A Clinical Trial of the American Heart Association Step One Diet for Treatment of Hypercholesterolemia

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Background. Although diet therapy is the primary treatment for hypercholesterolemia, a trial to determine the effectiveness of the new American Heart Association Step One Diet (AHA diet) in lowering cholesterol has to our knowledge never been carried out.

Methods. A clinical trial was conducted to assess the plasma lipids response and adherence to the AHA diet in 120 men and women with hypercholesterolemia. All subjects were advised to follow the AHA diet for 18 weeks.

Results. After 6 weeks of the AHA diet intervention, there were modest but significant reductions in plasma total cholesterol (−2.6%) and low-density lipoprotein (LDL) cholesterol (−3.5%), but no further significant reductions were observed thereafter. Rather, there was a tendency to return to and even exceed baseline levels of total cholesterol and LDL cholesterol over the subsequent 12 weeks, in spite of the subjects' reported continued adherence to the AHA diet and maintenance of weight loss throughout the entire study period. Nevertheless, 51% of the subjects had experienced improvement (−0.2% to −26.3%) in their plasma LDL cholesterol levels by the end of the study.

Conclusions. A probable reason for the limited response of the diet was low baseline levels in intake of saturated fat and cholesterol by participants. The subjects who were older and had higher levels of plasma LDL cholesterol and total fat intake at baseline experienced better plasma LDL cholesterol response to the AHA diet. Thus, practicing physicians should consider assessing the baseline dietary fat and cholesterol intake of patients with hypercholesterolemia before starting the AHA diet, since patients may already be following a relatively prudent self-selected diet. Additional dietary gains in lipid management might well require a more severe restriction of dietary fats and cholesterol. Long-term efficacy of the AHA diet should also be evaluated clinically with periodic lipid profiles.

Key words. Clinical trials; hypercholesterolemia; diet. *J Fam Pract 1991; 33:249-254.*

Diet therapy is the primary treatment for hypercholesterolemia. Reduction in total fat intake has been recommended by numerous national bodies.[1–8] Many dietary intervention studies involving qualitative and quantitative modification of fat intake have demonstrated the feasibility and efficacy of reducing plasma cholesterol by nutritional means.[9–12] The widely recognized old American Heart Association diet lowered plasma cholesterol from 5% to 7% over a long period and had little effect on fasting plasma triglycerides.[13,14] However, the 5% to 7% reduction recorded with the old American Heart Association diet is less than the decreases (10% to 20%) recorded with a similar diet during the past 30 years.[15]

Recently, the Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults provided the rationale for dietary change, outlined the vehicle for that change (ie, the Step One and Step Two diets), recommended treatment goals, and suggested how to monitor behavioral change.[16] A trial of the new Step One Diet recommended by the American Heart Association (AHA) for the management of hypercholesterolemia, however, has never been carried out.

The purpose of this study was to assess the efficacy of the AHA Step One Diet on the level of plasma lipids in hypercholesterolemia. The study emanates from the concern that the efficacy of this diet has never been proven, and that an untested diet is being recommended on the basis of suggestive evidence obtained in tests of a different diet.

Submitted, revised, June 6, 1991.

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ISSN 0094-3509

Methods

Recruitment

Potential subjects were initially identified from family practice clinics and community-based cholesterol screening programs. Cholesterol results from these various settings were merely used to target likely candidates for the study, but they were not used in the analysis of lipid results. Individuals were invited to be further screened for the study if they were between 20 and 70 years of age and had a previously recorded plasma total cholesterol between the 50th and 95th percentile for age and sex, as outlined by the Lipid Research Clinics.[17] Exclusion criteria included a history of diabetes, drug or alcohol abuse, use of lipid-lowering drugs, previous surgical treatment to lower the plasma lipids level, weight more than 20% above or below the ideal for height and sex, and pregnancy.

Two additional baseline fasting lipid profiles were obtained for eligible subjects: total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides. Subjects whose LDL cholesterol levels were between the 50th and 95th percentile for age and sex, based on the mean of the two baseline measurements, were invited to participate in this study. One hundred twenty participants gave informed consent for the study, which was approved by the Human Subjects Review Committee of the University of Minnesota.

Study Design

After initial enrollment, all participants were asked to attend a 2-hour nutrition education session on the AHA diet taught by a registered dietitian. Throughout the study a dietitian was available by telephone to answer diet-related questions. Recipes were included in a mailing that was sent to all subjects during each 6-week treatment period, and each subject received one telephone call from a dietitian to review his or her diet during the first 6-week period (3rd to 4th week). Some subjects were also called by a dietitian if food records needed clarification. The recommended eating pattern for the AHA Step One Diet provided guidelines for isocaloric reduction in total fat to not more than 30% of total calories, with saturated fatty acids comprising less than 10% of total calories. Dietary cholesterol intake was limited to 300 mg/d. Participants were advised to follow the AHA diet for the study duration (18 weeks) and encouraged to make it a lifelong eating pattern. Subjects were instructed in the maintenance of food records and informed that dietary adherence would be monitored every 6 weeks by analysis of 4-day records, including one weekend day. They were also asked to try to maintain present weight throughout the study period. Food records were coded by nutritionists trained and certified in the methodology of the Nutrition Coordinating Center at the University of Minnesota.

Measurements

Baseline screening and all subsequent blood samples for lipid measurements were obtained using a standardized protocol, and all blood samples were fasting morning specimens. Lipid measurements on plasma samples were done at the University of Minnesota Lipid Research Laboratory, a facility certified by the Lipid Standardization Program of the Centers for Disease Control (CDC). Total cholesterol and triglycerides were determined by enzymatic methods on a Roche COBAS analyzer (Roche Laboratories, Montclair, NJ). HDL cholesterol was measured in the supernatant after plasma was precipitated with heparin-manganese. LDL cholesterol was calculated as described by Friedwald and his associates.[18] To enhance the representativeness of the lipid measurements, the lipid values were obtained by drawing fasting morning samples on three consecutive and separate days and were then averaged. The averaged values were used in the analysis to reduce some of the individual sample variability that might have been present if only single samples had been used.

Dietary intake, including fat and cholesterol, was measured at baseline by means of a self-administered food frequency questionnaire.[19] Analysis was done with an optically scanned computerized nutrient databank. Four-day food records, including one weekend day, were collected. Food records were analyzed by the University of Minnesota Nutrient Data System Version 1.3. Body weight was measured in indoor clothing without shoes.

The above measures were repeated during week 6, week 12, and week 18.

Analysis

The main goal of dietary intervention in this study was to improve the level of plasma lipids. The mean percent change from baseline in the level of plasma lipids was used as the dependent variable for analysis. Paired *t* tests were performed to assess the statistical significance of percent changes from baseline in the level of plasma lipids. Adherence to the AHA diet was also evaluated using paired *t* tests for mean changes from baseline in nutrient intake.

According to whether the plasma LDL cholesterol

level showed improvement or no improvement at the end of the study, all study subjects were grouped into either respondents or nonrespondents. Then the comparison between the two groups was made in baseline characteristics, baseline nutrient intake, and dietary adherence. Student's *t* tests were used for the continuous variables, and chi-square tests for the categorical variables. A cut-off level of $P < .05$ was used for assessing statistical significance.

Results

Of the 120 subjects initially enrolled, 87 (73%) completed the study. No significant differences were observed between participants and nonparticipants in baseline characteristics, including age, sex, and plasma lipids level. Subjects who had dropped out were contacted to determine the reasons for discontinuing the study. The great majority of dropouts left the study because of the inconvenience of participating, work or family conflicts, other medical problems, or moving out of town. There were no apparent patterns or characteristics of dropout subjects that would appear to compromise the study conclusions.

Baseline characteristics of the participants who completed the study are presented in Table 1. There were 49 men and 38 women, and the mean age of participants was 50.1 ± 11.2 years. The mean total cholesterol level was 6.28 ± 0.75 mmol/L (243 ± 29 mg/dL), and the mean LDL cholesterol level was 4.37 ± 0.67 mmol/L (169 ± 26 mg/dL).

Table 2 shows the percent changes from baseline in the level of plasma lipids. After 6 weeks of the AHA diet intervention, there were modest but significant ($P < .01$) reductions in mean plasma total cholesterol (−2.6%) and LDL cholesterol (−3.5%), but no further reduction was observed at the end of week 12 (total cholesterol, −0.7%, LDL cholesterol, −1.7%) or week 18 (total cholesterol, 1.1%, LDL cholesterol, 0.9%). Rather, the values of total cholesterol and LDL cholesterol demonstrated a tendency to return to and even exceed their original baseline levels over the subsequent 12 weeks of the study (Figure 1). There were also small increases in HDL cholesterol (2.1%) and triglycerides (3.8%) and a small decrease in the ratio of total cholesterol to HDL cholesterol (−0.8%) at the end of the study (Table 2).

Table 1. Baseline Characteristics of Subjects (n = 87)*

Variable	Mean ± SD
Age (y)	50.1 ± 11.2
Height (m)	1.71 ± 0.12
Weight (kg)	76.0 ± 13.6
Total cholesterol (mmol/L)	6.28 ± 0.75 (243 ± 29 mg/dL)
LDL cholesterol (mmol/L)	4.37 ± 0.67 (169 ± 26 mg/dL)
HDL cholesterol (mmol/L)	1.27 ± 0.34 (49 ± 13 mg/dL)
Triglycerides (mmol/L)	1.45 ± 0.59 (128 ± 52 mg/dL)
Total cholesterol/HDL cholesterol	5.3 ± 1.4

**56% were male, 44% female.*
SD denotes standard deviation; LDL, low-density lipoprotein; HDL, high-density lipoproteins.

Table 2. Mean Percent Change* from Baseline in Value of Serum Lipids

Variable	Week 6	Week 12	Week 18
Total cholesterol	−2.6†	−0.7	1.1
LDL cholesterol	−3.5†	−1.7	0.9
HDL cholesterol	1.3	1.1	2.1
Triglycerides	3.0	4.1	3.8
Ratio of total cholesterol to HDL cholesterol	−1.8	−1.6	−0.8

$$*\textit{Percent change} = \frac{\textit{follow-up value} - \textit{baseline value}}{\textit{baseline value}} \times 100.$$

†$P < .01$.
LDL denotes low-density lipoprotein; HDL, high-density lipoprotein.

Dietary assessment at baseline showed that the mean intake of total fat was 31.6% of total calories; saturated fatty acids (SFA), 10.6%; polyunsaturated fatty acids (PFA), 6.8%; monounsaturated fatty acids (MFA), 11.5%; and dietary cholesterol, 232 mg/d (Table 3). Six weeks after initiating the AHA diet, the reported total fat, SFA, and dietary cholesterol levels were reduced; but PFA and MFA intakes were not increased (Table 4). During the subsequent 12 weeks, all participants reported continued adherence to the AHA diet, generally at levels similar to those reported at week 6 except for a sizable decrease in dietary cholesterol level. Mean intake of total calories at baseline was 1975 kcal/d (Table 3). The overall mean intake for all participants was 1793 kcal/d during the entire study period. There was a slight decrease in mean body weight throughout the entire study period (Table 4). Reported mean intake of water-soluble fiber at baseline was 5.9 g/d (Table 3).

Fifty-one percent of the subjects experienced improvement (range, −0.2% to −26.3%) in their plasma LDL cholesterol levels at the end of the study; 11.5% of the subjects experienced a reduction of more than 10% in plasma LDL cholesterol, 15.0% experienced a reduction of between 5% and 10%, 24.1% a reduction of between 0% and 5%, and 49.4% no reduction. The subjects who were older ($P < .05$) and who had higher levels of plasma LDL cholesterol ($P < .05$) and higher levels of total fat intake ($P < .05$) and polyunsaturated fatty acids ($P < .01$) at baseline experienced better plasma LDL cholesterol response to the AHA diet (Table 5). There was no

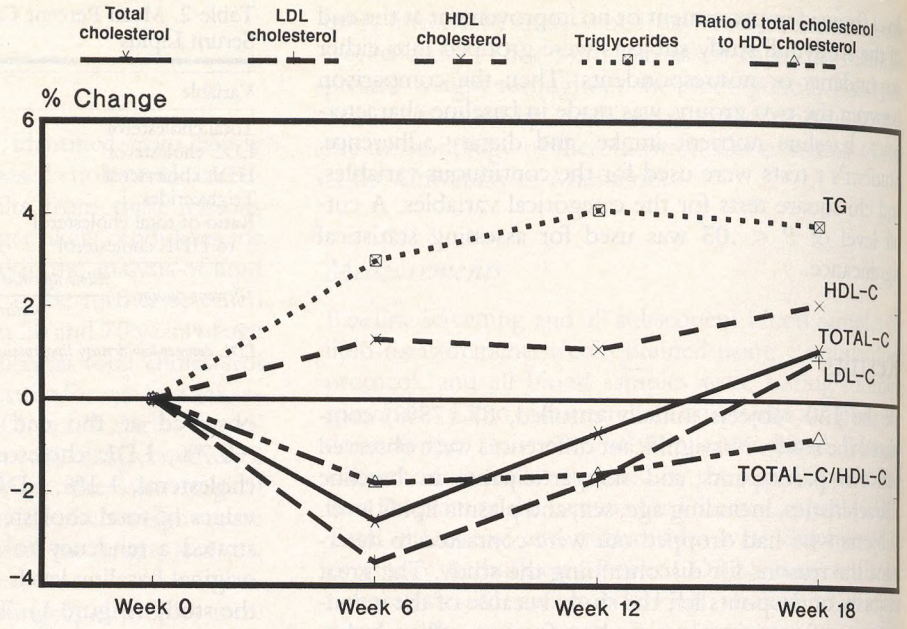

Figure 1. Mean percent changes in the value of serum lipids from baseline to that at 18 weeks in a group of 87 men and women with hypercholesterolemia participating in a clinical trial of the American Heart Association Step One Diet.

significant difference, however, between respondents and nonrespondents in dietary adherence to the AHA diet.

Discussion

Practicing physicians now have the capability, as well as the responsibility, to treat hypercholesterolemia. Historically, diet has been a common-sense approach to the control of plasma cholesterol levels. The American Heart Association defines the Step One Diet as one that limits fat intake to less than 30% of total calories, saturated fatty acids to less than 10% of total calories, and dietary cholesterol to 300 mg/d.[16] Those whose response to the Step One Diet is limited should progress to the Step Two Diet or to another trial on the Step One Diet. If the desired goal for lowering total cholesterol (and for lowering LDL cholesterol) has been attained, long-term monitoring can begin. If not, drug therapy should be considered. Drug therapy should be added to dietary therapy rather than substituted for it.

Table 3. Mean Baseline Nutrient Intake of Subjects Who Completed the Study

Variable	Mean ± SD
Total fat (% calories)	31.6 ± 6.1
SFA (% calories)	10.6 ± 2.4
PFA (% calories)	6.8 ± 1.6
MFA (% calories)	11.5 ± 2.7
Carbohydrate (% calories)	50.3 ± 6.8
Protein (% calories)	16.8 ± 2.8
Cholesterol (mg/d)	232 ± 96
Water-soluble fiber (g/d)	5.9 ± 2.2
Total calories (kcal/d)	1975 ± 617

SD denotes standard deviation; SFA, saturated fatty acids; PFA, polyunsaturated fatty acids; MFA, monounsaturated fatty acids.

Despite continued adherence to the AHA dietary recommendation and maintenance of weight loss throughout the entire study period in this study, the new AHA Step One fat-modified diet was not effective in improving the level of plasma lipids. A probable reason for the apparent failure of the diet, as was the case in the study by Van Horn et al,[20] was an already low baseline level of intake of saturated fatty acids and cholesterol by participants. All participants knew of their hypercholesterolemia before starting the study, and many had already been following a self-developed prudent diet. Consequently, there was a relatively small net change in the dietary fat and cholesterol with the recommended AHA fat-modified diet and, hence, only a small net change in the level of total cholesterol and LDL cholesterol.

This study also demonstrated that the values of total cholesterol and LDL cholesterol returned to and even exceeded their original baseline levels during the study period (Figure 1). The reason for this finding remains uncertain; it is unlikely that it is due solely to a low baseline level of intake of saturated fatty acids and cholesterol by participants. It was expected that subjects would have at least maintained their initial reductions in the level of total cholesterol and LDL cholesterol, considering good adherence to the diet during the entire study period. It is possible that subjects were progressively less adherent to the prescribed AHA diet but failed to report this behavioral change in their food records. Subjects were encouraged to maintain accurate food records and not change eating habits on the days recorded.

Table 4. Mean Changes in Nutrient Intake from Baseline to Week 18

Variable	Week 6 Mean ± SD	Week 12 Mean ± SD	Week 18 Mean ± SD
Total fat (% calories)	−2.7 ± 8.8*	−2.0 ± 9.4	−2.4 ± 8.4*
SFA (% calories)	−1.6 ± 3.5*	−1.5 ± 3.2*	−1.6 ± 3.2*
PFA (% calories)	−0.1 ± 2.8	0.4 ± 3.3	−0.1 ± 2.5
MFA (% calories)	−0.6 ± 3.9	−0.6 ± 3.9	−0.5 ± 3.8
Carbohydrate (% calories)	1.7 ± 10.8	2.1 ± 10.2	2.7 ± 9.5*
Protein (% calories)	0.9 ± 3.9	0.2 ± 3.7	0.1 ± 3.8
Cholesterol (mg/d)	−19 ± 204	−46 ± 140*	−51 ± 124*
Water-soluble fiber (g/d)	1.0 ± 3.6*	0.4 ± 2.9	−0.2 ± 2.8
Total calories (kcal/d)	−127 ± 686	−150 ± 749	−243 ± 687*
Weight (kg)	−0.6 ± 2.6	−1.1 ± 2.0*	−2.4 ± 2.5*

*$P < .01$.
SD denotes standard deviation; SFA, saturated fatty acids; PFA, polyunsaturated fatty acids; MFA, monounsaturated fatty acids.

They were specifically urged not to attempt to have the food records reflect a more idealized eating behavior than their actual experience, since that would confound the interpretation of the plasma lipid results. Despite these directives, it is human nature to want to appear adherent, and this factor may have contributed to the apparent failure of the diet. An indirect but objective indication that subjects were generally adherent to the diet is that they continued to gradually lose weight throughout the study.

It is noteworthy that there was a slight increase in the HDL cholesterol level at the end of the study (Table 2). This improved HDL cholesterol level resulted in a small decrease in the ratio of total cholesterol to HDL cholesterol, even though the LDL cholesterol level exceeded its baseline at the end of the study. The improvements in the levels of HDL cholesterol and the ratios of total cholesterol to HDL cholesterol during the study were not significant, however.

Even though this study showed no improvement in the mean plasma LDL cholesterol level for the group at the end of the study, 51% of the subjects did experience improvement. This made it possible to identify several baseline characteristics that were associated with a positive response: older subjects, higher LDL cholesterol levels, and an increased intake of total and polyunsaturated fat.

Since the National Cholesterol Education Program has published specific guidelines for the assessment of cardiovascular risk and goals for laboratory accuracy,[21] there has been considerable discussion about the biologic and analytic variability associated with cholesterol testing.[22–25] Factors that can affect individual variability in cholesterol levels include, but are not limited to, age, sex, diurnal variation, seasonal variation, exercise, weight change, dehydration, disease states, medications, and diet. Analytic variability can also be significant and can be affected by method of analysis, technique, specimen handling, and even minor factors such as the position of subject at phlebotomy and the length of tourniquet time. The relatively small mean changes in lipid levels in this study would all be considered within the range of analytic and biologic variability for individual testing. The standardized protocol for blood collection and handling,

Table 5. Comparison of Baseline Characteristics Between Respondents and Nonrespondents

Variable	Respondents (n=44)* Mean ± SD	Nonrespondents (n=43)† Mean ± SD
Age	52.6 ± 10.2	47.4 ± 11.8‡
Height (m)	1.73 ± 0.10	1.69 ± 0.13
Weight (kg)	76.0 ± 13.6	75.3 ± 16.2
Total cholesterol (mmol/L)	6.41 ± 0.67 (248 ± 26 mg/dL)	6.14 ± 0.80 (237 ± 31 mg/dL)
LDL cholesterol (mmol/L)	4.50 ± 0.62 (174 ± 24 mg/dL)	4.19 ± 0.65‡ (162 ± 25 mg/dL)
HDL cholesterol (mmol/L)	1.27 ± 0.31 (49 ± 12 mg/dL)	1.27 ± 0.34 (49 ± 13 mg/dL)
Triglycerides (mmol/L)	1.39 ± 0.53 (123 ± 47 mg/dL)	1.50 ± 0.64 (133 ± 57 mg/dL)
Total cholesterol/HDL cholesterol	5.3 ± 1.3	5.2 ± 1.5

**60% were male, 40% female*
†*59% were male, 41% female.*
‡*$P < .05$.*
SD denotes standard deviation; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

the CDC-controlled laboratory methods, and the averaging of three separate blood samples for each individual study endpoint were all incorporated to improve the accuracy of cholesterol measurement and strengthen the interpretation of group differences in this study.

This study's findings demonstrated that it is important that practicing physicians assess the baseline dietary fat and cholesterol intake of patients with hypercholesterolemia before starting dietary therapy. It appears that it is rather commonplace for subjects who are aware of their elevated cholesterol levels to have already initiated prudent eating habits. The patient who is effectively on a fat-modified diet may indeed feel like a treatment failure if there is no lipid improvement after formal instruction and implementation of the AHA Step One Diet. If initial dietary assessment of a patient indicates persistent hypercholesterolemia in the face of a relatively prudent diet, then the physician would be advised to initiate the Step Two Diet, or perhaps even consider going to pharmacologic intervention if lipids levels are very high.

This study simulated the real world of clinical practice in using only one formal instruction session and periodic encouragement in the form of diet record review and occasional mailed recipes. Support by means of additional counseling sessions may be needed if patients are to be expected to consistently make nutritious food selections.

Whether the participants in this study would respond to continued therapy over an extended period or would benefit from progression to the Step Two Diet are unanswered questions. Future research would be beneficial.

The major limitations of this study are the absence of a control group, and the short duration of the study. Long-term prospective studies with a control group should be performed. These studies should examine (1) the effectiveness of the AHA Step One Diet, (2) adherence to the AHA diet, (3) nutritional adequacy of the AHA diet for the treatment of hypercholesterolemia, and (4) dietary intervention in special groups, such as the elderly population and diabetic patients.

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