

# Atkins and other low-carbohydrate diets: hoax or an effective tool for weight loss?

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**Context** The Atkins diet books have sold more than 45 million copies over 40 years, and in the obesity epidemic this diet and accompanying Atkins food products are popular. The diet claims to be effective at producing weight loss despite ad-libitum consumption of fatty meat, butter, and other high-fat dairy products, restricting only the intake of carbohydrates to under 30 g a day. Low-carbohydrate diets have been regarded as fad diets, but recent research questions this view.

**Starting point** A systematic review of low-carbohydrate diets found that the weight loss achieved is associated with the duration of the diet and restriction of energy intake, but not with restriction of carbohydrates. Two groups have reported longer-term randomised studies that compared instruction in the low-carbohydrate diet with a low-fat calorie-reduced diet in obese patients (*N Engl J Med* 2003; 348: 2082–90; *Ann Intern Med* 2004; 140: 778–85). Both trials showed better weight loss on the low-carbohydrate diet after 6 months, but no difference after 12 months.

**Where next?** The apparent paradox that ad-libitum intake of high-fat foods produces weight loss might be due to severe restriction of carbohydrate depleting glycogen stores, leading to excretion of bound water, the ketogenic nature of the diet being appetite suppressing, the high protein-content being highly satiating and reducing spontaneous food intake, or limited food choices leading to decreased energy intake. Long-term studies are needed to measure changes in nutritional status and body composition during the low-carbohydrate diet, and to assess fasting and postprandial cardiovascular risk factors and adverse effects. Without that information, low-carbohydrate diets cannot be recommended.

The global rise in overweight and obesity has intensified the search for an effective weight-loss diet. The obesity epidemic persists despite a substantial decrease in fat intake, and a compensatory increase in the intake of carbohydrate, particularly as processed starchy foods and sugar, has been blamed.<sup>1</sup> Low-carbohydrate diets have been popular since the 1860s,<sup>2</sup> when William Banting claimed he lost 21 kg without feeling hunger. Many low-carbohydrate-diet books have followed, the most successful to date being *Dr. Atkins' New Diet Revolution*,<sup>3</sup> in which the eating plan describes not simply a diet but rather a "lifetime nutritional philosophy", with vitamin and mineral supplementation and regular exercise. The Atkins diet appealed immediately to many because, with the recommended restricted intake of carbohydrate to initially less than 20 g a day, mainly as salad greens and other non-starchy vegetables,<sup>4</sup> the unlimited intake of protein and accompanying fat paradoxically seems to promote weight loss. Whereas the Atkins diet permits no more than 5–10% of calorie intake from carbohydrate, Willett's new food-pyramid (with which the Atkins diet is often confused) allows 40–45 % of calorie intake from whole-grain foods, fruit, and vegetables (figure).<sup>5–7</sup> The benefits of the Atkins diet, which has been embraced by an estimated 20 million people worldwide, are claimed to be weight loss, maintenance of weight loss without hunger, good health, and disease prevention. It sounds ideal, but what is the scientific evidence to support these claims?

## Weight loss on low-carbohydrate diets

Several studies claim that low-carbohydrate diets are effective for weight loss. A systematic review of low-carbohydrate diets reported that the weight loss is associ-

ated with only the duration of the diet and the restriction of energy intake, not with carbohydrate restriction itself.<sup>8</sup> Only 107 articles out of the 2609 identified could be reviewed; only five studies evaluated participants for more than 90 days, but were not randomised and had no control group. There was insufficient evidence to make recommendations for or against these types of diets.<sup>8</sup>

In 2003, three randomised trials reported the longer-term effect of low-carbohydrate diets. In the first study, 132 severely obese individuals (39% had type 2 diabetes, and 43% had metabolic syndrome) were randomised to either an ad-libitum low-carbohydrate diet or an energy-restricted low-fat diet for 6 months.<sup>9</sup> Those on the low-carbohydrate diet had lost 3.9 kg more weight after 6 months (95% CI 1.6 to 6.3 kg), but at 12 months the difference was no longer significant (1.9 kg, –1.0 to 4.9 kg).<sup>11</sup> In another 6-month study, 53 obese women were again randomised to comparative diets,<sup>12</sup> and the low-carbohydrate group again lost more weight (8.5 kg [SD 1.0] vs 3.9 [1.0] kg after 6 months,  $p < 0.001$ ).

The third study over 12 months randomised 63 non-diabetic participants to the Atkins diet or an energy-restricted diet with an energy content of 25% fat, 15% protein, and 60% carbohydrate.<sup>12</sup> After 6 months the low-carbohydrate group did better, with a weight loss of 7.0% (SD 6.5) versus 3.2% (5.6,  $p = 0.02$ ), but after 12 months the difference between the groups was again no longer significant (4.4% [6.7] vs 2.5% [6.3]).

Although these studies provide evidence that a low-carbohydrate diet does produce increased weight loss over 3–6 months and might be superior to the recommended calorie-reduced low-fat diet, the 12-month studies also indicate that the low-carbohydrate diet may be no better in

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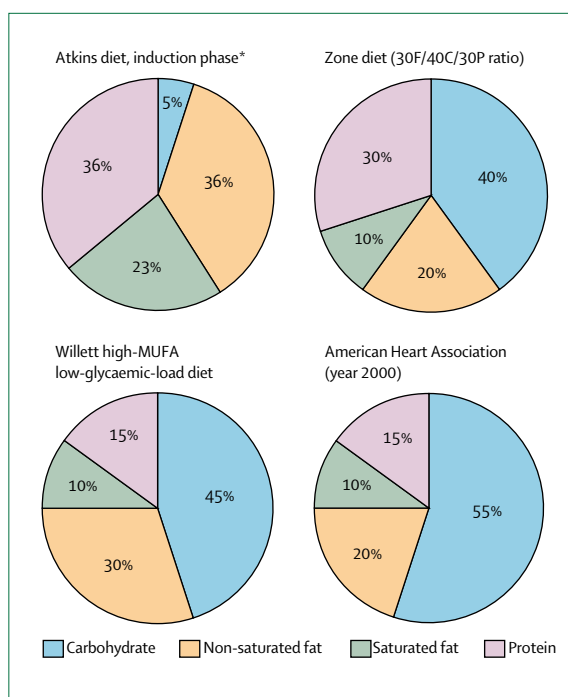


**Figure:** Dietary composition of Atkins diet compared with other popular diets and recommended diet from American Heart Association

\*Atkins diet induction phase is followed by ongoing and maintenance phases which allow up to 19% of energy from carbohydrate. Circles show proportion of total energy intake from each macronutrient. Non-saturated=total fat (ie, triglycerides) minus saturated fatty acids. In zone diet, F=fats, C=carbohydrate, P=protein. MUFA=mono-unsaturated fatty acids.

the longer term. The studies also had important limitations. Adherence to the diets was low, and dropout rates were high. Furthermore the low-fat diet used by Sahama et al<sup>9</sup> provided 33% of total calorie intake as fat, which is more than the 20–30% energy intake normally indicative of a low-fat diet. In addition, dietary compliance was not assessed by Foster et al.<sup>12</sup> The three studies are important, but are not evidence that low-carbohydrate diets in the long term are superior to the energy-restricted low-fat diet.

### Putative mechanisms behind the weight loss

During severe carbohydrate restriction, glycogen stores and associated bound water are depleted, hence weight loss could predominantly be fluid rather than fat loss. Two studies that measured body composition by dual-energy X-ray absorptiometry both failed, however, to find any indication of excessive reduction in lean body-mass.<sup>11,13</sup> So, the greater weight loss over 6 months seems to be attributable to fat loss, which is supported by beneficial changes in cardiovascular risk factors.

The depletion of glycogen stores produces ketotic acidosis similar to that seen during fasting, but the loss of energy via urinary excretion of ketones cannot account for more than a few kJ a day. Circulating ketones might also be appetite-suppressing, mimicking the anorexia of starvation. However, no association

between urinary ketones and weight loss was seen in one study,<sup>12</sup> and the low-carbohydrate group in another trial continued to lose weight for up to 6 months after plasma levels of  $\beta$ -hydroxybutyrate had returned to control values.<sup>11</sup>

According to Atkins' book, weight is lost on the ad-libitum diet because of increased energy expenditure.<sup>3</sup> However, although no studies have measured daily energy expenditure with this diet, there is no evidence that the high-fat high-protein diet is particularly thermogenic. Fat has a low thermogenic effect, and although a high-protein diet might increase 24-h energy expenditure by 2–3%,<sup>14</sup> such an effect cannot account for more than a small fraction of the observed weight loss.

The success of the low-carbohydrate diet might be due to the restriction of the variety of food choices—the monotony and simplicity of the diet could inhibit appetite and food intake. Also, protein induces a stronger satiating effect than fat and carbohydrate,<sup>15</sup> which would decrease ad-libitum food intake and bodyweight.<sup>16</sup> Weight loss on the low-carbohydrate diet is probably caused by a combination of restriction of food choices and the enhanced satiety produced by the high protein-content. This hypothesis remains to be confirmed. Also, a high-protein diet is not necessarily a high-fat diet.<sup>16</sup>

### Safety of low-carbohydrate diets

Somewhat surprisingly, greater improvements in some cardiovascular risk factors were seen in people on the low-carbohydrate diet. Triglyceride concentrations were significantly more reduced,<sup>9,12</sup> HDL-cholesterol improved more,<sup>11,12</sup> and indices of fasting insulin-sensitivity were greater,<sup>8,11</sup> although improvements in other blood lipids and blood pressure were the same for both diets. These findings agree with other studies, which have also shown improvements in LDL-cholesterol particle size and in postprandial blood-lipid profile.<sup>17</sup> Because even minor weight loss markedly improves lipid profile and glucose tolerance, these improvements can be attributed to the greater weight loss on the low-carbohydrate-diets. What happens to the risk factors when weight loss has declined? No weight-loss studies have been of sufficient duration to study this, but studies in epileptic children on a low-carbohydrate diet for seizure control showed an adverse effect on blood lipids that persisted over 2 years,<sup>18</sup> and ketosis might also pose a risk of cardiac arrhythmias.<sup>19</sup>

The most frequent complaints with low-carbohydrate diets are constipation and headache,<sup>20–22</sup> which is readily explained by the reduced intake of fruit, vegetables, and whole-grain bread and cereals. Restricted intake of these foods is not commensurate with long-term nutritional adequacy, and might pose a second-line increased risk of cardiovascular disease and cancer. Also, halitosis, muscle cramps, diarrhoea, general weakness, and rashes are more often reported on low-carbohydrate than on low-fat diets.<sup>22</sup>

## Future research

The mechanisms responsible for producing weight loss with the low-carbohydrate diet require clarification. Is increased 24-h energy expenditure responsible for the weight loss as claimed by Atkins? If weight loss is rather due to reduction in spontaneous energy intake, can it be achieved by increasing the protein in a low-fat diet?

Although there is no solid evidence to support advising against the short-term use of low-carbohydrate diets, as long as the individual loses weight, future research that assesses a broader spectrum of risk factors of thrombo-atherosclerotic disease might eventually warn against such diets. The macronutrient composition is also only one dimension of the diet, and the diet might have different contents of fibre and micronutrients within the same fat, protein, and carbohydrate content. Future studies should focus more on the foods making up the diets, and report more markers of nutritional status.

There is an urgent need for longer and larger studies in obese and moderately overweight individuals to assess weight-loss efficacy, with careful assessment of energy balance and body composition, cardiovascular and diabetes risk factors, constipation, markers of kidney and bone health, nutritional adequacy, dietary compliance, and quality of life. We do not know if moderately overweight people will get the same improvements in triglyceride and HDL levels as the obese participants in studies, or if low or high levels of physical activity will modify the effects. The studies should be sufficiently long (up to 2 years) to enable careful monitoring of cardiovascular risk factors during the weight-stability phase, and should also include obese individuals with impaired glucose-tolerance to examine the potential of low-carbohydrate diets to prevent type 2 diabetes.

## Recommendations to the public and patients

There is no clear evidence that Atkins-style diets are better than any others for helping people stay slim, and despite the popularity and apparent success of the Atkins diet, evidence in support of its use lags behind. Although the diet appears, as claimed, to promote weight loss without hunger, at least in the short term, the long-term effects on health and disease prevention are unknown.

Patients who want to try these diets should be told that, although safety cannot be guaranteed, they seem to be safe for short-term use (up to 6 months) as long as weight loss occurs. Scientifically, the most solid current recommendation for people who want to lose weight and keep weight off is a permanent switch to a diet reduced in calories and fat in combination with physical activity, which will also reduce the incidence of type 2 diabetes and re-infarction among high risk individuals.<sup>23,24</sup>

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## References

- Daniels SR. Abnormal weight gain and weight management: are carbohydrates the enemy? *J Pediatr* 2003; **142**: 225–27.
- Banting W. Letter of corpulence, 4th edn. London: Harisson, 1869.
- Atkins RC. Dr. Atkins' new diet revolution. New York: Simon & Schuster, 1998.
- Atkins Nutritionals, Inc. Introducing Atkins at home. Aug 5, 2004: <http://atkins.com/Archive/2001/12/15-325810.html> (accessed Aug 5, 2004).
- Freedman MR, King J, Kennedy E. Popular diets: a scientific review. *Obes Res* 2001; **9**: 1S-40S.
- Sears B. The zone. New York: Harper Collins, 1995.
- Krauss RM, Eckel RH, Howard B, et al. AHA dietary guidelines: revision 2000. A statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *Circulation* 2000; **102**: 2284–99.
- Bravata DM, Sanders L, Huang J, et al. Efficacy and safety of low-carbohydrate diets. *JAMA* 2003; **289**: 1837–50.
- Samaha FF, Iqbal N, Seshadri P, et al. A low-carbohydrate as compared with a low-fat diet in severe obesity. *N Engl J Med* 2003; **348**: 2074–81.
- Stern L, Iqbal N, Seshadri P, et al. The effects of low-carbohydrate versus conventional weight loss diets in severely obese adults: one-year follow-up of a randomized trial. *Ann Intern Med* 2004; **140**: 778–85.
- Brehm BJ, Seeley RJ, Daniels SR, D'Alessio DA. A randomized trial comparing a very low carbohydrate diet and a calorie-restricted low fat diet on body weight and cardiovascular risk factors in healthy women. *J Clin Endocrinol Metab* 2003; **88**: 1617–23.
- Foster GD, Wyatt HR, Hill JO, et al. A randomized trial of a low-carbohydrate diet for obesity. *N Engl J Med* 2003; **348**: 2082–90.
- Willi SM, Oexmann MJ, Wright NM, Collop NA, Key LL Jr. The effects of a high-protein, low-fat, ketogenic diet on adolescents with morbid obesity: body composition, blood chemistries, and sleep abnormalities. *Pediatrics* 1998; **101**: 61–67.
- Mikkelsen PB, Toubro S, Astrup A. The effect of fat-reduced diets on 24-h energy expenditure: comparisons between animal protein, vegetable protein, and carbohydrate. *Am J Clin Nutr* 2000; **72**: 1135–41.
- Porrini M, Santangelo A, Crovetti R, Riso P, Testolin G, Blundell JE. Weight, protein, fat, and timing of preloads affect food intake. *Physiol Behav* 1997; **62**: 563–70.
- Skov AR, Toubro S, Rønn B, Holm L, Astrup A. Randomized trial on protein versus carbohydrate in ad libitum fat reduced diet for the treatment of obesity. *Int J Obes* 1999; **23**: 528–36.
- Sharman MJ, Gómez AL, Kraemer WJ, Volek JS. Very low-carbohydrate and low-fat diets affect fasting lipids and postprandial lipemia differently in overweight men. *J Nutr* 2004; **134**: 880–85.
- Kwiterovich PO, Vining EPG, Pyzik P, Skolasky R, Freeman JM. Effect of a high-fat ketogenic diet on plasma levels of lipids, lipoproteins, and apolipoproteins in children. *JAMA* 2003; **290**: 912–20.
- Best TH, Franz DN, Gilbert DL, Nelson DP, Epstein MR. Cardiac complications in pediatric patients on the ketogenic diet. *Neurology* 2000; **54**: 2328–30.
- Sondike SB, Copperman N, Jacobson MS. Effects of a low-carbohydrate diet on weight loss and cardiovascular risk factors in overweight adolescents. *J Pediatr* 2003; **142**: 253–58.
- Westman EC, Yancy WS, Edman JS, Tomlin KF, Perkins CE. Effect of 6-month adherence to a very low carbohydrate program. *Am J Med* 2002; **113**: 30–36.
- Yancy WS, Olsen MK, Guyton JR, Bakst RP, Westman EC. A low-carbohydrate, ketogenic diet versus a low-fat diet to treat obesity and hyperlipidemia. *Ann Intern Med* 2004; **140**: 769–77.
- Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002; **346**: 393–403.
- Singh RB, Dubnov G, Niaz MA, et al. Effect of an Indo-Mediterranean diet on progression of coronary artery disease in high risk patients (Indo-Mediterranean Diet Heart Study): a randomised single-blind trial. *Lancet* 2002; **360**: 1455–61.

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