Review Article

The role of protein in weight management

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Several studies have shown that high protein meals and foods are more satiating than high carbohydrate or high fat meals when assessed by subjective ratings of satiety. Few of these studies were able to control for potentially confounding variables. Test meals differ widely in physical and sensory properties so it cannot be concluded that it is protein conferring these effects. When sensory properties are controlled up to 10-30% more calories are eaten at a subsequent meal with a high carbohydrate liquid meal than a high protein liquid meal with no difference in protein sources or BMI status. Weight loss studies examining the metabolic effects of isocaloric high protein energy restricted diets with high carbohydrate structured diets have not shown differences in kilojoule intake and weight loss despite expected satiety differences. Such studies do not allow the effects of increased satiety attributable to protein to be expressed as the dietary protocols have required all foods to be consumed. However, several longer term studies have noted improvements in body composition on a higher protein pattern despite similar weight loss. An interaction between protein intake and exercise on improved lean mass retention has also been observed. Studies comparing ad libitun high protein diets to high carbohydrate diets have usually shown greater weight loss on the high protein pattern and that enhanced satiety was the most important factor in the weight loss.

Key Words: protein, satiety, diet, weight loss

High-protein diets for weight management have only more recently been extensively scientifically studied despite long standing public interest in such dietary patterns. Such diets are thought to increase satiety,[1] facilitate weight loss,[2] improve body composition and cardiovascular risk factors.[3]

The composition of the food we eat can influence how much of it we eat on an occasion, termed "satiation" or reduce how much is eaten at the next eating occasion, termed "satiety". Much of the research that has been conducted on food composition has generally focused on "satiety" – subjectively defined as the feeling of fullness or satisfaction which follows eating. It is generally measured by questionnaire employing a visual analogue scale after a food has been consumed.[4] In addition some studies combine this approach with exposure of the participants to a buffet meal and measure *ad libitum* food consumed, which represents a more objective measure of satiety.[1]

Several studies have compared satiety after high protein or high carbohydrate or high fat meals. Typically, these studies compare satiety after different test meals in the same individual in a crossover design. In a recent review of such studies high protein meals were more satisfying with 11 of the 14 studies that compared high protein to at least one other macronutrient, found the protein preload significantly increased subjective ratings of satiety.[5] Few of these studies were able to control for potentially confounding variables. The test meals differed widely in physical and sensory properties so it cannot be concluded that it was the protein conferring these effects. Latner designed a study so that the sensory properties of the meals were exactly the same.[6] In 12 lean female students, 31% more calories were eaten at a subsequent dinner with a high carbohydrate liquid lunch (450 kcal, 99% carbohydrate from polycose) than high protein liquid (71% protein) meal or a 50% protein,50% carbohydrate lunch. The protein was a dried powder mix derived from whey. When protein is provided as a 50g dose in the form of a beverage and compared to an isocaloric, isovolumetric and palatability matched carbohydrate beverage, protein has also been shown to be more satiating than glucose. Bowen et al compared liquid preloads (1.1 MJ, 450 mL) containing 50g whey, soy, gluten, or glucose.[7] Energy intake at the buffet 3 hours after the preload was 10% lower after all protein preloads, compared with the glucose treatment ($p < 0.05$). Different protein sources behaved similarly. This study also demonstrated that the effect of protein on satiety appears independent of BMI status which is an important finding as almost all previous studies had been conducted in lean individuals.

To what extent do these short term effects of protein translate to changes in energy balance was investigated in by Fryer[8] who found 12 male students with 9 week dietary periods that feelings of hunger were lowest on the high protein diet. Skov *et al*[2] compared an *ad libitum* high protein diet to a high carbohydrate diet and found that enhanced satiety was the most important factor in the weight loss. In these studies protein was substituted for carbohydrate so it may have been the reduced carbohydrate rather than the increased protein that was important. However,

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controlled studies comparing single macronutrients would suggest that the high protein component is an important factor.[7] Weigle et al[9] measured hunger and fullness in subjects with mean BMI of 26 kg/m^2 on a high protein (30% energy) and lower protein (15% energy) diets with carbohydrate constant at 50% energy for 2 wks each. When allowed to be consumed *ad libitum* for 12 wks, satiety was increased with the isocaloric high-protein diet which was associated with an energy reduction of 441 ± 63 kcal/d, body weight decreased by 4.9 ± 0.5 kg, and fat mass decreased by 3.7 ± 0.4 kg. The authors suggested that the "anorexic" effect of protein may relate to the superior weight loss noted on low-carbohydrate diets. However, whether the normal protein diet eaten *ad libitum* would have resulted in similar changes could not be tested in this study design.

Several weight loss studies designed to examine the metabolic effects of isocaloric high protein energy restricted diets with high carbohydrate or high fat structured diets have not shown differences in kilojoule intake and weight loss despite expected satiety differences.[3;10-12] Such studies do not allow the effects of increased satiety attributable to protein to be expressed as the dietary protocols have required all foods to be consumed. However, several such studies have noted improvements in body composition despite similar weight loss of approximately 8.5%. The use of structured meal plans such as those employed in these studies appear to achieve almost a 2 fold greater weight losses in the short and longer term compared to *ad libitum* approaches. However this has not formally been tested in a randomised controlled trial. Studies of those who report long term success in weight loss report following a consistent eating pattern as a common characteristic.[13]

McMillan-Price *et al*[14] compared 2 high carbohydrate (diets 1,2) and 2 high protein diets (diets 3,4) consumed *ad libitum* for 12 wks with high (diets 1,3) and low GI (diets 2,4) comparisons. While all groups lost a similar mean +/- SE percentage of weight (diet 1, -4.2% +/- 0.6%; diet 2, -5.5% +/- 0.5%; diet 3, -6.2% +/- 0.4%; and diet 4, -4.8% +/- 0.7%; $p = 0.09$), the proportion of subjects in each group who lost 5% or more of body weight varied significantly by diet (diet 1, 31%; diet 2, 56%; diet 3, 66%; and diet 4, 33%; $p = 0.01$) suggesting that protein alone in unstructured ad libitum diets may not have clear cut benefits and that other dietary components may be important. On the other hand, high protein diets where carbohydrate is more severely restricted as in the Atkins diet have been shown to be more effective in weight loss after 1 year.[15] This observation could be due to the protein/carbohydrate ratio or a consequence of the restricted range of foods allowed on such a pattern as well as the simplicity of the approach could also be responsible.

Variety may stimulate food intake by delaying satiation and extending eating and food consumed by as much as 40%[16] Lower dietary variety within food groups has been shown to be associated with greater weight loss maintenance.[17] This is yet one more variable that needs to be considered when making conclusions about the mechanisms relating to satiety and satiation effects of dietary patterns and meals. One might speculate that the level of variety in high protein foods may be substantially lower than from high carbohydrate food sources although this scenario could change if a large variety of protein enriched foods are introduced into the food supply.

As kilojoule intake declines, either to achieve weight loss or where energy needs are lower as in older or sedentary individuals, fewer foods will need to provide more nutrients. To provide adequate nutrient intakes in these circumstances necessitates selection of foods that are naturally nutrient rich for the kilojoules they provide. The categorisation of foods that are naturally nutrient rich has recently been reviewed by Drewnowski.[18] The naturally nutrient rich score (NNR) is a nutrients-to-calories ratio. The initial version of the NNR Index was based on 14 nutrients: protein, calcium, iron, vitamin A, vitamin C, thiamine, riboflavin, vitamin B-12, folate, vitamin D, vitamin E, monounsaturated fat, potassium, and zinc with a more recent version adding fiber and pantothenic acid. NNR is the sum of the individual nutrients provided relative to the percent of daily nutrients provided by 2000 calories. Foods with more nutrients, higher nutrient concentrations and fewer kilojoules will have a higher score. Energy dense foods will tend to have lower NNR. For lower kilojoule diets, the choice of foods with higher NNR ensures nutritional adequacy. The NNR is based in a daily target for protein of 65g. Based on the NNR, animal protein foods provide higher scores than vegetable sources of protein such as legumes.

In conclusion, dietary protein is more satiating than carbohydrate or fat and has been shown to reduce food intake after controlled liquid preloads and meals and diets. This has been shown to be relevant to short term and long term weight loss. Higher protein dietary patterns that are low in saturated fat may be considered as a legitimate option for weight management.

AUTHOR DISCLOSURES

Manny Noakes, no conflicts of interest.

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