Low-Carbohydrate Diets Promote a More Favorable Body Composition Than Low-Fat Diets

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SUMMARY

A PRIMARY CONCERN WITH CONVENTIONAL WEIGHT LOSS APPROACHES IS THE LOSS OF LEAN BODY MASS THAT OCCURS WHEN FAT MASS IS DECREASED. CONSUMING MODERATE PROTEIN, WHILE RESTRICTING CARBOHYDRATE, ALLOWS FOR GREATER PRESERVATION OF LEAN BODY MASS. A LOW-CARBOHYDRATE DIET IN CONJUNCTION WITH PERIODIZED RESISTANCE TRAINING PROMOTES GREATER FAT LOSS WHILE PRESERVING LEAN BODY MASS AND PROMOTING ROBUST IMPROVEMENTS IN METABOLIC HEALTH.

INTRODUCTION

The proportions of fat and lean body mass determine an individual's body composition. The goal of many athletes and nonathletes is to decrease percentage body fat by simultaneously decreasing fat mass and increasing lean body mass. Beyond the well-characterized favorable effects on general health, a lower body fat is desirable for athletes to increase muscular force to body weight ratio and important for enhancing power production and mechanical efficiency. Lean body mass, specifically muscle mass, contributes directly to force production capacity and physical performance as well as insulin sensitivity and general metabolic health. There are also aesthetic and psychological benefits associated with improvements in body composition.

Most weight loss approaches that decrease fat mass also result in an undesirable loss of lean body mass. In fact, about one-quarter of the weight loss achieved through typical low-fat diet approaches is from lean body mass (11,9). Weight loss interventions that preserve lean body mass while reducing fat mass are preferred. The combination of caloric restriction and exercise can have a strong effect on improving body composition, but the type of diet and training program has a major influence on the magnitude of change. This brief review will focus on the effects of macronutrients on body composition.

THE CASE FOR LOW CARBOHYDRATE DIETS TO ENHANCE BODY COMPOSITION

A common, albeit inaccurate, axiom in nutrition is that *a calorie is a calorie* (i.e., the distribution of macronutrient has no effect independent of total energy). In respect to body composition, convincing evidence of the importance of macronutrient composition was presented in a comprehensive meta-regression of 87 diet trials (10). The authors concluded that diets lower in carbohydrate were associated with greater fat loss and diets higher in protein resulted in better preservation of lean body mass during weight loss. Furthermore, these effects were independent of energy intake and participation in exercise.

We have consistently shown in our work that very low carbohydrate ketogenic diets result in greater weight loss and fat loss compared with low-fat diets. In overweight men and women, we have repeatedly observed a 2-fold greater weight loss and fat loss in subjects restricting dietary carbohydrate versus fat despite similar caloric restriction between the diets (22,21). We have also examined the effects of very low–carbohydrate diets on body composition in normal-weight men (19). Twelve healthy normal-weight men switched from their habitual diet

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(48% carbohydrate) to a ketogenic diet (12% carbohydrate) for 6 weeks, and 8 men served as controls consuming their normal diet. Fat mass, assessed by dual energy x-ray absorptiometry, was significantly decreased (−3.4 kg) and lean body mass significantly increased (1.1 kg) after the ketogenic diet. There was a significant decrease in serum insulin (−34%), and 70% of the variability in fat loss on the ketogenic diet was accounted for by the decrease in serum insulin concentrations.

In addition to experimental demonstrations of its efficacy, the importance of carbohydrate restriction rests on the fundamental idea that carbohydrate is more than an energy source. In distinction to strategies based on reduction in dietary fat, the rationale for reduction in dietary carbohydrate derives from basic mechanisms. Carbohydrate is the major stimulus of insulin and, beyond its role in providing a source of energy, serves as a control element, either directly via glucose or fructose or indirectly through the effects of insulin and other hormones. It is difficult to attribute metabolic responses and clinical outcomes to one class of nutrients, but as a principle, one has to consider the inextricable link between dietary carbohydrate and the appearance of plasma glucose and insulin as an important modulator of cellular function.

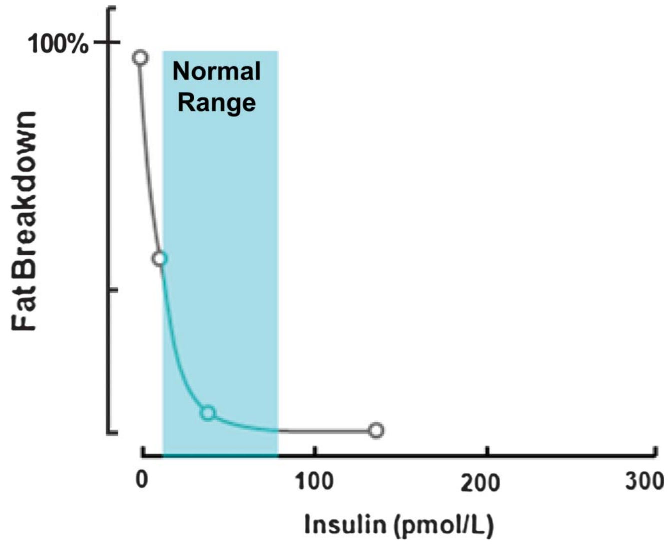

Figure 1. Fat breakdown as a function of insulin levels. Small reductions in insulin within the physiological range are associated with a large increase in lipolysis. Adapted from Jensen et al. (6).

INSULIN PHYSIOLOGY

The manifold functions of insulin can be summarized as anabolic. Insulin inhibits breakdown and promotes storage of nutrients. In this way, dietary carbohydrate–induced increases in circulating glucose and insulin levels serve as an important control element on metabolism, especially the regulation of fuel selection between carbohydrate and fat. Carbohydrate restriction stimulates a unique metabolic state characterized by increased fat oxidation and decreased fat synthesis. In fact, adipose tissue lipolysis is exquisitely sensitive to changes in insulin within the physiological range of concentrations (6) (Figure 1). Small to moderate decreases in insulin can increase lipolysis several-fold, the response being virtually immediate. Insulin also stimulates lipogenesis by increasing glucose uptake and activating lipogenic and glycolytic enzymes. Small reductions in insulin levels, such as that easily achieved with dietary carbohydrate restriction, remove the normal inhibition on fat breakdown. Thus, low-carbohydrate diets are associated with significant changes in lipid metabolism, favoring decreased storage and increased breakdown and oxidation of fat as well as improvement in atherogenic dyslipidemia. The ability of low-carbohydrate intake to inhibit lipogenesis and to bias lipid metabolism toward oxidation would allow for more effective processing of the ingested fatty acid mix. As an example, we showed a reduction in plasma saturated fatty acids in the low-carbohydrate arm of a dietary comparison in which this group consumed 3 times the amount of saturated fat as the low-fat arm (2), supporting the premise that ingested fat is efficiently used for fuel rather than stored when carbohydrate is restricted. In summary, the dominant hormone regulating metabolic processing of dietary fat is insulin, which is primarily stimulated by dietary carbohydrate. It is not surprising that dietary carbohydrate, beyond its role as a source of energy, has an important regulatory function in the control of body fat levels.

In skeletal muscle, insulin also has anabolic effects by increasing amino acid uptake and protein synthesis and inhibiting protein breakdown (17). Insulin is generally accepted as a stimulator of protein synthesis only when adequate amino acids are available (7), thus dietary carbohydrates alone are not a potent stimulus for increasing protein synthesis (1,18). However, many dietary protein supplements include carbohydrate as a way to increase insulin and potentially augment protein synthesis. While some evidence exists for an additive effect of protein and carbohydrate provided after resistance exercise on protein synthesis (14), other work has shown that carbohydrate does not augment the response induced by protein (8).

Prior work clearly shows that providing even small amounts of carbohydrate after exercise rapidly decreases nonesterified fatty acids and induces a shift from fat to carbohydrate oxidation (13). The relatively minor positive effect of carbohydrate and insulin on protein balance should be weighed against the more potent effects of carbohydrate ingestion on inhibition of fat breakdown and fat oxidation, which could be counterproductive for decreasing body fat.

IMPORTANCE OF RESISTANCE TRAINING

Diet alone can improve body composition, but the effects are augmented when combined with exercise. Although resistance training is not a potent stimulus for enhancing fat loss, overloading the musculature is necessary to create the anabolic stimulus for muscle fiber hypertrophy. In combination with the appropriate nutritional input, resistance training can enhance the proportion of fat loss during weight loss (24). Kraemer et al. (9) showed that overweight men who consumed a low-calorie, high-fiber, low-fat diet lost approximately 9.5 kg in 12 weeks. Two other groups who consumed the same diet but added either endurance training or a combination of endurance and resistance trainings showed the same weight loss. However, subjects who made only dietary changes had a fat loss of 69% of total weight loss, whereas subjects who added endurance training had a fat loss of 78% of weight loss, and subjects who also added resistance training lost almost exclusively fat (97% of weight loss). Therefore, the addition of weight lifting decreased the loss of lean body mass to 3%, compared with a 22% loss with endurance-only training and a 31% loss in muscle with diet only.

Although resistance training clearly improves body composition when added to a dietary program, the effects of diets varying in macronutrients consumed with and without exercise training have only been investigated in a few studies. Layman et al. (11) reported that a moderate low-carbohydrate diet (38:30:32; percent of carbohydrate to protein to fat) resulted in more favorable body composition changes than a low-fat diet (61:18:26; percent of carbohydrate to protein to fat) in middle-aged overweight women. The low-fat diet group consumed 0.8 g/kg protein, and the low-carbohydrate diet group consumed 1.6 g/kg protein. Both groups significantly decreased their total caloric intake by approximately 600 kcal from baseline, with no significant difference between the 2 treatment groups. After 16 weeks, the low-carbohydrate diet group lost approximately 2.0 kg more body weight than the low-fat diet group (mean ± SEM: 9.3 ± 0.8 kg versus 7.3 ± 0.5 kg, respectively). The addition of an exercise program (5 d/wk walking and 2 d/wk resistance training) to the low-carbohydrate diet had synergistic results. The low-carbohydrate exercise group had the largest weight reduction (11.2%) compared with the low-fat diet group (8.4%). The most favorable responses in fat mass were seen in the low-carbohydrate diet groups who lost an average of 7.3 ± 0.8 kg fat mass (4.3% relative body fat), whereas the 2 low-fat diet groups lost an average of 5.3 ± 0.3 kg fat mass (2.9% relative body fat). When comparing the 2 exercise groups, independent of diet treatment, those participants who received supervised training lost an average of 1.7 kg or 2.2% more than those who were less physically active and they had greater preservation of lean body mass. The combination of a low-carbohydrate diet and exercise had the most favorable response for both fat mass and lean body mass (Figure 2), suggesting this may be a logical effective intervention strategy for weight loss in middle-aged women.

We performed a similar experiment in overweight/obese men who were placed in a low-fat diet group that restricted fat to less than 25% of energy or a very low–carbohydrate ketogenic diet group that reduced carbohydrate to less than 15% energy. Both groups also participated in a resistance training program (see Practical Applications) (16). Body composition was assessed using dual energy x-ray absorptiometry before and after the 12-week program. The results were compared with non-training diet only groups. As expected, the low-carbohydrate diet group lost more fat, which was associated with greater decreases in insulin. Resistance training, independent of diet, resulted in increased lean body mass without compromising fat loss in both diet groups. The most dramatic reduction in percent body fat was in the low-carbohydrate diet resistance training group (−5.3%), followed by low-fat resistance training (−3.5%), low-carbohydrate diet only (−3.4%), and low-fat diet only (−2.0%) groups. These data show for the first time that resistance training is a potent stimulus to protect lean body mass in men consuming a low-carbohydrate diet, while still allowing for significantly greater fat loss.

When our work is compared with the findings of Layman et al. (11), a similar pattern and magnitude of change in body weight are seen across the 4 groups (Figure 2). The low-carbohydrate diet groups lost more body fat, independent of training, whereas resistance training had a favorable effect on lean body mass independent of diet. The combination of a low-carbohydrate diet and resistance training appears to be additive in the sense that it maximizes fat loss while preserving/increasing lean body mass. In other words, a low-carbohydrate diet combined with resistance training produces the greatest reductions in percent body fat.

HEALTH CONSIDERATIONS

For more than 3 decades, official recommendations have emphasized reduced total fat, saturated fat, and cholesterol intake as the primary method to achieve and maintain a healthy body weight (12). The best estimates of nutrient intake in the United States indicate that percent fat intake has declined over the past 3 decades, with a concomitant increase in carbohydrate intake (20). During the same time, obesity and diabetes rates have increased and heart disease remains the leading cause of death in most industrialized countries (15). The recent report of the massive trial in the Women's Health Initiative can only be described as discouraging with essentially no long-term effect on weight loss (4) or cardiovascular disease (CVD) (5) on a low-fat diet. In the area

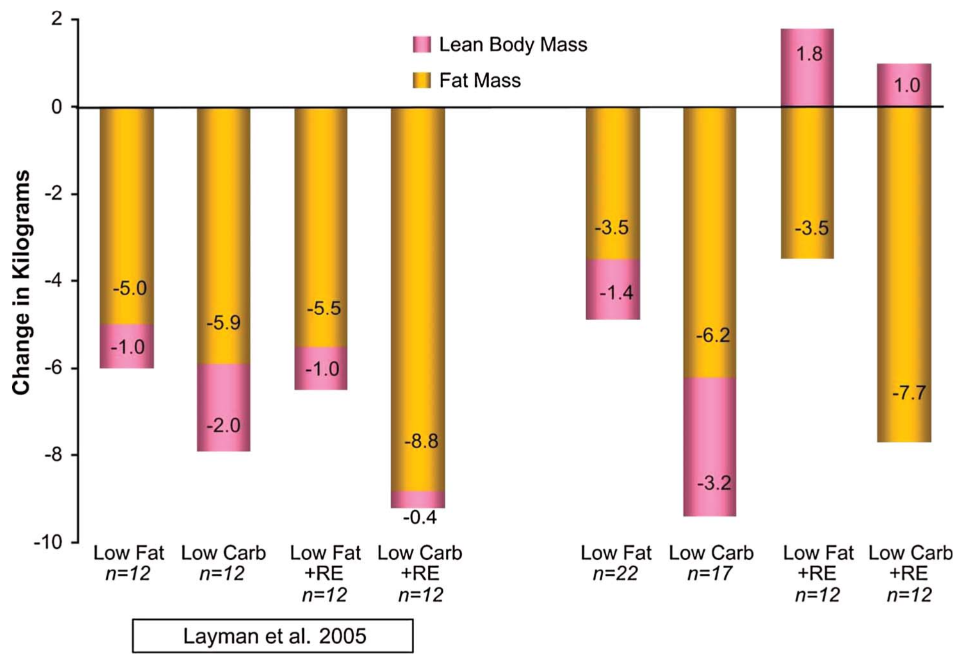

Figure 2. Effects of diet composition with and without resistance training on change in lean body mass and fat mass after 16 weeks in untrained women (11) and 12 weeks in untrained men (16). RE = resistance exercise.

of weight loss, experiments continue to show that carbohydrate restriction is at least as effective as low-fat diets, usually more effective. In addition to weight loss, emerging research is showing that carbohydrate-restricted diets are an effective strategy to improve the metabolic syndrome (insulin resistance syndrome), which represents a group of seemingly disparate physiologic signs that indicate a predisposition to obesity, diabetes, and CVD (22). Consistent with the idea that an intolerance to carbohydrate (insulin resistance) is an underlying feature of the metabolic syndrome, research has shown that a reduction in dietary carbohydrate results in global improvement in traditional and emerging markers associated with this syndrome, particularly the cardiometabolic profile (22,23). Notably, these same results are found even when body weight does not change, demonstrating that there are underlying mechanisms contributing to these favorable results independent of the effects of weight loss.

PRACTICAL APPLICATIONS

Athletes who want to decrease body fat and improve body composition should pay particular attention to dietary carbohydrate intake. In practice, there are many ways to restrict carbohydrate. In our research studies, dietetic counseling was focused on lowering carbohydrate intake to approximately

Table 1
Sample resistance training program for subjects consuming a low-fat and low-carbohydrate diet

Day 1 (mon) (8–10 reps) (120 s rest)	Day 2 (wed) (6–7 reps) (180 s rest)	Day 3 (fri) (8–10 reps) (120 s rest)
Squat	Barbell lunge	Squat
Dumbbell lunge	Leg curl/leg extension	Pull-down
Bench	Incline bench	One-leg lunge
Pull-down	Seated row	Upright row
Upright row	Shoulder press	Bench
Calf exercise	Calf exercise	Calf exercise
Ab exercise	Ab exercise	Ab exercise

Ab exercise = abdominal exercise; Reps = repetitions.

10–15% of total energy, but this level of restriction may not be necessary. We have observed favorable effects on body composition when subjects were instructed to consume beef, poultry, fish, eggs, oils, and heavy cream; moderate amounts of hard cheeses, low-carbohydrate vegetables, and salad dressings; and small amounts of nuts, nut butters, and seeds. Subjects restricted fruit and fruit juices, dairy products (with the exception of heavy cream and hard cheese), breads, grains, pasta, cereal, high-carbohydrate vegetables, and desserts.

When carbohydrate restriction is combined with resistance training, body composition is further decreased, primarily because of positive effects on lean body mass. The ideal training program to elicit optimal changes in body composition remains unclear, but the program used in our work was a nonlinear approach alternating among heavy, moderate, and light days. Sessions were about 45 minutes in duration performed 3–4 days per week for 12 weeks and included a variety of exercises (Table 1). Training loads were determined using repetition maximum (RM) zones (e.g., 1–10 RM) and were progressively increased over the training period (16).

The majority of studies indicate that protein intake is important before and after workouts to enhance muscle protein balance. A sensible strategy would be to consume 10–20 g of protein around the workout. In our low-carbohydrate diet training study, we had subjects in the low-carbohydrate diet group consume a protein supplement containing 18 g of protein before and after each resistance training session (16).

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