

Plenary 4: Gut Physiology: Gut Function and Nutrition

Relationships between gastrointestinal function and acute energy intake

C Feinle-Bisset

University of Adelaide Discipline of Medicine, Royal Adelaide Hospital, and NHMRC Centre of Clinical Research Excellence in Nutritional Physiology, Interventions and Outcomes, Adelaide, South Australia

The gastrointestinal tract is the first “port of call” for the actions of nutrients following ingestion, and all three macronutrients, carbohydrate, protein and fat, have potent modulatory effects on gastrointestinal function, including the stimulation of exocrine and endocrine secretions and modulation of pressures in the upper gastrointestinal tract, resulting in a slowing of gastric emptying. Of the three macronutrients, protein is now generally regarded as the most “satiating” nutrient. In contrast, due to its high energy density, wide availability and effects on the palatability of foods, dietary fat may promote passive overconsumption. Despite these detrimental effects, fat has potent effects on those gastrointestinal functions that favour the suppression of energy intake. For example, the presence of fat in the small intestine slows gastric emptying, leading to an increase in distension of the stomach. Distension of the stomach, particularly of the antrum, the distal region of the stomach, has been shown to be associated with increased perception of fullness and suppression of subsequent energy intake (1). The motor patterns in the gastrointestinal region that underlie the slowing of gastric emptying include a relaxation of the proximal stomach (or fundus), suppression of pressure waves in the antrum and duodenum, and stimulation of both tonic and phasic pressures in the pylorus, with the latter most likely being the most important mechanism. Interaction of fat with small intestinal receptors also triggers the release of gut hormones, including cholecystokinin (CCK), peptide YY (PYY) and glucagon-like peptide-1 (GLP-1), and the suppression of ghrelin. All these changes are thought to contribute to the suppression of energy intake. For example, we have recently found a strong inverse relationship between the stimulation of phasic pyloric pressures and the suppression of energy intake (2). Moreover, intravenous administration of gut hormones, eg CCK, suppresses energy intake (3), while receptor antagonists, eg the CCK₁ antagonist, loxiglumide, prevents the nutrient-induced suppression of energy intake (4).

The effects of fat on energy intake and gastrointestinal function are abolished when fat digestion is inhibited, questioning the usefulness of lipase inhibitors for successful and maintained weight loss. Furthermore, the effects of fat are dependent on fatty acid chain length, with fatty acids with ≥ 12 C atoms in the chain potently suppressing energy intake, while those with ≤ 10 C atoms largely ineffective (5). Modification of the length and/or region of small intestine exposed to nutrient also exerts a powerful effect on changes in gastrointestinal function and energy intake. For example in humans, allowing nutrient free access to the small intestine, suppresses ghrelin, and stimulates GLP-1, more than when access is restricted to the first 60 cm of the small intestine (6). An important role for distal small intestinal feedback is demonstrated by the success of gastric bypass surgery, directing nutrients to the distal gut, in accomplishing significant weight loss.

Gastrointestinal function can adapt to dietary restriction, or excess nutrient exposure, modifying the sensitivity to nutrient and/or hormonal stimuli. For example, a four-day fast markedly slows gastric emptying of a nutrient drink in both lean and obese subjects, compared with a pre-fasting condition (7). Conversely, consumption of a high-fat, high-energy diet accelerates gastric emptying and small intestinal transit of a fat-containing meal (8). Since obese individuals have an increased energy/nutrient intake, they may have a reduced ability to sense gut stimuli, associated with reduced modulation of gut functions, thus, compromising their capacity to limit their energy intake. Strategies are required to stimulate those aspects of gastrointestinal function that are associated with the suppression of energy intake, ultimately resulting in sustained weight loss in obesity.

References

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