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Effects of a Low-carbohydrate Diet on Body Composition

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## Introduction

It is widely recognized that obesity is on the rise in the United States, and with it, associated morbidity and mortality, such as heart disease and type 2 diabetes. Health care professionals admonish their patients to lose weight, but lack of effort or desire on the part of the patient is often not the problem. In 1999, one source reported that US consumers were spending \$3.3 billion dollars every year on "weight loss products and services." A nationwide telephone survey by that same source found that over 2/3 of the Americans they questioned were consciously trying either to lose or maintain weight. However, the majority of these people were not using a combination of calorie control and regular exercise to achieve their goals, despite the fact that this is by far the most pervasive recommendation of health professions and national health organizations. In fact, only half of those trying to lose weight reported consuming fewer calories. However, 90% of would-be weight losers did say they had "modified" their diet (1). Supporting this finding, the American Heart Association Nutrition Committee reported in 2001 that recent years have shown a decrease in the proportion of fat in the average American's diet, but that total energy intake had increased, leading to the observed fattening of the population (2). Some experts hypothesize that reducing fat as a means of making one's diet healthier has been overemphasized, and has led to this increased overall caloric intake (1).

This oversimplification by health care professionals is probably well intentioned, with the thinking that lack of complexity will lead to increased compliance. However, it has opened the door for many misconceptions, and never ending confusion regarding the efficacy and safety of so-called "popular diets". Books selling such diet plans look understandably attractive to the Barnes and Noble-browsing American, frustrated by repeated failed attempts to lose weight, sporting letters such as MD, and PhD on their covers, and filled with simplified physiological backing for their claims. Certainly to the average American, these claims understandably look as plausible as any other, and after all, conventional scientific wisdom has certainly been wrong in the past.

One area of emphasis of diets prescribed both by recognized health authorities, and by popular diets, is body composition, or what percentage of an individual's body weight is fat. Fat-free mass, or total body weight minus weight of body fat, is particularly important, due to its strong correlation with resting energy expenditure (REE). REE accounts for the vast majority of calories that an individual burns in a day, and therefore is extremely important in weight loss and maintenance. Muscle and other non-fat tissues are more metabolically active, gram for gram, than fat. A diet that reduces body weight primarily by reducing fat-free mass will not be successful for long, because the dieter's resting metabolic rate will decrease as their metabolically active tissues are lost (3). This is not disputed, and may be one reason that almost every diet professes to preserve fat-free mass, while burning fat. Another reason is that some of these diets include athletes in their target population. Athletes clearly are concerned with preserving speed and strength while they are attempting to control or lose weight. For example, the Zone diet, a popular low-carbohydrate diet based on an ideal ratio of carbs, fat and protein, specifically promises athletes "improvements in lean body mass" at the same time that body fat is reduced, along with improved energy (4).

Among the longest-lived and continuingly most popular bookstore diets is the Atkins Diet. The premise behind the weight loss plan of Dr. Robert Atkins is that obesity is a metabolic problem,

caused by hyperinsulinemia and insulin resistance. Atkins points to carbohydrates as the macronutrient specifically responsible for these things, and therefore recommends that their intake be restricted (5). The Atkins diet has three "phases", beginning with the "induction" phase, during which dieters are told to eat a maximum of 20 grams/day of carbohydrates. As target weight is approached and reached, carbohydrate allowances are gradually increased, with the final allowable daily consumption varying greatly between individuals in accordance with how many carbs they can get away with eating without gaining weight. There are no calorie restrictions associated with the Atkins Diet (6). High fat foods are encouraged and emphasized, and dieters are told to specifically avoid fruits, breads, grains, starchy vegetables and non-heavy cream based dairy products (5).

### Are There Physiological Premises Behind Atkins?

Despite the fact that the Atkins Diet food recommendations are virtually the opposite of those of any major health or nutrition organization, there are a few undisputed points. As discussed above, the importance of losing fat mass at a higher rate than fat-free mass is basically universally recognized. Also, virtually every study and review article published, regardless of its funding or its findings, points out that, in the end, weight loss requires a negative energy balance. To reverse weight gain, one must consume fewer calories, and burn more (1, 2, 5, 6, 7).

Beyond this simple beginning, the debate centers around if and how the body's metabolic processes can best be utilized to burn calories faster. Regrettably, the discussion far too rarely includes mention of increased physical activity, and it quickly departs from the simple idea of losing fat versus fat-free mass. Instead it revolves around some optimal combination or proportion of macronutrients, typically divided into carbohydrates, fat and protein (2).

One of the major claims of high-fat, high-protein diets is that they are more satiating, and therefore lead to decreased overall calorie consumption. This claim appears to be accurate. The American Heart Association Nutrition Committee describes high-protein diets with carbohydrate restrictions as "self-limiting," with caloric intakes typically below 1500 kcal/day.

Physiologically, the basis for this is largely the ketosis, an appetite suppressant, induced by diets such as Atkins' (2). Beyond this, low-carbohydrate diets point to a desire to have the body rely on gluconeogenesis from fatty and amino acid sources in the liver, versus hepatic glycogenolysis or blood glucose. To support their claims that fat-free mass is maintained, high-protein diets without calorie restrictions point to the fact that increased dietary protein reduces nitrogen losses when compared to very low energy diets. Hormonal changes, especially insulin, are also fundamental to the physiological premises of popular, low-carb diets. One study supported these claims by noting that, "substituting dietary protein for carbohydrates in an energy restricted diet maintained levels of thyroid hormones T3 and T4, and reduced insulin response to a test meal. These endocrine differences are consistent with higher rates of lipolysis." (6)

Other studies can also be found that tout the weight loss and body composition improvements associated with low-carb diets. In a 6-month study looking at 41 individuals following the Atkins Diet, 95% lost weight, and on average, two-thirds of the weight lost was estimated by caliper techniques to be fat mass. Researchers also found that blood pressure decreased in participants, and that 85% reported a perceived increase in energy (8). Another 10 week trial focusing on replacing carbohydrate consumption with protein while controlling fat intake found that subjects in the high-protein diet test group reported greater satiety and energy increases than the high-

carbohydrate diet control group. They also reported significant differences in the ratio of fat mass lost to fat free mass lost (6.36 in test group versus 3.92 in the carbohydrate group, with  $P < 0.05$ ). This study also cited others that obtained similar results, both in terms of satiety and fat-free mass preservation, when the carbohydrate to protein ratio was reduced from "normal" (3.4) to below 2.0 (6). Presumably, it is studies such as these that prompted Atkins to boast in a 2002 Time article, "At what point am I allowed to say, 'I told you so?'" (9).

### But What Does All the Data Really Say?

It turns out that what Atkins was boasting about was not peer-reviewed evidence to support his diet, but just that after almost 30 years his peers were grudgingly recognizing the need to test his claims in clinical trials. He cited the fact that the National Institutes of Health was starting to compare "controlled-carbohydrate" and "low-fat" nutrition (9). So what have his peers found? First of all, the studies mentioned above are not as rosy as they appear on the surface. Importantly, the 6-month Atkins Diet trial was funded directly by an unrestricted grant from the Atkins Center for Complementary Medicine. The study included no control, and deviated substantially from what the typical book buyer would actually experience. Participants were given nutritional supplements and counseled extensively regarding exercise, and had regular meetings following their progress (8), none of which are emphasized in the popular version of the diet (5). Upon detailed reading of the study, authors admitted that the 66% of weight lost being fat-free mass was a result "similar to other studies involving dietary interventions for weight loss", and that the body weight loss their participants showed was "similar to the effect of a medication recently approved from treatment of obesity." (8).

The second, protein-carb exchange trial mentioned above has similar problems. It too was funded by interested parties, including the Cattlemen's Beef Board and Kraft Foods. Upon careful review of the actual composition of the test diet, it bears almost no resemblance to any currently advised diet, popular or otherwise, but was instead selected to evaluate protein separately from fat. Other than the low carbohydrate to protein ratio in the test group, the diet was much more conscious of traditional health guidelines, such as dietary fiber recommendations, than any popular diet. Both the test and control groups were restricted to consume  $< 30\%$  of their calories from fat, and included 5-6 servings/day of vegetables. The differences they found in fat versus fat-free mass loss were also not as great as their conclusions made them out to be, with the actual raw data showing no statistically significant difference between the two groups in terms of average fat mass change, or fat-free mass change (6).

Other studies tend to corroborate what the two fully described above were largely forced to admit: body weight changes and body composition changes are, at least over the short term, not dependent on the macronutrient content of the diet. A carefully controlled, randomized, 12-week trial comparing the Atkins, Zone, and diabetic exchange diets showed, "no significant differences in total weight, fat or lean body mass loss when compared by diet group," but did show the typical problem of substantial attrition from all groups. Interestingly, the lowest attrition rate (36%) was from the diabetic exchange diet (10).

Over the long term, it is unlikely that the low-carbohydrate diets would continue to do as well. According to the American Heart Association Nutrition Council, the 20 grams/day of carbohydrates in the Atkins "induction" phase is only 20% on the minimum necessary to prevent the loss of lean muscle tissue (2). Other physiological evidence tends to point the same way.

Since glycogen depletion is an uncontested effect of a carbohydrate restricted diet, and glycogen stores are 4-6 times more hydrated than fat stores, it follows that a good deal of initial weight lost in these diets is water (2, 5). In addition, popular low-carbohydrate diets are generally very restrictive of food choices, and difficult to follow for long periods of time, and are constructed for weight loss, not weight maintenance (5). One study attempted to look at long term effects by simply polling people on what they were already eating, and classifying them according to several diet categories, including vegetarian, low-carb, high-carb/food pyramid compliant, and high-carb/food pyramid non-compliant, but low-fat, among others. They found that according to self-reported heights and weights, the body mass indices were lowest among vegetarian or high-carb/low-fat consuming women, and vegetarian or high-carb/food pyramid compliant consuming men. The same group performed a literature review of more than 200 studies, and found that, across the board, "weight loss is independent of diet composition," and, "energy restriction is the key variable associated with weight reduction in the short term" (7).

### Conclusions

The peer-reviewed literature on the subject overwhelmingly shows that, far from supporting their claims of enhanced weight loss and body composition improvement, popular diets are no more physiologically sound or easier to follow than the traditional diet recommended by the vast majority of health professionals across America. In addition, while current data suggests that these diets are just as good at initiating weight loss as a calorie-restricted, low-fat diet, there is little or no data supporting their continued efficacy over the long term, and there are serious safety concerns. The Atkins diet deviates entirely from the Food Pyramid recommendations (5), and even studies supporting it point out problems such as increased calcium excretion (potentially leading to osteoporosis), and significantly increased cholesterol in some subjects, despite weight loss (8). There are also concerns regarding vitamin deficiency, increased blood pressure, kidney damage, and increased incidence of low-dietary-fiber related cancers (2). The problem of the continuing popularity of diets such as the Atkins Diet therefore appears to be one of education. A study in 1999 found that the likelihood that a person exercised as part of a weight management program increased with educational level and decreased with age and Body Mass Index (1), indicating that our primary challenge as health care professionals is getting reliable and safe dietary information out to the people that need it most.

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