Popular diets – what is the evidence?

High Protein/Low carbohydrate

Dr Alexandra Johnstone
What is high protein diet?
What is a low-carbohydrate diet (ketogenic diet)
Do we need HP and LC for weight loss?
How do HP diets work?
Effectiveness of HP diets?
Safety of HP diets?
Do we need HP-LC for weight maintenance after weight loss?
With more than half of consumers in developed countries over the age of 14 now classified as overweight or obese, and obesity rates in China and India expected to double by 2020, global interest in weight management products “will likely remain high for the foreseeable future”, says Euromonitor International 2013.
• With the ever-increasing obesity problem comes the search for effective dietary strategies to
  (i) prevent weight gain,
  (ii) promote weight loss,
  (iii) maintain a lower body weight
• One diet does not achieve all of this for all people!

• High-protein diets seem to provide a tool to promote appetite control and hence body weight control: what is the role of low-carbohydrate?
Eat as much as you want and lose weight: the holy grail of dieting

How do HP-LC diets work?

- Dietary strategies that can help reduce hunger and promote fullness are beneficial, since these are limiting factors for success.
- No data to support metabolic advantages in low-carbohydrate diets and that weight loss results simply from reduced caloric intake, probably due to the increased satiety effect of protein.

- Reduction in appetite due to higher satiety effect of proteins
- Effects on appetite control hormones and to a possible direct appetite-suppressant action of the ketone bodies
- Reduction in lipogenesis and increased lipolysis
- Reduction in the resting respiratory quotient and, therefore, greater metabolic efficiency in consuming fats
- Increased metabolic costs of gluconeogenesis and the thermic effect of proteins
What is a high protein diet?

• The protein composition of an individual's diet can be considered in different ways, as the absolute amount of the protein (grams), the % of total energy (calories) as protein or the amount of protein ingested per kg of body weight.

• Normal protein intake in the UK is ~16% of energy intake (Henderson et al, 2003) for a sedentary adult, which is approximately 64-88g/d at energy balance for females and males, respectively.

• High protein diets reported in weight loss studies often include ~30% of energy intake as protein. There are many variants such as the Zone diet (Gardner et al, 2007) and the CSIRO diet (Wyld, Harrison & Noakes, 2010).

• In general, protein as a percentage of energy is doubled from 15% to 30%. Note, this does not mean that absolute protein intake (g) is doubled, as energy intake is reduced, with only a ~20% increase in the actual amount (g) of protein.
How much protein?

• It is still not clear exactly the amount (g or %), type of protein (vegetable, diary or animal) that is required to promote satiety required to induce or maximise protein induced satiety or whether there is a relationship with the energy density of the diet.

• The guidelines from the US Institute of Medicine allow for the inclusion of higher amounts of protein than previously recommended in a healthy diet (Trumbo et al, 2002). Thus, the acceptable protein distribution was set to 5-20% of calories for children aged 1-3yr, 10-30% for children aged 3-18yr and 10-35% for adults.

• There is no general consensus as to what a ‘high’ protein diet is: the food industry use the term ‘protein-enriched’ for 20% protein from calories (Westerterp-Plantenga, 2007). Often 30% used in weight loss diets.
Weight loss is greater on high-protein, low carbohydrate diets

<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Low-fat</th>
<th>High-protein</th>
<th>Difference (kg)</th>
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<tr>
<td>Samaha (2003)</td>
<td>132</td>
<td>-1.9</td>
<td>-5.8</td>
<td>3.9</td>
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<tr>
<td>Brehm (2003)</td>
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<td>-3.9</td>
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<tr>
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<td>-5.3</td>
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<tr>
<td>Yancy (2004)</td>
<td>120</td>
<td>-6.5</td>
<td>-12.0</td>
<td>5.5</td>
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- Up to 6 months benefit (Skov et al, 1999); at 12 months the difference is less clear (Due et al, 2004).
High protein weight loss diets and body composition

• In weight loss studies, free-living subjects feeding *ad libitum* from high protein diets show a weight loss of around ~1kg a week (Johnstone et al, 2008 and 2011) which is consistent with current dietary advice on rate of weight loss from health professionals (e.g. British Dietetic Association, www.bda.uk.com).

• As a result of the weight loss, there are significant improvements in body composition, blood pressure, and bio-markers of health.

• The reduction in body fat mass (kg) and maintenance of lean mass (kg) during weight loss has been reported previously by other authors and, in part, is related to the protein enriched composition of the diet (Wycherley et al, 2010).

• In a recent meta regression, Krieger et al, (2006) examined 87 short term studies and found that protein intakes of >1.05 g/kg of actual (rather than desirable body weight) were associated with 0.6 kg better retention of lean mass, and in studies greater than 12 weeks in duration, this increased to 1.2 kg. In studies that used a carbohydrate intake of less than 35–41% there was a 2 kg greater loss of fat mass, and this was accompanied by a 0.7 kg greater loss of lean mass. In studies of 12 weeks or more this increased to 5.6 kg and 1.7 kg, respectively.

In general, it is accepted that a reduced carbohydrate, high protein diet is associated with better fat loss and relatively less lean mass loss.
A dose dependent satiating effect of protein has been shown, with quite a range of concentrations of protein offered acutely, in a single meal, to subjects who are in energy balance and weight stable.

Persistent protein-induced satiety has been shown when a high protein diet is given for 24 h up to several days.

Role of type, amount (g or %) and interactions with energy density not defined.

Low carbohydrate or high protein?

Circa 2004

- Mechanism of appetite control – eat what you want and lose weight?

- Nutritionist question the effect on health – high fat diet!

- Role of low carbohydrate (ketosis) – do you need the very low carb intake?
What are ketogenic diets?

• Ketogenic diets are characterized by a reduction in carbohydrates (usually to less than 50 g/day) and a relative increase in the proportions of protein and fat in the diet (Cahill 1960s).

• Insulin activates key enzymes which store energy derived from CHO, and when there is an absence or scarcity of dietary CHO, the resulting reduced insulin level leads to a reduction in lipogenesis and fat accumulation.

• After a few days of fasting, glucose reserves become insufficient both for normal fat oxidation via the supply of oxaloacetate in the Krebs cycle and for the supply of glucose to the central nervous system (CNS).

• After 3–4 days without carbohydrate consumption the CNS is ‘forced’ to find alternative energy sources – ketone bodies (KBs), that is, acetoacetate, β-hydroxybutyric acid and acetone—a process called ketogenesis and which occurs principally in the mitochondrial matrix in the liver.

• Under normal conditions, the concentration of KBs is very low (<0.3 mmol/l) compared with glucose (~4 mmol), and as glucose and KBs have a similar kM for glucose transport to the brain the KBs begin to be utilized as an energy source by the CNS when they reach a concentration of about 4 mmol/l.

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?
• 17 obese but healthy men, studied for 2 x 4 week period

• All meals the same composition and energy density: provided ad libitum
• Weight loss is significantly more on the high-protein, low-carb diet \( (p=0.006) \)

Protein and appetite control for weight loss

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

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

Protein and appetite control for weight loss

- Weight loss is significantly more on the high-protein, low-carb diet \((p=0.006)\)

- Hunger is significantly less on the high-protein, low-carb diet \((p=0.020)\)

- Ad libitum intake is significantly less on the high-protein, low-carb diet \((p=0.020)\)

Relationship between carbohydrate intake and butyrate concentration in faeces

CIRCLE maintenance diet;  
\( \times \) moderate CHO diet;  
SQUARE low CHO diet

Correlation 0.76 (\( P<0.001 \), REML) Duncan et al. (2007) AEM
Conclusions

- Low carbohydrate intakes give lower faecal butyrate concentrations: negative long term impact on colonic health. Inappropriate long-term use of low CHO diets may compromise gut health.

- Linked to reduced population densities of Roseburia and E. rectale bacteria. Driven by low specific substrate or higher colon pH?

- High protein-low carb diets as a weight loss tool rather than a ‘diet for life’.

- There is no one dietary approach that will fix this complex problem, but high-protein diets seem to provide a tool to promote weight loss, in healthy subjects, at least.

- Recommend HP-MC diets as a weight loss tool: the benefits of weight loss need to be weighed against the consequences of excess adiposity on health.
Risks of HP-LC diets

- Both the safety and efficacy (St Jeor et al, 2001) of high-protein weight loss diets have been questioned, particularly in combination with low-carbohydrate advice (Astrup, 2005).
- This has been recently reviewed (Johnstone, 2012) with growing evidence to support the use of high-protein, moderate-carbohydrate diets as a dietary tool to achieve weight loss (e.g. 30% protein, 30% fat and 40% carbohydrate).

Bone health including osteoporosis
Renal function
CVD risk factors including lipaemia
Gut health
Antioxidant status
Dieting and stress and cognitive function

- Possible kidney damage due to high levels of nitrogen excretion during protein metabolism, which can cause an increase in glomerular pressure and hyperfiltration.
  
  *Meta-analyses and human studies, propose that even high levels of protein in the diet do not damage renal function. In subjects with intact renal function, higher dietary protein levels caused some functional and morphological adaptations without negative effects. There may actually be renal-related effects, but on blood pressure rather than morphological damage.*
Weight loss: type of protein

- Hunger (p=0.569)
- Fullness (p=0.404)
- Desire to eat (p=0.356)

2.41 and 2.27 kg on vegetarian and meat diets, respectively (p=0.356, SED 3.7)
Results: Gut hormones

- Measured PYY, GLP-1 and ghrelin plasma concentration for 5 hours after a standard breakfast test meal (by ELISA): ANOVA & AUC analysis.
  - GLP-1, no significant diet effect
  - PYY, $p<0.001$ for comparison of 3 diets, $p<0.001$ for comparison of WL diets
  - Ghrelin, $p=0.014$ for comparison of 3 diets, $p<0.001$ for comparison of WL diets

SOYA meal; meat meal; maintenance diet
Mechanisms of Protein Induced Satiety

The physiological processes of appetite control of protein-rich diets during negative energy balance is not clearly understood. Possible mechanisms include:

- Protein slows the rate of passage through the small intestine, which gives a physical sense of ‘fullness’.
- Protein stimulates the release of gut hormones (e.g. peptide YY), which promote the feeling of fullness or reduces feeling of hunger.
- Role of the liver in metabolite production from amino acids, which can be linked via the vagal nerve, to the brain’s sense of hunger.
- Direct action of amino acids in the brain, entering via across the blood brain barrier.

Various combinations of the above mechanisms will operate under contrasting conditions (and possibly expressed in different people). Work will focus on both type and amount of protein as an aid to curb hunger during weight loss. We will focus on interactions between the gut-brain axis and interactions with hedonic control of eating.

The physiological processes of appetite control of protein-rich diets during negative energy balance is not clearly understood. Possible mechanisms:-

- Protein slows the rate of passage through the small intestine, physical sense of ‘fullness’
  - Physical structure (solid vs liquid), energy density, volume and protein type-content on ad libitum food intake
- Protein stimulates the release of gut hormones (e.g. peptide YY), which promote the feeling of fullness or reduces feeling of hunger
  - Different feeding routes, including intravenous feeding and/or nasogastric feeding can help elucidate the potential feedback from the stomach and brain; measuring gut hormones; how much protein?
- Role of the liver in metabolite production from amino acids, which can be linked via the vagal nerve, to the brain’s sense of hunger
  - Measurement and manipulation of plasma amino acid profile will help understand the role of these within the context of circulating metabolite interactions. Thus, is rate of delivery of amino acids important?
- Direct action of amino acids in the brain, entering via across the blood brain barrier
  - Use of brain imaging tools to assess nutrient profile on motivation to eat. Assessing brain responses to feeding will further elucidate the role of physiology and learning

Weight regain was 0.93 kg less for participants on a high protein diet than for those on a low protein diet.

Fewer participants in the high-protein, low-GI groups dropped out of the project than in the low protein, (~26% vs. ~37%)
Weight maintenance after weight loss with high protein diets

• Lejeune et al, (2005) report a 20% increase in protein intake (through an unmatched supplement) during weight maintenance after a 4 week weight loss period reduced weight regain by 50% over the subsequent 3 months. After 6 months on a weight maintenance diet, there was a weight ‘regain’ of 0.8 kg (high protein group) vs. 3.0 kg (control group) (p < 0.05) and during follow-up of 1 year after the weight loss program, these figures were 1.0 kg vs. 3.9 kg (p < 0.05).

• Claessens et al, (2009) report a similar effect using a matched casein supplement over 12 weeks of weight maintenance, which amounted to a differential of 2.2 kg of fat.

• Layman et al, (2008) found that a weight loss diet that had double the amount of protein (1.6 g/kg vs 0.8 g/kg) led to better body composition at both 4 months and 12 months, especially in those participants who lost more than 10% of their body weight over this period.

• It is the aforementioned large-scale ‘Diogenes’ trial that provides the most convincing data on the benefits of high protein, low GI diets for longer-term weight control (Larsen et al, 2010). Specifically, weight regain was 0.93 kg less for the 773 participants on a high-protein diet than for those on a low-protein diet and 0.95 kg less in the groups on a low-GI diet compared to those on a high-GI diet.

These data provide some support the use of high-protein, moderate carbohydrate diets to achieve weight control. Thus, evidence indicates that a relatively high protein intake sustains weight maintenance by (i) favouring regain of fat free mass at the cost of fat mass at a similar physical activity level, (ii) reducing energy efficiency with respect to the body mass regained, and (iii) increasing satiety.
Meal requirements
Protein enriched (30% protein)
Moderate carbohydrates (40%)
Low fat (30%)
Vegetable - one serving per dish

The range is based on the principle that protein fills you up more than carbohydrate or fat do, and so keeps you fuller for longer. And because you feel fuller for longer, you should be able to control hunger more, reducing the temptation to snack.

• 5% weight loss over 4 weeks; total average weight loss is 4.73 kg (p<0.001)
• Weight loss over 8 weeks is sustained
Thank you,
Questions?

http://www.abdn.ac.uk/rowett/research-pages/obesity-and-metabolic-health/dr-alex-johnstone/