Protein, satiety and satiation

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Obesity – not a new problem!

‘obese people and those desiring to lose weight should perform hard work before food. Meals should be taken after exertion and while still panting from fatigue. They should, moreover, only eat once per day and take no baths and sleep on a hard bed and walk naked as long as possible’

*Hippocrates, 5th century B.C.*
Weight loss is easy - energy intake < expenditure

• Hunger is one of the main reasons why people fail to comply to a weight loss diet

• How can we develop dietary strategies that fulfill hunger and still achieve weight loss?

• Macronutrient composition of the diet is important to contribute to satiety during weight loss
Protein – satiation or satiety?

• Satiation - within meal
  • Feeding rate & meal size

• Satiety - between meal interval
  • Post-ingestive and post-absorptive consequences (gut – brain axis)
Protein – satiation or satiety?

Inter-meal interval is increased in mice fed a high whey, as opposed to soy and gluten, protein diets. Yu et al (2009) Appetite, 52,372–379.

- Whey protein most potent satiety effect (inter-meal)
- Similar effects in preloading studies in humans (~50g)
Weight loss at 6-months in RCTs of low-fat vs low-carbohydrate diets

Recently, there has been increased interest in the use of low-carbohydrate diets as potential therapy for obesity. The results of five RCTs in adults [1-5] found that subjects randomized to a low-carbohydrate, high protein/high fat diet (approximately 25-40% carbohydrate) achieved greater short-term (6 months) [1-4], but not long-term (12 months) [3, 5], weight loss than those randomized to a low-fat diet (approximately 25-30% fat, 55-60% carbohydrate). A consistent difference in weight loss at 6 months was observed between groups across studies; subjects randomized to the low-carbohydrate diet lost 4-5 kg more weight than those randomized to the low-fat diet. The data from these studies also found greater improvements in serum triglyceride and HDL-cholesterol concentrations, but not in serum LDL-cholesterol concentration, in the low-carbohydrate group than in the low-fat group. In addition, glycemic control was better with low-carbohydrate than a low-fat diet therapy in subjects who had type 2 diabetes [1, 5].


Protein effect?

- Mechanism of appetite control?
- Nutritionist question the effect on health?
- Role of low carbohydrate (ketosis) - additive effect?
Diet composition can affect hunger and appetite control, for weight loss: high-protein, low-carb diets

- Popular with dieters - eat less but feel less hungry - the ‘holy grail’ of dieting?

- What is the role of the low-carbohydrate component in high protein diets?
High protein weight loss diets

- Weight loss is significantly more on the high-protein, ketogenic diet ($p=0.006$)

- Hunger is significantly less on the high-protein, ketogenic diet ($p=0.020$)

- Ad libitum intake is significantly less on the high-protein, ketogenic diet ($p=0.020$)

Results - metabolic health

- Reduction in HOMA (insulin resistance) \((p<0.017)\)

- Reduction in cholesterol on both diets \((p=0.022)\)

Positron emission tomography (PET)

Whole body PET scan
Dynamic radio-nucleotide imaging tool
Appetite research: PET scan study

HP-LC and HP-MC weight loss diets

Hypothesis
Glucose uptake and metabolism differs within key areas of the brain known to be involved in intake regulation?
Nutritional challenges impact on brain metabolism and motivation to eat, which can be detected by Positron Emission Tomography

Johnstone, Broom, Welch & Lobley et al. IJO, 2008
Appetite Research
Protein induced satiety

• Compared two high protein diets – both significantly reduced ad libitum intake, relative to maintenance

• What about comparison of normal protein (NP) and high-protein (HP)?
Ad lib intake and body weight

• Increasing protein intake from 15 to 30% produces sustained decrease in ad libitum intake

• **Peptides or amino acids**
  Does dietary supplementation of amino acids within a normal-protein weight loss diet, change profile of ‘motivation to eat’ to that similar on a high-protein weight loss diets?

• **Bio-markers**
  Are alterations in plasma amino acids or gut-related hormones signals for altered appetite response or ‘motivation to eat’?
Fig. 1. The brain integrates long-term energy balance. Peripheral signals relating to long-term energy stores are produced by adipose tissue (leptin) and the pancreas (insulin). Feedback relating to recent nutritional state takes the form of absorbed nutrients, neuronal signals, and gut peptides. Neuronal pathways, primarily by way of the vagus nerve, relate information about stomach distention and chemical and hormonal milieu in the upper small bowel to the NTS within the dorsal vagal complex (DVC). Hormones released by the gut have incretin-, hunger-, and satiety-stimulating actions. The incretin hormones GLP-1, GIP, and potentially OXM improve the response of the endocrine pancreas to absorbed nutrients. GLP-1 and OXM also reduce food intake. Ghrelin is released by the stomach and stimulates appetite. Gut hormones stimulating satiety include CCK released from the gut to feedback by way of vagus nerves. OXM and PYY are released from the lower gastrointestinal tract and PP is released from the islets of Langerhans.
Fig. 2. Simplified representation of potential action of gut peptides on the hypothalamus. Access circulating agents into the arcuate nucleus of the hypothalamus is facilitated by a relaxed blood-brain barrier. Primary neurons in the arcuate nucleus contain multiple peptide neuromodulators. Appetite-inhibiting neurons (red) contain pro-opiomelanocortin (POMC) peptides such as melanocyte-stimulating hormone (MSH), which acts on melanocortin receptors (MC3 and MC4) and cocaine- and amphetamine-stimulated transcript peptide (CART), whose receptor is unknown. Appetite-stimulating neurons in the arcuate nucleus (green) contain neuropeptide Y (NPY), which acts on Y receptors (Y1 and Y5), and agouti-related peptide (AgRP), which is an antagonist of MC3/4 receptor activity. Integration of peripheral signals within the brain involves interplay between the hypothalamus and hindbrain structures including the NTS, which receives vagal afferent inputs. Inputs from the cortex, amygdala, and brainstem nuclei are integrated as well, with resultant effects on meal size and frequency, gut handling of ingested food, and energy expenditure. , direct stimulatory; ---|, direct inhibitory; - - ->, indirect pathways.
Plasma PYY after iso-energetic meals

So now I am going to show you the design of the study.
- Vols on Fixed intake for 4 weeks on each intervention diet with a maintenance period at the start
- For simplicity from now on HP-LC = K, HP-MC = NK
- Rotation of the crossover between K & NK diets was randomised

Measurements taken:
- Weekly blood samples
- Anthropometric – BodPod, BP, DXA, Skinfolds
- Daily urine spot samples to monitor levels of ketosis
- Daily Hunger & Satiety questionnaires using VAS
- Glucose Infusions
- PET Scans
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Hunger data
Diet effect (p=0.040)

‘Extremely hungry’ (mm)

‘Not at all hungry’ (mm)
Stable isotope protocol:
Oral and i.v. Leucine and Phenyalanine
Plasma Leucine (incomplete)

[Graph showing plasma leucine levels over time with breakfast and lunch markers.]

Legend:
- HP
- NP
- NP+AA

Rowett Institute of Nutrition and Health
Soya vs meat protein: effect on appetite

High Protein Weight Loss diet: 14 days on each

- Meat diet
- Soya diet

Appetite recorded every waking hour
Test meal challenge
Faecal samples
Conclusions

• High protein diets are a useful tool for short-term weight loss: 30% of restricted energy
• Do not need reduced carbs for appetite control
• Type of protein?
• Interaction with energy density?
| Vegetarian Atkins diet lowers heart risks – study | 'ECO-ATKINS' - University of Washington School of Medicine study points to potentially safer low-carb diets for people with heart problems |
| Scotland on Sunday, 15th June |   |
| IT IS the Mount Everest of the health campaigner – persuading Scottish men to give up their love affair with fried sausage and bacon, fatty mince, and giant plates of steak |   |
Final thought

‘Most people will not stay in treatment for obesity. Of those who stay in treatment, most will not lose weight, of those who do lose weight, most will regain it.’
Stunkard, 1958

‘Our obesogenic environment makes it easy to gain weight; weight loss is difficult. Development of preventative dietary strategies to control appetite and improve health will assist in achieving weight control.’
Johnstone, 2008