This article is a primer on low-carbohydrate diets: their history, how they have measured up in clinical trials, and how to work with them today.

For more than a century, low-carbohydrate diets have cycled in and out of fashion, each time returning with the promise of quick and easy weight loss. After the past 3 years of low-carbohydrate mania, it looks like the popularity of these diets is beginning to wane again. The descent has been rapid: The percentage of Americans following these diets dropped by 50% from January 2004 to September 2004. In October 2004, sales of The South Beach Diet slowed to less than one third of its volume in early March, which, according to some experts, was the peak of the most recent low-carbohydrate diet craze (Reuters Limited. Low carb sales slow as Americans craze cools increasingly consumers abandoning protein-heavy diets. Available at: http://www.msnbc.msn.com/id/6391728/. Accessed December 2004).

Despite the dramatic drop in public interest, dietitians will continue to encounter clients interested in using these diets to lose weight. Also, low-carbohydrate diets are likely to rebound in a matter of time, just as they have for the past 100 years.

This article reviews the history of low-carbohydrate diets, their safety, efficacy, and how dietitians can use them as the starting point of a long-term healthy weight-loss plan for clients who might otherwise try them on their own with little chance for long-term success and potential for physical harm. Nutr Today. 2006;41(3):99-105

Low-carbohydrate diets have been around for over a century; the names have changed more than the routine.

It was almost 100 years later, in the 1950s, that the low-carbohydrate diet gained new momentum. Dr Alfred W. Pennington had studied overweight employees at
E.I. duPont de Nemours and Co and prescribed a diet by which he said they would “eat fat and get thin.” Pennington’s theory, popularly known as the duPont diet, proposed that people gain weight when their bodies break down carbohydrates incompletely. His solution was to severely restrict the amount of carbohydrates that dieters ate.2

The next major commercial success came a decade later when another physician, Herman Taller, published Calories Don’t Count. Taller’s own doctor had advised him to supplement his diet with polyunsaturated oils in an effort to lower his cholesterol. Taller purportedly lowered his cholesterol level and lost weight despite consuming 5,000 calories per day. Based on his experience, Taller formulated a diet plan that included 2 tablespoons of oil before each meal. Unfortunately for Taller, he took his plan one step too far when he promoted Calories Don’t Count together with safflower oil capsules of the same name. He was found guilty of mail fraud and in violation of Federal drug laws. Government prosecutors called the sales tie-in a “worthless scheme foisted on a gullible public.”2

Then, approximately 10 years later, in 1972, cardiologist Robert Atkins published a book that may well be the most famous and most enduring low-carbohydrate diet plan: Dr. Atkins Diet Revolution. Influenced by Pennington and Taller, Atkins promoted a high-fat, low-carbohydrate diet that he supposedly followed to lose 28 lb. Before it was published, Atkins’ diet appeared in popular magazines such as Harper’s Bazaar and Vogue.

Later in that decade, in 1979, Dr Herman Tarnower wrote the best-selling Complete Scarsdale Medical Diet. This low-carbohydrate, low-energy diet was supposed to be followed for no more than 7 to 14 days.3

Twenty years later, Dr Atkins revised his book and published it as Dr. Atkins New Diet Revolution. By following the 4-phase diet plan described as a “lifetime nutritional philosophy,” he claimed that dieters would shed weight, improve their health, and prevent disease. The plan restricted carbohydrate consumption and permitted unlimited consumption of protein and fat. Since the 1970s, the Atkins books have sold more than 45 million copies.4 Today, 11 Atkins books can be purchased on the Atkins Web site.5

A string of low-carbohydrate diet books followed Dr. Atkins New Diet Revolution. In 1995, Dr Barry Sears published The Zone. He said that he wrote it to alert cardiologists to the potential of using food to treat heart disease and type 2 diabetes. According to Sears, the diet kept insulin levels within a specific range through carbohydrate restriction. Like Atkins, Sears published many follow-up books to his original best seller.6 One year later, in Protein Power, Drs Michael R. and Mary Dan Eades asserted that a carbohydrate-based diet is responsible for obesity and heart disease.7 Most recently, Dr Arthur Agatston, a cardiologist, published The South Beach Diet in April 2003. Although he denies that it is a low-carbohydrate diet, it restricts and then reintroduces carbohydrates in a 3-phase plan.8

What is new this time around is that low-carbohydrate mania has led the food industry to produce many low-carbohydrate products.

What is unique about the current surge in the popularity of low-carbohydrate diets is the enormous response of the food industry in producing low-carbohydrate products. More than 3,500 of these products, including new flavors and varieties of existing foods, were introduced in the past 2 years.9 Consumers can purchase low-carbohydrate versions of items such as chips, salad dressing, and ice cream (Table 1). Although lower in carbohydrates, these products are not necessarily more nutritious than their “regular” versions. In fact, some of them are actually higher in energy, fat, and sodium.

It is ironic that while food producers are developing and promoting new low-carbohydrate products, the Food and Drug Administration still has not defined any terms to describe the amount of carbohydrate in food. Although the Food and Drug Administration has received petitions asking it to define terms that characterize the level of carbohydrate in food, including “low carbohydrate,” “reduced carbohydrate,” and “carbohydrate-free,” the guidance, which would ensure that claims are not false or misleading, will likely come after the peak demand for these products has passed.

Safety and Efficacy of Low-Carbohydrate Diets

Despite the popularity of low-carbohydrate diets and widespread concern on potentially detrimental effects on cardiovascular risk, it is only very recently that such diets have been systematically studied to evaluate their safety and effectiveness. For one thing, it is extremely difficult to conduct studies of weight-loss diets. Adherence levels are difficult to measure and dropout rates are typically high. Until recently, there has been little or no funding to evaluate the effectiveness of commercial weight-loss diets.
Given the intense interest in the possible benefits of low-carbohydrate diets in recent years, it is worth reviewing the findings of the 5 randomized clinical trials published from 2003 to 2004. These trials compared the short-term effects of low-carbohydrate diets with conventional low-fat diets (Table 2).

The first of these, published in April 2003,\textsuperscript{10} included 53 healthy, obese women randomized to 6 months of either an ad libitum very-low-carbohydrate diet or an energy-restricted diet with 30% of the energy as fat. Brehm and colleagues found that the very-low-carbohydrate group lost significantly more weight and more body fat than did the low-fat-diet group. There were no significant differences between the groups in blood pressure, lipid, fasting glucose, and insulin levels. The authors concluded that a very low carbohydrate diet is more effective than a low-fat diet for short-term weight loss and is not associated with negative effects on cardiovascular risk factors in healthy women.\textsuperscript{10}

One month later, 2 studies were published in the same issue of the \textit{New England Journal of Medicine}. Foster and colleagues conducted a 1-year, multicenter, controlled trial with 63 obese men and women randomized to either a low-carbohydrate, high-protein, high-fat diet or a low-energy, high-carbohydrate, low-fat diet.\textsuperscript{11} These researchers found that the low-carbohydrate diet in this study produced greater weight loss than did the conventional diet for the first 6 months. At the end of 1 year, however, weight-loss differences between the groups were not statistically significant. They found greater improvement in some risk factors for coronary heart disease, such as high-density lipoprotein cholesterol (HDL-C) and triglyceride levels, but not in others, such as blood pressure, insulin sensitivity, and serum low-density lipoprotein cholesterol. These researchers suggested that the clinical significance of the improvements in the context of a high-fat diet was unclear and that additional research is needed to determine whether the beneficial effects of a carbohydrate-restricted diet outweigh its potential adverse effects on the risk of coronary heart disease in obese persons.

One year later, Stern and colleagues\textsuperscript{13} reported the 1-year results of the Samaha study’s subjects. Differences in weight loss between the study groups

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**Table 1. Comparison of Regular, Low-Carbohydrate, and Low-Fat Products**

<table>
<thead>
<tr>
<th></th>
<th>Regular</th>
<th>Edge (Low Carb)</th>
<th>Light (Low Fat)</th>
<th>Baked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (1 oz)</td>
<td>140</td>
<td>150</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>Total fat</td>
<td>7</td>
<td>9</td>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sodium</td>
<td>200</td>
<td>240</td>
<td>240</td>
<td>220</td>
</tr>
<tr>
<td>Total carb</td>
<td>17</td>
<td>9</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sugar</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Protein</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Regular</th>
<th>Carb Options</th>
<th>Low Fat</th>
<th>Fat-Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (2 tbsp)</td>
<td>160</td>
<td>150</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Total fat</td>
<td>17</td>
<td>16</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sodium</td>
<td>200</td>
<td>200</td>
<td>290</td>
<td>280</td>
</tr>
<tr>
<td>Total carb</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Sugar</td>
<td>&lt;1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Protein</td>
<td>&lt;1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Regular</th>
<th>Carb Smart</th>
<th>98%Fat-Free*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (1/2 cup)</td>
<td>150</td>
<td>130</td>
<td>90</td>
</tr>
<tr>
<td>Total fat</td>
<td>8</td>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>20</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Sodium</td>
<td>35</td>
<td>50</td>
<td>85</td>
</tr>
<tr>
<td>Total carb</td>
<td>17</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Sugar</td>
<td>16</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Sugar alcohol</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Protein</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Carb indicates carbohydrates.
*Chocolate brownie ice cream.

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The study by Samaha and colleagues\textsuperscript{12} included 132 severely obese men and women with a high prevalence of diabetes or metabolic syndrome randomized to either a low-carbohydrate diet or a low-fat, energy-restricted diet for 6 months. Consistent with the Brehm and Foster studies, in this study, subjects on the low-carbohydrate diet lost significantly more weight than did those on the low-fat diet. They also showed greater improvement in triglyceride levels and insulin sensitivity, even after adjusting for the amount of weight lost. The researchers cautioned, however, that the overall weight loss relative to the subjects’ severe obesity was small and that it is unknown whether the benefits of a carbohydrate-restricted diet extend beyond 6 months.

One year later, Stern and colleagues\textsuperscript{13} reported the 1-year results of the Samaha study’s subjects. Differences in weight loss between the study groups
Table 2. Comparison of Randomized, Controlled Clinical Trials Comparing Low-Carbohydrate and Conventional Low-Fat Diets

<table>
<thead>
<tr>
<th>Brehm</th>
<th>Foster</th>
<th>Samaha</th>
<th>Stern</th>
<th>Yancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects enrolled</td>
<td>53 healthy, obese women</td>
<td>63 obese men and women</td>
<td>132 severely obese men and women with a high prevalence of diabetes and the metabolic syndrome</td>
<td>132 obese men and women with a high prevalence of diabetes or the metabolic syndrome</td>
</tr>
<tr>
<td>Intervention</td>
<td>Both diet groups had biweekly meetings that addressed cooking tips, stress management, behavior modification, and relapse prevention. On alternating weeks, subjects met for individual counseling sessions.</td>
<td>Subjects on the low-carbohydrate, high-protein, high-fat diet met with a registered dietitian before beginning the program and were given Dr. Atkins’ New Diet Revolution to read and follow.</td>
<td>Both diet groups separately attended weekly 2-hour group-teaching sessions for 4 weeks, followed by monthly 1-hour sessions for 5 additional months. Subjects received a diet overview handout, instructional nutritional labels, sample menus and recipes, and a book on counting energy and carbohydrates.</td>
<td>Diet groups met in weekly counseling sessions for 4 weeks, followed by 11 monthly sessions.</td>
</tr>
<tr>
<td>Duration (months)</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Mean weight lost</td>
<td>LCD, 8.5 kg; LFD, 3.9 kg</td>
<td>LCD, 4.4 kg; LFD, 2.5 kg (not significant)</td>
<td>LCD, 5.8 kg; LFD, 1.9 kg</td>
<td>LCD, 5.1 kg; LFD, 3.1 kg (not significant)</td>
</tr>
<tr>
<td>HDL-C</td>
<td>No significant differences between groups</td>
<td>Significant increase in LCD group</td>
<td>No significant difference between groups</td>
<td>Significant increase in LCD group</td>
</tr>
<tr>
<td>LDL-C</td>
<td>No significant differences between groups</td>
<td>No significant differences between groups</td>
<td>No significant differences between groups</td>
<td>No significant differences between groups</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>No significant differences between groups</td>
<td>Significant decrease in LCD group</td>
<td>Significant decrease in LCD group</td>
<td>Significant decrease in LCD group</td>
</tr>
</tbody>
</table>

LDL-C indicates low-density lipoprotein cholesterol; LCD, low-carbohydrate diet; LFD, low-fat diet.
were no longer statistically significant. Subjects on the low-carbohydrate diet did have greater improvements in triglyceride, HDL-C, and hemoglobin A1c levels, however, even after adjusting for weight loss. These researchers suggested that these findings give further evidence that carbohydrate restriction in obese persons, who may be overconsuming carbohydrates at baseline, may have favorable metabolic effects.

Finally, in May 2004, Yancy and colleagues reported the results of a study that included 120 overweight, healthy hyperlipidemic patients randomized to either a low-carbohydrate diet with nutritional supplementation or a low-fat, energy-restricted diet. The study, supported by a grant from the Robert C. Atkins Foundation, reported similar findings as the previous studies did, including greater weight loss and improvements in triglyceride and HDL-C levels in the subjects on the low-carbohydrate diet at 6 months.

Most of the researchers attributed the weight loss in the low-carbohydrate groups to reduced energy intake. They suggested that the spontaneous restriction of food intake to a level equal to a conventional, energy-restricted diet could be a result of the simplicity of the low-carbohydrate diet, its limited food choices, and possibly, higher levels of satiety.

The improvements in HDL-C and triglyceride levels suggest that the increased weight loss associated with the low-carbohydrate diet may offset the adverse effect of saturated fat intake. Although uncommon during weight loss, HDL-C is known to increase when dietary carbohydrate is replaced by saturated, monounsaturated, or polyunsaturated fat.

Although these studies mark the beginning of meaningful research on low-carbohydrate diets, they have serious limitations, including small sample sizes, short durations, varying intervention methodologies, high dropout rates, poor or unknown compliance levels, and reliance on self-reported data.

Furthermore, they do not provide information on the long-term health effects of low-carbohydrate diets. Will any beneficial, short-term effect of these diets outweigh potential cardiovascular, renal, bone, and cancer risk? Also, what will be the long-term effects of repeated use of nutritionally inadequate diets and diets that fall far outside the Dietary Guidelines for Americans? Finally, what are the effects of repeated use of very low carbohydrate intakes that promote ketosis?

Transforming a Low-Carbohydrate Diet Into a Healthful Lifestyle

Despite the limitations of the studies and the outstanding questions that remain about the long-term safety and efficacy of low-carbohydrate diets, can dietitians use these diets to help their patients forge a path toward a more healthful and sustainable diet?

Currently, there is no strong evidence of harm associated with low-carbohydrate diets in the short term, although it is reasonable to be concerned about individuals with increased cholesterol levels who choose this route. The quick initial weight loss may give clients some reinforcement and motivate them to remain committed to future weight loss. Similarly, the favorable changes in triglycerides and HDL-C levels that the study subjects experienced can demonstrate the potential health benefits of weight loss and may encourage further adherence to a more healthful diet.

As usual, dietitians should first talk to their clients about the potential benefits, drawbacks, and risks associated with low-carbohydrate diets so that they can make informed decisions. This also will provide dietitians leverage to suggest how clients can begin to make healthy modifications to the low-carbohydrate diet. Also, clients should have a thorough physical evaluation and receive approval from their physicians to move forward.

Talking points, including the following, can help dietitians transform a low-carbohydrate diet into a healthful lifetime weight-management strategy:

Adherence is key. A recent study of 4 popular diet plans in the Journal of the American Medical Association found that the amount of weight loss was associated with self-reported dietary adherence levels but not with diet type. Dansinger and colleagues conducted this 1-year randomized trial with 160 overweight or obese adults who had at least 1 metabolic cardiac risk factor to evaluate the clinical effectiveness and sustainability of the Atkins, Zone, Weight Watchers, and Ornish plans.

Unlike the prior studies, these researchers provided standardized recommendations across all the study groups for taking supplements, engaging in exercise, and seeking external support. Although dietary adherence decreased progressively throughout the study to a similar extent in each study group, all 4 diets did achieve modest statistically significant weight loss at 1 year. However, there was no association between diet type and weight loss, only between dietary adherence and weight loss, for each diet.

The challenge of maintaining a low-carbohydrate diet was evident in all of the randomized clinical trials. In the Foster study, after 1 year, the subjects on the low-carbohydrate diet regained more weight than did the low-fat-diet subjects. The Brehm study found a gradual increase in carbohydrate consumption in the final 3 months of the study, also suggesting diet recidivism. Higher discontinuation rates in the Atkins and Ornish diet groups in the Dansinger study also reinforce this.
To improve long-term diet adherence, dietitians should help their clients incorporate a variety of food choices into their diets, such as daily consumption of fresh fruits and vegetables and whole grains.

**Smart food choices may reduce serious health risks.** High intake of saturated fats, trans-fats, and cholesterol increases the risk of unhealthy blood lipid levels, and that, in turn, may increase the risk of coronary heart disease.\(^8\) Also, although risk of adverse effects from excess amounts of protein seems quite low, data on this issue are limited and moderation is advisable.\(^9\)

**Behavior before diet.** The National Weight Loss Registry, a longitudinal prospective study of nearly 3,000 people who have maintained a weight loss of at least 30 lb for at least 1 year, has suggested that no diet is more successful than others in reducing weight. Although the weight-loss registry has limitations, including self-report data and certain biases, there are consistent themes that emerge strongly enough that they are worth sharing with clients struggling with their weight.\(^10\)

Many clients do not realize that they can lose or gain weight eating just about anything. They do not know that weight gain and loss are simply a matter of math—energy (calories) in and energy out. Although there was little similarity in how members of the weight-loss registry lost weight, they consistently have kept it off with 4 behaviors: eating a low-fat, high-carbohydrate diet, self-monitoring weight and food intake, eating breakfast everyday, and doing 60 to 90 minutes of physical activity everyday.\(^11\)

**Long-term goals are essential.** Short-term achievable goals are important, but successful weight management requires a lifelong commitment to healthful lifestyle behaviors. Changes in food intake and exercise habits remain the hallmarks of weight loss and are essential in the prevention of weight gain. Dietitians can help their clients by guiding them through goal-setting exercises that emphasize both short-term and long-term goals that encourage lifestyle changes.

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**The Future of Low-Carbohydrate Diets**

From Banting to Atkins to South Beach, low-carbohydrate diets have had many lives. Given the public's appetite for a “quick fix,” they likely will have many more to come. However, rather than refusing to consider popular fad diets altogether and potentially alienating clients, dietitians can work within the framework of such diets, making changes to them to make them more healthful and sustainable. By meeting their clients part-way, dieticians can help their clients begin the slow course toward healthful, lifelong behavior change.

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**REFERENCES**


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**Nestlé Forms New Nutrition Board**

Nestlé Nutrition announces the formation of its Healthcare Nutrition Advisory Board. Nutritional experts from the United States include the following:

- Robert Baldassano, MD, Children’s Hospital of Philadelphia and School of Medicine, University of Pennsylvania, Philadelphia, Pa.
- Mark DeLegge, MD, Medical University of South Carolina, Charleston, SC.
- William Klish, MD, Baylor College of Medicine, Houston, Tex.
- Ainsley Malone, MS, RD, Mt Carmel West Hospital, Columbus, Ohio.
- Stephen McClave, MD, University of Louisville School of Medicine, Louisville, Ky.
- Gary Zaloga, MD, Methodist Research Institute and Indiana University School of Medicine, Indianapolis, Ind.

**New ADAF Fund in Honor of ADA President, Becky Reeves**

The ADA Foundation has established the Rebecca Snowball Reeves—Continuing Education Fund to honor Becky for her service to the organization. This fund will annually provide up to $1,000 for a dietetics professional (with interest in research or the prevention or treatment of obesity) to attend a conference, seminar, or other continuing education event in tribute to Becky’s lifelong obesity research career at Baylor College of Medicine.

**Calendar**

- **American College of Nutrition’s 47th Annual Meeting**
  **October 5-8, 2006**
  Reno, Nev
  For more information, log on to http://www.amcollnutr.org.

- **10th Annual Conference of the Community Food Security Coalition in Conjunction With Food Secure Canada**
  **October 7-11, 2006**
  Vancouver, Canada
  For more information, log on to http://www.foodsecurity.org.

- **International Food and Nutrition Conference**
  **October 8-10, 2006**
  Kellogg Conference Center, Tuskegee, Ala
  For more information, contact Adelia Bovell-Benjamin at 334-727-8717 or send an e-mail to IFNC2006@gmail.com.

- **International Probiotics Symposium**
  **October 26-27, 2006**
  Montreal, Canada
  For more information, log on to http://www.probiomtl.org/2006/index.htm.