Nutrition Interventions for the Athlete with Digestive Distress

**OBJECTIVES:**
- Describe GI issues and gut microbiome alterations associated with endurance exercise.
- Detail the low FODMAP elimination diet short term for athlete with IBS.
- List foods that are high and low FODMAP.

**Exercise-induced gastrointestinal distress**

Main causes:
- Mechanical
- Ischemic
- Nutritional
- Nutritional
- Type of carb-oxidation rate & accumulation in gut
- Cumulative effect of FODMAPs in the gut-cotonic effect
- Macronutrient composition (ie too much fiber, fat such as Ketogenic diet)

**GI Symptoms**

- 5O-83% of runner’s impacted by GI disturbances
- Oesophagus: Nutr J 1999; 8:41-459
- GERD, during aerobic exercise/ Lower esophageal sphincter tone decreases
- Neurogastroenterol Mot 1999; 11:41-439

**Mechanical effects**

- Blood is shunted from viscera to active tissues (skeletal muscle, heart, lung & brain)
- Splanchic blood flow is decreased and gastric emptying may slow—especially when hypo-hydrated—may lead to mucosal ischemia and gut permeability: Gut mucosa susceptible to endotoxin translocation.
- Intestinal ischemia may manifest as cramps, diarrhea.

**Disclosers**

- 21 Day low FODMAP Menu Plans
- Low FODMAP Cookbook (Monash University reviewed; proceeds support research)
- Low FODMAP patient handouts reproducible for low FODMAP diet
- Published Books: 21 Day Tummy & cookbook, CID to Eating well with IBS
- Medical Advisory Nestle, Inc & Foodicine, Inc.
**GI Symptoms/ Carb in athlete**

- Caffeine intake associated with lower GI distress (cramps, flatulence, urge for BM)
  - Wilson, PB, Eur J Sport Sci 2015
- Ingesting mix of glucose & fructose increases exogenous carb oxidation while minimizing GI distress. Glucose intake associated with greater GI distress; mix of glucose & fructose may be more optimal saccharide profile
  - Wilson, BP et al J Am Coll Nutr 2015
- Gluc-Fruct likely improves GI discomfort & endurance running performance compared to Glu only
- Glucose + fructose increases gastric emptying and fluid delivery
  - Nunnari 2014; 6, 491-499

**Eating Disorders: FGD overlap**

101 Females admitted to ED unit screened for FGDs: 98% had one FGD
- 52% IBS
- 51% functional heartburn
- 51% functional abdominal bloating
- 24% functional constipation
- 23% functional dysphagia
- 22% functional ano-rectal pain
- 52% of the sample satisfied the criteria for at least 3 coexistent FGIDs

**Eating Disorders**

- Pelvic floor dysfunction/dysynergia common in ED population. If constipation or abdominal bloating are key symptom, consider eval. for pelvic floor w/ u.
  - Pelvic floor dysynergia: the external anal sphincter & puborectalis muscle contracts rather than relaxes during an attempted BM. There is the sensation of incomplete emptying of the rectum. Normal bowel movements involves relaxation of both of these muscles.

**Athletic hepatitis**

- Extreme exercise may cause decrease blood flow to the liver tissues, resulting in transient elevation of LFTs to about 2x normal.
- Intense exercise essential to maintain hydration and minimize overuse of any drugs that may dehydrate such as caffeine / alcohol, or those that are toxic to liver, including OTC Tylenol.
- Ultra marathoners can see transient rise in hepatic enzymes, rise in total bilirubin, direct bilirubin, AST, ALT: in some cases the levels remain elevated up to 7 days post event.

**Non Celiac Athletes & Gluten**

- N=40 (15:25 female)
- 41%, including 8: world or Olympic medalists follow GFD 50-100% of the time; 57% self-diagnosed gluten sensitivity
- Those who followed GF diet 16.7% experienced GI symptoms alone
- Fatigue was attributed to gluten intake.
- Sources of gluten free information: online 28.7%, trainer/coach 26.2% or other athletes 17.4%
- 5-10% of population is estimated to benefit from GF diet but 41% in this group followed the diet.
  - Lis, DM Int J Sports Nutr Exerc Metab. 2015
Effects of Short-Term Gluten-free Diet on Performance in Non-celiac Athletes

- 13 endurance cyclists no IBS or CD: 7 days gluten containing followed by 10-day washout, and crossed over GF diet; randomized, double blinded crossover
- Questionnaire re; GI sx, 15 min timed trial, measures of inflammatory markers (cytokine markers, & more) which showed little difference on GF and gluten containing diet.
- A short-term GFD had no overall effect on performance, GI symptoms, well-being, and a select indicator of intestinal injury or inflammatory markers in non-celiac endurance athletes.
- ? Length of study—not long enough to show benefit; small study size.

Lis, DM Med Sci Sports Exerc. 2015

Diet & IBS symptoms

- NCGS – low FODMAP vs. GF diet
- Aim: To assess the effect of diet with different FODMAP and gluten combinations on abd pain, bloating, and distention
- Diet combos:
  - Low FODMAP and GF
  - Low FODMAP and normal gluten
  - Normal FODMAP and normal gluten (control group)

Placentino et al DDW 2014

? Benefit of GF diet in setting of IBS

- 60 IBS pts; randomized to 3 diets, Symptom survey to monitor.
- Low FODMAP and GF and low FODMAP w/ gluten BOTH showed significant improvement in bloating, abdominal distention and pain.
- No significant difference in improvement from GF low FODMAP compared to gluten containing low FODMAP diet
- Eliminating gluten in addition to low FODMAP diet in patients with IBS does not offer additional GI symptom benefit.

Placentino et al DDW 2014

Low FODMAP diet

- Low FODMAP diet: a concept developed by dietitian, Sue Shepherd & colleagues, at Monash Univ. (Australia) to manage IBS/ FSG symptoms.
- Elimination diet: FODMAP intake is reduced significantly; then individual FODMAPs are re-introduced methodically to help patient identify their personal triggers.

Acronym stands for:

- Fermentable
- Oligosaccharides (fructans/OSs)
- Disaccharides (Lactose)
- Monosaccharide (fructose)
- Fructan (sugar alcohol: mannitol, sorbitol)
Characteristics of FODMAPs

- Poorly absorbed by the small intestine and delivered to the large intestine.
- Small, osmotically active molecules increasing water load to the colon.
- Rapidly fermentable by gut bacteria resulting in gas.

Why are FODMAPs malabsorbed?

- **Lactose**: reduced activity of brush border enzyme, lactase; secondary LI observed in post-infectious IBS & SIBO
- **Fructose**: poor absorption due to its slow, low-capacity transport mechanism across the epithelium & SIBO
- **Fructans/ GOS**: humans lack digestive enzymes
- **Polyols**: too large for passive diffusion; absorbed in pores in small intestine.

FODMAPs & IBS

FODMAPs do not cause the underlying FGDs but represent the opportunity to reduce symptoms.

Symptoms are triggered due to response of the enteric nervous system to the luminal distention in IBS.

FODMAPs & IBS

Symptoms are triggered via luminal distention in IBS likely due to:

- Nature of gut flora
- Dymotility impacting fluid and gas clearance
- Visceral hypersensitivity
FODMAPs effects are cumulative

Evidence: FODMAPs diet is better than standard IBS diet advice.

2011 Kings College London study:
76% of IBS patients on low FODMAP diet reported satisfaction with their symptom score compared to 54% standard IBS diet group.

Staudacher et al. J Hum Nutr Diet 2011 (5);487-95.

King’s College Study

82 Patients with IBS
39 in standard IBS diet (NICE guideline) group
43 in low FODMAP diet group

Pt.'s rated symptom change using seven-point Likert scale taken from the validated IBS Global Improvement Scale

Nice Standard Guidelines

In brief:
- Have regular meal times
- Drink at least 8 cups of fluid esp. H2O
- Restrict tea/coffee to 3 cups
- Reduce ETOH and ‘fizzy drinks’
- It may be helpful to increase fiber
- Limit fresh fruit to 3/day
- If with diarrhea, limit sorbitol

Low FODMAP vs. Std. Diet

Evaluation of Hydrogen Production in Individuals with IBS & Healthy Controls with Low and High FODMAP diet

Study Subjects:
15 IBS (Rome III)
15 Healthy Volunteers
No Co-morbidities
No antibiotics 8 weeks prior to study

Ong et al. J Gastro Hep 2010
Study Design

- Randomized, single blinded crossover intervention study
- Low FODMAP diet (9 g) diet followed by 7 day washout then high FODMAP (50 g)
- Symptoms tracked and breath hydrogen and methane measured on day 2 of each diet q hour x 14 hours.

Results

- Breath hydrogen increased in controls & those with IBS on high FODMAP diet but increased more in those with IBS
- Breath CH₄, produced by 10 subjects within each group, was reduced with high FODMAP intake in healthy subjects, but was not different in patients with IBS
- GI symptoms and lethargy were significantly increased in those with IBS compared to controls with HFD

Low FODMAP vs. Typical Australian Diet

- This trial compared GI symptoms over 3 weeks of low FODMAP diet with the moderate FODMAP intake on a typical Australian diet in unselected patients with IBS who had not previously received advice from a dietician.
- Randomized, controlled, cross-over trial

Methods

- 38 participants:
  - 30 IBS & 8 healthy controls
  - Inclusion of healthy controls was to ensure the typical Australian diet utilized did not induce symptoms in the general population.
  - Almost all food, comprising 3 main meals & 3 snacks daily provided.
  - GI symptoms were measured daily during the baseline week and interventional diet periods using a 100 mm visual analogue scale (VAS)

Results: FODMAP vs. Traditional Diet

- Subjects with IBS had lower overall gastrointestinal symptoms scores while on a diet low in FODMAPs, compared with typical Australian diet
- Symptomatic relief was noted by 50% in 70% of IBS pts. (Noted as good sx control)
- Symptoms were minimal and unaltered by either diet among controls.
- Of the 70% of subjects who felt better on the low FODMAP diet, this encompassed subjects across all four subtypes of IBS

MRI Study: FODMAPs effect on small & large intestine contents

- Purpose: Investigate the action of fructose and inulin on the small bowel and colon in healthy subjects using MRI technique.
  - 16 healthy subjects (no IBS)
  - Randomized single-blind crossover study

Murray et al J Gastroenterol 2014-Nottingham, UK
Methods

- Volunteers underwent a baseline fasted scan 45 min before ingestion of the test meals.
- Test drinks=500 ml H₂O w/ either 40 g gluc, fructose, inulin or mix of 40 g gluc + 40 g fructose
- Followed by a scan every hour up to ≈300 min. After each scan, breath hydrogen (H₂) tests were performed using a portable hand-held breath H₂ meter

Breath Hydrogen

Murray, et al 2014 Am J Gastro

Small bowel water content

Murray, K et al Differential effects of FODMAPs (fermentable oligo-, di-, mono-saccharides and polyols) on small and large intestinal contents in healthy subjects shown by MRI. A J Gastro 2014 Jan;109(1):110-9

MRI-results

- Fructose but not inulin distends the small bowel with water.
- Adding glucose to fructose reduces the effect of fructose on SBWC and breath hydrogen.
- Inulin distends the colon with gas more than fructose, but causes few symptoms in healthy volunteers.

MRI in IBS patients

- N=29 IBS patients (22 female, 7 male)
- Aim: test whether fructose or inulin would cause more IBS symptoms than glucose
- Participants given 500 ml water flavored w/ lime juice with 40 g glucose, fructose or inulin.
- Symptom endpoints were evaluated: gas/flatus, bloating, pain/discomfort, diarrhea
- Secondary endpoints: composite symptom intensity, breath H₂, SBWC, colonic volume and colonic gas

MRI Study

- Measurements were taken at baseline, 60, 120, 180, 240, and 300 minutes
- Fructose increased SBWC while inulin increased colonic gas more than glucose or fructose.
- Similar findings occurred in patients that had symptoms and those that did not—suggesting a difference in sensory response to the luminal distention.

Murray, K et al Differential effects of FODMAPs (fermentable oligo-, di-, mono-saccharides and polyols) on small and large intestinal contents in healthy subjects shown by MRI. A J Gastro 2014 Jan;109(1):110-9

Nottingham digestive diseases biomedical research unit, UKE, DDW 2015 presentationID326
FOODMAP Diet Approach @ present

- Remove high FODMAP containing foods for 2-6 weeks on elimination phase
- Followed by re-introduction of FODMAPs or “challenge” phase of the diet.
- End Goal: pt. satisfied w/symptom management
- Full elimination FODMAP diet is a learning diet NOT lifelong!

FOODMAPs: richest sources

<table>
<thead>
<tr>
<th>FODMAP</th>
<th>Richest Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fructans</td>
<td>Wheat, rye, onions, garlic, artichokes</td>
</tr>
<tr>
<td>GOS</td>
<td>Legumes</td>
</tr>
<tr>
<td>Lactose</td>
<td>Milk</td>
</tr>
<tr>
<td>Fructose</td>
<td>Honey, apples, pears, watermelon, mango</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>Apples, pears, stone fruits, sugar-free gum/mints</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Mushrooms, cauliflower, sugar-free gum/mints</td>
</tr>
</tbody>
</table>

Caution: High FODMAP

Low FODMAP diet

- Prior to start: Patient should be screened for celiac w/ serology testing: Tissue Transglutaminase Antibodies (tTG-IgA), Deaminated gliadin peptide (DGP-IgA and IgG), & Total serum IgA
- Assess for any alarm features: bloody stool, weight loss, night sweats, etc. If so, refer back to GI.
- Assess appropriateness for full elimination diet and level of instruction
- Eating disorder? Willingness to change diet.

FOODMAP Checklist

Caution: High FODMAP Grocery Shopping
Low FODMAP balanced plate

Monash U. Low FODMAP App

Low FODMAP not DAIRY free

Lactose
- Avoid lactose rich containing items: milk, yogurt, custard and wet cheeses: ricotta and cottage, ice cream.
- Choose:
  - Most hard and/or aged cheeses
  - Lactose free yogurt such as Green Valley
  - or Yoplait lactose free.
  - Butter only trace of lactose = low FODMAP.

Fructose
- Dietary fructose, is a six-carbon monosaccharide that is distributed widely in plant foods and exists mainly in 3 forms:
  - Fructose—monosaccharide
  - Part of sucrose—a disaccharide of fructose + glucose
  - In chains of fructans
- It is estimated 1 in 3 malabsorb fructose but not all that malabsorb develop GI distress.
- Glut 2 and Glut 5 major pathway for fructose transport—but recent identification of other pathways discovered making this scenario more complex.
- Symptom exacerbation may be related to osmotic effects in some individuals vs. gas. Clinical observations imply that breath testing has little clinical predictive value.
Fructose

- Fructose absorption enhanced by the presence of glucose.
- Foods with excess fructose (>0.15g) are considered a source of excess fructose (Monash U guidelines).
- Food with equal fructose: glucose ratio=FOODMAP friendly.
- Common food sources with excess fructose: mango, watermelon, apples, pears, HFCS, honey, agave syrup, sugar snap peas, asparagus, rum

Study: Fructose + Erythritol

- N=37 healthy, non DM subjects
- Cross over intervention study
- Subjects given: Fructose 50 g, Fructose in combo w/ 50 g glue or 33.3 g erythritol
- Fruc-glu mix produced a 4-fold decrease in breath hydrogen compared to fructose alone.
- Co-ingestion of fruct + erythritol—doubled hydrogen production and caused symptoms (watery stool, GI sx).

Kim, Y et al. Nutr Res. 2011 Nov

Fructose + erythritol

- Erythritol is poorly fermented by colonic bacteria—so the rise in hydrogen was related to reduced absorption of fructose.
- Likely, erythritol interferes with absorptive pathway of fructose at epithelial level.
- Erythritol used in presence of fructose would be unfavorable for patients w/ IBS.
- Truvia, stevia product—has erythritol—if added to fruit recipe such as smoothie could exacerbate GI symptoms.
- Sorbitol intake also exacerbates fructose malabsorption.

Oligosaccharides:

- Fructans and Galacto-oligosaccharides (GOS)
- Water-soluble fibers
- Common sources: legumes, onion, garlic, onion, wheat; inulin (chicory root extract)
- Newer sources identified: Teas (fennel, colon, chamomile), carob

Galacto-oligosaccharides (GOS)

- Oligosaccharide, chains of galactose, water-soluble fiber
- Indigestible; humans lack hydrolyses
- Rich sources: Legumes
- Beans well-known to contribute to gas!
- Canned beans-less GOS

Products vary with same name
Culturelle w/ inulin

Polyols

Sugar alcohols
- Sorbitol, xylitol, mannitol, maltitol, isomalt
- Poorly absorbed in the small intestine as they are too large for passive diffusion; osmotically active.

Polyols: Mannitol

High Mannitol sources: cauliflower, mushrooms, snow peas, watermelon

Moderate amounts of mannitol:
- celery (1/4 large stalk/rib), sweet potato (1/2 cup)

Alternative low polyol sweeteners:
- aspartame, stevia, sugar, maple syrup

Polyols: Sorbitol

High Sorbitol sources: apples, apricots, blackberries, peaches, nectarines, pears, plums (fruits primarily)

Drinks/sugars: apple juice, pear juice, gum and mints with sorbitol.

FODMAP cut off for polyols: 0.3 gm per serving:
- 1 medium pear = 3.8 g sorbitol
- 5 cherries = 0.3 g sorbitol

LOW FODMAP Exercise fueling

- Maple sugar candy, banana, gu chew, Bonk breaker energy chews, Hammer gel, Clif citrus shot (has caffeine), Human chix energy gels (strawberry, blueberry), Pocket fuel pineapple coconut kicker trash blend.
- Beverages: Gatorade made with sugar, Infinit speed lemon-lime flavor, Bonk Breakers real hydration mix (lemon-lime)
- Bonk Breakers hydration mix: Organic Evaporated Cane Juice Crystals, Organic Glucose, Sodium Citrate, Calcium Citrate, Potassium Citrate, Citric Acid, Natural Lemonade Flavor, Sodium Chloride, Magnesium Chloride, Ascorbic Acid, Limes.
Low FODMAP carb loading

- Rice, bananas, potatoes, lactose free milk, Sourdough or gluten free bread options, suitable jam = excellent carb-rich choices for low FODMAP diet.
- Smoothies made with suitable ingredients (lactose free yogurt, pure maple syrup, low FODMAP fruit [1 serving])
- Rice cake, peanut butter, banana slices, a few semi-sweet chocolate chips
- Sweeten oats/smoothies with pure maple syrup

Reintroduction/challenge phase

- Maintain low FODMAP diet 2-6 weeks until good symptom control;
- Challenge individual FODMAP group (lactose, fructose...)
- Choose food that contains only that FODMAP
- Add to diet for 3 days during the test week.

Challenge foods

- **Lactose**: ½ - 1 cup milk
- **Fructose**: 1-2 tsp. honey or ½ mango
- **Fructans**: 2 slice wheat bread, 1 TB onion, 1 garlic clove OR try sourdough white first for more gentle challenge
- **GOS**: ½ cup beans
- **Polyols**: ½ cup mushrooms, 1/3 cup cauliflower (mannitol) or 2 fresh apricots, 6-8 blackberries (sorbitol)

Re-challenge Phase

- Reintroduce challenge foods in setting of low FODMAP diet.
- Day #1 add in challenge food. Note symptoms.
- Day #2, if no symptoms, double challenge food portion.
- Day #3, can keep portion same as day #2 and assess tolerance—or up the portion to desirable amount and test tolerance.
- Abort challenge if undesirable symptoms occur.

Athlete Eating Trends that can contribute to GI distress

- Smoothies: Fructose load or FODMAP load (more than 1 serving of fruit), hidden FODMAP ingredients (agave, honey)
- Power bars: hidden FODMAPs (inulin, agave, fructose)
- Protein supplements: Whey concentrate (has lactose possibly) vs. isolate; added sugar alcohols or inulin, fructose

Supplement Products- Huge Business!
Surge: Agave 1st ingred.

GU hydration w/ xylitol

Cliff Hydration: suitable product per ingredients.

Gut Microbiome connection

Gut microbiome changes in 4 weeks w/ low FODMAP diet

Low FODMAP and microbiome

- 27 IBS & 6 healthy subjects were randomly put on 21-day diets, differing only in FODMAP content: low ~3.05 g/day vs typical Australian diet ~23.7 g/day.
- Then crossed over to the other diet with ≥21-day washout period. Feces passed over a 5-day run-in on their habitual diet and from day 17 to day 21 of the interventional diets were pooled, and pH, short-chain fatty acid concentrations and bacterial abundance and diversity were assessed.
- Fecal indices were similar in IBS and healthy subjects during habitual diets.


Cliff Hydration: Organic Glucose, Organic Dried Cane Syrup, Citric Acid, Sea Salt, Calcium Citrate, Magnesium Citrate, Potassium Citrate, Natural Flavor.

Ingested glucose, fructose, and sucrose, through a low-FODMAP diet, have altered luminal bifidobacteria. Fecal indices were similar in IBS and healthy subjects during habitual diets.
Gut microbiome change

- The low FODMAP diet was associated with higher fecal pH (7.37 vs. 7.16), similar short-chain fatty acids concentrations, greater microbial diversity, and reduced total bacterial abundance compared with the Australian diet.
- The typical Australian diet increased relative abundance for butyrate-producing Clostridium cluster XIVa and mucus-associated Akkermansia muciniphila, and reduced unfavorable mucus consuming Ruminococcus torques.


Exercise: gut microbiome

- Exercise induces a more diverse microbiome including key player: Increase in beneficial, Akkermansia muciniphila (may also be related to enhanced diet w/ exercise)
- Exercise linked with decreased risk of GI cancer, reflux, IBS and diverticulitis.
- Intense, prolonged exercise in the heat is linked with gut permeability.
- Effect of diet & exercise on intestinal integrity and microbial diversity (rat study)
- Exercise protected duodenal morphology in presence of high fat diet
- High fat diet increased intestinal inflammation and exercise reduced it.


Intestinal Permeability

- Ingestion of glutamine prior to exercise reduces gut permeability.
- 0.9 g/kg of fat-free mass of glutamine (GLN)


Fermentation and metabolites

- Carbohydrates are the cores of activity for gut bacteria, degrading plant polysaccharides into SCFA.
- Butyrate and propionate (SCFA) regulate intestinal physiology and immune function while acetate acts as a substrate for lipogenesis and gluconeogenesis. Butyrate associated with + effect to colonic mucus, decrease colonic cancer risk.
- Fermentation of protein creates SCFA and also potentially harmful compounds r/t IBD and cancer-- might be of concern with HIGH protein Paleo/ Ketogenic style diets with very low percentage of carb in diet.
- In animal studies, by products of protein fermentation: ammonia, phenols, amines and hydrogen sulfide associated w/ leaky gut, DNA damage, inflammation & cancer.


Key RD Points

- Low FODMAP diet is typically followed for 2–6 weeks. It is an elimination/learning diet to determine individual food triggers in individuals with IBS.
- Low FODMAP diet is not a LONg term diet due to changes in gut microbiome—long term impact unknown.
- Patients education should emphasize what patient CAN eat vs. focusing on what they can not.
- Challenge phase of the diet is done methodically.
- Low FODMAP diet should include “well-balanced plate” nutrition goals.

Take away for athlete

- FODMAP subtypes (excess fructose, lactase and polyols) due to osmotic effects, may contribute to lower GI symptoms, particularly diarrheal/ runner’s trots.
- Encourage re-fuels and hydration options with balance of glucose vs. fructose vs. intrinsic fructose and without polyols to better absorbability and GI symptom control.
- Modify FODMAPs with runner’s trots/diarrheal symptom profile? Trail low FODMAP carb loading for endurance runner with history of diarrheal symptoms during event day.
- Adjust diet according to symptoms: flatulence: reduce fructans/GOS, GERD-some evidence suggest fructans contribute to upper GI as.
- Long term impact of high protein, low carb diet unknown potentially detrimental to colonic health.