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Comparative Effects of Physical Training and Diet in Normalizing Serum Lipids in Men with Type IV Hyperlipoproteinemia

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SUMMARY The effect of mild physical training (PT) (group A), Type IV hyperlipoproteinemia (HLP) diet (group B), and PT plus Type IV HLP diet on serum lipids (group C) in 46 men with Type IV HLP was studied. Significant reductions in mean triglyceride (TG) levels from 163, 229, 196, to 136, 145, 116 mg/100 ml serum were found for groups A, B, and C, respectively. Following six weeks of intervention, cholesterol levels also dropped for all groups with the greatest reductions occurring in groups B and C. Minimal weight

losses were found for all groups while groups A and C displayed significant reductions in body fatness, but both of these changes appeared independent of lipid reductions.

It was concluded that either mild PT or HLP diet or both are effective means of lowering TG levels in Type IV HLP individuals. Furthermore, it appears that patients need to participate regularly in formal programs in order to maintain adherence to these interventions.

HYPERTRIGLYCERIDEMIA is often associated with hyperprebetalipoproteinemia (Type IV HLP), and hypertriglyceridemia has in turn been recognized as one of the metabolic disorders associated with coronary heart disease.^{1, 2} While dietary management is a recognized means of reducing serum triglyceride (TG) levels,^{3, 4} there is evidence that physical activity may also be a means of lowering serum triglyceride concentrations.^{5, 6} However, little is known about the comparative effectiveness of these interventions in normalizing hypertriglyceridemia in men with Type IV HLP. Therefore, the purpose of this study was to compare the effectiveness of physical training, of dietary management, and of physical training and dietary management combined, in reducing serum TG concentrations. In addition, we investigated the effect of these interventions on

serum cholesterol and insulin levels and on the presence or absence of prebeta lipoprotein bands on paper electrophoresis.

Methods

Subjects

Forty-six men with Type IV HLP were selected from a group of approximately 400 faculty members identified as having hyperlipidemia during examinations in the Periodic Health Appraisal Unit, The University of Michigan. Type IV HLP was defined as fasting serum TG levels greater than 150 mg/100 ml plus the presence of a definite prebeta band on lipoprotein electrophoresis,⁷ and the absence of fasting chylomicronemia. Criteria for exclusion from the study included persons with insulin-dependent diabetes; those receiving drugs which affect lipid metabolism; and those having cardiac or other medical conditions that would contraindicate physical training. Informed consent was obtained from each subject prior to his commencement of the study.

Each subject had three 12-hour postabsorptive blood samples drawn on consecutive mornings to establish baseline serum lipid levels and to ensure that at least two of the three initial values met the above criteria. Weight was measured at each visit; during one of the initial three visits, anthropometric measurements were made. Following the blood

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sample on the third visit, instructions were given for performing the graded exercise test, and each subject was allowed one to two minutes of practice walking on the motordriven treadmill. Approximately two days following this practice session, each subject performed a graded exercise test on a treadmill at a speed of three mph as described by Montoye et al.⁸ Each subject was encouraged to walk to exhaustion to determine his maximal oxygen uptake (Max $\dot{V}O_2$). During this test a bipolar C_{M_5} (V_5 and manubrium) electrocardiogram was monitored, and blood pressures were obtained by auscultation to determine whether any excessive pressor response to exercise was present. The data from this initial test were used to determine the work intensity, duration, and the characteristics of the individualized physical training programs to be subsequently prescribed.

Prior to the initiation of the study, a diet history was taken by a dietitian using a three-day diet record for two typical work days and one weekend day, and by dietary interviewing in the form of food-frequency questioning. From these data, the customary caloric consumption and composition of the diet for each subject were calculated. Included in this composition were: percent of protein, fat, carbohydrate and alcohol; polyunsaturated/saturated fat ratio; sugars/starch ratio as percent of carbohydrate calories; mg dietary cholesterol; mg caffeine; and meal patterns (distribution of calories).

Following these initial determinations, subjects were randomly assigned to one of three groups: physical training (group A); dietary management (group B); and physical training together with dietary management (group C). Midway (3 weeks) through the study, one blood sample was drawn (12 hours fasting, 24 hours after the last exercise bout) for biochemical blood studies (serum lipids, lipoprotein electrophoresis, and insulin values). During this visit for blood drawing, diet compliance and body weights were checked to assure adherence to the experimental protocol. At the end of the experimental period, biochemical tests, cardiovascular stress testing, and anthropometric measurements were performed on each subject according to the same protocol as previously described for obtaining baseline values. At the conclusion of the study, a Type IV HLP diet was given to those subjects who received only physical training (group A), and physical training instructions were given to those subjects who received only dietary management (group B).

An evaluation of fasting serum lipids was made on 36 of the subjects approximately one year later. During this visit, body weights were taken and a questionnaire was given to each subject to obtain information regarding his current physical activity and dietary status.

Analytical Methods

Serum cholesterol and triglyceride concentrations were determined according to the method of Block et al.⁹ and the method of Block and Jarrett¹⁰ respectively. Paper lipoprotein electrophoresis was done by the method of Lees and Hatch,¹¹ and serum insulin levels were determined by the method of Morgan.¹² Determinations of lean body mass, percent fat, and body weight were determined as described by Faulkner.¹³ Bicristal and biacromial measurements were obtained and used to determine frame size. Ideal weight was

then determined using Metropolitan Life Insurance tables.¹⁴ Minute ventilation was measured by a Parkinson-Cowan Dry Gas Meter. A Godard Capnograph and Beckman O_2 analyzer (Model F-3) were used for measuring concentrations of expired CO_2 and O_2 , respectively. These measurements were used to calculate maximum oxygen consumption (functional capacity) according to standard formulas.¹⁵

Intervention: Physical Training

Subjects in groups A and C were given training programs which consisted of fast walking, jogging, or cycling. The prescribed intensity of the activity was based on 70% of their maximum heart rate obtained during their graded exercise test. Subjects were asked to maintain this exercise-induced heart rate for 30 min three days per week. Since the subjects were exercised without supervision, they were asked to keep a daily log book in which their routine workouts and any supplementary exercise could be recorded.

Intervention: Dietary Management

Subjects in groups B and C were given a Type IV hyperlipoproteinemia diet⁴ with calories prescribed so as to maintain constant weight. This was done in an attempt to exclude the variable of weight loss from this study. The Type IV diet consisted of 20% protein, 40% fat, and 40% carbohydrate. The carbohydrate was divided into 30% sugars and 70% starch, while the polyunsaturated to saturated fat ratio was 1:1. Alcohol intake was limited to the following: not more than one bottle of beer per day, or one four ounce glass of wine per day or 1.5 ounce of hard liquor per day. The exercise group (group A) remained on an ad libitum diet and was instructed to increase total calories if needed for weight maintenance, but to do so by keeping the percentages of protein, carbohydrate and fat and other nutrients unchanged. Adherence to the diets for each group was monitored by dietitian interviews at the third and sixth week intervals.

Statistical Methods

Serum lipid and insulin data obtained from this study were analyzed using a repeated measures analysis of variance design.¹⁶ This statistical method was applicable since the same individuals had measurements repeated at three time points (baseline, three weeks, and at completion of six weeks intervention). Basically, use of this technique allows for partitioning the data into components measuring differences among the intervention groups (groups A, B, C averaged over time), differences over time within groups (averaged over individuals), different patterns over time among the three intervention groups (group by time interaction), and an error term.

A number of other statistical techniques were used in the analysis, primarily to verify that the assumptions for the analysis of variance (ANOVA) were not seriously violated. A one-way analysis of variance was used on the values at the baseline, to insure that the randomization was valid. An analysis of covariance was used, with weight as the covariate, to determine whether differences in the serum lipids were due to inadvertent changes in body weight. Finally, correlation matrices were calculated, both as a

TABLE 1. *Baseline Characteristics for Each Group*

Group	Age (yr)	Height (cm)	Weight (kg)	Percent ideal weight* (%)	Bicristal diameter (cm)	Bicromial diameter (cm)	Adipose mass† (%)
Group A (physical training) N = 15	44 ± 7.8	178.2 ± 9.2	79.3 ± 11.7	114.1 ± 20.0	29.4 ± 2.3	35.3 ± 2.1	15.7 ± 3.5
Group B (diet) N = 16	45 ± 6.2	180.0 ± 9.0	83.9 ± 13.2	119.9 ± 22.9	30.2 ± 1.6	35.6 ± 1.8	15.5 ± 3.3
Group C (physical training + diet) N = 15	47 ± 5.6	181.0 ± 5.4	84.7 ± 10.7	118.1 ± 19.1	30.2 ± 1.8	34.0 ± 3.1	16.9 ± 3.1

Data expressed as mean ± SD.

No significant among-group differences were found for any of these baseline measures.

*Metropolitan Life Insurance Tables, 1959¹⁴.

†Determinations based on skinfold measurements (see Methods and reference 13).

check on the assumptions of the covariance analysis made in the ANOVA and also to describe relationships among other variables. Computation for these analyses was performed using the University of Michigan Statistical Research Laboratory MIDAS program.¹⁷

Results

Baseline Measurements

Baseline characteristics and anthropometric measurements for each group are presented in table 1. Serum lipids and insulin levels, maximum oxygen capacity ($\dot{V}O_2$), body weights, relative weight and body fatness, and dietary intake data at baseline are presented in tables 2, 3, 4, and 5. Periods I, II, and III indicated in these tables are defined as follows: baseline measures, measures taken three weeks following intervention, and measures taken following six weeks of intervention, respectively. The results of a one-way analysis of variance used on all the above baseline values showed no

significant differences at the 5% level among the groups (A, B, and C) for all baseline values except baseline maximum $\dot{V}O_2$ values. This was true for maximum oxygen capacity values whether these data were expressed as L/min or ml/kg/min. However, since the subjects served as their own controls in assessing the effects of the three interventions, this difference among groups does not pose a problem in further analysis of the data.

Effects of Interventions on Serum Lipids and Insulin

Serum cholesterol, triglycerides, and insulin values are presented in table 2. Comparison of data from Periods II and III (averaged over time) showed significant among-group differences ($P < 0.05$). The diet group and the diet plus physical training groups had lower mean cholesterol levels than did the physical training group. There was a significant difference over time in the mean cholesterol levels in all three groups ($P < 0.001$). The mean cholesterol levels were reduced over time, the largest reduction occurring

TABLE 2. *Effect of Physical Training, Type IV HLP diet, and Physical Training Plus Diet on Serum Cholesterol, Triglyceride, and Insulin Concentrations.*

Group	Metabolic Variable	Period I (baseline)	Period II (at 3 weeks)	Period III (at 6 weeks)
Group A (physical training) N = 15	Cholesterol***, *	219.3 ± 6.2	207.2 ± 4.8	212.6 ± 5.4
	(mg/100 ml)			
	Triglycerides***, **	163.0 ± 23.4	154.0 ± 23.2	135.5 ± 19.4
	(mg/100 ml)			
	Insulin***	9.9 ± 1.8	7.2 ± 1.3	10.3 ± 2.8
	(μU/ml)			
Group B (diet) N = 16	Cholesterol***, *	204.5 ± 10.8	183.8 ± 8.5	187.6 ± 9.7
	(mg/100 ml)			
	Triglycerides***, **	229.3 ± 36.4	135.1 ± 17.1	144.5 ± 25.0
	(mg/100 ml)			
	Insulin***	17.5 ± 4.9	7.2 ± 1.6	11.7 ± 2.2
	(μU/ml)			
Group C (physical training + diet) N = 15	Cholesterol***, *	200.0 ± 7.0	182.6 ± 6.7	180.7 ± 5.3
	(mg/100 ml)			
	Triglycerides***, **	195.9 ± 21.0	110.5 ± 12.3	116.0 ± 12.1
	(mg/100 ml)			
	Insulin***	11.9 ± 1.3	6.8 ± 1.8	11.3 ± 2.4
	(μU/ml)			

Data expressed as mean ± SEM.

No significant among-group differences were found for these baseline measures (by ANOVA).

Differences among and within groups were tested using repeated measures analysis of variance design.

*Significant differences among groups.

**Significant differences among groups.

***Significantly different pattern of response (interaction analysis).

***Significant differences in means over time (within group analysis).

TABLE 3. Oxygen Uptake at Subjective Maximum Exercise Before and After Experimental Period

Group	Period I (Baseline) Subjective max exercise (Max $\dot{V}O_2$) (L/min)	Period III (at 6 weeks) Subjective max exercise (Max $\dot{V}O_2$) (L/min)
Group A (Physical training) N = 15	2.55 \pm 0.16	2.73 \pm 0.15
Group B (Diet) N = 16	2.40 \pm 0.12	2.41 \pm 0.14
Group C* (Physical training and diet) N = 14	2.94 \pm 0.11	3.06 \pm 0.12

Data expressed as mean \pm SEM.Analysis by ANOVA and paired *t*-tests.

Significant among-group differences were found for both the baseline and final measures.

*Initial and final results from one patient were omitted since he was prematurely stopped during his second treadmill test due to electrocardiographic ST-segment changes (see page 656).

between Periods I and II, with mean cholesterol levels tending to stabilize following this initial reduction. There was no significant group-by-time interaction. That is, essentially the same pattern of reduction over time was observed in the three groups, but the magnitude of the cholesterol reduction was smallest in the physical training group (group A).

Logarithms of the triglyceride values reported in table 2 were used in the analysis since the distribution of the original values was quite skewed. Taking data averaged over time from Periods II and III, we found no significant differences in the mean triglyceride values among the groups. However, there was a significant difference within each group over

time with the mean triglyceride values, showing a reduction over time ($P < 0.001$). Most of the reduction occurred from Period I to Period II, but there was some continued reduction to Period III in the physical training group. There was also a significant ($P < 0.05$) group-by-time interaction among the mean triglyceride values. Thus, although the intergroup differences averaged from Periods II and III were not significant, there was a difference in the pattern of mean triglyceride levels over time among the three groups. Data in table 2 show that group A exhibited a gradual, continued reduction in triglyceride levels over the entire period, while group B and, even more so, group C showed a large initial reduction followed by a slight rise in the triglyceride level at Period III. The amount of this increase at Period III for groups B and C was quite small, and represented no significant change from measurements obtained at Period II. A correlation coefficient ($r = 0.58$) was found between initial serum triglyceride levels and absolute changes in triglycerides in the dietary group (group B) while only a weak correlation ($r = 0.38$) was found between these same measurements for the training group (group A).

A logarithmic transformation of the insulin concentrations presented in table 2 was also used before analysis to improve normality and stabilize variance. The high mean fasting insulin value with a high standard error for group B at Period I is primarily due to one subject having a value of $83 \mu\text{U/ml}$. This value was found even though this subject stated that he had fasted and had no medical history of diabetes mellitus; he was not markedly overweight (% ideal wt = 117%). Taking the averaged Period II and III data, no significant differences among the groups (averaged over time) were found ($P > 0.1$). As can be seen in table 2, the

TABLE 4. Effect of Physical Training, Isocaloric Type IV HLP Diet, and Physical Training Plus Diet on Body Weight, Percent Ideal Weight† and Percent Body Fatness‡

Group	Measurement	Period I (baseline)	Period II§ (at 3 weeks)	Period III (at 6 weeks)
Group A (physical training) N = 15	Body weight*, ** (kg)	79.3 \pm 3.0	78.7 \pm 3.1	78.5 \pm 4.0
	Percent ideal weight*, ** (%)	114.1 \pm 5.0	113.3 \pm 5.0	112.9 \pm 5.1
	Body fatness (%)	15.7 \pm 0.9	—	14.3 \pm 0.7***
Group B (diet) N = 16	Body weight*, ** (kg)	83.9 \pm 3.2	83.1 \pm 3.0	81.8 \pm 3.1
	Percent ideal weight*, ** (%)	119.9 \pm 5.7	118.8 \pm 5.6	116.9 \pm 5.5
	Body fatness (%)	15.5 \pm 0.9	—	14.9 \pm 0.8
Group C (physical training + diet) N = 15	Body weight*, ** (kg)	84.7 \pm 2.8	83.0 \pm 1.9	81.7 \pm 2.7
	Percent ideal weight*, ** (%)	118.2 \pm 4.9	115.9 \pm 5.1	113.9 \pm 4.6
	Body fatness (%)	16.9 \pm 0.8	—	14.9 \pm 0.8***

Analysis for body weight and percent ideal weight by repeated measures ANOVA.

Analysis for body fatness by ANOVA and paired *t*-tests.

No significant among-group differences were found for the baseline measures (by ANOVA).

†Percent ideal weight was based on the ratio of actual weight to ideal body weight as given for each patient in the Metropolitan Life Insurance tables¹⁴.‡Calculated on the results of 4 skinfold measurements—sites were triceps, infrascapular, supra-iliac and umbilical¹⁵.

§Skinfold measurements were not taken at Period II.

*Significant differences in means over time (within group analysis) $P < 0.05$.**Significantly different pattern of response (interaction analysis) $P < 0.05$.***Significantly different from value at period I, $P < 0.01$.

TABLE 5. *Calories and Diet Composition of Physical Training, Isocaloric Type IV HLP Diet, and Physical Training plus Diet Groups*

Group	Diet Intervention	Period	Calories	Protein (%)	Fat (%)	CHO† (%)	Ethanol (%)	P/S*	Sugars as % of CHO (%)	CHOL‡ mg	Caffeine (%)
Group A (Physical training N = 15)	—	Period I (baseline)	2477	16.6	37.6	41.7	4.5	0.6	52	399	399
	none		§								
Group B (Diet) N = 16	—	Period I (baseline)	2434	16.5	37.6	40.3	5.6	0.5	47	479	500
	Therapeutic	Period I (baseline)	2366	20.3	40.3	34.8	4.6	1.1	30	334	540
	Adjusted therapeutic	Period II (at 3 weeks)	2497	20.3	40.3	34.8	4.5	1.1	30	339	540
Group C (Physical training and diet) N = 15	—	Period I (baseline)	2301	16.6	37.5	40.6	5.3	0.6	47	373	704
	Therapeutic	Period I (baseline)	§	20.0	40.0	35.1	4.9	1.1	30	332	540
	Adjusted therapeutic	Period II (at 3 weeks)	2480	20.0	40.0	35.5	4.5	1.1	30	347	540

Data expressed as mean values. Data given for % protein, % carbohydrate, % fat and % ethanol indicate percentage of total calories.

No significant among-group differences were found for the baseline measures.

*Ratio of polyunsaturated fat to saturated fat (P/S = polyunsaturates/saturated fats).

†Carbohydrates.

‡Cholesterol.

§Individualized caloric prescription was made, instructing subject to increase total calories without change in dietary proportions, so as to keep weight constant throughout study. Average increase in intake was approximately 125 calories to account for the additional caloric expenditure due to exercise.

mean insulin values decreased in all three groups from Period I to Period II, and then returned to near the baseline (Period I) values. The differences over time within groups were significant ($P < 0.01$). However, the group-by-time interaction was not significant, indicating that essentially the same pattern over time was observed in all three groups.

Effects of Interventions on Prebeta Lipoproteinemia

The percentage of subjects having prebeta bands in groups A, B, and C at baseline was 100%; at the 3 week period (Period I), percentages were 92, 86, and 81% respectively; and at the 6 week period (Period III) percentages were 100, 93, and 93%, respectively. Thus, while there were some reductions in the frequency of hyperprebetalipoproteinemia in Period II, this frequency returned to baseline levels at Period III. (While ultracentrifugal analyses were not done to distinguish very low density lipoprotein [VLDL] from sinking prebeta LPP,¹⁸ evidence indicates¹⁹ that the large majority of prebeta bands, especially in overweight middle-aged men, will represent VLDL).

Effects of Interventions on Oxygen Uptake

Men in groups A and C showed an increase of 9.5% and 6.9%, respectively, following the mild physical training program (table 3). However, adherence to the prescribed physical exercise program varied widely among individuals within groups A and C as ascertained by their daily exercise log books. One subject in group C was stopped early in his final treadmill test because of exercise-induced electrocardiographic ST-segment changes which were not present during his initial treadmill test. Since no abnormal electrocardiogram response was seen on his first treadmill test, he

participated fully in the exercise plus dietary program and showed a 14% reduction in his triglyceride level. However, since his final treadmill test was stopped prematurely, data presented in table 3 do not include either initial or final maximum oxygen consumption values for this subject.

The slight (1.8%) increase in oxygen uptake at subjective maximum exercise in the diet group (group B) is not significantly different from the baseline value.

Effect on Interventions of Body Weights and Adiposity

In spite of the effort to maintain isocaloric diets, significant differences ($P < 0.05$) in mean body weights were observed over time (table 4). However, no significant differences were found in the mean body weights among the groups. There was also a significant ($P < 0.05$) group-by-time interaction among the mean body weights. Thus, group C displayed a 1.7 kg reduction in their mean body weights at Period II, while 0.6 and 0.8 kg reductions were found in groups A and B respectively, during the initial three weeks of intervention. Mean weight continued to decline for group C beyond the three week period, showing a total reduction of 3.0 kg at period III. By comparison, groups A and B demonstrated overall weight losses of 0.8 and 2.1 kg, respectively, at Period III. Values for percent ideal weight and percent body fatness are also presented in table 4. The percent ideal weight data parallel the findings obtained by body weights. Even though significant weight reductions were found for all groups at Period II, groups A and C were the only groups to display significant reductions in body fatness ($P < 0.05$).

To determine if body weight changes were responsible for the changes in serum cholesterol, triglyceride, and insulin concentrations, a one-way analysis of variance with one

covariate was used. In this approach, the dependent variable used was calculated by determining the difference between time periods (Period II-Period I; or Period III-Period I) for cholesterol, or triglycerides, or insulin concentrations; the covariate was calculated by determining the difference between these same time periods for absolute weight, percent ideal weight or percent body fatness (table 4). In other words, changes in serum cholesterol, triglyceride, or insulin concentrations from baseline period to Periods II or III, or Period II to III were tested to see whether the changes observed with the interventions were significantly different after adjusting for any changes in absolute weight, percent ideal weight, or percent body fatness for that time period. These analyses revealed that there was an independent effect, apart from any change in absolute weight, percent ideal weight, or percent fatness, of the three interventions on serum cholesterol, triglycerides, and insulin for any given time period ($P < 0.05$).

Initial Dietary Intake Histories, Diet Prescribed during Intervention Periods

A comparison of the baseline dietary information with the therapeutic Type IV isocaloric diet showed that only modest changes were needed in the percent of calories obtained from fat, while the percent protein was increased 3.8% and the percent from carbohydrates was decreased 5.5% (table 5). This diet called for an increase in the polyunsaturated-to-saturated fat ratio, and a decrease in the sugars-to-starch ratio. Furthermore, cholesterol and ethanol intakes were reduced by approximately 30% and 18%, respectively. Associations were found between baseline ethanol intake and baseline serum triglycerides ($r = 0.54$) and between baseline ethanol intake and baseline serum cholesterol levels ($r = 0.31$). An inverse relationship was found between the polyunsaturated to saturated fat ratio (P/S) and serum cholesterol ($r = -0.34$), for all groups combined.

Serum Lipids, Body Weight, and Dietary Histories, After One Year

The one year follow-up analysis (Period IV) of serum lipids (13 group A subjects, 11 group B subjects, 12 group C subjects) revealed that serum cholesterol levels were unchanged in groups A and B, while group C displayed a significant increase in cholesterol levels, as compared to their postexperiment (Period III) value ($P < 0.05$). Comparison of serum triglyceride concentrations between Period IV and Period III showed significant increases ($P < 0.05$) in all groups, with the Period IV values being not significantly different from the Period I values. Body weights taken at Period IV showed a 2% reduction for group A while essentially no change was found for groups B and C when compared to their corresponding values obtained at Period I. Answers from questionnaires showed that 69, 18, and 47% of the patients from Groups A, B, and C respectively, were more active than prior to the experiment, but did not strictly adhere to a program of moderately sustained exercise two to three times per week. It was also found that adherence to the Type IV diet was moderately maintained. While many reported that they were able to maintain a reduced saturated fat intake, they found it difficult to maintain a reduced intake of sugars.

Discussion

The results of this study demonstrate that the interventions used effectively normalized hypertriglyceridemia, a metabolic disorder associated with coronary heart disease.^{1, 2, 7} Furthermore, it was found that a significant reduction in serum TG levels occurred within three weeks with dietary management, a finding consistent with other reports;^{20, 21} this reduction persisted when measured at six weeks. Physical training was also effective in reducing serum TG concentrations, but this response did not occur as quickly or display the same pattern of reduction over time as compared with the dietary group, since significant reductions were seen only after six weeks of intervention. Also noted was the reduction of serum cholesterol levels in these Type IV HLP individuals, with the greatest reduction occurring in the diet plus exercise group. That a reduction in cholesterol levels occurred in the dietary groups (groups B and C) is not surprising, since studies employing similar dietary regimens have also found reduced cholesterol levels.^{21, 22} However, studies employing physical training interventions have reported equivocal results for this intervention on cholesterol levels.^{5, 23}

An interesting finding in this study was the close concurrence between the baseline dietary patterns for all subjects and the current Type IV HLP dietary recommendations of the NIH,⁴ and probably exemplifies the health consciousness of these university faculty members. One factor worthy of note was that serum TG levels decreased with physical training, even though exercise subjects were instructed to increase their caloric intake moderately so as to compensate for the additional exercise caloric expenditure (i.e., in order to preserve the isocaloric state). However, the importance of dietary modification in lowering serum TG was nicely illustrated. This reduction was accomplished with only modest alterations in the intake of total calories, percent carbohydrates, percent alcohol, dietary cholesterol, polyunsaturated/saturated fat ratios and the sugars/starch ratios. This finding further supports the contention that decreased calories (for overweight individuals), and avoidance of excess carbohydrates (especially sugars) and alcohol are important dietary modifications for lowering serum TG levels in carbohydrate-induced patients.^{3, 4, 21, 22, 24} It is possible that the increase in P/S ratio from 0.5 to 1.1 may also have helped to lower TG levels.²⁵ This study was of course not designed to test the relative effectiveness of these several changes in nutrient intake. The significant relationship found in this study between initial TG levels and ethanol consumption for all subjects is consistent with the work of others.^{26, 27} The finding that initial serum cholesterol levels were significantly related to the P/S ratio but not to dietary cholesterol intake supports a recent report from the Framingham Study²⁸ and suggests that dietary cholesterol intake may not be the most influential factor affecting serum cholesterol levels, at least in Type IV HLP.

The observed 7–10% increase in maximum oxygen consumption resulting from the mild physical training program was comparable to that reported for middle-aged men participating in a moderate-intensity physical conditioning program.²⁹ The moderate exercise intensity was prescribed because it was felt that even though these patients were thought to be free of coronary heart disease, they had been

rather sedentary and did display a risk factor, namely hypertriglyceridemia. Furthermore, since the patients were exercising without supervision, it was felt that a more conservative approach toward progressive training to improve their metabolic status was necessary.

While the results in this study show that either a Type IV diet or a moderate physical training program is an effective means of reducing serum triglyceride levels in Type IV patients, comparisons between the two interventions show that the percent change from pre-experimental to post-experimental measurement in triglyceride levels was significantly greater for the diet group. It should be considered, however, that the dietary group displayed a somewhat more abnormal initial triglyceride level, which may have resulted in the greater subsequent percentage reduction in serum triglyceride concentrations. A similar finding has been reported⁴⁰ and is consistent with our result of a higher positive correlation between the initial serum triglyceride level and absolute change in triglycerides in the dietary group, as compared to the training group.

The finding that physical training resulted in a gradually continued reduction in serum triglyceride levels while dietary management (and even more so, physical training together with dietary management) resulted in a large initial reduction followed by a slight increase suggest different metabolic adaptations or different psychological and behavioral responses to these interventions. Furthermore, the observation that triglyceride reductions did not level off at three weeks in the exercise group as they did in the dietary intervention group raises the question of whether continued mild physical activity might result in a further reduction of serum triglyceride concentrations. Interestingly, the concurrent reduction in serum insulin and triglyceride values for all three interventions during the first three weeks is consistent with the theory proposed by Olefsky et al.³⁰ concerning the interaction of serum insulin and triglyceride levels in Type IV HLP patients. However, in the present study mean insulin values returned to near baseline values by six weeks while triglycerides remained reduced or continued to decrease. Thus the relationship, rather than being linear, may be complex.

In agreement with some workers who have found only weak correlations between triglyceride levels and obesity^{31, 32} and contrary to the suggestions of others,^{33, 34} we found no significant correlation between initial plasma triglyceride or insulin levels and initial values of absolute weight, percent ideal weight, or percent fat. This finding supports the contention of Olefsky et al.³² that obesity in itself may not be the only factor determining hypertriglyceridemia. The reduction in serum triglyceride levels observed in this study for all groups could have been in part a manifestation of mild caloric deprivation, since reduction in body weight is generally thought to influence triglyceride levels.^{30, 35, 36} Even though significant weight losses occurred by six weeks for all three groups, and a significant diminution of total body fat occurred in the two groups engaged in mild physical training, our results showed that no significant weight loss had occurred by three weeks, in spite of significant triglyceride reductions having occurred in the dietary groups and in the diet plus exercise group. Also, while there was a

significant decline in weight in the exercise group between the third and sixth weeks, and in all groups between baseline and Period III, an analysis of covariance indicated that the change in weight did not significantly influence the decline in triglyceride level. Therefore, it is proposed that the observed reduction in triglyceride concentrations in these Type IV HLP individuals resulted primarily from the imposed dietary or exercise interventions. However, a possible synergistic effect of weight reduction may have occurred between weeks three and six in the exercise group, and between baseline and week six, in all groups.

The results of our study are of clinical significance since it appears that serum triglyceride levels in men with Type IV HLP can be restored to or toward normal levels within a few weeks through physical training or dietary management or a combination of physical training plus diet, and that these changes appear to be independent of moderate weight losses. Since different patterns of serum lipid reductions with respect to time are dependent on the type of intervention imposed, clinical follow-up should be scheduled with this factor considered. Furthermore it appears that an exercise prescription involving moderate activity, such as is often given in office management, can lower lipids even without modifying existing dietary habits, provided these dietary habits are similar to a Type IV diet. Consideration must be given to careful, regular, and repeated measurement of serum lipids and surveillance of dietary and exercise regimens in Type IV patients, since our results demonstrate that without involvement in a formal program, patients tend to revert back to their pre-experimental habits.

In summary, in men with Type IV HLP, modest alterations in dietary composition, even without caloric restriction, can be an effective measure for lowering serum triglyceride levels. Also a physical training program of moderate intensity (active dynamic exercise, designed to elicit a heart rate equal to 70% of maximum as determined by a graded exercise test), performed at least three times weekly for 30 min each time, can be an effective means for lowering serum lipid values in such men. Furthermore, a program involving both physical training and a Type IV diet is also an effective means of lowering serum triglyceride levels and appears to be a reasonable clinical approach to management. When overweight is present, ample evidence^{30, 36} indicates the importance of achieving ideal weight as a further necessary component in the management of Type IV HLP.

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