles or interventions to direct performance improvements in athletes remains limited and heterogeneous. Consequently, the most immediate applied priority is to support GI tolerance and reliable fueling execution through individualized nutrition, hydration, heat acclimation, gut training, and recovery strategies. Microbiome-focused interventions should therefore be considered adjunctive and applied cautiously, with clear alignment among the intervention, dose, duration, baseline diet, athlete population, intended outcome, and available clinical evidence.

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