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The Basics of Preventing and Managing Gastrointestinal Symptoms in Ultra-Endurance Sports

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Exercise-associated gastrointestinal symptoms (GIS) are a common feature of ultra-endurance sports. These include both upper- (gastro-oesophageal and gastro-duodenal originated: projectile vomiting, regurgitation, urge to regurgitate, gastric bloating, belching, stomach pain, and heartburn/gastric acidosis) and lower- (intestinal originated: flatulence including lower-abdominal bloating, urge to defecate, abdominal pain, abnormal defecation including loose water stools, diarrhea and blood in stools) gastrointestinal symptoms, and other related symptoms (e.g., nausea, dizziness, and stitch). Consistently, >60% of ultra-endurance athletes report severe GIS during single-stage or multi-stage ultra-endurance competitions, conducted in both hot and temperate ambient conditions.[4,14,29,30] Indeed, GIS experienced during competition are a main factor for reported reduced workload, cessation of activities, and withdrawal from ultra-endurance competition. It also appears that mode of exercise can influence the occurrence and severity of GIS, with running or activities containing a running element showing greater incidence and severity of symptoms. From a performance perspective, recent evidence has shown that reducing GIS during endurance running can substantially enhance performance outcomes.[3]

The underlying causes of exercise-associated GIS appear to be multifactorial and complex in nature, however stem from exercise-induce gastrointestinal syndrome. For a comprehensive overview of the syndrome, exacerbation factors, and health implication, refer to Costa et al.[5] In short, at the onset of exercise, the increase in sympathetic drive and redistribution of blood flow to the working muscles and peripheral circulation (i.e., to aid thermoregulation), promotes a scenario of gut ischaemia and reduced gut functional capacity. These primary drivers may prompt secondary outcomes that include: 1) increased gut injury and permeability, and subsequent intestinal bacterial endotoxin translocation and systemic inflammatory responses; and 2) impaired intestinal transporter activity, malabsorption, reduced gastric emptying and intestinal transit. Both the primary drivers and secondary outcomes may increase the risk of developing GIS during and/or after ultra-endurance activities.

Within the public domain, there exists a substantial amount of testimonials and anecdotal comments suggesting a wide array of diets, nutritional supplements, and pre-exercise behaviours to prevent exercise-associated GIS. Despite a substantial amount of research being conducted to understand the potential causal mechanisms for gastrointestinal disturbances induced by exercise, limited research has been done in determining effective prevention and management strategies. To date, from a scientific perspective, controlled laboratory research has explored the impact of maintaining euhydration, nutritional interventions prior to exercise, feeding during exercise, gut-training, and dietary modification

on markers of gastrointestinal integrity, function and/or symptoms. These will now be explored.

1. Maintenance of euhydration

The negative impact of dehydration on endurance performance, especially in hot ambient conditions is well documented.[1,6,9] There is now emerging evidence that dehydration may have a negative impact on the gut leading to greater incidence and severity of GIS. Controlled laboratory trials have shown that pre-exercise dehydration resulted in impaired gastric emptying and greater GIS.[31] Dehydration developing during running exercise results in higher intestinal injury, malabsorption of food consumed 2 hours before exercise, greater overall gut discomfort, and greater incidence and severity of GIS.[25] Additionally, dehydration following 1 hour of high intensity running was sufficient to raise gastroduodenal and intestinal permeability above resting levels.[14] Indeed, field studies and laboratory trials support the maintenance of hydration, with *ad libitum* water intake being an important factor in potentially attenuating exercise-associated systemic responses (i.e., endotoxaemia and cytokinaemia).[7,8]

- The evidence shows that commencing running in a euhydrated state and maintaining euhydration throughout can attenuate exercise-induced gut disturbance and reduce incidence and severity of GIS. Conversely, over-hydration is also not recommended, given that hyponatraemia is also associated with incident and severity of gastrointestinal symptoms.[11]

2. Nutritional interventions

Research into the role of nutritional interventions on gut integrity and function in response to exercise stress in humans is limited to date; however investigations have examined antioxidants (i.e., ascorbic acid), certain amino acids (i.e., L-arginine, glutamine, and L-citrulline), and bovine colostrum supplementation.[5] The results of these interventions appear to be ambiguous with no clear pattern for improvements in gut status and limited indication of the impact on GIS. Studies have mainly focused primarily on intestinal permeability as a marker of gut integrity, without displaying evidence of improvements to gut motility, malabsorption, intestinal injury, systemic responses, and symptoms. It is therefore difficult to translate findings into practical recommendations. One study did however show that consuming 10g L-citrulline prior to 1 hour of high intensity cycling attenuated splanchnic ischaemia and intestinal injury during exercise, compared with placebo.[32] However, the pre-exercise L-citrulline supplementation had no influence on intestinal permeability and failed to maintain the improved gut profile in the recovery period after exercise. In addition, it is a common practice for ultra-endurance athletes (e.g., ultramarathon runners) to supplement with sodium, prior to and during exercise, with one focus being on preventing nausea during prolonged continuous exercise. To date, no research has confirmed these practices support the prevention or reduction of nausea and/or vomiting.[12,13]

- Due to study limitations, ambiguous outcomes and modest degree of responses observed, there is no clear evidence that nutritional supplement interventions prevent or reduce exercise-associated GIS.

3. Feeding during exercise

The frequent and consistent consumption of carbohydrate during endurance exercise appears to be a protective strategy against exercise-associated gut disturbances due to ingested carbohydrate stimulating and maintaining blood flow to the gut and surrounding tissues and reducing intestinal injury and permeability (i.e., the so called "leaky gut") in response to exercise stress.[15,20,23,26] In a recent study, 15g of glucose was administered pre-exercise and every 20 minutes thereafter during moderate intensity running for 2 hours in 35°C ambient conditions; abolition of intestinal injury, reduced gut permeability, and systemic inflammatory responses, compared with those administered water alone, were observed.[26] Similar results were observed when energy matched protein hydrolysate was administered at the same time points. Therefore, carbohydrate intake at 45g/h during exercise appears to be well tolerated and not promote greater incidence or severity of GIS compared with water; unlike energy-match protein that results in increased symptom reports. However, higher rates of multiple transportable carbohydrates (90g/hr), as recommended in the literature, appear to be less tolerable and promote GIS.[3,21]

- Research investigating the role of feeding during exercise clearly shows that some form of nutrition during ultra-endurance activities appears to reduce the physiological effects that potentially lead to GIS. Therefore, ultra-endurance athletes would benefit from frequently consuming nutrition during exercise, within tolerance levels, and those that struggle with ingesting food and fluid would benefit from training the gut.

4. Gut training

Whilst the ability to train the gut has been commented and speculated on at length, to date only one study has comprehensively investigated a strategic gut-training protocol to prevent or attenuate exercise-associated GIS. A two week period of repetitive gut-challenge using 90g/h multi-transportable carbohydrate (2:1 glucose to fructose ratio) or carbohydrate rich food consumed during 1 hour of running at moderate intensity in thermoneutral conditions resulted in significant improvement in GIS, with no changes observed with placebo treatment.[3,21] Despite female runners reporting greater occurrence and severity of GIS, male runners responded better to the gut-training with greater improvements in overall gut discomfort and total and upper-gastrointestinal symptoms. Moreover, history of GIS and being accustomed to training with race nutrition did not influence gut-training outcomes. Whilst the gut-training resulted in abolition of malabsorption and increased blood glucose availability, it did not influence exercise-induced intestinal injury.

- The improvements in GIS observed in a wide range of endurance athletes (i.e., fitness level, gender, and symptom history) suggests that ultra-endurance athletes would benefit from a structured gut-training protocol leading into competition, and such reductions in GIS may result in performance improvements, as per research outcomes.[3]

5. Probiotics

It is a common belief that probiotic supplementation may have favourable effects on gut health in populations with compromised intestinal integrity.[27] The possible benefits of probiotic supplementation has therefore extended to the sport and exercise realm. Despite the frequent practice of supplementing athletes with probiotics to prevent or manage exercise-associated GIS, to date there has only been three cross-over and blinded studies attempting to investigating the potential impact of probiotic supplementation on gut integrity and/or symptoms in response to exercise stress. Two interventions found long-term multi-strain probiotic supplementation (14 and 4 weeks, respectively), had no effect on exercise-associated systemic inflammation compared with placebo, in response to 90 min of high intensity cycling,[17] and no improvements in exercise-associated gut disturbances and systemic inflammation were observed compared with placebo in response to running to fatigue (approximately 35 min) in hot ambient conditions.[28] A more recent intervention reported a substantial increase in endotoxaemia (i.e., the so called 'blood poisoning') and systemic inflammatory responses in the recovery period with consumption of a commercially available probiotic beverage (i.e., *Lactobacillus Casei*) beverage for seven days prior to 2 hours running in hot ambient conditions.[7] In all trials, no improvement in exercise-associated GIS were observed between probiotic administration and placebo. One additional study attempted to determine the role of multi-stain probiotic (with and without prebiotics and antioxidant content) supplementation for twelve weeks prior to a long course triathlon on markers of intestinal integrity.[24] However serious methodological limitation (sampling points and negligible fluctuations in measured variables) does not allow for any meaningful translational interpretations.

- At present, it would be advisable to withhold probiotic intake before ultra-endurance training and/or competition, especially in hot conditions, due to potentially unknown or underlying hidden outcomes.

6. Dietary modification

The use of gluten-free diets by non-coeliac athletes has recently been on the rise, with anecdotes and testimonials indicating improvements in GIS and sports performance. In contrast to this, an elegant study by Lis et al.[18] using blinded cross-over study design with competitively trained cyclists on either a gluten-free or gluten-containing diet for seven days prior to a high intensity cycling protocol, found no difference in performance, GIS, intestinal injury, or systemic inflammatory responses between the two diets. Whilst it appears from the anecdotal evidence and testimonials that a gluten-free diet improves gut health and sports

performance, the research does not support any significant physiological effect. A reduction in fermentable carbohydrate (FODMAP) content that often accompanies a gluten free diet is however more plausible. The role of the low FODMAP diet to treat GIS in functional gastrointestinal disorders (e.g., irritable bowel syndrome), similar to those symptoms experienced by ultra-endurance athletes is well documented,[10,22] with emerging cases providing supportive evidence of improved exercise-associated GIS (especially lower-GIS) with short-term adherence to a low FODMAP.[19]

- The current research evidence does not support gluten-free diets in non-coeliac athletes to treat exercise-associated GIS. Although more research is needed, the application of a short-term low FODMAP diet before exercise may have merit.

Practical recommendations:

The current scientific literature supports the following measures to prevent or manage exercise-associated GIS in response to ultra-endurance activities:

- Consider the factors that exacerbate exercise-induced gastrointestinal syndrome (see Costa et al.[5]) and attempt to minimise their influence. For example:
  - Adhere to comfortable training and race pacing strategies to avoid the onset of GIS.
  - Reduce heat stress by acclimating to heat before travelling to competitions set in hot ambient conditions. Ensure hydration is maintained leading up to competition.[2]
  - Avoid using non-steroidal anti-inflammatory drugs (aspirin and ibuprofen) leading up to and during competition.

- Start training and/or competition in a euhydrated state and maintain euhydration throughout. By the same token avoiding overhydration.

- Avoid overfeeding and or overdrinking during exercise to the point of overwhelming the stomach.

- Identify individual carbohydrate intake tolerance levels during ultra-endurance activities and consume carbohydrates evenly and more frequently throughout. Avoid long periods without carbohydrate consumption.

- Hypertonic solutions reduce gastric emptying rates, so it is advised to use lower carbohydrate concentration beverages with low osmolality. Consider consuming adequate water alongside any solids being consumed, including semi-solid forms such as gels.

- Train your gut to cope with food and fluid intake during exercise (solid and liquid forms) using a structured gut-training protocol.

- There is emerging evidence for the use of an acute low-FODMAP diet (which will include the reduction in dietary fibre) in the days leading up to competition and/or periods of intensified training in reducing exercise-associated GIS. See a qualified Sports Dietitian for guidance on following a low FODMAP diet during a period of intensity training or leading into ultra-endurance competition.

- There is no substantial evidence to support the acute or chronic consumption of dietary supplements to reduce exercise-induced GIS, and subsequent symptoms.

- To date, there is no evidence to support the acute and longer-term consumption of probiotics to reduce exercise-induced gastrointestinal syndrome, and subsequent symptoms.

- To date, there is no evidence to support adherence of a gluten free diet in non-coeliac runners to reduce exercise-induced GIS, and subsequent symptoms; unless specified by a health practitioner in response to a positive diagnosis of intolerance.

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