

Weight loss and metabolic benefits with diets of varying fat and carbohydrate content: separating the wheat from the chaff

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SUMMARY

With the rising prevalence of both obesity and diabetes, the contributing role of diet to the prevention and treatment of these conditions has become a major focus of research, clinical practice, and public policy. There has been intense debate over which dietary regimens might be most effective for weight loss, with interest centered on the potential for specific dietary macronutrients to affect body composition, metabolism, and overall health. This Review addresses two regimens with distinct macronutrient prescriptions that have been widely touted as being beneficial for weight loss and/or metabolic profile: diets low in carbohydrate and diets high in monounsaturated fat. Although data from recent randomized, controlled trials suggest these popular diets may be useful for weight control, cardiovascular health, and glycemic control, longer studies of the efficacy and safety of varying macronutrient content are needed to strengthen the evidence base for nutritional recommendations. Until more support for specific macronutrient combinations is available, practitioners can recommend an array of diets with moderate amounts of macronutrients, tailored to individual needs and preferences.

KEYWORDS high monounsaturated fat diet, low carbohydrate diet, macronutrients, Mediterranean diet, weight loss

REVIEW CRITERIA

A literature search was conducted by searching PubMed for articles published between 1987 and 2007, using the terms "low carbohydrate diet", "Mediterranean diet", and "high monounsaturated fat diet". The search was limited to studies of adults and the English language. Published reviews from professional journals were also used as references for this article.

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Learning objectives

Upon completion of this activity, participants should be able to:

- 1 Describe macronutrient dietary recommendations of the Institute of Medicine for healthy adults.
- 2 Name and describe weight loss diets of varying carbohydrate and fat content.
- 3 Compare short- and longer-term weight loss and lipid profile outcomes of a low-carbohydrate diet with a low-fat diet.
- 4 Describe the typical Mediterranean diet.
- 5 Identify potential benefits of a high-monounsaturated fat with a low-fat, high-carbohydrate diet.

Competing interests

The authors declared no competing interests. Désirée Lie, the CME questions author, declared no relevant financial relationships.

INTRODUCTION

The concurrent rise in the prevalence of obesity¹ and diabetes² over the past two decades is a major public health concern. Lifestyle behaviors, such as nutrient-poor diets and physical inactivity, have been implicated in the increasing occurrence of both obesity³ and diabetes.⁴ Large randomized, controlled trials (RCTs) have demonstrated long-term weight loss and reduced incidence of diabetes with lower-fat diets and increased physical activity in people at high risk.^{5,6} Lifestyle modification, therefore, remains the first clinical approach when patients present with obesity and attendant metabolic consequences.

With a pressing need for the prevention and treatment of obesity and its comorbidities, the therapeutic role of diet has become a major focus

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of research, clinical practice, and public policy. Consequently, there has been a surge of interest in the potential effects of diets with varying macronutrient content, with intense debate about the ideal combination of carbohydrate, protein, and fat for effectively managing obesity and its metabolic consequences such as diabetes and other cardiovascular risks.

The Acceptable Macronutrient Distribution Ranges (AMDRs) established by the Institute of Medicine⁷ are widely used as dietary guidelines for healthy adults, as well as for persons with diabetes.⁴ The AMDRs are as follows: 45–65% of total calories derived from carbohydrate; 10–35% from protein; 20–35% from total fat. The overarching goals of these recommendations include reduction of cardiovascular risk and achievement of glycemic control, along with weight management. Specific dietary strategies to reach these goals must be sensitive to the needs, values, and preferences of the individual patient.⁴

Similarly to many past and current nutritional recommendations for health promotion and disease treatment,⁸ the diet recommendations of expert bodies such as the Institute of Medicine,⁷ American Heart Association,⁹ American Diabetes Association,⁴ and European Association for the Study of Diabetes¹⁰ are based on the clinical expertise and distillation of available evidence by groups of leading practitioners. Although long-term dietary interventions are difficult to implement, there have been a number of recent randomized, controlled effectiveness studies that have strengthened the evidence on which to base clinical nutrition practice. These studies have provided additional, but not yet sufficient, evidence for modification of current nutritional guidelines. Despite a recent flurry of research, many fundamental questions related to dietary macronutrients and their effects on energy balance and metabolism remain unanswered.

The unceasing demand by patients and health-care providers for effective weight-loss methods has led to the use of a wide number of unproven strategies. It is, however, essential for clinicians to be aware of the latest research findings related to dietary macronutrients and the sometimes-controversial interpretation and application of these findings. This Review, therefore, will address two dietary approaches with a focus on macronutrient composition rather than energy restriction to promote weight loss and improve cardiovascular risk: diets low in carbohydrate and diets high in monounsaturated fat (MUFA).

DIET DEBATES: A BATTLE OF MACRONUTRIENTS

Since few nutritional guidelines are based on strong evidence from rigorous trials, there is considerable latitude for the manipulation and promotion of specific macronutrient combinations by health-care professionals, self-proclaimed experts, and the diet industry. The purported benefits of popular diets for improvement of body composition and health are often attributed to the relative distribution of macronutrients. These diets cover a wide range of macronutrients from the Ornish diet, a very-low-fat, high-carbohydrate diet regimen,¹¹ to Atkins' very-low-carbohydrate, high-fat diet,¹² with a multitude of diets with varying levels of carbohydrate and fat between these two extremes. Since some of the alternative diets derive a large proportion of energy from fat, there has been considerable concern about potential deleterious effects on cardiovascular risk.¹³

Although the profusion of unsubstantiated dietary regimens has been viewed in some quarters as misleading or even dangerous, one benefit of these popular diet plans has been to stir debate about the health effects of macronutrient distribution in the diet. Recently, several approaches with specific prescriptions of dietary macronutrients have been examined in controlled human studies. Two of these approaches (i.e. restriction of carbohydrate and enrichment of MUFA) have received considerable attention. Although some low-carbohydrate studies have examined modifications in dietary quality (e.g. fiber content and glycemic index),¹⁴ this article will focus on the effects of variations in the quantity of carbohydrate and MUFA in the diet. Although the published data related to low-carbohydrate and high-MUFA diets are not sufficient to make overarching clinical recommendations, an appraisal of the research in this area provides insights into the effectiveness of specific dietary constructs to improve important parameters of health.

Diets low in carbohydrate

The popular weight-loss diets that have contributed to the diet industry's financial success can be divided into two camps, namely low-carbohydrate or low-fat. Although the medical community traditionally has supported the moderately low-fat, high-carbohydrate diet for cardiovascular health,⁹ the effectiveness and safety of weight-loss diets have only recently

been tested in long-term RCTs. In a 2001 scientific review of popular diets,¹³ only four studies of low-carbohydrate diets were identified within the previous 20 years, with the longest being 12 weeks.^{15–18} The authors, therefore, noted that the evidence for the effects of low-carbohydrate diets on weight loss and metabolic outcomes was based on uncontrolled or nonrandomized trials or observational studies. They concluded that controlled clinical trials of both low-carbohydrate and low-fat diets are needed to assess long-term effectiveness and potential health benefits or detriments.

Several RCTs with at least 6 months of a low-carbohydrate diet intervention for weight loss have been published recently. Although the primary outcome measure of these studies has been weight loss, the majority of trials have also examined the diets' effects on body composition, cardiovascular risk factors, and glycemic control. The results of these trials are, therefore, relevant for the vast number of overweight and obese persons, particularly those who are also attempting to manage diabetes.

In one of the first of these published studies, the effects of a low-carbohydrate diet (allowing 20–60 g of carbohydrate daily) with no energy restriction were compared with a conventional energy-restricted low-fat diet, with no more than 30% of energy as total fat. No recommendations for the specific type of fat were given.¹⁹ In this trial of obese women, the low-carbohydrate dieters lost an average of 8.5 kg, significantly more than the 3.9 kg lost by the low-fat dieters during the study; the majority of weight loss in both diet groups occurred during the first 3 months of dieting. Similarly, fat mass decreased significantly more in the low-carbohydrate group, compared with the low-fat group, in proportion to the amount of weight lost. Several cardiovascular risk factors (i.e. blood pressure, lipid levels, markers of systemic inflammation,²⁰ and fasting glucose and insulin levels) improved in both diet groups over the study period.

These findings suggest that a low-carbohydrate diet is more effective than a low-fat diet for short-term weight loss, without detrimental impact on common cardiovascular risk factors. In addition, participants assigned to the low-carbohydrate diet had a spontaneous restriction of food intake that was comparable to the energy restriction prescribed for the low-fat diet group, possibly because of the satiating effect of dietary protein or the limited variety of food choices.

Similar responses to low-carbohydrate diets were reported in 6-month RCTs that included more-severely obese men and women with a high prevalence of hyperlipidemia, diabetes, or metabolic syndrome.^{21,22} Again, results showed that the low-carbohydrate dieters lost significantly more weight than comparable participants following a low-fat diet. Additional benefits of the low-carbohydrate diet suggested by these studies included greater improvement in levels of triglycerides^{21,22} and HDL-cholesterol.²² In addition, diabetic participants in the low-carbohydrate diet group showed a greater reduction in serum glucose levels than those in the low-fat diet group. Insulin sensitivity, measured only in participants without diabetes, improved more among those on the low-carbohydrate diet.²¹

Foster and colleagues studied the impact of 1 year of dieting in obese men and women and found that the low-carbohydrate diet was more effective for weight loss after 3 and 6 months than the low-fat diet but, importantly, not after 12 months;²³ however, the low-carbohydrate group continued to exhibit greater improvement in specific cardiovascular risk factors at 12 months (i.e. increased HDL-cholesterol and decreased triglyceride levels). These findings were supported by a 1-year follow-up of participants from a 6-month RCT,²⁴ which additionally showed that, for diabetic participants, HbA_{1c} levels decreased more in the low-carbohydrate group. Several other controlled studies of carbohydrate-restricted diets with long-term follow-up have shown similar results, with no differential in weight loss between the diet groups beyond 6 months,^{25–29} but continued improvement in HDL-cholesterol^{26,27,29} and triglyceride levels in low-carbohydrate groups.²⁷

A larger, year-long clinical trial ($n=160$) of overweight and obese adults compared four popular diets with dissimilar levels of macronutrients: a very-low-carbohydrate diet (Atkins diet), a moderately low-carbohydrate diet (Zone diet), a moderately low-fat diet (Weight Watchers diet), and a very-low-fat diet (Ornish diet).³⁰ After 12 months of dieting, mean weight loss ranged from 2.1 kg to 3.3 kg for the four diet groups, with no significant differences between the groups. Increased self-reported dietary adherence was associated with greater weight loss and improvement in several cardiovascular risk factors (i.e. C-reactive protein and insulin levels and the ratio of total cholesterol to HDL-cholesterol), regardless of diet type. The authors, therefore, concluded

that the key determinant of clinical benefits was dietary adherence rather than the particular macronutrient distribution of the diet.

A recent meta-regression analysis of short-term studies of low-carbohydrate dietary interventions (i.e. 4–26 weeks' duration) found that low-carbohydrate diets are associated with greater reduction in body mass and percentage body fat than higher-carbohydrate diets.³¹ A meta-analysis of longer-term RCTs ($n=447$) drew the conclusion that low-carbohydrate, non-energy-restricted diets are advantageous for weight loss compared with energy-restricted, low-fat diets after 6 months, but the difference in weight loss between diets dissipates after 12 months.³² Neither diet showed a clear advantage related to cardiovascular risk factors. Whereas total cholesterol and LDL-cholesterol levels decreased more in the low-fat dieters, HDL-cholesterol and triglyceride levels improved more in the low-carbohydrate dieters. Without further evidence from long-term trials, it is uncertain whether the potential of low-carbohydrate diets for beneficial changes in weight and lipid profile outweighs the unfavorable changes.^{32–34}

One recent study diverges from the apparent consensus that low-carbohydrate diets have only short-term weight-loss advantages that dissipate over time. A well-designed, 1-year trial of overweight and obese women compared four diets with varying macronutrient composition (i.e. a conventional moderately low-fat diet and the Atkins, Zone, and Ornish diets). The very-low-carbohydrate diet group showed more weight loss and more-favorable improvement in cardiovascular risk factors (i.e. blood pressure, HDL-cholesterol, and triglyceride levels), even when controlled for weight loss.³⁵ With mean 1-year losses of 1.6 kg to 4.7 kg among the four diets, and a moderate amount of variability within the diet groups, one underlying message of this study is that modest weight loss can be achieved with assorted diets of varying macronutrient content.

In conclusion, evidence from recent RCTs provides reassurance to clinicians that low-carbohydrate diets can incur some relative benefits for weight loss and cardiovascular risk factors for up to 12 months. Given the potential for increased LDL-cholesterol levels and individual variability in metabolic response, clinicians are, however, cautioned to carefully monitor cardiovascular risk factors, as well as medications, in patients who are following low-carbohydrate diets.^{33,36}

Importantly, the metabolic effects of dietary regimens in recent studies of low-carbohydrate and control diets have been closely tied to weight loss, and it has not been possible to discern specific effects of nutrients *per se* on blood pressure, lipids, or indices of glucose tolerance. Since the ultimate success of most diets for weight management is due to consistent and long-term compliance, a major issue emerging from the latest research is whether some diets are more likely to be followed, perhaps because of specific and severe limitation of food choices or the more satiating effect of allowed foods.

Diets high in monounsaturated fat

If the long-term benefits of varying macronutrient distribution are unclear for weight loss, are there other advantages to systematically varying the fat and carbohydrate content of the diet? For example, can the fat content of diets be structured to improve metabolic parameters? Decreasing the intake of saturated fat and cholesterol with the goal of decreasing plasma lipid levels has been an almost universal prescription for those at risk for cardiovascular disease or diabetes over the last three decades. There has, however, been controversy over how best to replace saturated fat in the diet. Specifically, it has been argued that diets high in MUFA may be healthier than diets that substitute carbohydrate for saturated fat.³⁷ High-MUFA diets typical of the Mediterranean region emphasize the consumption of vegetables, fruits, whole grains, legumes, nuts, and specific oils (e.g. olive oil, canola oil), while limiting the intake of saturated fats from meat, poultry, and dairy products.³⁸

Earlier population-based studies, such as the classic studies of Keys,³⁹ have suggested an association of the Mediterranean diet with enhanced longevity and quality of life. Yet this alleged connection has not been rigorously tested in well-designed, long-term clinical trials. Over the past two decades, many short-term efficacy studies, some in the highly controlled setting of in-patient metabolic wards, have compared the effects of high-MUFA diets with high-carbohydrate, lower-fat diets. Results from this work^{40–47} suggest that high-MUFA diets may improve blood pressure, plasma lipid levels, and glycemic control at least as well as isocaloric high-carbohydrate diets, without the associated detrimental changes in triglyceride and HDL-cholesterol concentrations. In addition, the superior acceptability and palatability of high-MUFA diets may enhance dietary adherence.⁴⁸

Limitations of these comparative diet studies include small numbers of participants and short duration. With no clear definition of the term “high-MUFA diet”, the prescribed level of MUFA in the study diets varied considerably, from ~14% to 49% of total energy intake as MUFA.

In the mid-1990s, the American Diabetes Association published diet recommendations suggesting that 60–70% of total energy should be derived from carbohydrate and MUFA.⁴⁹ An American Heart Association Science Advisory⁵⁰ concurred that high-MUFA diets with limited amounts of saturated fat can be used to manage cardiovascular risk. Yet practitioners have been reluctant to recommend high-MUFA diets, perhaps because of the steadfast belief that high-fat diets will cause increased energy intake and weight gain when consumed outside of a controlled setting, even in light of recent studies showing positive effects of high-fat, low-carbohydrate diets on weight loss.³²

In 2003, a 6-month RCT was published, comparing the effects of a comprehensive Mediterranean Lifestyle Program that included diet, exercise, stress management, group support, and smoking cessation to usual care in 237 postmenopausal women with type 2 diabetes.⁵¹ The intervention group showed greater decreases in body weight, BMI, and HbA_{1c} levels. Because of the multifactorial nature of the intervention, however, study results cannot be attributed solely to diet effects. Another 6-month RCT corroborated the weight-loss advantage of a high-MUFA diet, using a low-calorie, formula-based diet supplemented with almonds in a group of overweight and obese adults.⁵²

A recent systematic review of studies using Mediterranean-type diets⁵³ identified only one published RCT with the primary objective of testing the effects of at least 6 months of dieting on anthropometric parameters.⁵⁴ This 18-month prospective trial ($n=101$) compared a Mediterranean-type diet containing 35% of total energy from fat (15–20% from MUFA) with a conventional low-fat diet containing 20% of total energy from fat (7–8% from MUFA) in overweight and obese adults; both diets were energy-controlled.⁵⁴ Results showed that participants in both diet groups lost similar amounts of weight (i.e. about 5% of body weight) at 6 months and 12 months; however, the Mediterranean-diet group maintained their lost weight, whereas the low-fat group regained lost weight at 18 months.

When both active participants and dropouts who were available for measurements ($n=61$) were included in the analyses, the Mediterranean-diet group showed greater reduction in body weight, BMI, percentage body fat, and waist circumference compared with the low-fat-diet group after 18 months of dieting. The authors attributed the favorable anthropometric changes and higher participation rate in the Mediterranean-diet group (54% versus 20% in the low-fat group) to the increased palatability of moderate-fat diets, which enhances dietary adherence and weight maintenance.

The main objective of other published, long-term RCTs was to assess the potential benefits of Mediterranean-type diets on cardiovascular mortality and risk in populations with prior myocardial infarctions,^{55–57} ischemic heart disease⁵⁸ or identified cardiovascular risk factors,^{59,60} with weight loss only as a secondary endpoint. The Lyon Diet Heart Study^{55–57} and Indo-Mediterranean Heart Study⁵⁹—long-term, secondary prevention trials—showed fewer cardiac deaths and nonfatal myocardial infarctions in the Mediterranean-type-diet group than in the low-fat-diet group. Some of these studies documented greater improvement in body weight and BMI,^{59,60} as well as waist circumference,⁶⁰ blood pressure,^{59,60} levels of serum cholesterol,^{59,60} triglycerides,^{58–60} fasting blood glucose,^{59,60} and insulin resistance⁶⁰ in those individuals assigned to a Mediterranean-style diet.

To make definitive, scientifically based diet recommendations, it is essential that controlled long-term trials be conducted to demonstrate the health effects of specific percentages of MUFAs and carbohydrates in the diets of overweight people, including those with diabetes.

Preliminary results are available from an RCT comparing the effects of a high-MUFA diet and a low-fat, high-carbohydrate diet on body weight, cardiovascular risk factors, and glycemic control over 12 months in 124 overweight people with type 2 diabetes.⁶¹ Energy in the high-MUFA diet was distributed as approximately 45% carbohydrate, 15% protein, and 40% fat (with half being MUFA); energy in the low-fat diet was distributed as approximately 60% carbohydrate, 15% protein, and 25% fat. Both diet prescriptions included comparable caloric restriction and equal amounts of saturated fat. Both diet groups showed similar weight loss (about 4 kg) and comparable improvement

in body fat, diastolic blood pressure, HDL-cholesterol, HbA_{1c}, and fasting glucose and insulin levels over 1 year. These results suggest that high-MUFA diets can be healthy alternatives to lower-fat, high-carbohydrate diets without negative impact on anthropometrics, cardiovascular risk factors, or glycemic control.

CONCLUSIONS

Although research studies indicate that diets with distinct variations in carbohydrate, protein, and fat may offer potential health benefits, even the longest published trials are relatively short. Although 1 year may seem impossibly long for those conducting or participating in a clinical trial, it comprises only a short time in the life of an overweight person. Despite recent advances in clinical nutrition from controlled dietary trials of moderate duration, longer studies of the efficacy and safety of diets with varying macronutrient content would greatly strengthen the evidence base for modification of current recommendations for weight control. The practicality and cost effectiveness of such research will need careful consideration. In addition, acute studies that establish the physiologic mechanisms by which specific macronutrients contribute to long-term outcomes would be a valuable complement to extended dietary interventions.

Current diet recommendations by the major expert committees and organizations do not encompass extreme restriction in any macronutrient, but they do allow for diverse diets with varying amounts of carbohydrate, protein, and fat. Until more evidence for specific macronutrient combinations is available, practitioners can recommend an array of diets with moderate amounts of macronutrients, tailored to patients' needs and preferences. Indeed, long-term dietary adherence may be improved with individualized diets that are satiating, palatable, and moderate in carbohydrate, protein, and fat.

KEY POINTS

- Although diets with distinct variations in carbohydrate, protein, and fat may offer potential health benefits, long-term clinical trials are needed to test the effectiveness and safety of these diets
- Until more evidence for specific macronutrient combinations is available, practitioners can recommend an array of diets with moderate amounts of macronutrients, tailored to the needs and preferences of patients

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Competing interests

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