THE EFFECTS OF AN EXERCISE TRAINING PROGRAM ON SERUM CHOLESTEROL AND TRIGLYCERIDE LEVELS IN WOMEN USING ORAL CONTRACEPTIVES

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Oral contraceptives containing synthetic estrogens and progestogens are in wide-spread use in the world today. Since their introduction in 1961, millions of women have used these drugs (25). Americans have been concerned about potential undesirable side effects arising from their use. One such side effect being investigated is the effect on lipid metabolism (10, 60, 80, 85).

Of primary concern are the serum lipids which are fats circulating in the blood. Total lipids are comprised of triglycerides, non-esterified fatty acids, phospholipids and cholesterols, some of which are in a free form, while others are part of lipoproteins and chylomicrons. Although a number of hypotheses have been advanced to explain the relationship of oral contraceptives to lipid metabolism, at this time the mechanism by which oral contraceptives alter lipid metabolism are unknown (10, 60, 63, 98).

Significant elevations of serum triglycerides and slight elevations of cholesterol with the use of oral contraceptives are widely reported in the literature (8, 24, 51, 60, 80, 94). It is well established that elevated levels of triglycerides and cholesterol in the blood are associated with accelerated development of atherosclerosis and are implicated in coronary heart disease (6, 33, 54, 57). Consequently, these two lipids were chosen for study in this investigation.

The relationship of elevated serum cholesterol and triglycerides to cardiovascular disease has stimulated much research in the area of

exercise and its effect on blood lipids in men (16, 31, 61, 68, 69). It is generally agreed that exercise will lower the levels of serum triglycerides (19, 41), but the findings relative to the effect on cholesterol are equivocal (39, 48, 67, 77). The physiological-biochemical mechanism for these alterations remains obscure.

Statement of the Problem

Little research has been conducted with women to determine the effect of exercise on their blood lipid levels. The focus on women and this topic has received little attention at research meetings and in the literature, presumably since women are commonly thought to be less prone to cardiovascular disease than men (6, 44, 57, 64, 72, 82). However, it is possible that the wide-spread and long-term use of oral contraceptives, with the associated rise in triglyceride and cholesterol levels, in otherwise healthy women, could place them at greater risk for coronary disease (51, 52, 63, 82, 92). Women using the "pill" who fall in the upper ranges for lipid levels should be concerned about this side effect (10, 52, 64, 97).

Therefore, because of the popularity of this form of birth control, it is the opinion of this writer that methods of management of blood lipid levels should be investigated. Research experts in coronary heart disease prevention also suggest that management of risk factors may be important (29, 57, 86). Intervening action might take the form of diet and/or exercise. This proposed study is an attempt to determine if exercise training has the potential to lower these lipids, and hence be a method of management of blood lipid levels for women using oral contracep-

tives, and therefore ultimately reduce their susceptibility to vascular disease.

This writer could find no literature citing studies showing interaction effects of oral contraceptives and exercise training upon serum lipids. Therefore, a controlled investigation was undertaken to examine the effects of exercise training on a group of women using oral contraceptives compared to a control group not using these steroids.

The specific objectives of this study were 1) to determine if exercise training of sufficient intensity and duration to elicit improved working capacity would lower the serum cholesterol and triglyceride levels and 2) to compare women using oral contraceptives with women not using them, in their physiological and blood lipid response to the exercise program.

Delimitations

The following delimitations were imposed by the investigator in order to conduct the study using available facilities and equipment:

1. the sample size was limited to 24 (18 subjects to train; 6 for controls);
2. participants were between the ages of 25 to 40 years;
3. duration of the training program was limited to 6 weeks.

It was felt that meaningful trends could be observed for this specific age group in a training period of this duration.

Certain limitations were also present in the study. The subjects were unable to maintain a controlled uniform diet. Neither was it possible to syncronize the pre and post-training blood sampling with a particular

point in the menstrual cycle for each subject. A variety of birth control pills were used, although all were of the combined type (i.e., containing both estrogenic and progestational components).

Summary

It is speculated that the elevated lipid levels of women using the combined pill place them at greater risk of cardiovascular disease. Therefore, it was judged important to investigate the effects of training on women, as a possible method of intervention for this risk factor.

Chapter 2

REVIEW OF LITERATURE

Exercise and Lipid Metabolism

A review of the literature indicates that the effect of exercise on the concentration of lipids in circulating blood has not yet been clearly established. It is difficult to compare the findings reported in the literature, when the factors which are assumed to influence lipid concentration, (i.e., diet, adipose tissue stores, length of training period and intensity of exercise) have not been uniformly controlled.

The lipids of concern in this study are triglycerides and cholesterol. Triglycerides are a combination of glycerol with three fatty acids (87), and they comprise approximately 98% of the lipids of adipose tissue and 30% of plasma lipids (21). In blood, triglycerides are contained mainly in chylomicrons which are small particles of fat appearing after digestion and absorption of fat extracted from food. Other triglycerides are found predominately bound to the very low density pre-beta-lipoproteins (29, 32) and are affected by oral contraceptives (51, 94).

Cholesterol is a sterol that is widely distributed in animal tissues as well as in oils and fats. It can be synthesized in the liver and it is important in bodily metabolism as it is a precursor for other steroid hormones (46, 87). In plasma, cholesterol is found mainly in the low density beta-lipoproteins and to a lesser extent in the high density alpha-lipoproteins (21).

Triglycerides. Some investigators report that moderate exercise for a few hours has no effect on the level of triglycerides in the blood, whereas 9 hours of prolonged exercise has caused a significant lowering (19, 20). The serum triglyceride level has more commonly been reported to decline during physical training (19, 37, 73). However, it has also been observed that this reduction is transient, since the level returned gradually to the baseline after training ceased (73).

Triglyceride level has been shown to be directly related to body fat as measured by skinfolds (16, 54, 68), and to fluctuate in direct proportion with changes in weight (3, 4, 5). Diet is known to affect the level of triglycerides in the blood (16); however, there is conflict as to whether fasting influences this blood lipid (19, 34).

Several hypotheses have been advanced to explain the actions of exercise on triglyceride metabolism. These include the idea that exercise reduces the influx of triglycerides from the intestines (34, 59); heavy exercise decreases hepatic blood flow (20, 50) and causes diminished hepatic synthesis of lipoproteins (19, 20) and a decrease in hepatic triglyceride pools (20). The triglyceride concentration in plasma is probably reduced by exercise because of decreased influx to the plasma and/or increased efflux from plasma (20).

Cholesterol. Many investigators have found that prolonged exercise did not significantly affect cholesterol levels in plasma (19, 20, 33, 34, 37, 56) so long as the subject stayed in caloric balance (76). If the training was combined with weight loss, the cholesterol level was apparently lowered (19, 34, 35, 69, 76, 93). Others studying training effects found

reductions in cholesterol in people who had no weight loss, but who experienced a decline in the body fat depot (39, 77). In one study investigating the effect of an exercise program on both men and women, Doležel (26) reported that exercise caused blood cholesterol levels to rise after training. It rose to a greater degree in young women than it did in young men. In contrast, other workers (39, 77) found serum cholesterol was reduced in subjects participating in exercise programs.

Still other factors have been found to affect levels of circulating cholesterol. It has been observed that the greater the amount of adipose tissue, the higher the level of cholesterol (54, 55, 68). Early in a fast, women mobilize fat and hence their blood lipid level rises. Cholesterol levels follow the same pattern of elevation as the blood lipids generally (12, 19), and it is thought that this increase begins in men after approximately 12 hours of fasting (50). Womens' increased mobilization of fat probably begins sooner than that in men (12). Diet also affects the cholesterol level (20, 75, 76). Diets rich in fat are associated with high levels of plasma cholesterol, but a lack of unsaturated fatty acids in the diet may similarly result in the elevation of serum cholesterol. Ingestion of unsaturated oils seems to have a depressant effect on circulating cholesterol (14). Finally, cholesterol levels may also be affected by seasonal changes (14, 70, 89, 95).

Cholesterol metabolism is very complex and the influence of exercise upon this parameter is poorly understood (67, 70). One hypothesis is that physical activity increases metabolism which speeds up the processes of cholesterol excretion and prevents synthesis of this sterol (76). Another is that the massaging action of muscles enhances cholesterol

mobilization so it can be utilized, and further that exercise facilitates the clearing of fats from the arterial wall and hence lowers the rate of fat deposition therein (14, 76). Others hypothesize that hard exercise prevents the accumulation of metabolites that are needed for cholesterol synthesis (76). Some state oxidation of cholesterol is elevated by strenuous exercise (40, 62).

Oral Contraceptives and Lipid Metabolism

Oral contraceptives contain synthetic estrogens and progestogens, which are forms of the natural female sex hormones. They are primarily designed to prevent ovulation (79, 94). A variety of the synthetic forms of the hormones are used, depending on the prescribing physician. Dosages also vary between commercial pills. In the more popular combined type of pill, the progestational component commonly varies from 0.5 mg to 2.5 mg, whereas the estrogenic component is smaller, ranging from 0.05 mg to 0.10 mg (See Appendix E). One of the side effects from the use of these drugs is a change in serum lipid concentration (60, 97).

Triglycerides. Considerable biochemical research was done on lipid metabolism during the 1950's, prior to the introduction of the "pill" (25). However, these investigations did not examine the effect of oral contraceptives on serum triglyceride levels in healthy pre-menopausal women (25). Thus, the striking increases in fasting serum triglycerides in women using oral contraceptives, discovered in the late 1960's, was unexpected (25). The works of Beck (9, 10) and Glueck (38) confirmed that use of conventional oral contraceptives caused a rise in serum triglycerides in healthy normal women.

The degree of elevation in serum triglycerides varies with the type of oral contraceptive used. Doar (25) hypothesized a relationship between the estrogen content of the pill and the triglyceride level, and speculated that it is estrogen rather than progestogen that causes the rise. Others also suggest that the estrogenic component of the pills mediates the rise (51, 80, 82, 85).

Progestational compounds used alone as oral contraceptives seemed to have little effect, or else produced decrements in triglyceride levels (38). It is suggested that the synthetic progestogens may be fairly inert metabolically in regard to effect on plasma lipids (38). With respect to the combined pills (progestogen and estrogen), Doar (25) and Adams and Oakley (1) proposed that certain progestogens such as norethisterone, may be metabolized to estrogenic compounds with a secondary effect on lipid levels. Whether this secondary effect raises or lowers the levels is still open to question.

There seems to be no correlation between the duration of contraceptive therapy and serum lipid levels (80). Doar (25) reported that there was a mean increase of 47% in triglyceride level after only 2 weeks of usage, and that the level rose to a plateau at 6 to 8 weeks with little subsequent change observed. After 3 months there was no relation between duration of medication and change in serum triglyceride or cholesterol levels. Doar (25) further reported that 95% of the subjects using oral contraceptives experienced this rise in lipids.

Although the mechanism by which contraceptive steroids alter lipid metabolism is unknown (10, 45, 60, 98), there are several hypotheses as to the cause of the increase in triglyceride concentration. Some

investigators speculate there is an increased influx of triglyceride, which is partly offset by increased efficiency of removal (45, 58). It is suspected that progestogens are responsible for increased rate of clearing, but that estrogen overrides this effect by causing synthesis of triglycerides (38).

The elevated lipid levels in women using oral contraceptives generally fall within the clinically normal range (38, 94). This range is 30-160 mg/100ml for triglycerides for those under 50 years of age (53).

Cholesterol. A study of women in India using the "mini-pill" or the combined pill exhibited significant elevations in serum cholesterol (80). Estrogen reduces serum cholesterol (13, 14, 55, 76), but some steroid combinations may act synergistically to increase serum lipid levels (25). Since cholesterol is a precursor of estrogens (11, 46), perhaps the use of synthetic estrogens suppresses the body's production of natural estrogen, and therefore creates a larger reservoir of cholesterol which is expressed by higher blood cholesterol levels (88).

Smith, Goldsmith and Lawrence (82) found no differences in cholesterol levels between women using oral contraceptives and those not using that medication, but observed that other researchers had reported changes in cholesterol when using contraceptive agents different from Norinyl 1+80, which was the agent used in their study.

The range of normality for cholesterol is considered to be 110-250 mg/100ml for those under 50 years of age (46, 53). However, some physicians state that normal may not necessarily be healthy, especially

for those in the upper ranges (51, 82).

Effects of Exercise Training on Women

Hanson and Nedde (43) in a comprehensive review of literature, stated that there were few available reports pertaining specifically to training programs for women. Of those reports only one failed to show any significant improvement in cardiorespiratory function, and even that study showed a small increase in maximal oxygen uptake. Therefore, it is agreed that most researchers believe that women benefit from physical training, and that they will benefit in the same proportion and in the same parameters of fitness as men (7, 15, 17, 27, 28, 36, 43, 78). Yeager and Brynteson (99) found that a 30 minute training program, 3 days per week for 6 weeks with the heart rate kept at 70-80% of its maximum, was sufficient to improve the cardiovascular response to exercise in their subjects. Whitten and Whitten (96), in a 7 week study of untrained females, found that there were no significant difference between gains in working capacity made in a 3 day per week training program as compared to a 5 day per week program. Since women in the 5 day program complained of muscle soreness and "shin splints" from running, he concluded that 3 day programs for untrained women were best for optimal results in cardiovascular endurance. These findings in part were used as the basis for the determination of the treatment to be given the subjects in this study.

Summary

From a review of the literature there seems to be general agreement that exercise training will lower the triglyceride levels in the

blood. Cholesterol does not seem to be affected. However, since so many variables affect both blood lipids, and especially cholesterol, better experimental control of these interferring variables during an investigation is needed before the question is decided. Most studies relating to exercise and its effects on blood lipids have been focused on men and it is not definitely known if women respond in the same way.

There seems to be general agreement that most women using birth control pills with an estrogenic component will experience a significant rise in blood triglyceride levels and a lesser increase in cholesterol levels.

It is generally accepted that exercise training will produce improved cardiorespiratory function in men and that women will also benefit in the same proportion, given a similar training stimulus.

Chapter 3

METHODOLOGY

Subjects

The subjects were 24 adult women volunteers from the community. They ranged in age from 25 to 39 years. The women were free from any known metabolic diseases and were using no medication. These subjects were judged untrained at the onset of the investigation. None had regularly engaged in physical activity more than three times a week for 30 min, that was intense enough to cause them to perspire.

The subjects were non-obese as determined by Seltzer and Mayer's age-adjusted criterion of minimum triceps skinfold thickness (22). Obesity standards for Caucasian American women consider 29 mm at the triceps site for ages 25 to 29 years and 30 mm for ages 30 to 50 years to be the minimum for obesity. All subjects had lower skinfolds than these standards.

Nine subjects who used oral contraceptives comprised the pill group (PG). This group was using various brands of the combined pill. The estrogenic component of the pill was either ethinyl estradiol or mestranol, with the mean of the dosage of this component being 0.07 ± 0.02 mg. The progestational agent in these pills was either norgestrel, norethindrone, norethindrone acetate, ethynodiol or ethynodiol diacetate. The mean dosage of this component was 1.2 ± 0.6 mg. Appendix E presents individual pill components for each PG subject. Nine other subjects who were not using oral contraceptives were designated as the no-pill group

(NPG). These two groups participated in all testing and training. The remaining six subjects were used only as sedentary controls to determine the possibility of seasonal changes in cholesterol. They did not participate in any other aspect of the study.

Table I summarizes the pre-training characteristics of the two groups participating in the study. Hematocrit, hemoglobin, resting heart rate and blood pressure values all fall within the clinically normal range (87, 91). The difference in age between the PG and the NPG reflects a difficulty in finding volunteers in the upper age range who were using birth control pills, and subjects in the lower age range who were not using these pills. Differences in the means between the groups for maximum ventilation ($\dot{V}e_{max}$), maximum oxygen uptake ($\dot{V}O_2max$) and cholesterol may be age-related (7, 27, 46). The higher triglyceride mean for the PG parallels the findings reported in the literature (8, 45, 97).

Pre-training Evaluation

All subjects were asked to have a medical examination. Details of the study were explained to the subjects so that they could give informed consent prior to participation (See Appendix A). Personal questionnaires concerning physical characteristics, medical history and prior activity were completed (see Appendix B). Each subject submitted a 24 hour record of her dietary intake for each day preceding blood sampling. Recording forms were provided for this purpose (see Appendix D).

TABLE I

Pre-Training Characteristics of Subjects

Characteristic	PG MEAN ± SD	NPG MEAN ± SD
Age (yr)	28.8 ± 4.4	33.3 ± 4.6
Height (cm)	163.6 ± 6.2	161.7 ± 7.8
Weight (kg)	59.6 ± 6.3	59.6 ± 9.6
Sum of Skinfolds (mm)	80.9 ± 16.8	90.6 ± 28.0
Triglyceride (mg/100ml)	93.6 ± 39.7	51.8 ± 12.8
Cholesterol (mg/100ml)	190.3 ± 21.2	213.6 ± 44.2
Hematocrit (%)	41.1 ± 2.7	39.1 ± 2.2
Hemoglobin (gm/100ml)	14.8 ± 0.8	14.0 ± 0.8
$\dot{V}e_{max}$ (liters)	75.6 ± 6.8	65.5 ± 14.1
$\dot{V}O_2max$ (liters)	1.97 ± 0.28	1.80 ± 0.15
Resting Heart Rate (bt/min)	72.3 ± 10.9	71.3 ± 7.7
Resting Blood Pressure (mmHg)-Systolic	112.6 ± 7.6	110.8 ± 7.4
Diastolic	77.6 ± 6.7	72.1 ± 7.4

Blood Sampling. The subjects were weighed while dressed in lightweight clothing, on a Detecto-Medic scale, to the nearest 1/4 lb. To determine a pre-training baseline for serum triglycerides and cholesterol, a fasting blood sample was then taken from each subject, on each of three different mornings, in the week prior to the start of the training program. The subjects were asked to fast 9 hours prior to giving blood. The mean fast ±SD for the PG was 10.5 ± 1.3 hours and for the NPG was 10.1 ± 1.4 hours. Approximately 6 ml of blood were taken from the antecubital vein after the subject had rested in the supine position for at least 20 min. No tourniquet was used to occlude the vein, as suggested by Stoker and Wynn (84). Hematocrit and hemoglobin determinations were made immediately. The remaining blood was centrifuged in a Damon International Model HN-S Centrifuge and the serum obtained was frozen for later cholesterol and triglyceride analysis.

Hemoglobin. Triplicate values for hemoglobin were determined each day using the Hycel Cyanmethemoglobin method. Standards and unknowns were read on the Hitachi Model 102 Digital Spectrophotometer with a flow cell attachment. The accepted value was the average of the three samples, except where one sample was known to be inaccurate because of error in technique. Then, the remaining two values were averaged.

Hematocrit. Capillary tubes for hematocrit were flame sealed and centrifuged in a micro-hematocrit centrifuge for 6 min, then read on an International Micro-Capillary Reader. The same procedure as that used for hemoglobin was used to arrive at an accepted daily value for hematocrit.

Serum Lipids. The Oxford Tri-Chol Reagent Set was used to determine triglyceride and cholesterol. With this method, triglycerides are extracted from serum, saponified to fatty acids and glycerol, with the glycerol then being oxidized to formaldehyde. Quantitation of formaldehyde is done by a colorimetric method based on a modification of the Hantzsch reaction. For cholesterol, the Oxford Tri-Chol method involves a colorimetric determination of total cholesterol, based on a modified Kiliani-Zak reaction (53). Readings were taken on a Coleman Junior II Spectrophotometer. Daily values were accepted when duplicates of a sample were different by no more than 10% of each other.

A baseline for pre-training serum lipid levels for each subject was established. This was done by comparing the triglyceride values. The 2 days closest in value were averaged for the baseline. Alternately, if the third day's triglyceride value was within ± 15 mg/100ml of the median value for the three separate days, then pre-training triglyceride level was represented by a mean value for the 3 days. The days chosen for baseline triglycerides were also accepted for the cholesterol baseline, as well as for all other blood measures.

Skinfold Measurements. Five skinfold fat measurements were taken in triplicate on the left side of the body using Harpenden calipers. The measurements were:

1. triceps - taken at the mid-posterior mid-point between the tip of the acromion and the tip of the olecranon process with the elbow in 90^{o} flexion.

2. subscapular - taken at the tip of the scapula with the subject in a relaxed standing position.

3. umbilicus - taken at the level of and adjacent to the umbilicus.

4. suprailiac - taken at the tip of the iliac crest in the mid-axillary line.

5. front thigh - taken at the mid-point between the greater trochanter and the lateral epicondyle of the femur in the mid-line of the front thigh with the leg relaxed.

The sum of the means for the five sites was used to represent the total skinfold fat for each subject.

To isolate the exercise treatment as the factor causing any change in the lipids, it was considered important that there be no change in the subjects' total skinfold measurements. The PG pre-training mean was 80.9 ± 16.8 mm and the post-training mean was 79.5 ± 14.4 mm, indicating a 1.73% reduction in skinfold totals. The NPG experienced a 0.77% reduction, with the pre-training mean being 90.6 ± 28.0 mm and the post-training mean being 89.9 ± 25.9 mm. Since neither group showed a directional trend within groups (see Appendix G), and since the average change was less than 2%, this small variation was interpreted as a limitation inherent in skinfold measurement technique. Therefore, on the basis of this rough estimate of body composition, it was assumed that body fat content remained constant across the training program. Consequently, any changes observed in lipids after training could not be attributed to systematic variations in the total adipose depot.

Cardiorespiratory Measurements. Each subject was given an exercise stress test on a Quinton Model 24-72 treadmill equipped with an ECG Monitoring System and Programmed Exercise Control, to determine cardio-

respiratory capacity and to measure the $\dot{V}O_2max$. In the week prior to the stress test the subjects were given the opportunity to practice running on the treadmill and to become familiar with the gas collection apparatus. A list of instructions relating to standardized pre-test behavior was given to each subject (see Appendix C).

Upon reporting to the laboratory for the stress test, the subjects' resting heart rate and blood pressure were taken with the subjects in the sitting position. Following this the stress test was administered. The stress test was continuous, with incremental workloads applied at 2 min intervals as shown in Table II. The subject exercised at each stage for 2 min and then progressed to the next level, unless she indicated that she could continue only at the present stage, to approach exhaustion by extending the time beyond 2 min.

During the stress test metabolic measures were made using open circuit spirometry techniques. Inspired air was measured on a Parkinson-Cowan CD-4 gas meter every 30 sec. After the subject's heart rate reached approximately 135 bts/min, samples of expired air were collected in aluminum bags, during the middle 20 sec of each minute in each stage of the test, until the subject indicated she could no longer continue running. Expired oxygen and carbon dioxide were analyzed on Beckman OM-11 (O_2) and LB-2 (CO_2) electronic respiratory gas analyzers. All values were corrected to dry atmospheric conditions and standard temperature and pressure. During the stress tests, dry bulb temperature for the PG showed a mean of 22.71 ± 0.55 ^{o}C. For the NPG, the mean temperature was 22.93 ± 0.95 ^{o}C. Maximum ventilation at standardized conditions

Table II

Stress Test Protocol

Stage	Speed (mph)	Grade (%)
1	3.5	0
2	4.0	0
3	5.0	0
4	6.0	0
5	6.0	2.5
6	6.0	5.0
7	6.0	7.5

($\dot{V}e_{STPD}max$), $\dot{V}O_2max$, and maximum heart rate (HR_{max}) were calculated for each subject.

Control of Subjects' Behavior During Training Program

In weeks one, three and six of the 6 week training program, each subject maintained an accurate daily record of all food and drink ingested, for computer analysis of caloric intake and nutrient content. The Human Nutrition and Foods Department (VPI and SU) Nutrient Intake Computer Program, based on the United States Department of Agriculture's Nutritive Value of Foods, Home and Garden Bulletin No. 72 (90) was used for this analysis. No attempt was made to control the diet; however, each subject weighed herself daily on rising, and was requested to maintain a constant body weight by adjusting her caloric intake to compensate for any variation attributable to the exercise treatment.

Both groups experienced a 0.1 kg mean increase in weight representing a 0.16% change. The pre-training mean for both groups was 59.6 kg with the standard deviations being ± 6.3 kg and ± 9.6 kg for the PG and NPG, respectively. The post-training mean for the PG was 59.7 ± 6.6 kg and for the NPG was 59.7 ± 9.7 kg. Although weight change is considered a factor affecting changes in lipid level (30), the change in this study was negligible and hence this variable was considered controlled for the purposes of this investigation.

The average daily caloric intake of the PG during training, based on the means of the 1st, 3rd and 6th weeks' intakes, was 1737 ± 306 Kcal. For the NPG the average was 1603 ± 333 Kcal. The average daily percent of calories derived from fat for both groups was similar to the American

average of 40% (65). The means were 39.44 ± 3.73% and 41.88 ± 3.97% for the PG and NPG, respectively. Examination of the subjects' daily food intake showed no substantial variations from their usual patterns of consumption throughout the study, and they were similar to pre-training records. The composition of the food remained relatively constant. Fat consumption, which is considered to be a factor affecting serum lipid levels (14) fluctuated daily but generally fell within the range of 35-45% of the total calories. Hence, a change in the regular diet of the subjects was ruled out as a possible factor accounting for any change in lipid levels.

The subjects were asked not to engage in any regular strenuous activity other than the training program during the experiment. All except three complied with this request. Those three reported infrequent participation in recreational activities such as tennis, racquetball and cycling, with none participating more than a total of 6 hours during the entire training period.

Exercise Training Program

An exercise program on the treadmill was designed for each subject on the basis of her preliminary treadmill stress test. The exercise treatment was 30 min of treadmill running, 3 days a week for 6 weeks, with the speed adjusted continuously so that the subject worked in an individualized protocol to maintain a working heart rate equivalent to approximately 75% of her maximum metabolic capacity (75% $\dot{V}O_2max$).

To verify that each subject's training heart rate approximated 75% of the $\dot{V}O_2max$, an oxygen uptake procedure was done in connection

with a training session for each woman at a point one-third of the way through the program. Each subject was measured for HR and $\dot{V}O_2$ during a 1 min interval, after she had reached a physiological steady-state. Table III shows the percent of HR_{max} and $\dot{V}O_2max$ attained by the subjects during this procedure. In training sessions following this submaximal test, individual subject's workloads were adjusted if necessary to more closely approximate the target training intensity (75% $\dot{V}O_2max$).

Post-Training Evaluation

Fasting blood samples were again taken on days one and two following the last training session. The subjects were asked to duplicate as closely as possible, the pre-test diet they had consumed on the days before the pre-training blood samples were taken. The mean caloric consumption for the PG immediately prior to blood sampling was 1795 ± 431 Kcal pre-test and 1762 ± 461 Kcal post-test, while the percent calories from fat were 40.27 ± 6.43% and 38.14 ± 5.32%. For the NPG, the pre-test mean was 1604 ± 318 Kcal and the post-test mean was 1593 ± 341 Kcal. The percent of calories from fat for this group was 39.52 ± 7.82% and 43.22 ± 7.25% pre-test and post-test. The procedures already described for the pre-training tests were employed. The mean fast for the PG was 9.8 ± 0.7 hours and for the NPG was 9.3 ± 0.9 hours. The values for the 2 days' blood samples were averaged to give the post-training baseline.

Within 1 week following cessation of the training, the subjects were given a $\dot{V}O_2max$ test on the treadmill to determine if there had been an improvement in their exercise capacity. Again, the procedures used for the pre-training tests were employed. However, the mean dry bulb

Table III

Submaximal $\dot{V}O_2$ Test During Training

Measures	PG Mean ± SD	NPG Mean ± SD
HR_{max} (bts/min)	190 ± 11	180 ± 7
Fraction HR_{max} (%)	87.0 ± 2.5	87.9 ± 3.1
$\dot{V}O_2max$ (liters/min)	1.97 ± 0.28	1.80 ± 0.15
Fraction $\dot{V}O_2max$ (%)	80.0 ± 11.2	85.1 ± 12.5

temperature during these tests was somewhat higher at 26.18 ± 1.14 ^{o}C for the PG and 24.78 ± 0.26 ^{o}C for the NPG. Post-training body weight, skinfold measurements, resting heart rate and blood pressure were taken at the time the stress test was administered.

Statistical Treatment

Multivariate analyses of covariance (MANCOVA), one-way classification, on the mean scores of the PG and NPG for the variables triglyceride and cholesterol, were performed to determine if there were any significant differences between the two groups for these variables, as a result of the exercise treatment. Similar analyses were conducted on the mean scores for $\dot{V}e_{max}$ and $\dot{V}O_2max$ to determine the possibility of significant differences between the PG and NPG on these variables. If the probability level (p) was less than 0.05 using Wilks' lambda criterion as a test of significance, then the changes were considered statistically significant. If significant differences between the groups were observed, through MANCOVA analyses, then simultaneous confidence intervals were computed to determine which variables were the main cause of this difference.

To determine if any significant change ($p < 0.05$) occurred within each group as a result of the exercise training, Hotelling's T^2 for dependent variables (pre-test to post-test differences) was used for the combined variables triglyceride and cholesterol, and again for the linear combination of $\dot{V}e_{max}$ and $\dot{V}O_2max$ for each group. If significant Hotelling's T^2 were observed then simultaneous confidence intervals were established for the individual lipid variables for each group to deter-

mine which lipid contributed to the significance. This procedure was also done for the $\dot{V}e_{max}$ and the $\dot{V}O_2max$ variables for each group.

Summary

In summary, 18 subjects participated in the training. They comprised two groups, one designated the pill group (PG; n = 9) and the other designated the no-pill group (NPG; n = 9). These subjects were considered healthy, in that values for all measurements taken, fell within the clinically normal ranges. The remaining six subjects became seasonal controls for cholesterol.

Testing procedures for all pre-tests and post-tests were duplicated as closely as possible. Subjects generally followed the instructions that were given them. Each subject was given an individualized training program on the treadmill, based on her own metabolic capacity.

Variables that were considered important factors affecting lipid level were controlled, and hence were assumed to have no effect on lipid measures in this study. These variables were weight, total skinfold fat, and diet.

$\dot{V}e_{max}$, $\dot{V}O_2max$, triglyceride and cholesterol were the variables chosen on which to compare changes between groups and within groups as a result of the exercise training. Multivariate statistics were applied to these variables to determine if significant ($p < 0.05$) changes occurred in physiological capacity or blood lipid levels within or between groups.

Chapter 4

RESULTS AND DISCUSSION

In the following section, results of the analyses of the physiological variables and then of the lipid variables are discussed. For each of these two categories of variables, multivariate analyses of covariance (MANCOVA), one-way classification, was used to compare differences between the PG and the NPG. Hotelling's T^2 was used to compare pre-test and post-test differences within the groups.

Although all 24 subjects finished the study, upon completion of lipid analyses, it was discovered that one subject in the NPG had extreme hyperlipidemia (227% above clinically normal values for triglyceride concentration). Subsequent examination of the subject by a physician confirmed this pathological state. Since this study was primarily concerned with women in the normal range for lipid values, the hyperlipidemic subject's data were excluded from the statistical analyses, thus reducing the NPG to eight subjects. Data for individual subjects on all important parameters are located in the Appendixes.

Changes in Physiological Measures After Training

One of the objectives of this study was to determine if exercise training of sufficient intensity and duration to elicit improved working capacity, would lower the serum cholesterol and triglyceride levels in the subjects. $\dot{V}e_{max}$ and $\dot{V}O_2max$ were chosen as the parameters to determine whether working capacity had improved.

Within Group Differences. Hotelling's T^2 for dependent variables was employed on the linear combination of the $\dot{V}e_{max}$ and $\dot{V}O_2max$ pre-test and post-test means for each group, to determine if there were any significant changes as a result of training. This analysis indicated there was no significant difference between the pre-test and post-test means for these variables for the PG ($T^2 = 6.62$; $p > 0.05$). However, for the NPG, significance was found ($T^2 = 81.93$; $p < 0.05$). Therefore, simultaneous confidence intervals for the NPG were calculated to determine which of the variables contributed to the significant difference. If the simultaneous confidence intervals did not span the point zero, then the difference between the pre-test and the post-test means was statistically significant ($p < 0.05$). If the intervals did span zero, then the difference was not significant. As can be seen in Table IV, the pre-test to post-test difference between the means for $\dot{V}e_{max}$ was 13.4 liters and for $\dot{V}O_2max$ was 0.29 liters. The calculated simultaneous confidence intervals for both variables did not span zero. Therefore the analysis indicates that the NPG improved significantly in both $\dot{V}e_{max}$ and $\dot{V}O_2max$.

The improvement shown by the NPG is in agreement with other studies (17, 23, 28, 36, 42, 43, 81) designed to quantify the effects of training, where subjects were training between 60% and 85% of their metabolic capacities.

Although the improvement in the working capacity of the PG was statistically non-significant, examination of the individual data indicate that eight of the nine subjects did increase their $\dot{V}e_{max}$ and $\dot{V}O_2max$. Subject C in the PG remained the same pre-test and post-test

Table IV

Simultaneous Confidence Intervals for $\dot{V}e_{max}$ and $\dot{V}O_2max$ for the No-Pill Group

	Pre-test Mean	Post-test Mean	Differences	Confidence Intervals
$\dot{V}e_{max}$	65.5 ± 14.1	78.9 ± 15.6	+13.4	(+18.979, + 7.812)
$\dot{V}O_2max$	1.80 ± 0.15	2.09 ± 0.29	+0.29	(+ 0.541, + 0.041)

(see Appendix K). Figure 1 illustrates the changes for these two variables in both groups.

The PG experienced a 12.5% improvement in $\dot{V}e_{max}$ and a 10.2% improvement in $\dot{V}O_2max$, compared to the NPG who experienced a 20.5% and a 16.1% improvement, respectively. Holloszy (47) after an extensive review of the literature, states that the majority of studies indicate a 10-20% increase in $\dot{V}O_2max$ after a 3 to 6 month program of training. The present study showed comparable improvement in 6 weeks. Perhaps the smaller improvement experienced by the PG can be explained by the fact that they had a 15.4% greater $\dot{V}e_{max}$ and a 9.4% greater $\dot{V}O_2max$ than the NPG at the beginning of the study. Those with lower aerobic capacities at the onset of training will tend to experience larger improvements than those with higher capacities initially (27, 42). The PG may have been closer to their maximum potential prior to training.

Further evidence that both groups did improve in their working capacity is shown by the fact that every subject attained a higher treadmill stage or continued in the post-training stress test longer than they did in the pre-training test (see Appendix L).

Therefore, it seemed that the exercise treatment was sufficient to elicit significant improvement in the NPG, and although not significant statistically, also elicited improvement of practical significance in the PG.

Between Group Differences. A second objective of this study was to compare women using oral contraceptives with women not using them, in their physiological responses to the exercise program. MANCOVA, one-way

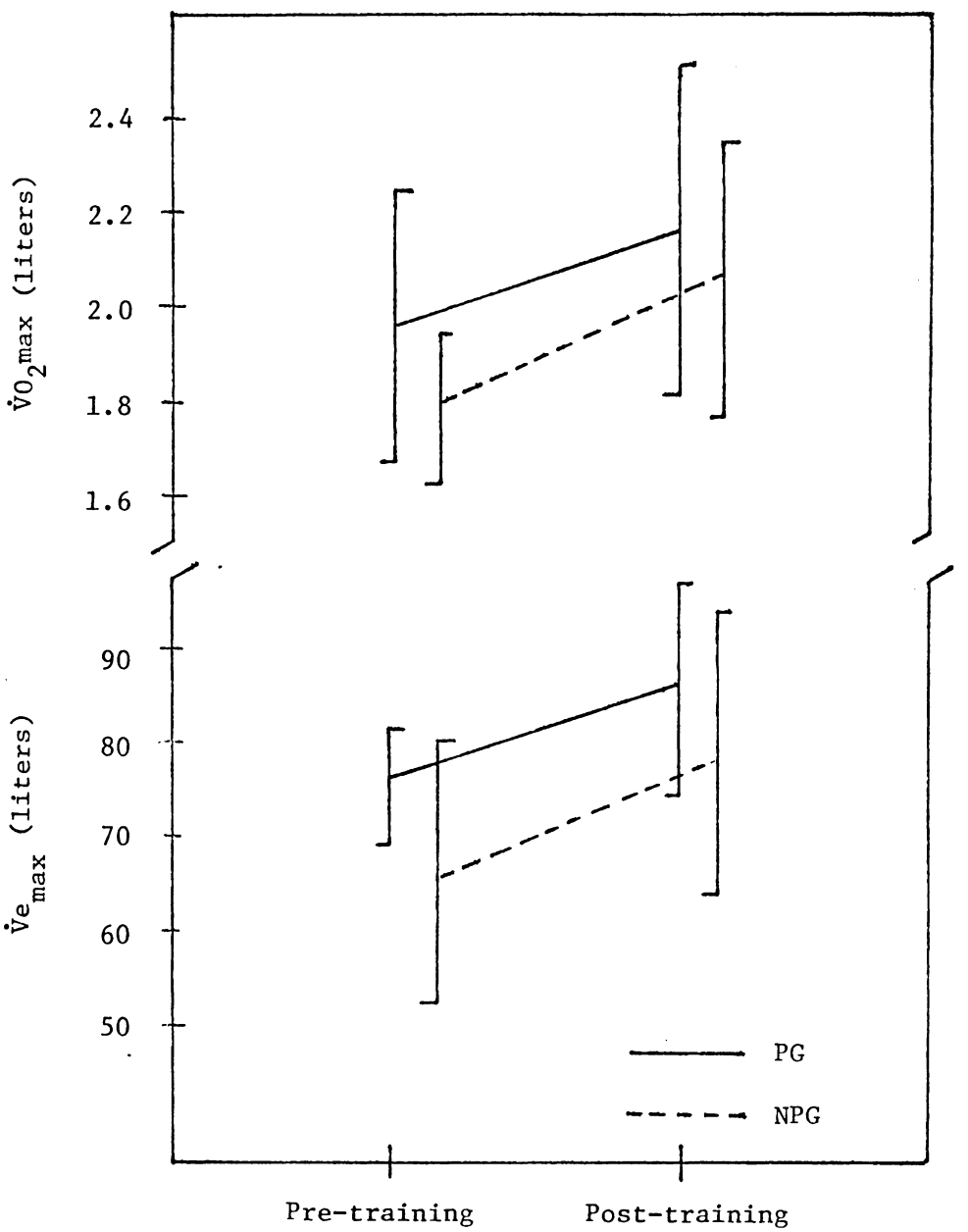

Figure 1

Mean Changes in Physiological Measures in the Pill Group and No-Pill Group After 6 Weeks Training at 75% of the $\dot{V}O_2max$ (Vertical Line Indicates Standard Deviation)

classification on the linear combinations of the pre-test and post-test means of the PG and NPG for $\dot{V}e_{max}$ and $\dot{V}O_2max$ were conducted to determine if there were any significant differences between the two groups. Wilks' lambda criterion as a test of significance indicated that there was no significant difference between the PG and NPG in their physiological response to exercise ($F = 1.63$; $p = 0.24$). Table V summarizes these results.

Therefore, it would seem that the exercise treatment was uniformly applied to the two groups. They both were affected in the same way by this treatment, and it was assumed that use of oral contraceptives did not limit or modify the PG's adaptation to training.

Changes in Lipid Measures After Training

The primary purpose of this study was to determine whether exercise would lower the triglyceride and/or cholesterol levels of the subjects, and hence be a method of control of lipid level for women using oral contraceptives.

In the previous chapter it was demonstrated that other variables (diet, fasting times, skinfolds and weight) known to affect lipid levels, were controlled, thereby isolating exercise as the factor responsible for any change. Because cholesterol is thought to be affected by seasonal changes, six subjects served as controls for this factor. Examination of their pre-test mean (207 ± 8.0 mg/100ml) and post-test mean (207 ± 10.9 mg/100ml) for cholesterol indicates that time of year had no influence on the concentration of that lipid.

TABLE V

Means, Standard Deviations and Differences in $\dot{V}e_{max}$ and $\dot{V}O_2max$ for the Pill Group and No-Pill Group

		Pre-test Mean ± SD	Post-test Mean ± SD	Difference	Adjusted Post-test Mean
PG	$\dot{V}e_{max}$	75.6 ± 6.8	85.0 ± 10.7	+ 9.4	80.0
	$\dot{V}O_2max$	1.97 ± 0.28	2.17 ± 0.35	+ 0.20	2.05
NPG	$\dot{V}e_{max}$	65.5 ± 14.1	78.9 ± 15.6	+ 13.4	84.5
	$\dot{V}O_2max$	1.80 ± 0.15	2.09 ± 0.29	+ 0.29	2.22

Within Group Differences. Employing the same statistical procedures as that used for $\dot{V}e_{max}$ and $\dot{V}O_2max$ (Hotelling's T^2), it was determined that there were no significant changes in either triglyceride or cholesterol concentration for the PG ($T^2 = 0.944$; $p > 0.05$). Likewise there were no statistically significant changes in these lipids for the NPG ($T^2 = 6.619$; $p > 0.05$). Figure 2 describes the mean changes for the two groups. Only slight decreases in cholesterol were seen in the NPG.

Pre- to post-training changes in lipid variables, except for NPG cholesterol reduction with training, were very small as shown by the differences recorded in Table VI. These findings seem to agree with the majority of investigations of the effect of exercise on cholesterol. Lack of change in cholesterol level as the result of exercise alone is widely reported in the literature (36, 41, 56, 66, 67, 73, 74, 86).

When examined on a group basis no significant change was observed. However, when data for individual subjects were examined, it was found that those subjects with the highest cholesterol values at the beginning of the study experienced the greatest decrease in this lipid. If subjects exhibited elevated cholesterol values initially, the concentration of this lipid seemed to decrease through training. In contrast, subjects in the lower range or near average for cholesterol for their age (2), experienced no change or even had slightly increased values (see Appendix M).

This lack of change experienced by some of the subjects perhaps could be explained by the fact that there is a mechanism in the body that prevents cholesterol from going below certain levels. It has been hypothesized that this mechanism raises or lowers cholesterol levels as

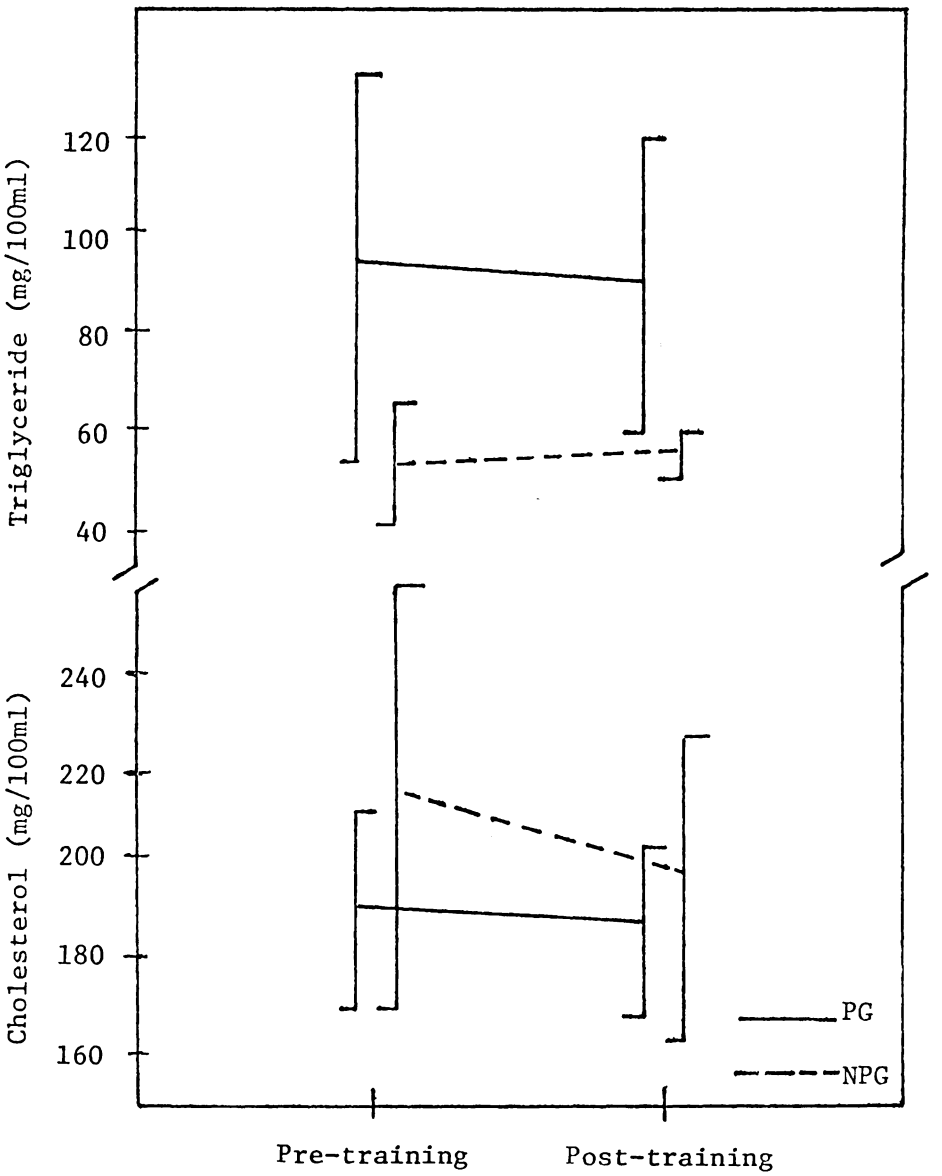

Figure 2

Mean Changes in Lipid Measures in the Pill Group and No-pill Group After 6 Weeks Training at 75% of the $\dot{V}O_2max$ (Vertical Line Indicates Standard Deviation)

TABLE VI

Means, Standard Deviations and Differences in Triglyceride and Cholesterol for the Pill Group and the No-pill Group

		Pre-test Mean ± SD	Post-test Mean ± SD	Difference	Adjusted Post-test Mean
PG	Triglyceride	93.6 ± 39.7	88.1 ± 30.9	- 5.5	75.6
	Cholesterol	190.3 ± 21.2	186.0 ± 17.7	- 4.3	194.6
NPG	Triglyceride	51.7 ± 12.8	54.0 ± 5.5	+ 2.2	68.1
	Cholesterol	213.6 ± 44.2	195.4 ± 32.0	-18.2	185.7

necessary (86), and is thought to be under the control of the reductase enzyme, hydroxymethylglutaryl-CoA (49, 83). At the beginning of the exercise training these latter subjects probably were at their optimal level of cholesterol. A possible explanation why some of the subjects experienced a slight increase in cholesterol is that an individual's cholesterol concentration can vary 20 mg/100ml on any one day (86).

Contrary to findings in this study, triglyceride levels are thought to decrease as a result of training (41, 73). Most earlier studies involved men (18, 50, 71, 73, 85) who usually have higher triglyceride levels than women, and many were conducted on subjects suffering some form of hypertriglyceridemia (18, 73). Because most of the subjects in this study, especially in the NPG were at the lower end of the range of clinical normality (NPG $\bar{X}$ = 51.8 ± 12.8 mg/100ml), it is not unexpected that their triglyceride concentrations would remain constant.

Examination of the data for the PG show that although their decrease in triglycerides as a group was not statistically significant, six subjects did decrease, and two experienced an increase (see Appendix M; PG subjects B, Q). Shortly after the study began, one subject who experienced an increase was required by her physician to change her brand of oral contraceptive to a brand with a higher estrogen content. The other who experienced an increase reported that she had only been using the "pill" for 1 month. Since the rise in serum triglyceride is dose-related to estrogen (9, 25, 38, 83, 85, 94), and takes approximately 6-8 weeks to reach a plateau (25), these two subjects were still experiencing the effects of the change due to estrogen. The initial rise that occurs when first using oral contraceptives, or when increasing dosage

was still in effect when the post-training blood samples were taken. If the estrogen dose change had not intervened in this study, it could be speculated that these two subjects might also have experienced a decline in triglycerides. Combined with the other subjects in their group, a significant decrease for the PG for this variable might have been seen. Lack of statistical significance in this case may also have been a function of the small sample size. It would seem that an elevated triglyceride level is necessary before any potential decrease might be seen from an exercise treatment. The slight gain seen in the NPG was negligible and considered within the range of measurement error.

Between Group Differences. Using MANCOVA to compare the two groups on the lipid measures with respect to the exercise treatment, it was found that there were no significant differences between the PG and the NPG ($F = 0.72$; $p = 0.51$). Therefore, the blood lipid responses to the exercise program of women using oral contraceptives were the same as women not using oral contraceptives. According to these analyses oral contraceptives do not affect the way in which women respond to exercise for the variables, triglyceride and cholesterol.

Summary

Analyses of the data in this study indicate that oral contraceptives have no effect on the responses of women to exercise training. Both the PG and the NPG responded essentially in the same manner on all variables, $\dot{V}e_{max}$, $\dot{V}O_2max$, triglyceride and cholesterol.

Only the NPG experienced a significant within group change ($p < 0.05$) for any of the variables. This change was an improvement in $\dot{V}e_{max}$ and $\dot{V}O_2max$ as the result of exercise training.

Examination of data from individual subjects showed some trends after exercise training. These were: 1) members of the PG improved to an extent of practical importance in $\dot{V}e_{max}$ and $\dot{V}O_2max$; 2) individuals with high cholesterol values experienced a decline; and 3) members of the PG who had been using the same oral contraceptive more than 6 weeks prior to the study experienced a decline in serum triglyceride concentration.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Since the elevated serum lipid levels in women using oral contraceptives are thought to place them at greater risk for cardiovascular disease, examining potential methods of lowering these lipids was deemed important for women using the "pill". This study attempted to determine whether one modifiable environmental factor, exercise training, would lower serum triglyceride and cholesterol concentrations. A second objective of this study was to compare the physiological and serum lipid responses to training of women using oral contraceptives, with women not using these hormones.

Several factors cited in the literature as having an influence on serum triglyceride and/or cholesterol changes were held constant in an attempt to isolate exercise as the agent of change. Body weight, total skinfold thickness, diet, fasting times and method of blood sampling were controlled throughout the study. Data collected for these variables supported the judgement that exercise had been isolated.

Two groups of women were given an exercise program that involved running on a treadmill at approximately 75% of their metabolic capacity. They ran for 30 min each session, 3 days per week, for 6 weeks. Diet and weight were monitored throughout the study, and skinfold measures were taken prior to and following training. Blood measures (hemoglobin, hematocrit, triglyceride, cholesterol) and physiological measures (heart

rates, blood pressure, $\dot{V}e_{max}$, $\dot{V}O_2max$) were also taken prior to and after the training treatment.

It was found using multivariate statistics, that there were no significant ($p < 0.05$) differences as the result of exercise, between the group using oral contraceptives (PG) and the group not using the "pill" (NPG), for either metabolic capacity (linear combination of $\dot{V}e_{max}$ and $\dot{V}O_2max$) or serum lipids (linear combination of triglyceride and cholesterol levels).

Within group analyses showed that the NPG experienced a 20.5% improvement in $\dot{V}e_{max}$ and a 16.1% improvement in $\dot{V}O_2max$. This was statistically significant ($p < 0.05$). The PG experienced a 12.5% improvement in $\dot{V}e_{max}$ and a 10.2% improvement in $\dot{V}O_2max$, which was not statistically significant.

Within group changes in the lipids were not statistically significant for either group, however the NPG showed a slight downward trend in cholesterol. Across both groups, individuals with higher lipid levels prior to training generally experienced a lowering effect after exercise training.

Conclusions

Based on the results of this experiment, the following conclusions were made:

1. A training program consisting of 30 min of treadmill running, 3 days per week, at an intensity of at least 75% of the subject's metabolic capacity, did improve physical working capacity in the women.

2. Oral contraceptives were not associated with the womens' ability to improve physical working capacity.

3. Oral contraceptives were not associated with a differential response to training for the variables of serum triglyceride and cholesterol.

4. Women who had serum cholesterol concentrations that were in the upper range were observed to reduce this measure through training, whereas those in the lower range or near average showed no decrease in the level of this lipid after training.

5. Women who were in the upper range for serum triglyceride concentration were observed to reduce this lipid level, whereas those who had low values initially did not exhibit any decrease in the concentration through training.

Recommendations

Recommendations for further research in this area include the following:

1. Select female subjects on the basis of high triglyceride and/or cholesterol concentrations, since the initially high lipid levels would increase the possibility of treatment effect, if in fact a mechanism operates to lower cholesterol and triglycerides with training.

2. Coordinate pre- and post-training blood sampling with a specific day of the menstrual cycle for each subject, since serum cholesterol is known to vary with the changes in estrogen levels associated with the cycle.

3. Select subjects more homogeneous for age, weight, and skinfold thickness, and feed them a uniform diet, to provide even more vigorous control over these variables than was possible in this study.

4. Since serum triglyceride concentration is dose related to estrogen, select subjects who are all using the same brand and dosage of oral contraceptive and who have been using that medication for at least 3 months.

5. Use lipoprotein electrophoretic methods to analyze the serum lipids to determine if specific fractions of the total serum lipids are differentially affected by exercise training (e.g., alpha or beta-cholesterol).

6. Train women at different fractions of their aerobic capacity to determine the threshold at which lipid reduction occurs, if in fact it does occur.

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APPENDIX A

INFORMED CONSENT

I, _____, do hereby voluntarily agree and consent to participate in an exercise testing program conducted by the personnel of the Human Performance Laboratory of the Division of Health and Physical Education of Virginia Polytechnic Institute and State University, to study and test my physical fitness.

To evaluate my cardiorespiratory endurance, I voluntarily agree to perform an exercise test on a bicycle ergometer or motor driven treadmill. With either machine, I understand the procedure will be to increase the workloads from low to high in a progressive manner at intervals of 3-6 minutes until a state of fatigue is approached. Fatigue is defined as the point where work has become very hard as indicated by my feelings of effort or discomfort, dizziness, nausea, breathlessness, chest pain or any other negative symptoms which I report to the testor. I understand that blood pressure and electrocardiogram will be monitored before, during and following exercise and that, on some occasions, expired air will be collected and oxygen intake determined. I further understand that this exercise is near-maximal in nature, but that I will not be asked to exercise to the limits of exhaustion.

I also voluntarily agree to allow personnel of the Human Performance Laboratory to measure my skinfold fat, body circumferences, height and weight and to collect blood samples for determination of serum chemistry.

Risks of the test include occasional changes in the rhythm of the heart rate and the possibility of extreme changes in blood pressure. There are slight possibilities of fainting and heart attack; these chances are increased if a hot shower is taken shortly after strenuous exercise testing. Competent test supervision protects against injury by providing appropriate precautionary procedures. If these precautions are insufficient, a telephone is available which would be used to call the local hospital for emergency service.

Benefits of testing include estimation of physical working capacity and determination of a suitable training program.

I understand that I may abstain from participation in any part of the testing or withdraw from the program should I feel the activities might be injurious to my health. I understand that any test and class data of a personal nature will be held confidential. Data used for research purposes may only be used when not identifiable with me.

I have read the above statements and have had the opportunity to ask questions.

Date: _____ Time _____AM/PM

Participant Signature _____ Witness _____
HPE Personnel

PHYSICIAN'S RECOMMENDATION FORM

I, Dr._____, the attending physician of_____ certify that this patient has no cardiovascular, metabolic or other diseases which would contra-indicate near-maximal exercise stress testing or participation in an endurance exercise program.

Signed_____,M.D.

Physician's comments

_____

_____

_____

_____

Note to Physician: If you want a copy of your patient's exercise performance records for your files, please indicate below:

YES _____

CONSENT FORM - SPOUSE

Date:_____

I,_____, spouse of_____, do hereby voluntarily agree and consent to my spouse's participation in an exercise-research testing program and physical training program conducted by the personnel of the Human Performance Laboratory of the Division of Health and Physical Education of Virginia Polytechnic Institute and State University, to study and test my spouse's physical condition. I have read participants' informed consent form which specifies the exercise test procedures and the risks and benefits of the test (copy attached). I have been fully and completely informed as to the possibilities of physical risk inherent in any physical testing program and I hereby fully assume those risks and any consequences arising therefrom.

Signed:_____

APPENDIX B

SUBJECT HISTORY

Name_____ Address_____

Date_____ Phone (Home)_____

(Work)_____

Age_____ Birth date: Day_____ Month_____ Year_____

Height:_____ in_____ cm_____ Weight:_____ lb_____ kg_____

Do you take any kind of medication? yes / no
If so specify below:

Oral Contraceptives:

Dem/ulen_____

Norlestrin 21 - 1 mg_____

Norlestrin 21 - 2.5 mg_____

Norlestrin 21 - 5 mg_____

Ovral_____

Loestrin 1.5/30_____

Loestrin 1/20_____

Other (specify)_____

_____

_____

Other types of regularly used Medication:

_____

_____

_____

Physician who prescribes medication:

_____

Dr._____

Length of time using medication:

_____ yr_____ mo_____

Do you participate in any regular physical activity of approximately 30 min duration, that is of sufficient intensity to cause you to perspire?
yes / no

Once a week _____ Twice a week _____ three or more times a week _____

Describe the nature of any physical activity in which you participate (swimming, tennis, running, etc.) and the approximate amount of time spent per week._____

_____

_____

_____

APPENDIX C

PARTICIPANT INSTRUCTIONS FOR EXERCISE TESTING

Prior to reporting for your tests, it is essential that you adhere to the following guidelines:

1. See your family physician before your scheduled test session. It is generally desirable for all people to have a medical examination once each year. For those who are going to perform exercise stress tests and participants in exercise training, it is strongly urged. This check-up should include, among other measures, a complete, 12-lead electrocardiogram. Bring a signed statement of your physician, indicating that you are healthy and that there is no medical reason which would preclude your participation in exercise testing and endurance training. Failure, on your part, to obtain a medical check-up, will not exclude you from the program. However, the medical examination is a precautionary procedure that is included for your protection. If a physical contra-indication is reported by the physician, he will recommend that you not participate. We will not allow you to enter the program, under those conditions. If you elect to participate without a physical exam, your risks, as described in the informed consent form, may increase. Therefore, it is encouraged that you comply with this request, so that the risks can be kept as small as possible.

2. Avoid eating any food during the 4 hrs preceding your test. (For example, if scheduled for an 8:00 a.m. test, don't eat breakfast before the test; if tested at 3:00 p.m., don't eat lunch beforehand).

3. Before retiring the evening before your test, consume 3 glasses of clear fluid (juice, water, etc.). If your test is scheduled after 10:00 a.m., also drink 1-2 glasses of water before reporting to the laboratory.

4. Sleep 7-8 hours the night before your test.

5. Empty your bladder and bowels just before reporting to the laboratory.

6. Don't consume any alcoholic beverages or non-prescription drugs during the 12 hours preceding the test. Don't use tobacco during the 3 hours before the test.

7. When reporting for testing, you must wear a halter top and shorts to permit us to make make measurements easily. Men will be assisting with some tests and will be in the laboratory while you are there.

8. Bring your informed consent form, unsigned, to the laboratory. You may wish to ask questions about the test prior to giving your written consent.

APPENDIX D

INSTRUCTIONS FOR RECORDING FOOD INTAKE

1. Please describe food as accurately as possible, particularly sauces, casseroles or mixed dishes. Give method of preparation such as fried, boiled, etc.
2. Estimate in tsp. or tbsp. spreads, sauces, salad dressings.
3. List cheeses, lunchmeats, sausages, eggs, breads & similar foods by kind & number of slices or items:
   e.g., 2 sausage links
   1 slice whole wheat bread
4. Give dimensions of cakes, pies, & similar foods:
   e.g., sponge cake 1½" x 1½"
5. Vegetables, cooked fruit, puddings or other foods that can be measured by a cup, estimate in that manner:
   e.g., 1/4 cup peas
6. List beverages by the cup or oz.
7. Fresh fruit by the pieces:
   e.g., 1 medium orange
8. Meats by the ounce or give dimensions of portions. The following is a guide of equivalent measures to aid in determining portion size.
   2 thin slices lean meat, 4 inch square = 2 ozs.

   3 inch diameter, 1/2 inch thick meat patty = 2 ozs.

   4 inch square, 1/2 inch thick fish fillet = 2 ozs.

   2 slices breast meat poultry or equivalent = 2 ozs.
9. Record all food and beverages consumed in a 24 hour period on the following pages. There is one page for each day.
10. Please record the date & your weight for that day. The weight should be taken in the morning before breakfast & with a minimum of clothing on.

Date: _____

Weight: _____ lbs.

FOOD AND DRINK RECORD:

APPENDIX E

ORAL CONTRACEPTIVES FOR INDIVIDUAL SUBJECTS

Subject	Estrogen (mg)	Progestogen (mg)	Brand-Name
A	0.05	2.5	Norlestrin-21
B[a]	0.05	0.5	Ovral
C	0.08	1.0	Ortho-Novum 1/80-21
D	0.08	1.0	Ortho-Novum 1/80-21
J	0.05	0.5	Ovral
P	0.10	2.5	Enovid - E 21
Q[b]	0.05 0.10	0.5 1.0	Ovral Ovulen - 21
T	0.05	1.0	Ortho-Novum 1/50-21
Y	0.05	1.0	Ortho-Novum 1/50-21
N = 9			
$\bar{X}$, SD	0.07 ± 0.02	1.2 ± 0.6	

[a]Subject B had used oral contraceptives only 1 month prior to first blood sampling.

[b]Subject Q was required to change brands 2 weeks into the study.

APPENDIX F

FASTING TIMES PRECEDING BLOOD SAMPLING FOR INDIVIDUAL SUBJECTS AT PRE-TRAINING AND POST-TRAINING

Group	Subject	Pre-Sampling Fasting Times (hr) Pre-training	Post-training
Pill	A	12.7	9.0
	B	9.3	9.4
	C	11.6	10.1
	D	12.2	10.3
	J	10.0	10.1
	P	9.6	8.8
	Q	9.0	10.7
	T	10.1	9.7
	Y	10.3	10.5
N = 9			
$\bar{X}$, SD		10.5 ± 1.3	9.8 ± 0.7
No-Pill	E	13.1	9.6
	K	9.4	7.4
	L	8.9	9.1
	M	9.6	9.5
	N	9.4	10.8
	O	9.8	9.2
	R	9.6	9.4
	S	10.9	9.4
N = 8			
$\bar{X}$, SD		10.1 ± 1.4	9.3 ± 0.9

APPENDIX G

TOTAL SKINFOLD THICKNESS OF INDIVIDUAL SUBJECTS
AT PRE-TRAINING AND POST-TRAINING

Group	Subject	Total Skinfold Thickness (mm)[a] Pre-training	Post-training
Pill	A	72.6	70.0
	B	63.1	66.9
	C	67.7	68.2
	D	68.4	69.1
	J	87.2	87.1
	P	83.1	81.7
	Q	93.5	83.9
	T	75.6	76.0
	Y	117.2	112.4
$\underline{N}$ = 9 $\bar{X}$, SD		80.9 ± 16.8	79.5 ± 14.4
No-Pill	E	111.0	110.9
	K	150.6	143.3
	L	89.5	90.6
	M	75.6	75.8
	N	68.1	67.3
	O	67.1	67.7
	R	77.2	76.4
	S	85.9	87.0
$\underline{N}$ = 8 X, SD		90.6 ± 28.0	89.9 ± 25.9

[a]Sum of five sites: triceps, subscapular, umbilicus, suprailiac and front thigh.

APPENDIX H

WEIGHT OF INDIVIDUAL SUBJECTS AT PRE-TRAINING AND POST-TRAINING

Group	Subject	Body Weight (kg) Pre-training	Post-training
Pill	A	47.9	47.9
	B	65.8	67.6
	C	62.1	63.1
	D	62.1	62.1
	J	63.3	63.1
	P	56.2	56.1
	Q	68.0	67.6
	T	56.2	55.2
	Y	55.1	55.1
N = 9			
$\bar{X}$, SD		59.6 ± 6.3	59.7 ± 6.6
No-pill	E	73.3	73.5
	K	73.0	73.5
	L	61.2	60.1
	M	62.1	61.9
	N	52.2	52.2
	O	54.4	54.4
	R	47.2	47.9
	S	53.5	54.0
N = 8			
$\bar{X}$, SD		59.6 ± 9.6	59.7 ± 9.7

APPENDIX I

DIET ANALYSES FOR DAYS PRECEDING BLOOD SAMPLING FOR PRE-TRAINING AND POST-TRAINING AND FOR WEEKS DURING TRAINING

		$\bar{X}$ Daily Caloric Intake (Kcal)			$\bar{X}$ Daily Fat Intake as Percent of Calories (%)		
Group	Subject	Pre-training	Post-training	$\bar{X}$ of[a] 3 weeks	Pre-training	Post-training	$\bar{X}$ of 3 weeks
Pill	A	1094	1137	1133	27.7	30.4	34.8
	B	2143	2052	1767	49.7	38.5	41.5
	C	1868	1385	1635	41.8	34.2	39.0
	D	1391	1542	1825	36.4	47.2	45.3
	J	1639	1311	1453	44.1	34.6	39.4
	P	1574	1654	1822	45.5	42.9	42.8
	Q	1847	2097	2021	36.4	34.2	37.8
	T	2526	2236	1836	38.3	42.0	33.5
	Y	2085	2450	2154	42.4	39.4	40.8
N = 9							
$\bar{X}$, SD		1795 ± 431	1762 ± 461	1737 ± 306	40.3 ± 6.4	38.1 ± 5.3	39.4 ± 3.7

[a] $\bar{X}$ of the 1st, 3rd, and 6th weeks.

APPENDIX I

(CONTINUED)

Group	Subject	$\bar{X}$ Daily Caloric Intake (Kcal)			$\bar{X}$ Daily Fat Intake as Percent of Calories (%)		
		Pre-training	Post-training	$\bar{X}$ of[a] 3 weeks	Pre-training	Post-training	$\bar{X}$ of 3 weeks
No-pill	E	1349	1818	1371	56.3	56.3	46.1
	K	1965	2055	1835	36.0	36.1	36.2
	L	1318	1710	1557	43.2	48.4	46.8
	M	2129	1661	1838	34.3	32.6	37.2
	N	1426	1854	1967	35.1	41.9	40.1
	O	1786	1368	1903	39.0	41.6	44.5
	R	1327	1156	1279	41.0	44.3	43.4
	S	1542	1129	1082	31.2	44.6	40.8
N = 8							
$\bar{X}$, SD		1604 ± 318	1593 ± 341	1603 ± 333	39.5 ± 7.8	43.2 ± 7.2	41.9 ± 4.0

[a] $\bar{X}$ of the 1st, 3rd, and 6th weeks.

APPENDIX J

FRACTION OF MAXIMAL HEART RATES AND MAXIMUM OXYGEN UPTAKE FOR INDIVIDUAL SUBJECTS DURING SUBMAXIMAL TEST

Group	Subject	HR_{max} (bts/min)	Fraction HR_{max} (%)	VO_2max (liters/min)	Fraction VO_2max (%)
Pill	A	190	85.8	1.75	80.8
	B	194	89.2	2.39	101.7
	C	190	91.0	2.19	89.0
	D	200	86.5	1.74	73.0
	J	164	90.2	2.10	81.0
	P	198	85.9	1.62	79.0
	Q	196	85.7	2.30	76.1
	T	188	84.0	1.85	83.2
	Y	188	85.1	1.78	83.1
N = 9					
$\bar{X}$, SD		190 ± 11	87.0 ± 2.5	1.97 ± 0.28	80.8 ± 11.2
No-Pill	E	174	86.2	1.75	79.4
	K	188	90.4	2.03	100.5
	L	182	87.9	1.96	104.1
	M	186	87.6	1.90	88.4
	N	186	87.6	1.69	70.4
	O	176	84.1	1.72	89.0
	R	168	94.0	1.68	75.6
	S	180	85.0	1.63	73.6
N = 8					
$\bar{X}$, SD		180 ± 7	87.9 ± 3.1	1.80 ± 0.15	85.1 ± 12.5

APPENDIX K

MAXIMUM VENTILATION AND MAXIMUM OXYGEN UPTAKE FOR INDIVIDUAL SUBJECTS AT PRE-TRAINING AND POST-TRAINING

		Maximum Ventilation (Liters)		Maximum Oxygen Uptake (Liters)	
Group	Subject	Pre-training	Post-training	Pre-training	Post-training
Pill	A	59.9	67.4	1.75	1.80
	B	84.4	103.7	2.39	2.87
	C	79.3	78.1	2.19	2.19
	D	78.1	84.8	1.74	2.02
	J	76.8	92.8	2.10	2.50
	P	77.2	89.8	1.62	1.89
	Q	76.0	77.4	2.30	2.32
	T	71.3	91.3	1.85	1.94
	Y	77.4	79.9	1.78	1.97
N = 9					
$\bar{X}$, AD		75.6 ± 6.8	85.0 ± 10.7	1.97 ± 0.28	2.17 ± 0.35
No-pill	E	71.9	90.5	1.75	2.15
	K	91.7	107.7	2.03	2.35
	L	67.4	76.9	1.96	2.29
	M	52.8	68.8	1.90	2.33
	N	51.8	57.4	1.69	1.82
	O	76.4	86.1	1.72	2.29
	R	54.1	68.9	1.68	1.58
	S	58.0	75.0	1.63	1.88
N = 8					
$\bar{X}$, SD		65.5 ± 14.1	78.9 ± 15.6	1.80 ± 0.15	2.07 ± 0.29

APPENDIX L

STRESS TEST PERFORMANCE DATA FOR INDIVIDUAL SUBJECTS AT PRE-TRAINING AND POST-TRAINING

Group	Subject	Pre-training				Post-training			
		Speed (mph)	Grade (%)	Time in Final Stage (min)	Total Time (min)	Speed (mph)	Grade (%)	Time in Final Stage (min)	Total Time (min)
Pill	A	6.0	2.5	1	9	6.0	2.5	3	11
	B	6.0	2.5	1	9	6.0	5.0	4	14
	C	6.0	2.5	1	9	6.0	2.5	4	12
	D	4.0	0.0	3	5	6.0	2.5	2	9
	J	6.0	2.5	1	9	6.0	2.5	3	11
	P	5.0	0.0	3	7	6.0	2.5	2	10
	Q	6.0	2.5	1	9	6.0	5.0	2	12
	T	6.0	2.5	2	10	6.0	2.5	4	12
	Y	6.0	2.5	1	9	6.0	2.5	4	12
	$\bar{X}$	5.7	1.9	1.6	8.4	6.0	3.1	3.0	11.4

APPENDIX L

(CONTINUED)

Group	Subject	Pre-training				Post-training			
		Speed (mph)	Grade (%)	Time in Final Stage (min)	Total Time (min)	Speed (mph)	Grade (%)	Time in Final Stage (min)	Total Time (min)
No-pill	E	5.0	0.0	2	6	6.0	0.0	2	8
	K	6.0	0.0	2	8	6.0	5.0	1	11
	L	6.0	2.5	2	10	6.0	2.5	4	12
	M	6.0	2.5	1	9	6.0	2.5	3	11
	N	6.0	2.5	3	11	6.0	2.5	4	12
	O	6.0	0.0	3	9	6.0	5.0	1	11
	R	6.0	0.0	1	7	6.0	2.5	1	9
	S	6.0	0.0	1	7	6.0	2.5	2	10
	$\bar{X}$	5.9	0.9	1.9	8.4	6.0	2.8	2.3	10.5

APPENDIX M

CHOLESTEROL AND TRIGLYCERIDE VALUES FOR INDIVIDUAL SUBJECTS AT PRE-TRAINING AND POST-TRAINING

Group	Subject	Cholesterol (mg/100ml) Pre-training	Cholesterol (mg/100ml) Post-training	Triglyceride (mg/100ml) Pre-training	Triglyceride (mg/100ml) Post-training
Pill	A	193	175	135	122
	B	187	206	46	66
	C	205	190	153	118
	D	191	194	110	83
	J	219	180	58	56
	P	198	196	134	135
	Q	158	161	67	93
	T	156	162	63	49
	Y	206	210	76	71
N = 9					
$\bar{X}$, SD		190.3 ± 21.2	186.0 ± 17.7	93.6 ± 39.7	88.1 ± 30.9
No-pill	E	198	201	31	51
	K	255	204	54	62
	L	174	153	74	60
	M	185	176	55	56
	N	286	244	45	46
	O	159	154	47	48
	R	246	216	46	55
	S	206	215	62	54
N = 8					
$\bar{X}$, SD		213.6 ± 44.2	195.4 ± 32.0	51.8 ± 12.8	54.0 ± 5.5

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THE EFFECTS OF AN EXERCISE TRAINING PROGRAM ON SERUM CHOLESTEROL AND TRIGLYCERIDE LEVELS IN WOMEN USING ORAL CONTRACEPTIVES

by

Elizabeth Ann Ritchey

(ABSTRACT)

The purpose of this study was to determine if a training program consisting of 30 minutes of running on a treadmill, 3 days per week for 6 weeks, would lower serum cholesterol and/or triglyceride concentration in women using oral contraceptives. The intensity of the training was maintained at approximately 75% of the subject's pre-training maximal oxygen uptake. Comparisons were made in the variables triglyceride, cholesterol, maximum ventilation and maximum oxygen uptake, prior to and following training, between subjects who used birth control pills and those who did not.

Eighteen women volunteers between the ages of 25-39 years, participated in the training program. Nine women were using oral contraceptives of the combined type. The subjects were free of metabolic diseases and were judged to be sedentary.

Fasting blood samples were taken prior to and following the training program for lipid analyses. Maximum oxygen uptake and ventilation were determined by pre-training and post-training stress tests. To isolate training as the factor responsible for any changes in serum lipid concentration, the factors of body weight, skinfold thickness, fasting times and dietary patterns were held constant across the training period.

Using multivariate analysis of covariance, one-way classification, to compare the group using oral contraceptives with the group not using them, no significant differences ($p < 0.05$) were found between the groups for either the blood lipids or the measures of functional capacity.

Hotelling's T^2 for comparison of pre-test to post-test differences within groups was employed using the linear combinations of the means of maximum ventilation and maximum oxygen uptake. The same analysis was used for the linear combination of the means of triglyceride and cholesterol. Only the group not using oral contraceptives showed significant difference ($p < 0.05$) in any of the variables. This difference was an increase after training, in maximum ventilation and maximum oxygen uptake.

Other changes as a result of training were noted, although differences were not statistically significant at the 0.05 level of probability. These changes were 1) an improvement in the physical working capacity of the group using oral contraceptives, 2) a decrease in serum triglyceride and/or cholesterol levels in subjects whose initial values were in the upper ranges of clinical normality for these lipids. Exercise did not appear to affect the lipid levels of subjects who initially had low or average values.