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Ingestive Science: The Control of Eating

Critical Analysis of Popular Diets and Supplements

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Measuring Food Intake

- Problem: The act of measuring may alter intake
 - *"Demand characteristics"*: the beliefs about food(s), past experience, and desire to be a "good subject" that influence responses
 - *Instructions* to subjects matter: "Eat as you normally do" vs. "eat to comfortable fullness"
- Choices: "Naturalness" vs. precision
- Free-living observational vs. lab studies

Power and Errors in Eating Studies

- Statistical power is often low- small n , large variability in consumption
- Thus, *type II errors* are common (missing a real effect)
- *Type I errors* (finding an effect when there is none) are less common

Key features of the Appetite Control System-I

- Redundancy: overlapping control mechanisms (defense of weight is highly conserved genetically)
- Bias towards overconsumption (genetic?)
- Sensory cues are used to learn about certain foods (what tastes good, what causes harm)
- Change in environment can change eating
 - External: temperature of air or food
 - Internal: being pregnant, being happy, feeling ill

Key Features of the Appetite Control System-II

- Weight equilibrium ($EI = EE$) is the norm for adults, but a new, higher wt will also be maintained
- Intake is influenced by *physiologic* (eg drop in blood glucose predicts onset of meal), *learned* (eg, that smells good, let's eat) and sometimes *pathologic* factors (eg, eating disorders)



Components of Feeding Behavior:

- Meal size
- Meal frequency
- Rate of meal ingestion
- Composition of meal

Satiety (“Fullness”) Signals-Terminology

- *Satiation*: intra-meal satiety; eg: CCK- ends meals but does not increase time between meals
- *Post-ingestive (PI) satiety*: maintenance of inhibition over further intake (between meals)
- *Sensory-specific satiety (SSS)*: decreased desire for a food just eaten, but not general satiety; eg, 10 licorice sticks = 150 kcal

Satiety (“Fullness”) Signals- Measurement

- How can we measure a subjective sensation like hunger?
 - ***Visual analog scales (VAS)***: 100mm, anchored at ends only (“extremely” and “not at all” hungry)
 - Better than bipolar scale (hungry to full)
 - Better than **categorical scale** (not, somewhat, moderately, very, most hungry ever)



Components of the Appetite-Control System

- Orosensory
- Gastrointestinal
- Liver
- Circulating factors
- Nutrient stores
- Central and peripheral nervous system



Orosensory Component

- Learned component is very important
- Smell is more specific than taste
- **Obese**: generally similar in taste preferences to lean, but find more palatable than lean the mixture of sugar and fat
- Primary tastes (in order of US preference):
 - **Sweet**
 - **Salty**
 - **Unami (MSG)**
 - **Sour**
 - **Bitter**



Gastrointestinal Component

○ Stomach:

- Regulates the flow of energy into the small intestine
- Places a physical constraint on meal size (gastric band)
- Its size adapts to habitual meal size (starved must eat small, freq meals initially to recover their weight)
- Stretch and CCK receptors in stomach communicate with CNS to regulate speed of ingestion and meal end
- Small intestine stretch and chemo/osmoreceptors feed back to stomach to regulate gastric emptying rate



Liver Component

- Liver receives, metabolizes, distributes and stores all nutrients (except chylomicrons, which are absorbed into lymphatics: this may account for the lesser/delayed satiety of fatty meals)
- Liver may sense food: rats- portal vein infusion of glucose while feeding increases the rat's preference for that food
- Poisoning liver metabolism: stimulates feeding



Circulating Factors Component

- Evidence for circulating appetite control factors: “sham fed” dogs (distended stomach) are hyperphagic
- However, direct feeding IV (TPN) is less satiating than equal kcal orally
- Circulating factors may include hormones, neurochemicals, and circulating nutrients themselves (eg, glucose)



Nutrient Stores Component

- Distinct from circulating nutrients' effect
- Energy intake tends to increase after weight loss
- Parabiotic (shared circulation) rats: overfeed one- the other eats less, loses weight
- Leptin (satiety h.) levels are higher in obese because leptin is stored in adipose tissues
- Yet, little is known about how nutrient stores affect eating behavior



Central and Peripheral Nervous System Component-I

- Very complex and not fully understood
- Involves hormones/peptides; other messengers like ATP, Ca; from gut, tissues and brain
- Learned component and imprinted component interact (eg, cats who learn to eat fruit)

Central and Peripheral Nervous System Component-II

- Brain areas that process peripheral (vagal) and CNS feeding signals: area postrema, nucleus of the solitary tract
- AP/NST are linked to the forebrain's paraventricular nucleus, lateral and ventromedial hypothalamus
- LH and VMH contain glucosensitive neurons

Central and Peripheral Nervous System Component-III

In animal models:

- Steroids, NE, NPY, GABA → CHO intake
- Opioids, aldosterone, galanin → fat intake

In obesity, find ↓ sympathetic activity, and thus blunted post-prandial thermogenesis

Diet Composition and Satiety-I

Hierarchy of satiety per kcal:
protein, complex CHO, simple CHO, fat,
EtOH

EtOH may even stimulate further food
intake

Liquids are less satiating than solids



Diet Composition and Satiety-II

- Micronutrients:
 - When made deficient in a micronutrient, rats will select a diet that corrects the deficiency
 - Humans may overeat in general to correct micronutrient deficiencies

Post-Absorptive Influences on Appetite

- Blockade of glucose or fat metabolism → increased EI in animals
- High rates of glucose/fat oxidation → decreased EI in animals
- Humans: 6-12% drop in blood glucose → meal initiation
- Humans: high fat does not suppress appetite



Obesity and Macronutrients

- Obese prefer fattier foods more than lean
- “Passive” overconsumption of calories may occur on high fat diets
- Prevalence of obesity in populations correlates with % dietary energy from fat
- Some evidence for genetically-influenced ease of wt gain on high fat diet (+FHx)