The Effect of High-, Moderate-, and Low-Fat Diets on Weight Loss and Cardiovascular Disease Risk Factors

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Over 60% of Americans are overweight and a number of popular diets have been advocated, often without evidence, to alleviate this public health hazard. This study was designed to investigate the effects of several diets on weight loss, serum lipids, and other cardiovascular disease risk factors. One hundred men and women followed one of four dietary programs for 1 year: a moderate-fat (MF) program without calorie restriction (28 patients); a low-fat (LF) diet (phase I) (16 patients); a MF, calorie-controlled (phase II) diet (38 patients); and a high-fat (HF) diet (38 subjects). Weight, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), homocysteine (Ho), and lipoprotein(a) [Lp(a)], were measured every 4th month. The TC/HDL-C ratio was calculated and fibrinogen levels were measured at baseline and after one year. The MF diet resulted in a 2.6% (NS) decrease in weight compared with 18.4% (p=0.045) decrease in patients on phase I, 12.6% (p=0.0085) decrease in patients on phase II, and 13.7% (p=0.025) decrease in those on the HF diet. TC was reduced by 5% (NS) in the MF group, 39.1% (p=0.0005) in the phase I group, and 30.4% (p=0.0001) in the phase II group. HF group had a 4.3% (NS) increase in TC. LDL-C was reduced by 6.1% (NS) on MF, 52.0% (p=0.0001) on phase I , and 38.8% (p=0.0001) on phase II. Patients on HF had a 6.0% (NS) increase in LDL-C. There were nonsignificant reductions in HDL-C in those on MF (–1.5%) and HF (–5.8%). Patients on phase I showed an increase in HDL-C of 9.0% (NS), while those on phase II diet had a 3.6% increase (NS) in HDL-C. TC/HDL-C increased (9.8%) only in patients following the high-fat diets (NS). Patients on MF had a 5.3% (NS) reduction in TC/HDL-C, while those on LF had significant reductions on the phase I (–45.8%; p=0.0001) diet and phase II diet (–34.7%; p=0.0001). TG levels increased on both the MF (1.0%) and HF (5.5%) diets, although neither was statistically significant. People following the phase I and II diets showed reductions of 37.3% and 36.9%, respectively. Ho levels increased by 9.7% when people followed the MF diet and by 12.4% when they followed the HF diet. Patients following the phase I and phase II diets showed reductions of 13.6% and 14.6%, respectively. Only those following phase II diets showed a tendency toward significant improvement (p=0.061). Lp(a) levels increased by 4.7% following the MF (NS) diet and by 31.0% (NS) on the HF diet. Patients following phase I showed a 7.4% (NS) reduction and a 10.8% reduction (NS) following phase II. Fibrinogen levels increased only in individuals following HF diets (11.9%), while patients following MF (–0.6%), phase I (–11.0%), and phase II (–6.3%) diets showed nonsignificant reductions in fibrinogen. Patients on MF demonstrated nonsignificant reductions in weight, LDL-C, TC, HDL-C, TC/HDL-C ratios, and fibrinogen and nonsignificant increases in TGs, Lp(a), and homocysteine. There was significant weight loss in patients on phase I and II and HF diets after 1 year. Reductions in TC, LDL-C, TGs, and TC/HDL ratios were significant only in patients either following a LF diet or a MF, calorically reduced diet. Only patients following HF diets showed a worsening of each cardiovascular disease risk factor (LDL-C, TG, TC, HDL-C, TC/HDL ratio, Ho, Lp(a), and fibrinogen), despite achieving statistically significant weight loss. (Prev Cardiol. 2002;5:110–118) ©2002 CHF, Inc.

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The subject of obesity and related health problems[1–3] has become more of an issue in the United States during the last several decades. The problem has increased sufficiently during the last 10 years,[4,5] to result in 61% of Americans being classified as overweight. This is not just an American epidemic, but a worldwide problem as the American diet and lifestyle are exported throughout the world, with 54% of Russian citizens, 51% of UK residents, 50% of Germans, 36% of Brazilians, and even 15% of the Chinese population[6] being affected.

With so many people being overweight, almost three quarters of Americans surveyed have admitted to trying to lose weight through dietary means and/or increased exercise; however, patient expectations of weight loss[7] are not consistent with outcomes. Perhaps more important is the issue that the majority of Americans are not trying to lose weight for health reasons, but rather to improve their physical appearance and/or comfort. As a result, several popular weight loss programs have appeared that promise weight loss but do not address potential health concerns associated with these dietary programs.

Any dietary program that reduces the number of calories a person eats to fewer than what he or she needs will result in weight loss. A dietary program may be viewed as helpful as long as it results in weight loss without significant adverse side effects. Some research has looked at the effect of dietary and lifestyle changes on serum cholesterol levels[8–12] both with and without the additional use of cholesterol-lowering medications. Other research has also been published regarding the effect of increased dietary fat consumption on forearm blood flow,[13] coronary blood flow,[14,15] blood pressure,[16] plasma lipids,[17] and other concerns.[18] Still other research has demonstrated that low-fat diets can reverse coronary artery disease,[19,20] as long as caloric consumption is controlled.

While there are many ways to characterize the different dietary programs available, most can be classified into one of three groups: 1) high-fat, low-carbohydrate, high-protein; 2) moderate-fat, high-carbohydrate, moderate-protein; and 3) low-fat, high-carbohydrate, moderate-protein diets. Despite decades of discussion of these various dietary approaches, little if any comparative information exists about the long-term effects of these diets, the duration of time necessary for individuals to lose weight on these diets, and their subsequent effects on risk factors associated with heart disease and other health problems. In an effort to study the effect of these diets, we followed 100 people who remained on one of four dietary programs for a minimum of 1 year. Throughout this time, we measured weight loss as well as changes in lipids, homocysteine, lipoprotein(a) [Lp(a)], and fibrinogen levels.

METHODS

Patient Selection

Patients were selected for this study following their presentation to the institute for weight loss concerns. Patients had to be following no specific dietary program for the 6 months prior to enrolling in this study and could not be taking any dietary supplements for weight loss. They were allowed to participate only if they had no other active medical problems, including documented coronary artery disease, juvenile-onset diabetes mellitus, hypertension, cancer, or were pregnant. Patients had to commit to staying on the dietary regimen for a minimum of 1 year and were randomly assigned to one of the four dietary regimens based upon dietary preferences.

Dietary Regimens

High-Fat (HF) Diet. This diet is defined as one in which patients consume 55%–65% of their daily caloric intake in the form of fat calories. Less than 100 g of carbohydrates (RCHO) were consumed daily and protein intake constituted 25%–30% of the total caloric intake. Patients ate until satiated.

Moderate-Fat (MF) Diet. Patients following this dietary program consumed 20%–30% of their calories in the form of fat. Approximately 60% of their calories were from carbohydrate sources and the remaining calories were derived from protein. Patients consumed 10–12 calories per pound per day on this diet.

MF, Calorie-Controlled (Phase II) Diet. Patients following this program were asked to consume 350–500 fewer kilocalories per day than required[15,20] to maintain body weight. This was determined by multiplying their current weight in pounds by 10 kcal/lb to determine the required kcal intake per day; 350–500 was subtracted from this figure to determine the desired daily intake of calories. Of these calories, 15% were protein and 70% were carbohydrate, with an emphasis on complex carbohydrates vs. simple sugars. The remaining 15% of the calories could be consumed as fat in a 2:1 ratio of nonsaturated (polyunsaturated and monosaturated) to saturated fat, with no more than 5 g of saturated fat intake per day.

Low-Fat (LF) (Phase I) Diet. The LF diet consisted of fruits, vegetables, a limited amount of grain/cereals for breakfast and a multiple vitamin that included 100% of the US Department of Agriculture recommended daily intake of vitamins and minerals. Patients ate until satiated. Of the caloric intake, 10% was fat, 15% was protein, and 75% was carbohydrate, with an emphasis on complex vs. simple carbohydrates as shown in Table I.

Exercise Regimen

Each individual was instructed to exercise an average of 3–5 times per week, beginning with stretching for 15 minutes, followed by walking for 30 minutes, and then relaxing and stretching for an additional 15 minutes.

Monitoring

Patients returned on a monthly basis to review their progress, answer any questions regarding dietary habits, and determine if they were having any medical problems, which would require removal from the study. Weights were recorded at the beginning of the study and at the end of months 4, 8, and 12. Fasting venous blood was drawn at the beginning of the study and at the end of months 4, 8, and 12. The tests included total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), homocysteine, and Lp(a). The TC/HDL-C ratio was calculated for each of these intervals. Fibrinogen levels were measured at the beginning and end of the year.

Statistical Analysis

The results for each of the independent variables (weight, TC, LDL-C, HDL-C, TG, homocysteine, Lp[a], TC/HDL, and fibrinogen) were determined at baseline and at 4, 8, and 12 months for each dietary group. The final independent variable, fibrinogen, was measured at baseline and 12 months for each dietary group. Analysis of differences between groups was determined by two-tailed nonmatched *t* tests. Graphic representation of percent change from baseline was displayed as bar graphs.

RESULTS

The study population consisted of 53 women and 47 men between the ages of 23 and 67 (43±8)

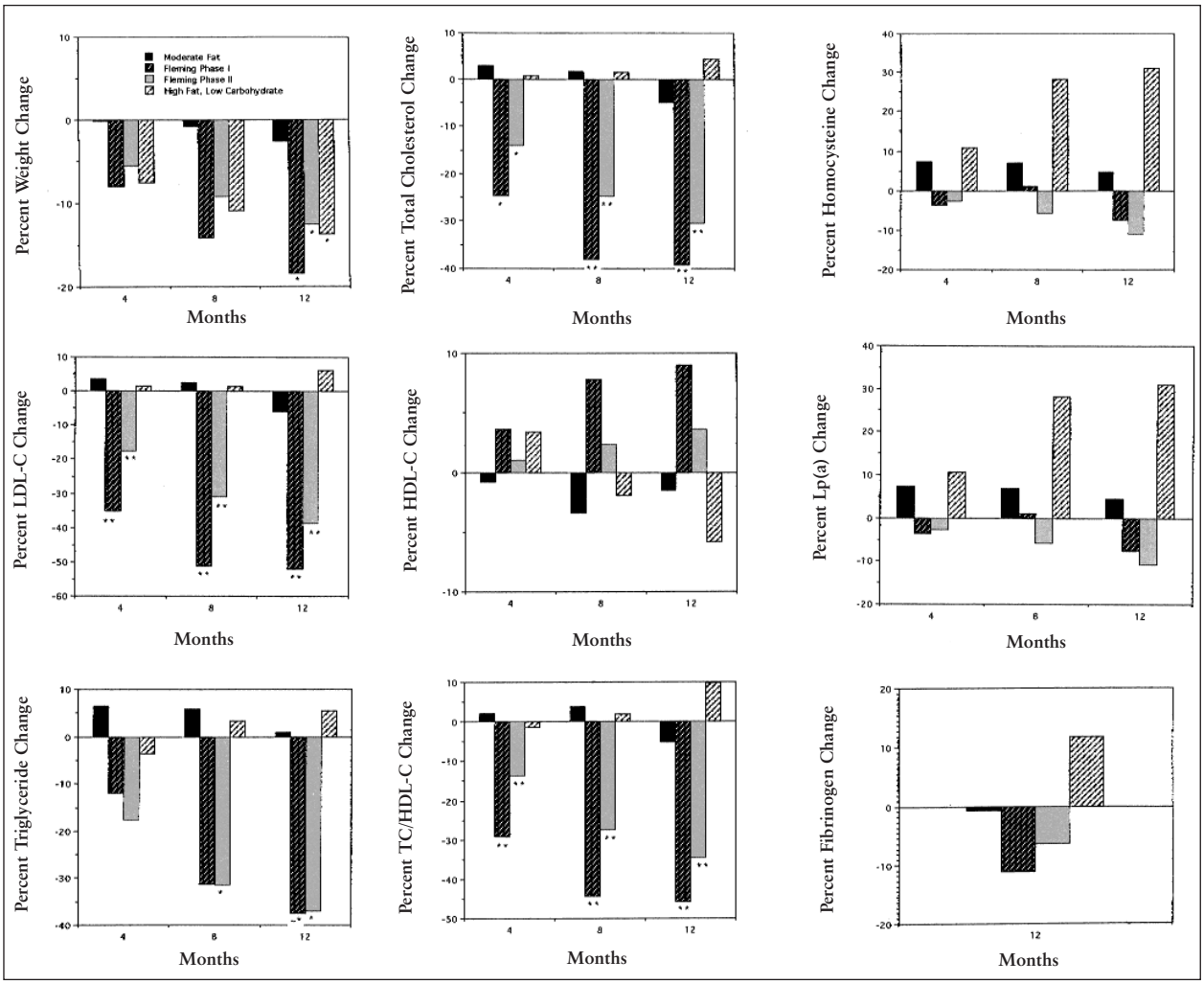

*Figure. Bar graphs of percent change of different independent variables over time. Each bar graph depicts the percent change from baseline for each independent variable for patients following 1) the moderate-fat diet (solid black bars); 2) the low-fat (Fleming phase I) diet (black with white strips); 3) the moderate-fat, calorie-controlled (Fleming phase II) diet (gray bars); and 4) the high-fat, low-carbohydrate (HF) diet (white bars with black strips). *Statistically significant changes compared with baseline values. LDL-C/HDL-C=low-density/high-density lipoprotein cholesterol; Lp(a)=lipoprotein(a); TC=total cholesterol*

Table I. Description of Different Diets

Diet	Total Calories (kcal/Day)	Fat (g/% kcal/Total kcal/Day^{-1})	Carbohydrates (g/% kcal/Total kcal/Day^{-1})	Protein (g/% kcal/Total kcal/Day^{-1})
Typical American diet	2200	85/35%/770	275/50%/1100	82/15%/330
High-fat	1400–1500	97/55%–65%/870	36/10%/145	100/25%–30%/400
Moderate-fat	2000–2200	58/20%–30%/525	315/60%/1260	79/15%/315
Moderate-fat, calorie-controlled (phase II)	1500–1600	26/15%/232	271/70%/1085	58/15%/232
Low-fat (phase I)	1300–1400	15/10%/135	253/75%/1012	51/15%/202

years. No statistical differences existed between groups for either age or sex. Patients reported that they exercised for at least three sessions per week for an average of 30 minutes each, although the level of intensity varied from person to person. Patients following the phase I and II programs tended to exercise more frequently; however, the duration of time was not significantly different from that in the other groups. The average weight for patients entering the study was 283±74 pounds in the phase I (LF) group, 243±56 pounds for those beginning the MF diet, 232±43 pounds for those beginning the HF diet, and 226±54 pounds for those beginning the phase II (MF, calorie-controlled) diet. Those entering the phase I group were statistically (p=0.010) heavier than those beginning the phase II dietary program. There were no other significant differences between groups and their initial weights.

Subjects following the MF diet showed a 2.6% reduction in weight from the beginning to the end of the study. This was not statistically significant and represented a change from 243±56 to 237±47 pounds—an average weight loss of 1.9 ounces per week. Those people following the phase I (LF) diet showed the greatest weight loss, reducing from 283±74 to 231±66 pounds at the end of 1 year. This represented a loss of 1 pound per week. The reduction of 18.4%, as shown in the Figure, was statistically significant (p=0.045), but only at the end of the year. At 8 months, the difference between baseline and the end of the 8th month had not yet reached statistical significance (p=0.12).

Patients following the phase II diet showed a statistically significant (p=0.0085) weight loss at the end of 1 year of dieting, beginning at 226±54 pounds and ending at a weight of 197±36 pounds, which, as shown in the Figure and Table II, represented a 12.6% reduction in weight, at the rate of 0.55 pounds per week. Those individuals following the HF diet showed a statistically significant (p=0.025) weight loss of 13.7% (Figure), beginning at 232±43 pounds and ending at 200±38 pounds. This represented a weight loss of 0.6 pounds per week. Like those following the phase I diet, reductions in weight for people following phase II and the HF diets were statistically significant only at the end of 1 year of dieting, as shown in the Figure. In each case, the total daily caloric intake for people following the phase I and II diets and the HF diet was 1600 or fewer calories per day.

Individuals following the MF diet showed increases in TC during the first 8 months of the study (p=NS), which peaked at 4 months with a 3% increase. By the end of the study, people following the MF diet showed a 5% reduction in TC, which was not significant. Patients following the MF, calorie-controlled diet (phase II) showed statistically significant (p=0.0009) reductions in TC during the first 4 months, with a 14.0% reduction in TC, which continued to drop throughout the study to a 24.7% reduction at 8 months (p=0.0001) and a 30.4% (p=0.0001) reduction at 12 months. Despite the continued drop in TC from baseline, there was no significant difference (p=0.18) between the 8- and 12-month results.

Patients following the LF (phase I) diet showed the greatest reductions in TC, beginning with a 24.5% reduction (p=0.0073) at 4 months, a 37.9% reduction (p=0.0001) at 8 months, and a 39.1% reduction (p=0.0001) at 12 months. The reduction was statistically significant for each 4-month period, except for the 4 months between the months 8 and 12, when the decrease in TC persisted but was statistically insignificant (p=0.80). Those patients following the HF diet demonstrated increased TC levels from the beginning to the end of the study, with a 0.7% increase at 4 months, a 1.5% increase at 8 months, and a 4.3% increase at 12 months. This increase in TC was not statistically significant.

Further differentiation of lipid components included evaluation of changes in "bad" (LDL-C) cholesterol. Individuals following the MF diet showed a nonsignificant increase (+2.6%) in LDL-C during the first 8 months of their dietary regimen, with a subsequent reduction (p=0.38) in LDL-C by the end of the 12th month of dieting, which was 6.1% below baseline levels. Patients

following the phase II diet (MF, calorie-controlled) showed an initial reduction of 17.7% ($p=0.0014$) during the first 4 months, which continued to improve during the next 4 months, with a 31.1% ($p=0.0001$) reduction at 8 months, compared with baseline values. Further improvement was noted during the last 4 months, with a 38.8% reduction compared with baseline ($p=0.0001$) values; however, these values were not statistically different ($p=0.16$) from those seen at the end of the 8th month of dieting.

Patients following the LF (phase I) diet showed the greatest reduction in LDL-C, with a 35.2% drop ($p=0.0018$) during the first 4 months. At the end of the 8th month of dieting, patients following phase I showed a 51.2% reduction ($p=0.0001$) in LDL-C, compared with baseline values. By the end of the 12th month of dieting, phase I patients had a 52.0% reduction ($p=0.0001$) from baseline values, which was essentially unchanged from the end of the 8th month of dieting ($p=0.92$).

Finally, patients following the HF diet showed a progressive increase in LDL-C throughout the 12 months of dieting, which was 6.0% higher than baseline values ($p=$NS).

Assessment of "good" (HDL-C) cholesterol showed an initial increase of 3.4% during the first 4 months on the HF diet. This increase was not statistically significant ($p=0.72$). During the remaining 8 months of the HF diet, the HDL-C levels decreased by 1.9% at the end of the 8th month, and by 5.8% by the end of the study, compared with baseline

Table II. Percent Change From Baseline Values for Each of the Independent Variables Studied

DIET		%WT				%T/H		
MONTH	4	8	12	EFFECT	4	8	12	EFFECT
MF	0	–0.8	–2.6	↓	MF	+2.1	+3.8	–5.3	↓
Phase I	–8.0	–14.2	–18.4	↓	Phase I	–29.2	–44.3	–45.8	↓
Phase II	–5.5	–9.2	–12.6	↓	Phase II	–13.8	–27.4	–34.7	↓
HF	–7.5	–10.9	–13.7	↓	HF	–1.4	+1.8	+9.8	↑
		%TC		↓			%TG		
MF	+3.0	+1.7	–5.0	↓	MF	+6.5	+6.0	+1.0	↑
Phase I	–24.5	–37.9	–39.1	↓	Phase I	–11.8	–31.3	–37.3	↓
Phase II	–14.0	–24.7	–30.4	↓	Phase II	–17.5	–31.5	–36.9	↓
HF	+0.7	+1.5	+4.3	↑	HF	–3.5	+3.3	+5.5	↑
		%LDL					%Ho		
MF	+3.7	+2.6	–6.1	↓	MF	+7.2	+6.2	+9.7	↑
Phase I	–35.2	–51.2	–52.0	↓	Phase I	–4.2	–11.1	–13.6	↓
Phase II	–17.7	–31.1	–38.8	↓	Phase II	–9.3	–12.2	–14.6	↓
HF	+1.3	+1.5	+6.0	↑	HF	+6.8	+9.4	+12.4	↑
		%HDL					%Lp(a)		
MF	–0.8	–3.4	–1.5	↓	MF	+7.4	+7.1	+4.7	↑
Phase I	+3.6	+7.8	+9.0	↑	Phase I	–3.6	+1.1	–7.4	↓
Phase II	+1.0	+2.4	+3.6	↑	Phase II	–2.7	–5.8	–10.8	↓
HF	+3.4	–1.9	–5.8	↓	HF	+10.8	+28.3	+31.0	↑
		%Fib							
MF	–	–	–0.6	↓					
Phase I	–	–	–11.0	↓					
Phase II	–	–	–6.3	↓					
HF	–	–	+11.9	↑					

MF=moderate fat; HF=high fat; %Wt=percent change in weight; %TC=percent change in total cholesterol; %LDL=percent change in low-density lipoprotein cholesterol; %HDL=percent change in high-density lipoprotein cholesterol; %T/H=percent change in TC/HDL–C ratio; %TG=percent change in triglycerides; %Ho=percent change in homocysteine; %Lp(a)=percent change in lipoprotein(a); %Fib=percent change in fibrinogen

values. Neither decrease was statistically significant. Patients following the MF diet showed a steady and persistent decrease in HDL-C, with reductions of 0.8% at the end of the 4th month, 3.4% at the end of the 8th month, and 1.5% at the end of the 12th month, relative to baseline values. This decrease in HDL-C was not statistically significant ($p=0.81$). Increased HDL-C levels were seen in patients on both the phase I and phase II diets, as shown in Table II. These increases were not statistically significant for either group, although the greatest increase (+9.0%) in HDL-C was seen in those following the phase I diet.

Based upon the TC and HDL-C values measured for each individual, the TC/HDL-C ratios were calculated. The initial (baseline) and final (month 12) ratios for each group are shown in Table III. Patients following the HF diet initially demonstrated a 1.4% decrease, going from a ratio of 6.13 to a ratio of 6.04. This was not statistically significant, and the ratio increased to 6.24 at the end of the 8th month, representing a 1.8% increase above baseline values. By the end of the 12th month of dieting, those following the HF diet showed a 9.8% increase in TC/HDL ratios from baseline values. The ratio at the end of the 12th month was 6.73, which was not statistically significant ($p=0.44$).

Patients following the MF diet showed an initial increase at the end of both the 4th and 8th month of their dieting. The baseline ratio of 7.16 increased by 2.1%, to 7.31 by the end of the 4th month, followed by a 3.8% reduction from baseline, to 7.43 at the end of the 8th month. However, by the end of month 12, patients following the MF diet showed a 5.3% decrease compared with baseline values. This ratio of 6.78 was not significantly different from the baseline value.

Reductions in TC/HDL-C ratios were seen in patients following both the LF (phase I) and MF, calorie-controlled (phase II) diets. Those following the LF diet had an initial ratio of 7.23, which was significantly lower ($p=0.0076$) at the end of the 4th month. This was a 29.2% reduction, as shown in Table II. This decrease continued and was 4.02 at the end of the 8th month, representing a 44.3% reduction, which was significant ($p=0.0001$). A slight improvement was seen during the remaining 4 months on the LF diet, with a final ratio of 3.92, which was not significantly different ($p=0.78$) from the ratio seen at the end of the 8th month on the LF diet. Patients on the phase II diet showed a 13.8% reduction at the end of the 4th month of dieting, beginning with a ratio of 5.87. By the end of their 4th month, the ratio was 5.04 ($p=0.034$). By the end of the 8th month, the ratio had dropped by 27.4% from baseline values, to a ratio of 4.25. This change was statistically significant ($p=0.0001$). At the end of the 12th month, the ratio had decreased further to 3.82, representing a 34.7% drop from baseline ($p=0.0001$). This value was not significantly different ($p=0.78$) from the value seen after 8 months of phase II dieting.

The final component of lipid assessment consisted of TG measurements. Those individuals who followed HF diets showed an initial improvement during the first 4 months, dropping their TG levels by 3.5%; however, their TG levels increased above baseline values, by 3.3% and 5.5%, by the end of the 8th and 12th months, respectively. These increases were not statistically significant. Patients following the MF diet without calorie control showed initial increases in TGs of 6.5% after 4 months of dieting, 6.0% after 8 months of dieting, and 1.0% above baseline values following 12 months on the MF diet. These changes were not statistically significant.

Significant reductions in TG levels were seen in people following both phase I and phase II diets. Those following LF diets (phase I) showed a 37.3% reduction by the 12th month of dieting, which approached significance ($p=0.051$). People following phase II diets demonstrated a 36.9% reduction by the end of the 12th month of dieting which was statistically significant ($p=0.0095$).

The remaining three independent variables represented markers of inflammatory and clotting changes associated with coronary artery disease.[21] The first of these was homocysteine, which increased in individuals following both the MF and HF diets. While neither increase was statistically significant, those following the MF diet showed a 9.7% increase after 12 months of dieting, while those following a HF diet had a 12.4% increase. People following phase I and II diets showed 13.6%

Table III. TC/HDL-C Ratios at Baseline and at the End of Month 12 of Dieting

DIET	BASELINE TC/HDL-C RATIO	MONTH 12 TC/HDL-C RATIO
High-fat	6.13	6.73
Moderate-fat	7.16	6.78
Moderate-fat, calorie-controlled (phase II)	5.87	3.82
Low-fat (phase I)	7.23	3.92

TC/HDL-C=total/high-density lipoprotein cholesterol

and 14.6% reductions from baseline values, respectively. Those on the phase II diet approached significantly ($p=0.061$) reduced levels.

Lp(a) levels increased only in individuals following a MF or HF diet, with the MF group showing a 4.7% increase at the end of the 12th month of dieting. The increase was greater (+31.0%) for those consuming the HF diet, but these increases were not statistically significant. A reduction in Lp(a) was seen in patients following either the phase I or II diet. These decreases, of 7.4% and 10.8%, respectively, were not statistically significant.

Finally, changes in fibrinogen levels were documented, with reductions in fibrinogen seen for all diets except the HF diet, which showed an 11.9% increase by the end of 12th month of dieting. Neither this increase, nor the decreases seen in people following the MF (–0.6%), phase I (–11.0%), or phase II (–6.3%) diets were statistically significant. Changes were not due to supplemental estrogen intake and could not be accounted for on the basis of gender.

DISCUSSION

Patients who enrolled in this study included a relatively even number of men and women who, for the most part, would be considered to be middle-aged or slightly younger. The average weight entering the study was 241 pounds. Only those following the LF diet (phase I) were significantly heavier than the other groups; however, there were no differences in cardiovascular disease risk factor levels.

Despite the beliefs, practices, and desires of many people who want to lose weight suddenly, this research clearly shows that long-term weight loss requires a time commitment. For a variety of reasons, including water loss, weight loss can and does occur in the first few weeks to months; however, sustained and significant reduction in weight requires a persistent change in dietary and lifestyle habits. These reductions in weight were "statistically significant" only at the end of the year. The MF diet without caloric reduction, which is typical of or slightly better than the current American diet, did not result in weight loss, but did show worsening of some of the cardiovascular disease risk factors in as little as 1 year.

While patients following the MF diet demonstrated initial increases in TC, there was a 5% decrease by the end of the study, which was not significant. Similarly, people following HF diets showed initial increases in TC, which persisted. These increases amounted to a 4.3% increase in TC by the end of the study. Patients following both the MF, calorie-controlled diet (phase II) and the LF (phase I) diet showed significant reductions in their TC levels, which were most pronounced by the end of the 8th month of dieting. Further improvement was noted throughout the study, but was less pronounced during the last 4 months of the diets, suggesting that most of the TC reduction occurs during the first 8 months of dietary change.

Like TC, changes in LDL-C were initially worse during the first 8 months on a MF diet without calorie control; however, by the end of the 12th month, there was a nonsignificant improvement in relation to baseline values. This is in contrast to people following HF diets, where LDL-C continued to increase throughout the dieting period, with an overall 6.0 percent increase, which was not statistically significant. Those individuals who followed the MF, calorie-controlled (phase II) diet showed improvement throughout the 12 months of dieting, and like those following the LF (phase I) diet, showed most of the lipid improvement during the first 8 months of dieting, with little (but some) additional benefit occurring during the last 4 months.

Changes in HDL-C were not significantly different for any of the groups in this study despite dietary changes and recommended exercise regimens. The greatest amount of weight loss and the greatest increase in HDL-C was seen in those following the LF (phase I diet). It is possible that further increases in exercise recommendations could further augment HDL-C changes.

People who followed the phase I (LF) diet had the greatest initial TC/HDL-C ratio of 7.23. They were also the most overweight and potentially the least active. As a group, they demonstrated not only the greatest weight loss, but the greatest decrease in TC and LDL-C and the greatest increase in HDL-C, and thus the greatest decrease in the TC/HDL-C ratio. While they started with the greatest ratio (greatest risk), they ended up with the next-to-lowest ratio of 3.92. Only those following the phase II diet had a lower ratio (3.82) at the end of the 12th month of dieting. Only those individuals following the HF diet ended up with a TC/HDL-C ratio greater than what they started with, as shown in Table III.

Significant reductions in TG levels were seen only in individuals who were on calorie-controlled diets. There was no association between weight loss and actual reductions in lipid levels, including TC, LDL-C, HDL, TC/HDL ratios, and TGs. Homocysteine levels increased in individuals following HF and MF diets, which might have been due to the increased protein load on these diets, a deficiency in folate or vitamins B_6 or B_{12}, or all of the above. Those individuals on phase I and II diets, with lower protein intake, demonstrated actual reductions in homocysteine levels. In the phase I group, part of this could have been due to folic acid or vitamin B_6 and B_{12} supplementation; however, the phase II group, which had the greatest reduction in homocysteine, did not have vitamin or mineral supplementation, although their protein intake was less than that seen on either the MF, HF, or typical American diet.

Individuals consuming an HF or MF diet without caloric reduction showed increases in their Lp(a) levels,

which were not statistically significant. Improvements/reductions in Lp(a) were seen in individuals following phase I and II diets. Of the four diets, only the HF diets resulted in an increase in fibrinogen levels.

CONCLUSIONS

Efforts to lose weight have become a national concern, with more than 60% of all Americans being classified as overweight. These concerns are translated into major health problems not only for us but also for our children, as more and more of our children and teenagers are diagnosed with weight problems.[1–6] A search of the literature now reveals more than 1200 books dealing with the issue of weight loss, with almost 90% of them published during the last 5 years. Most experts would agree that caloric restriction would result in weight loss.

Recent work that we and others have published[13,14,19–21] address not only certain causes of heart disease but also the risk[15] associated with certain popular dieting methods. Still other work[8–10] has described the effects of medical and dietary changes on lipids. This is the first longitudinal study using dietary changes without medications to determine the effect of dieting on weight loss as well as assessment of risk factors known to be associated with heart disease, strokes, and peripheral vascular disease.

Each of the diets employed in this study, including MF, HF, LF (phase I), and MF, calorie-controlled (phase II) diets resulted in some degree of weight loss, although the weight loss on the MF diet was negligible. The greatest weight loss was seen in individuals following the phase I diet (1.0 lb/wk), whose caloric intake was 1300–1400 calories per day, as shown in Table I. The group that lost the second greatest amount of weight (0.6 lb/wk) were those following the HF (ketogenic) diet, with caloric intake of 1400–1500 calories per day. The group with the third greatest weight loss (0.55 lb/wk) were individuals following the phase II diet, whose caloric intakes ranged from 1500–1600 calories per day. The group with the least amount of weight loss (1.9 oz/wk) was the group following the MF diet without caloric control, who consumed an average of 2000–2200 calories per day. Regardless of the dietary program used, the key is the same; one must reduce caloric intake to lose weight. The second law of thermodynamics still applies!

However, weight loss is not the only issue that concerns us. Clearly, everyone knows someone who has been overweight and lived into his 90s without a heart attack or stroke, and everyone knows someone who was the picture of health (lean, strong, athletic) and died in his 30s while jogging, walking, or participating in some other healthful activity. Therefore, the issue of weight and weight loss alone cannot be the only factor considered as dietary programs are applied for weight loss, as we have already seen.[13–15,19–21]

In this study, significant weight loss occurred in three of the four groups. Each group kept their caloric intake to 1600 calories per day or less. As a group, the results of weight loss were significant only at the end of the year. Hence, weight loss, like weight gain, is not a sudden process but a long-term, sustained reduction in calories that takes time. Significant reductions in TC, LDL-C, and TGs were seen only in those individuals following phase I (LF) and phase II (MF, calorie-controlled) diets. The majority of the effect was seen by the end of the 8th month on the diets. Improvement seen after that was still present, but lessened. Despite continued weight loss, there was not an associated decrease in lipids. Similarly, improvements in HDL-C were seen only in people following phase I or II diets. However, these changes were minimal, suggesting little, if any, dietary effect. The greatest improvement was seen in individuals who were more active and lost the most weight.

Phase I and II individuals also demonstrated an expected improvement in TC/HDL ratios, since they had the greatest reductions in TC and improvements in HDL-C. These changes subsequently changed their risk ratios, as shown in Table III. Perhaps most interesting were the increased levels of homocysteine, Lp(a), and fibrinogen seen in patients following HF diets. These factors appeared to be more dietary and less related to vitamin and mineral supplementation, as suggested by comparing the results in patients following the phase II diet and those following the HF diet, none of whom took additional supplements, as did those following the phase I diet.

In the end, people following an MF diet without caloric restrictions neither gained nor lost weight. They also appeared to have little appreciable change in their risk factors for heart disease, although the cumulative effect of each of these risk factors would confer an increased risk of heart disease, later if not sooner. People following either LF or MF, calorie-controlled diets not only showed weight loss but experienced reductions in all of the risk factors for heart disease, strokes, and peripheral vascular disease. Those following HF diets may have lost weight, but at the price of increased cardiovascular risk factors, including increased LDL-C, increased TGs, increased TC, decreased HDL-C, increased TC/HDL ratios, and increased homocysteine, Lp(a), and fibrinogen levels. These increased risk factors not only increase the risk of heart disease, but also the risk of strokes, peripheral vascular disease, and blood clots.

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ERRATUM

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The Effect of High-, Moderate-, and Low-Fat Diets on Weight Loss and Cardiovascular Risk Factors
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The author noted the following:

- Page 110: In the abstract, the number of subjects following the high-fat diet should have been 18.
- Page 111: The last sentence of the first paragraph under the heading "Methods" should have read as follows:
  "Patients had to commit to staying on the dietary regimen for a minimum of 1 year and were randomly assigned to one of the four dietary regimens."
- Page 112: A portion of the figure was scaled incorrectly; it should have appeared as follows: