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The Effect Of A Single Period Of Aerobic Exercise On The Concentration Of Serum Cholesterol In Humans

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THE EFFECT OF A SINGLE PERIOD OF AEROBIC EXERCISE ON

THE CONCENTRATION OF SERUM CHOLESTEROL IN HUMANS

(TITLE)

BY

Stanley B. Blank

THESIS

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FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
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I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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ADVISER

October 13, 1980
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DEPARTMENT HEAD

THE EFFECT OF A SINGLE PERIOD OF AEROBIC EXERCISE ON THE CONCENTRATION OF SERUM CHOLESTEROL IN HUMANS

by

Stanley B. Blank

A Thesis Abstract

presented to the faculty of

The Physical Education Department

Eastern Illinois University

Fall 1980

The purpose of this study was to determine whether a single period of aerobic exercise will cause a reduction in serum cholesterol concentration.

Ten adult individuals from Salem, Illinois were selected to participate in the study. The subject group consisted of seven males ranging in age from 17 to 46, and three females ranging in age from 31 to 41. Each subject was known to participate in regular periods of exercise and for the purposes of this study the subjects were considered to be moderately trained. Each subject was given an information sheet concerning the test one week prior to the test.

The test procedure consisted of a pre-exercise blood sample taken from each subject. The subjects then jogged at an aerobic pace for 30 minutes. Heart rates were taken at five minute intervals during the exercise to determine exertion levels. At the end of the 30 minute exercise period, a post-exercise blood sample was obtained. The pre-exercise and post-exercise blood samples were analyzed at the Salem Memorial Hospital Laboratory, Salem, Illinois.

A t-test for correlated data was used to determine whether a significant difference between the pre-exercise and post-exercise serum cholesterol levels existed. A Pearson-Product Moment Correlation was used to determine whether a relationship existed between the fitness level, as measured by the distance run, and the absolute amount of post-exercise serum cholesterol change.

Based on the results of the study, it is concluded that a single period of aerobic exercise decreases the post-exercise concentration of serum cholesterol in normal individuals.

ACKNOWLEDGMENTS

The author would like to express his sincere appreciation to Dr. M. Thomas Woodall, Dr. William Buckellew, and Dr. Russell D. Fischer for their patient guidance and understanding during the course of this study.

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INTRODUCTION

The compound cholesterol was first described in the latter half of the eighteenth century. As early as 1789 a large quantity of the substance was prepared from the alcohol-soluble part of human gallstones. The crystalline nature of this substance was believed to be related to "fatty wax", a matter obtained from grave wax. In 1816, the designation "cholesterine" was introduced from Greek: chole, bile; and steros, solid. Cholesterine was found in both human and animal bile. The discovery of cholesterine in the brain in 1834 was followed by the discovery of cholesterine in human blood four years later. Atheromatous arteries were first linked with cholesterine in 1843. The term "cholesterol" was first used in 1859 when cholesterine was discovered to be an alcohol or sterol. Esters of cholesterol were first synthesized in 1859, and in 1910, cholesterol esters were shown to be the chief constituents of atheromatous deposits in arteries. The presently accepted chemical formula for cholesterol was derived in 1932 (Cook, 1958:1-2).

Cholesterol is a tasteless, odorless, white fatty alcohol or sterol (Hyperlipoproteinemia, 1979). Cholesterol is the most abundant sterol in the mammalian tissues, (Kritchevsky, 1979:3) and is present in the tissues and structures, most notably the cell membranes; of nearly every living creature, including man (Cook, 1958:146-148). The approximate distribution of cholesterol in human tissues is shown in

Table 1 (Sabine, 1977:6, Table 2.1).

The average adult male, if such existed, would weight about 70 kg., of which just over 0.2 percent, or about 145 g., would be cholesterol. As can be seen in Table 1, approximately 8 percent or about 11.6 g. of the total-body cholesterol is contained in the blood (Sabine, 1977:1).

The sterol cholesterol in the blood is found in both the free form and as cholesterol esters. Esterified cholesterol, or cholesterol connected with one of the many long chain fatty acids, makes up approximately 72 percent of the total serum cholesterol. Cholesterol found in the "free" form is, in a sense, never "free" since it is always present as a component of macromolecular complexes or beta-globulins. Beta-globulins contain almost all the lipoproteins. "Free" cholesterol, therefore, implies that it is not esterified (Brobeck, 1973).

Cholesterol is not soluble in water, and since water is a major constituent of blood serum and plasma, cholesterol is not soluble in blood serum or plasma. In order to be carried in the blood, it must combine with proteins, which are soluble. This combination of blood proteins, cholesterol, and certain essential lipids, such as triglycerides and phospholipids, is called a lipoprotein (Lamb, 1980).

There are four classes of lipoproteins. 1) The chylomicrons are composed mainly of triglycerides, with small amounts of cholesterol and phospholipids. 2) Very low density lipoproteins (VLDL), also known as pre-beta lipoproteins, are composed primarily of triglycerides, but to a lesser degree than chylomicrons. 3) Low density lipoproteins (LDL) or beta-lipoproteins are made up of nearly 50 percent cholesterol.

Table 1

Approximate Distribution of Cholesterol in a 70 kg. Man

System	Organ Weight (g)	Percentage of Total Body Cholesterol
Brain and Nervous System	1,600	22
Connective Tissue Including Adipose and Body Fluids	12,100	22
Muscle	30,000	21
Skin	4,200	11
Blood	5,400	8
Bone Marrow	3,000	5
Liver	1,700	4
Alimentary Tract	2,500	3
Lungs	950	1
Kidneys	300	1
Adrenal Glands	12	1
Other Glands, Heart, Spleen, Skeleton, Blood Vessels	7,850	1

In 4) high density lipoproteins (HDL) or alpha-lipoproteins, the principal components are phospholipids; there is also a lesser amount of cholesterol involved (Lipids, 1978:5). Figure 1 illustrates the components of the major lipoproteins (Lipids, 1978:5, Fig. 1).

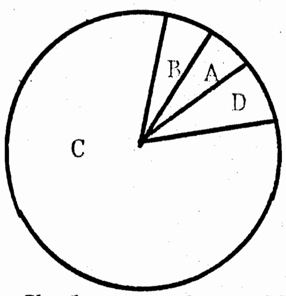
Figure 1 shows the relative makeups of each of the four major lipoproteins and the varying amounts of triglycerides, cholesterol, phospholipids, and proteins each one contains.

The lipoprotein metabolic cycle begins in the liver, which is the principal site of cholesterol synthesis in the body, although many other tissues are capable of cholesterol synthesis (Cook, 1958: 202). The liver synthesizes VLDL, which is the parent lipoprotein. Enzymatic actions of lipoprotein lipases remove a large portion of the triglycerides, along with some protein, from VLDL. This produces intermediate-density lipoprotein (IDL), which contains equal parts of triglyceride and cholesterol. Enzymatic processes further degrade IDL, removing virtually all triglycerides. This leaves a high-cholesterol LDL. LDL is the principal carrier of cholesterol in the blood serum or plasma. HDL, which is also manufactured by the liver, acts as a "de-cholesterolizer". This lipoprotein completes the metabolic process by carrying cholesterol from peripheral tissues back to the liver where it is catabolized and excreted. Chylomicrons, although containing some cholesterol, are used chiefly as triglyceride transporters and sources of energy for skeletal and cardiac muscles. Chylomicrons are not responsible for the deposition of cholesterol in the tissues (Lipids, 1978:9). In addition to hepatic and other tissue synthesis of cholesterol, dietary cholesterol may contribute up to 40 percent of the total plasma cholesterol, although dietary effects are usually not grossly

KEY

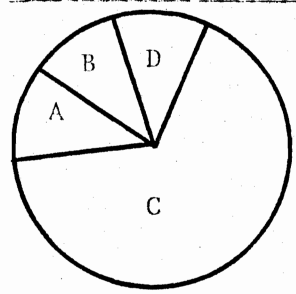
A. Protein
B. Cholesterol
C. Triglycerides
D. Phospholipids

Chylomicrons



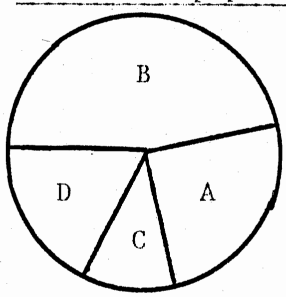
Cholesterol: 3-5%
Triglycerides: 85-95%
Phospholipids: 5-10%
Protein: 1-3%

VLDL - Pre-Beta Lipoproteins



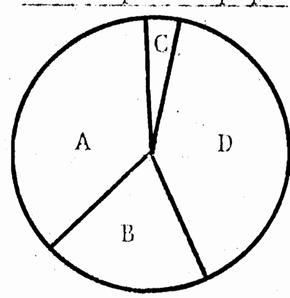
Cholesterol: 10-15%
Triglycerides: 60-70%
Phospholipids: 10-15%
Protein: 10%

LDL-Beta Lipoproteins



Cholesterol: 45%
Triglycerides: 5-10%
Phospholipids: 20-30%
Protein: 25%

HDL-Alpha Lipoproteins



Cholesterol: 20%
Triglycerides: Trace
Phospholipids: 30%
Protein: approx. 50%

Figure 1

Composition and Characteristics of
the Major Lipoproteins

evident (Sabine, 1977:215).

In the blood, a total plasma cholesterol concentration would be distributed as follows: (200 mg./100 ml.) VLDL, 10 mg./percent: LDL, 140 mg./percent: HDL, 50 mg./percent. Table 2 shows plasma cholesterol concentrations in normal americans (Wintrobe, 1974).

As can be seen from Table 2, plasma cholesterol concentrations in the blood increase throughout life. The greatest increase appears between the second and third decades of life, with substantial increases in each decade thereafter.

The total amount and distribution of plasma cholesterol observed at any one time will be a balance struck or reached between the relative rates of a large number of processes. These processes are as follows:

1) The entry into the plasma of freshly absorbed cholesterol from the diet. This source is also called exogenous cholesterol.

2) The entry of freshly synthesized cholesterol from the liver and other sites. This source is also called endogenous cholesterol. This process can be affected by certain drugs and thyroid disorders.

3) The re-entry of cholesterol from depot stores.

4) The interchange of cholesterol between various forms.

5) The metabolism of the lipoprotein fractions.

6) The uptake of cholesterol from the plasma by the liver and other organs, either for excretion, further metabolism, or storage (Sabine, 1977:71).

According to the World Health Organization (Van Bell, 1965:1), athérosclerosis is "a variable combination of changes of the intima of arteries consisting of the focal accumulation of lipids, complex

Table 2

Plasma Cholesterol Concentrations in Americans

Age; yrs.	Cholesterol mg./100 ml.
1-19	175 (120-230)
20-29	180 (120-240)
30-39	205 (140-270)
40-49	225 (150-310)
50-59	245 (160-330)

carbohydrates, blood and blood products, fibrous tissue and calcium deposits, and associated medial changes."

Atherosclerosis appears to have its beginnings in the first decade of life. Fibromuscular intimal thickening takes place at this time, including the development of intimal cushions at the branch sites of major arteries (i.e. carotid, coronaries, renal, and abdominal). Upon this matrix of intima thickening, lipid accumulates in the form of fatty streaks. These fatty streaks consist microscopically of smooth muscle cells in the intimal layer, which are filled with lipid deposits, mainly cholesterol and cholesterol esters. These fatty streaks may regress and disappear, remain unchanged, or progress into formations called plaques. The most important alteration of the intima of arteries in atherosclerosis is the accumulation of lipid materials, of which cholesterol is of the utmost importance (Van Belle, 1965:2).

In populations prone to atherosclerotic vascular disease, plaques begin to appear in the third decade. Atherosclerotic plaques are made up of smooth-muscle cells, connective tissue, and lipid deposits, mainly cholesterol. Hypertension appears to be a stimulus for plaque development. Further accumulation of cells, connective tissue, and fat over decades usually results in severe or complicated lesions leading to blockage of the involved arterial lumen and infarction of the tissue it supplies (Cecil, 1979:1218-1219).

The elevation of plasma or serum cholesterol levels has long been associated with an increase in cardiovascular risk of atherosclerosis. For both sexes combined, the relative incidence of infarction between the ages of 30 and 49, at starting levels greater than 260 mg./percent, was three to five fold that of men and women with cholesterol levels less than 220 mg./percent. There appears to be a continuous gradient of risk of atherosclerosis as the cholesterol level ascends (Framingham, 1968).

Recent studies show that the level of cholesterol rich low-density lipoprotein (LDL), the major carrier of cholesterol in our blood, is directly related to the degree of cardiovascular risk. Conversely, the level of high-density lipoprotein cholesterol (HDL) is inversely related to the degree of cardiovascular risk. The measurement of both LDL and HDL levels in the blood gives more meaningful information than the total determination of plasma cholesterol (Cecil, 1979:1220).

Statement of the Problem

The purpose of this study was to determine whether a single bout of aerobic exercise would have an effect on serum cholesterol concentrations in normal individuals.

Delimitations

This study was delimited to the effect of one isolated period of aerobic exercise on the concentration of serum cholesterol. The aerobic exercise used in this study was in the form of jogging for a thirty minute time period.

Justification of the Study

Almost half of all human beings die of arteriosclerosis; approximately two-thirds of the deaths are caused by thrombosis of one or more coronary arteries, and the remaining one-third by thrombosis or hemorrhage of vessels in other organs (Guyton, 1971).

Elevated serum cholesterol is a primary risk factor in coronary artery disease. Individuals with high levels of cholesterol in the blood are at a greater risk for development of atherosclerotic complications and premature heart attacks than in individuals with low or normal levels (DeBakey, 1977:301).

Kritchevsky (1979:1) stated that patients with high levels of plasma cholesterol tend to have a much greater risk of myocardial infarctions compared to those with relatively lower levels of plasma cholesterol. Increased levels of plasma cholesterol are associated with an increased rate of deposit of cholesterol in the tissues, including the arterial intima. The reduction of plasma cholesterol, and therefore the reduction of the rate of cholesterol deposit, may reduce the risk of myocardial infarction by limiting the size of cholesterol deposits within the arterial intima.

The cholesterol levels of 220-246 mg./percent, which are often considered as satisfactory for the middle-aged American male, are higher than usually found among middle-aged males in countries with a low incidence of atherosclerosis. The optimal serum cholesterol level for the middle-aged American male may be 200 mg./percent or less (Arteriosclerosis, 1971).

Dr. Michael DeBakey (1977:155) stated that "if we could lower the plasma or serum cholesterol content of everyone in the United States below 150 mg./percent, we could probably wipe out coronary artery disease."

If a single bout of aerobic exercise, such as jogging, will decrease the concentration of cholesterol in the blood, then aerobic exercise could be valuable in reducing the risk of atherosclerosis and myocardial infarction.

Limitations

This study was limited by several factors. Although it was stressed to the subjects to refrain from eating before the test as described by Wintrobe (1974) and Kritchevsky (1979:7) who suggest fasting 14 to 16 hours before the test, it was impossible to oversee each subject to determine whether this was done as requested.

Van Belle (1965:112) suggested that certain drugs may affect cholesterol synthesis in the human body. The subjects were not questioned concerning the drugs taken before the study (i.e. prescription drugs, steroids, antibiotics, and certain over-the-counter medication).

Kritchevsky (1979:7) presented evidence that it is important to standardize postural positions for the collection of blood. Ideally, subjects should be placed either in a recumbent position, a sitting position, or a standing position and be allowed to remain in this position for at least fifteen minutes before a blood sample is taken. If a sample is taken immediately after a change of posture (i.e. from a standing to a sitting or recumbent position), changes in plasma cholesterol concentrations occur. In this study, the subjects were not standardized for postural position when the blood samples were taken.

Pinckney (1973) suggested that anxiety can raise the cholesterol level in the bloodstream via release of hormones. Anxiety may have affected the measurement of serum-cholesterol levels in some of the subjects.

Definitions of Terms

The following terms have been defined for this study using Taber's Cyclopedic Medical Dictionary (1977).

Arteriosclerosis

Arteriosclerosis is the term applied to a number of pathological conditions in which there is a thickening, hardening, and loss of elasticity of the walls of blood vessels, especially the arteries.

Atheroma

An atheroma is a fatty degeneration or thickening of the wall of the larger arteries.

Atherosclerosis

Atherosclerosis is a form of arteriosclerosis in which there are localized accumulations of lipid containing material (atheromas) within or beneath the intimal surfaces of blood vessels.

Cholesterol

Cholesterol is a monohydric alcohol; a sterol widely distributed in animal tissues. Cholesterol is synthesized in the liver and is a constituent of bile. Disorders in cholesterol metabolism can result in atherosclerotic changes in arterial intimas.

Hyperlipidemia

Hyperlipidemia is an increase above normal levels of the blood's lipid content which may be in the form of hypercholesterolemia (elevated cholesterol) or hypertriglyceridemia (elevated triglycerides).

Hyperlipoproteinemia

Hyperlipoproteinemia is an elevation of any of the lipoprotein constituents of the blood.

Infarction

An infarct is an area of tissue in an organ or part of which undergoes necrosis following cessation of blood supply. Myocardial infarction refers to an infarct of the myocardium of the heart.

Intima

The intima is the innermost coat of a structure, as a blood vessel.

Ischemic Heart Disease

Ischemic heart disease (IHD) is heart disease caused by oxygen insufficiency of the myocardium through atherosclerotic deposits in the arterial intima.

Lipid

Lipids are any one of a group of fats or fatlike substances, characterized by their insolubility in water and solubility in fat solvents such as alcohol, ether, and chloroform.

Lipoproteins

Lipoproteins are conjugated proteins consisting of simple proteins combined with lipid components such as cholesterol, phospholipid, and triglyceride.

Phospholipid

Phospholipid is a lipoid substance containing phosphorous, fatty acids, and a nitrogenous base.

Plaques

Plaques are patches on a surface, such as the intimal surface of an artery.

Serum Globulins

Serum globulins are a group of simple proteins that are soluble in blood serum or plasma. These globulins contain all the lipoproteins and are labeled alpha, pre-beta, and beta according to their lipoprotein association.

Sterol

A sterol is one of a group of substances related to fats and belonging to the lipoids. They are alcohols and are found free or esterified with fatty acids. Cholesterol is the most abundant sterol.

Triglyceride

Triglycerides are a combination of glycerol with fatty acids. Most animal fats are triglycerides.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter was organized to include two main areas. The first area concerns literature that is concerned with aerobic exercise and the reduction or change in plasma or serum lipid concentrations, most notably, cholesterol. The second area deals with literature that discusses the effects of aerobic exercise on the levels of LDL and HDL cholesterol in the blood.

Exercise and Serum Lipid Concentrations

In his study of four subjects trained with hard endurance exercise, Golding (1961) concluded that such activities can readily reduce total serum cholesterol concentrations, especially if the concentrations were high initially. Golding received reductions in cholesterol levels in all four subjects, averaging twenty-eight standard scores, which were significant at the 1 percent level of confidence.

Boyd and Oliver (Cook, 1958:188) imply that exercise may have an effect on plasma cholesterol levels when they stated that "all lipid metabolism, including the plasma cholesterol levels, must be profoundly affected by the caloric balance between energy intake and expenditure."

Page (Cook, 1958:430) suggested that plasma cholesterol levels are lower in rats who are exercised regularly for months than in their sedentary controls. Page commented that it may be the massaging action of exercise on the blood vessels and tissues that increases the clearing of lipid from the vessel wall by the lymph apparatus. Page also found that atherosclerosis usually occurs much more severely in places where the blood vessels are not subjected to the massaging action of muscles.

In his study of people in Cape Town, South Africa, Keys (1956) concluded that physical activity does indeed lower serum cholesterol concentrations. Keys also concluded, however, that habitual diet habits low in total lipid content had more influence upon the total serum cholesterol concentrations than did physical activity.

While studying short term, moderate intensity training programs of seven weeks duration with two to three workouts a week, Kilbom (1971) discovered significant decreases in blood cholesterol levels. The subjects used in this study were young and middle-aged females.

Mann, et al (1969) reported decreases in both serum triglyceride and cholesterol levels in individuals engaged in regular aerobic exercise programs. This change is most evident in individuals who initially have high levels of serum cholesterol prior to training.

In the Jewish Community Feasibility Study where a multifactoral approach was used (Morse, 1974), serum cholesterol levels obtained before and after physical training showed an average reduction from 263 mg./percent to 242 mg./percent serum cholesterol concentration.

Oscai, et al (1972) reported that after a single period of work, which consisted of jogging for three miles at a ten minute pace, serum triglyceride reduction occurred. This training effect lasted two days or longer.

In a study of two swimmers trained with an endurance swimming program, Pohndorf (1958) found that daily swimming significantly lowered serum cholesterol levels. After the initial reduction in cholesterol concentration, occasional swimming (two times per week) seemed to maintain a lower level of cholesterol.

Sabine (1977:255) stated that there is very good evidence that exercise can increase plasma cholesterol catabolism considerably in man. This catabolism is measured in terms of conversion of cholesterol to bile salts and/or the amount of CO_2 excreted.

There have been studies indicating that cholesterol levels may rise or stay the same as a result of exercise (Morse, 1974). The majority of the research tends to support the idea that exercise is one of several significant factors involved in maintaining blood cholesterol levels within limits generally considered normal.

Effects of Exercise on HDL-LDL Levels in the Blood

Recent studies (Cecil, 1979:1220) have shown that the measurement of HDL and LDL cholesterol concentration in the blood may give a more accurate picture of cholesterol and may provide more information than the determination of total plasma or serum cholesterol alone. The level of cholesterol-rich low density lipoproteins (LDL) are directly related to the risk of cardiovascular disease or atherosclerosis. LDL cholesterol tends to carry and deposit cholesterol at the arterial intima. High density lipoprotein cholesterol levels (HDL) are inversely related to cardiovascular risk. HDL tends to carry cholesterol away from the arterial intima and to the liver, where it is catabolized and excreted from the body.

In the monograph "Arteriosclerosis" (1977:20) it is reported that high, beneficial levels of HDL are most apt to occur in women, in people who exercise vigorously, and in those who consume moderate amounts of alcohol.

Berg, et al (1976) reported that the mean HDL concentrations were significantly lower in Swedish men with coronary heart disease than in healthy, middle-aged Swedes. These results accord with the hypothesis that high levels of HDL, to some extent, protect against ischemic heart disease or coronary artery disease.

Gordon (1977) in a study connected with the Framingham study decided that the combination of a moderate total cholesterol level (less than 260 mg/percent), high HDL cholesterol, and low triglycerides generally could be related to a very low incidence of coronary artery disease.

According to Hartung (1980) HDL-cholesterol concentrations were found to be higher in 147 middle-age men runners and joggers than in inactive controls. The mileage was positively correlated with HDL-cholesterol, but not with total cholesterol. Some high-mileage runners had relatively low HDL-cholesterol levels, and some low-mileage joggers had very high HDL-cholesterol levels, but there were few other differences between subgroups. Jogging eleven miles per week may result in dramatic increases in HDL-cholesterol for some men, while in others, forty miles per week produces only modest increases. In general, the data support the contention that regular endurance activity elevates the HDL cholesterol levels over a prolonged period. The authors hypothesized that an exercise-mediated increase in HDL-cholesterol may take months or years to manifest itself.

Miller (1975) reported that the body cholesterol pool increases with decreasing plasma HDL levels. HDL facilitates the uptake of cholesterol from peripheral tissues and its transport to the liver for catabolism and excretion. Plasma HDL levels are reduced in several conditions associated with an increased risk of future coronary artery disease, including hypercholesterolemia and hypertriglyceridemia. Subjects with ischemic heart disease (IHD) or coronary artery disease have lower levels of HDL than healthy subjects within the same community. A reduction of plasma HDL concentration may accelerate the development of atherosclerosis through hyperlipidemia and by impairing clearance of cholesterol from the arterial wall. The development of atherosclerosis might be more successfully prevented by increasing plasma HDL levels, and hence the clearance of cholesterol from the artery wall, than by conventional attempts to reduce the plasma cholesterol and other lipoprotein levels alone. Miller also stated that the incidence of ischemic heart disease in Eskimos in rural Greenland, despite their having hyperlipoproteinemia of LDL levels in plasma, is consistent with such a protective effect of increased HDL levels.

In a study of thirty-two sedentary men with coronary artery disease, Streja and Mymin (1979) reported that after a thirteen week moderate program of exercise, high density lipoprotein levels increased significantly. The participants did not change their dietary or smoking habits. Participants walked or jogged 2.82 km. three times a week. Subjects maintained 70 percent to 80 percent of their maximum heart rates for 20 to 30 minutes each session. No changes occurred in plasma triglycerides or LDL cholesterol levels. The authors conclude that moderate activity can be used to increase HDL-cholesterol concentration in people prone to cardiovascular disease.

According to Wood (1977) recent studies have shown consistent association between low plasma concentrations of HDL-cholesterol and an increased risk of coronary artery disease. In Wood's study of male and female runners vs. matched control groups, the runners showed modestly lower total cholesterol levels, while triglyceride levels were 50 percent less than in the controls. HDL-cholesterol levels were higher in runners and LDL-cholesterol levels were lower than the controls. All differences were statistically significant (p less than 0.05) and only partially attributable to known factors other than high physical activity level.

Summary

Golding (1961) concluded that endurance exercise lowered serum cholesterol concentrations. Boyd and Oliver (Cook, 1958:188) implied that exercise may affect cholesterol concentrations by affecting energy expenditure. Page (Cook, 1958:430) found lower cholesterol levels in rats that were exercised, and suggested that the massaging action of exercise on arteries may cause a lowering of plasma cholesterol concentrations. Keys (1956) concluded that exercise does lower serum cholesterol levels. Kilbom (1971) found lowered serum cholesterol levels in young and middle-aged women who engaged in moderate exercise. Mann (1969) reported a lowering effect in both triglyceride and cholesterol levels in individuals who engage in regular aerobic exercise programs. In the Jewish Community Feasibility Study (Morse, 1974) serum cholesterol showed an average reduction from 263 mg./percent to 242 mg./percent after physical training. Oscai (1972) reported that after a single period of exercise, serum triglyceride levels showed a reduction that lasted two days. Pohndorf (1958) found that daily swimming significantly lowered serum cholesterol levels. Sabine (1977:255) stated that exercise in man can increase catabolism of cholesterol in the blood. Some studies have shown that cholesterol levels stay the same, or may even rise during exercise (Morse, 1974), but the majority of research tends to support the idea that regular aerobic exercise may decrease serum cholesterol concentrations in individuals, especially if hypercholesterolemia is present before the physical training program begins.

A direct relationship exists between the level of LDL-cholesterol levels and the development of coronary artery disease. An inverse relationship exists between the relationship of HDL-cholesterol levels and coronary artery disease (Cecil, 1979:1220).

In the monograph "Arteriosclerosis" (1977:20) it was reported that vigorous exercise can induce high levels of beneficial HDL-cholesterol. Berg (1976) reported that in men with coronary artery disease, HDL levels are significantly lower than in middle-aged healthy men. This supports the contention that high levels of HDL may offer some protection against coronary artery disease. Gordon (1977) related a relatively low plasma cholesterol level, a high HDL-cholesterol level, and a low triglyceride level generally is related to a very low-incidence of coronary artery disease. According to Hartung (1980) HDL-cholesterol concentrations were found to be higher in 147 middle-age men runners and joggers than in inactive controls. Miller (1975) reported that plasma cholesterol levels increased with decreasing plasma HDL levels. Coronary artery disease may be more successfully prevented by increasing plasma HDL concentrations, as is found in the Eskimos of Greenland. Streja and Mymin (1979) reported that after a thirteen week moderate program of exercise, HDL-cholesterol levels increased significantly. According to Wood (1977) male and female runners showed modestly lower total cholesterol levels, while triglyceride levels were 50 percent less than the controls. HDL-cholesterol levels were higher and LDL-cholesterol levels were lower in the runners as compared to the controls. These studies suggested that aerobic exercise increased the levels of HDL-cholesterol in the blood. HDL-cholesterol levels appear to be important in preventing coronary artery disease. Not only is the level of HDL-cholesterol in the blood significant in the prevention of coronary artery disease, but the ratio of HDL-cholesterol levels to LDL-cholesterol levels seems to be of some importance also.

Chapter 3

METHODOLOGY

The purpose of this study was to determine whether a single period of aerobic exercise would affect serum cholesterol levels in normal individuals. This chapter includes a description of the subjects, testing procedures, and the methods used in the testing.

Subjects

Ten adult individuals from Salem, Illinois were selected to participate in this study. The subject group consisted of seven males ranging in age from 17 to 46, and three females ranging in age from 31 to 41. Each subject was known to participate in regular periods of exercise, particularly jogging and tennis, and for the purposes of this study the subjects were considered to be moderately trained. Four of the subjects were members of the Salem "Run For Your Life" group. None of the subjects reported any known physical abnormality or disability at the time of the study.

Preliminary Information

One week before the testing was to take place, each subject was given an information sheet describing details of the cholesterol run and a note describing fasting procedures for the night before the test. A copy of this information sheet is included in Appendix A. The instructions contained in the sheet differ from the fasting procedures given by Wintrobe (1974) and the activity level before the blood sample was taken differs from procedures found in Kritchevsky (1979:7), Hartung (1980), and Wood (1977). Wintrobe recommended fasting 14 to 16 hours before a blood sample is drawn and Kritchevsky, Hartung, and Wood recommended that individuals remain relatively inactive for approximately eight hours before a blood sample is obtained in order to insure that a resting sample is procured.

Testing Procedures

The test site was the Salem Community High School track, Salem, Illinois. Cooperation was obtained from the Salem Memorial Hospital in providing personnel to obtain blood samples. All syringes and vacutainer tubes were provided by Salem Memorial Hospital.

Pre-Test Procedures

Each subject reported to the track at 7:00 a.m. dressed in appropriate running apparel. The subjects were seated in folding chairs, or were allowed to lie down on cots for the drawing of the blood samples. Two registered nurses volunteered their time and performed the actual blood drawing. For the sake of time, convenience, and uniformity it was decided that the subjects should begin jogging at two minute time intervals as soon as the pre-test blood sample was obtained.

Test Procedures

To minimize the time between the drawing of the first blood sample and the beginning of the exercise, the subjects were started at two minute intervals. The subjects were instructed to jog around the track at their own pace for thirty minutes. Under no circumstances were they to cross the anaerobic threshold, or become "out of breath". At five minute intervals after the beginning of the exercise each subject was stopped and a 15 second carotid heart rate was taken by the experimenter. The subject was then instructed to continue jogging. A total of six heart rates were taken for each individual during the exercise. The staggered starting times facilitated the taking and recording of heart rates. Heart rates were obtained to determine at what percentage of the maximum age-related heart rate each subject was working (Morse, 1974). No recovery heart rates were obtained from the subjects. The number of laps were counted and recorded for each subject to determine, along with heart rates, the relative fitness level of each individual. Volunteers were enlisted by the experimenter to help count laps for the subjects.

Post-Test Procedures

At the end of the thirty minute exercise period a final heart rate was recorded. The subjects were then taken to the chairs or cots and instructed to rest and recover for five minutes prior to obtaining the final blood sample. Due to the staggered starting times, the final samples were also taken at two minute intervals. After the final blood sample was obtained, the experiment was terminated and the subjects were allowed to depart.

Statistical Analysis

The pre-test and post-test blood samples were taken to the Salem Memorial Hospital Laboratory, Salem, Illinois for analysis immediately after the last blood sample was collected. The data for this study was obtained from the cholesterol level analysis and was expressed in terms of milligram percent, or the number of milligrams of cholesterol per 100 milliliters of blood serum or plasma. The number of laps run in 30 minutes by each subject was collected as data and recorded. A 15 second carotid heart rate from each subject was taken and recorded at five minute intervals during the run and was expressed in terms of beats per minute. A total of six heart rates were recorded.

A t-test for correlated data was used to determine if a significant difference existed between the pre-exercise and post-exercise cholesterol levels in the subjects tested.

A Pearson Product Moment Correlation was applied to the data to determine whether a relationship existed between the number of laps or distance run in 30 minutes and the absolute change from pre-exercise to post-exercise cholesterol levels in each subject.

The number of laps or distance run by each subject in 30 minutes was also used and expressed as a measure of relative fitness among the subjects. Heart rates were used to compute each subject's level of exertion by comparing maximum individual exercise heart rates and age-related maximum heart rates (Morse, 1974). The above data was not analyzed statistically, but was presented for the purposes of documenting subject workload during the experiment.

Chapter 4

ANALYSIS OF THE DATA

The purpose of this study was to determine whether a single period of aerobic exercise has an effect on the concentration of serum cholesterol in normal individuals. The period of exercise consisted of a thirty minute jog around the local high school track. Pre-exercise and post-exercise blood samples were taken from each individual. Heart rates were taken at the carotid pulse for 15 seconds at five minute intervals, including an immediate post-exercise heart rate. A total of six heart rates were recorded. The number of laps run by each individual was also recorded.

Data Conversion

The blood samples were analyzed by the Salem Memorial Hospital Laboratory and converted to cholesterol levels measured by the number of milligrams of cholesterol per 100 milliliters of blood serum. This is abbreviated as mg./percent. The 15 second heart rates were converted to beats per minute or BPM. The track was a 400 yard track, so the number of laps ran by each individual was left in numerical form as a relative indicator of distance, and not converted to either an English or a metric distance.

Findings

Data for the study was obtained from the analysis of cholesterol levels of the pre-test and post-test blood samples. This analysis was performed at the Salem Memorial Hospital Laboratory, Salem, Illinois. The cholesterol levels were expressed in milligram percent. Distances run in laps and 15 second carotid heart rates at five minute intervals were also taken and recorded. The findings from this study have been presented in the remainder of this chapter.

Pre-Exercise and Post-Exercise Cholesterol Concentrations

The pre-exercise and post-exercise cholesterol concentrations, (mg./percent) along with the age and sex of each subject is shown in Table 3. A copy of the actual laboratory data sheet has been placed in Appendix B.

According to data presented in Table 3, six of the subjects experienced a drop in their post-exercise serum cholesterol levels. Three of the subjects experienced no change in post-exercise cholesterol concentrations, and one subject experienced an increase in post-exercise serum cholesterol levels. The average age of the subjects was 30.7 years. The average pre-exercise cholesterol concentration was 169.8 mg./percent, and the average post-exercise cholesterol level was 165.5 mg./percent. This represents an average post-exercise drop in cholesterol concentration of 4.3 mg./percent.

The t-score for this set of data with nine degrees of freedom is 1.65. This value was not significant (p less than .05).

After omitting subject one, due to the unusual increase in post-exercise serum cholesterol, the data was analyzed again. Table 4 illustrates the new data.

With the omission of subject one, the mean age drops from 30.7

Table 3

Pre-Exercise and Post-Exercise Cholesterol Concentrations of Subjects

Subject	Sex	Age	Pre-Exercise Cholesterol Concentration (mg./%)	Post-Exercise Cholesterol Concentration (mg./%)
1	F	31	170	181
2	M	30	136	134
3	M	46	189	189
4	M	18	92	87
5	F	41	209	209
6	M	42	260	260
7	M	17	117	111
8	M	31	192	180
9	M	20	135	116
10	F	31	198	188
Mean			169.8	165.5

Table 4

Pre-Exercise and Post-Exercise Serum Cholesterol Concentrations, Omitting Subject 1

Subject	Sex	Age	Pre-Exercise mg./%	Post-Exercise mg./%
2	M	30	136	134
3	M	46	189	189
4	M	18	92	87
5	F	41	209	209
6	M	42	260	260
7	M	17	117	111
8	M	31	192	180
9	M	20	135	116
10	F	31	198	188
Mean			169.7	163.7

years of age to 30.66 years of age. The average drop in cholesterol between pre-exercise and post-exercise levels increases from 4.3 mg./ percent to 6.0 mg./percent. The t-score for this set of data with eight degrees of freedom is 2.74, which is significant at the .05 level.

Heart Rates and Measurement of Exertion

The data in Table 5 represents the heart rates for each time interval during the 30 minute exercise period and the distance traveled in laps by each subject.

According to the data in Table 5, there does not appear to be any major differences in the heart rates of the subjects. The data presented in Table 6 illustrates this further by classifying heart rates according to the average heart rate for the six time intervals and converting this average to a percentage of the age related maximum heart rate (220 beats minus age) (Morse, 1974).

From the percentages of maximum heart rates presented in Table 6, it may be inferred that the exercise was probably aerobic for each subject (Costill, 1979). The highest maximum exertion found was only 62.2 percent of subject number five's maximum age-related heart rate. Although the data was not treated statistically, a comparison of the data presented in Tables 5 and 5 tends to illustrate that the percentages of maximum heart rates among the subjects do not seem to vary as much as the number of laps run.

Some subjects covered a much longer distance than other subjects, yet the level of exertion does not seem to vary greatly. As an example, subject nine ran a distance of 16 laps at 55.0 percent of his maximum exertion heart rate. Subject one covered a distance of eight and one-half laps at 58.5 percent of her maximum exertion level. An inference

Table 5

Heartrates (BPM) and Distance
Traveled by Each Subject

Subject	5 min	10 min	15 min	20 min	25 min	30 min	Laps (400 yd./lap)
1	108	104	112	120	108	112	8.50
2	88	84	88	92	92	100	12.75
3	80	80	88	88	100	104	10.25
4	84	100	108	112	108	112	13.00
5	104	112	112	112	116	112	8.75
6	100	104	104	112	108	108	10.50
7	112	116	120	116	116	120	16.00
8	100	112	100	112	116	120	10.50
9	104	104	112	112	112	116	16.00
10	96	92	100	100	100	100	11.50

Table 6

Average Heart Rates of Subjects
as a % of Maximum Heart Rates

Subject	Age	Ave. H.R. BPM	Max. H.R. BPM	% of Max. H.R.
1	31	110.6	189	58.5%
2	30	90.6	190	47.6%
3	46	90.0	174	51.7%
4	18	104.0	212	51.4%
5	41	111.3	179	62.2%
6	42	106.0	178	59.6%
7	17	116.7	203	57.5%
8	31	110.0	189	58.2%
9	20	110.0	200	55.0%
10	31	98.0	189	51.9%

might be made from this example that subject nine was in better physical condition than subject one, due to subject nine's ability to run nearly twice as far as subject one at approximately the same level of exertion.

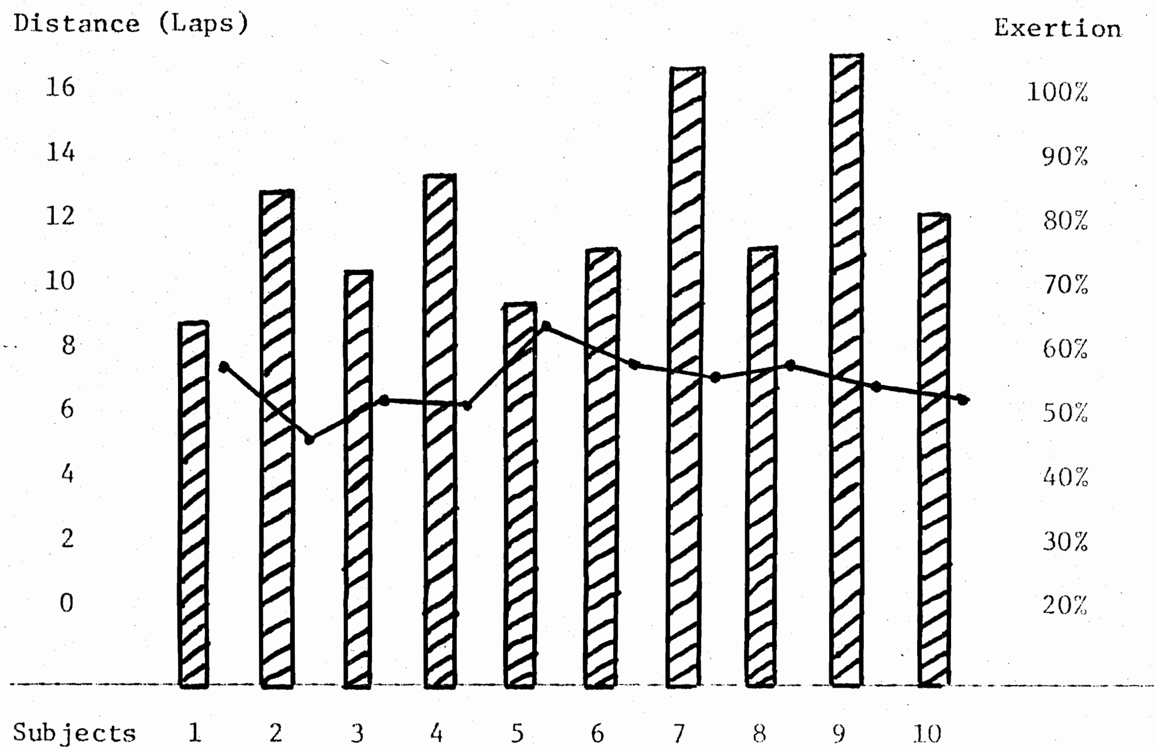
Distance Run and Physical Fitness

The distance run in this exercise might have been the best indicator of physical fitness. Figure 2 illustrates a comparison of the distance run by each subject and the level of exertion of each subject. The level of exertion was determined by the highest percentage of the age-related maximum heart rate achieved by each subject (Morse, 1974).

The graph shown in Figure 2 illustrates that the maximum difference among the subjects occurred in the distance run, with minimum differences occurring in levels of exertion as measured by the percentage of the maximum heart rate achieved. The differences in distances run and exertion levels were not treated statistically.

Distance Run and Cholesterol Concentrations

The comparison of distance run and change in cholesterol levels from pre-exercise to post-exercise samples has been shown in Figure 3. The greatest change in cholesterol levels occurred in subjects one, eight, nine, and ten. The coefficient of correlation between the absolute amount of post-exercise serum cholesterol concentration change and the distance run was r=.67. After omitting subject one from the same data, the coefficient of correlation changed to r=.57.



KEY

Distance Run in Laps

Exertion Level as Measured in Percentage of Maximum Heart Rate Achieved

Figure 2

A Comparison of Distance Run and Exertion

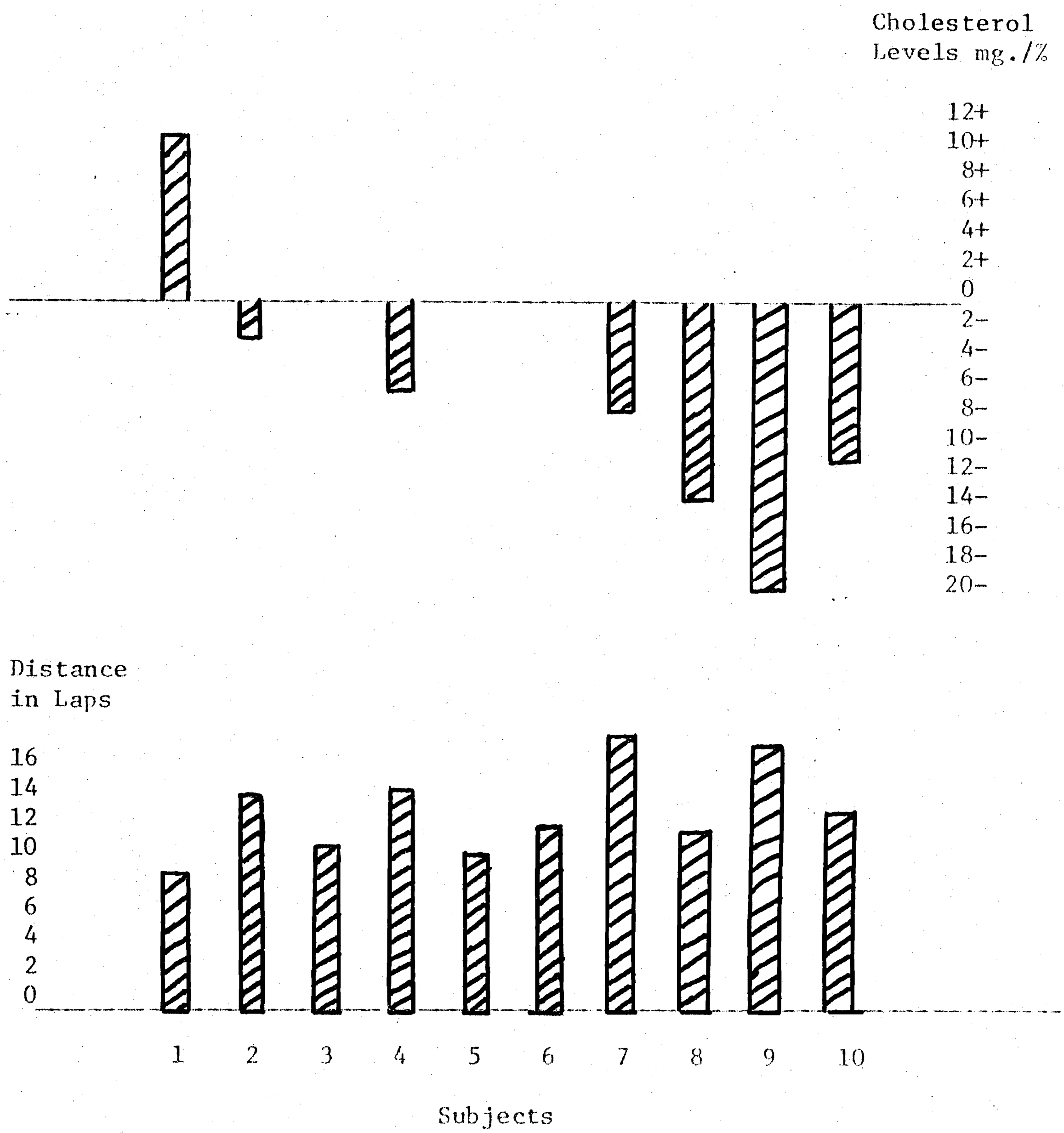


Figure 3

A Comparison of Distance Run
and Cholesterol Levels

Discussion

The elevation of serum or plasma cholesterol has long been associated with an increase of cardiovascular risk due to atherosclerosis (Framingham, 1968). Lower levels of serum cholesterol are indicated in the prevention of coronary artery disease. One author has said that if it were possible to lower serum cholesterol levels to 150 mg./percent or below in individuals, coronary artery disease could be virtually eliminated (DeBakey, 1977:155). Exercise can have a beneficial effect in the lowering of serum cholesterol levels (Keys, 1956) (Pohndorf, 1958) (Golding, 1961) (Kilbom, 1971).

Using all ten subjects in the study, the difference between the pre-exercise and post-exercise cholesterol values are not significant at the .05 level of confidence. This would indicate that chance might have had a great effect on the results of the study.

Subject number one experienced an increase in post-exercise serum cholesterol levels. While this is not inconsistent with some of the literature (Morse, 1974), it appears unusual in this study. Subject one was a female member of the Salem, Illinois "Run-For-Your-Life" group. During the weeks of jogging with RFYL group she experienced intense itching over most of her body when she jogged. The itching apparently subsided after several weeks of training, although it failed to disappear entirely. This problem was not thought to be serious either by the author, or by the subject's physician.

Recently, Siegel (1980) reported that intense all-body itching during exercise is an early symptom of exercise-induced anaphylaxis. The possibility that subject one has an allergic reaction to certain levels of exertion is present. In exercise-induced anaphylaxis, tissue edema is present. Edema of the tissue might cause a constriction of the blood vessels, and thereby a removal of plasma or serum from the vessels. The removal of blood plasma or serum from the vessels, without a corresponding removal of cholesterol would result in an actual increase of cholesterol concentration in the blood, though the amount of total cholesterol within the serum or plasma might remain the same.

The measurement of cholesterol levels by using the number of milligrams of cholesterol per 100 milliliters of plasma or serum would allow a "pseudo-lowering" of cholesterol levels to take place. A reduction of the number of milliliters of blood serum or plasma (blood volume) without a corresponding decrease in the number of milligrams of cholesterol in the serum or plasma would lead to an appearance and actual measurement of an increased serum cholesterol concentration or level. The post-exercise serum cholesterol concentration rise in subject one might be explainable due to exercise induced anaphylaxis.

After omitting subject one from the data, the fall in post-test serum cholesterol concentrations became significant at the .05 level.

Fitness levels in terms of the distances the subjects ran were then compared to the absolute change in post-exercise cholesterol levels. The coefficient of correlation between the distance run and the absolute post-exercise change in serum cholesterol levels was r=.67. After omitting subject one from the data again, the coefficient of correlation dropped to r=.57.

Several studies speculate upon the mechanism of serum cholesterol reduction during exercise. Sabine (1977:71) mentioned that exercise may increase catabolism of cholesterol by a large amount. Boyd and Oliver (Cook, 1958:188) contended that cholesterol levels in the blood are due to a direct relationship to energy intake and energy expenditure. Other evidence suggests that the levels of HDL-cholesterol, and the ratio of HDL-cholesterol to LDL-cholesterol also has some effect on the level of serum cholesterol (Wood, 1977) (Hartung, 1980).

There may be other explanations. Seventy-two percent of the cholesterol in the blood is esterified with one of several long chain fatty acids. Fatty acids are burned as fuel in endurance exercise longer than 15 minutes duration (Newsholme, 1977). If esterified cholesterol fatty acids are used as fuel, then transient decrease in the post-exercise serum cholesterol levels may occur.

Kritchevsky (1979:7) documented an increase in serum cholesterol of 12.5 percent when a subject moves from a recumbent to a standing position. This increase is due to an increase in orthostatic pressure on the blood vessels, forcing plasma or serum out of the vessels and into the lymph. An increase in orthostatic pressure may cause a rise in serum or plasma cholesterol concentrations due to a decrease in blood plasma, not an increase in serum cholesterol. If the above statement is true, then during exercise, cholesterol concentrations should be increased due to orthostatic pressure from muscles on the blood vessels (Morse, 1974).

An increase in orthostatic pressure on the blood vessels may cause an increase in plasma or serum cholesterol concentrations. Therefore, a decrease in orthostatic pressure on the blood vessels and subsequent dilation of the vessels and infusion of plasma could cause a decrease in plasma or serum cholesterol concentrations. A decrease in serum or plasma cholesterol would not be from an actual decrease in the amount of cholesterol present, but would result from a relative increase in plasma volume.

Blood vessels during exercise dilate, but are also under constant pressure from the contracture of muscles. Immediately following a period of exercise, muscle pressure on the blood vessels decreases, allowing the vessels to dilate to a greater extent. A dilation of blood vessels and subsequent reduction of orthostatic pressure on the blood vessels immediately after or during the recovery period of exercise may account for the decrease in plasma or serum cholesterol concentrations in post-exercise individuals.

The three older individuals in the study did not experience a decrease in post-exercise cholesterol concentrations. This may be due to a lack of training effect and subsequent lack of vessel dilation.

The limitations to the study concerning lack of proper diet control, failure to standardize postural position when taking blood samples, and failure to instruct subjects concerning proper activity levels may have affected the data.

The results of this study indicate that there is a significant decrease in post-exercise serum cholesterol levels in normal individuals after one period of aerobic work. This decrease in serum cholesterol after exercise may be age related.

There appears to be a relationship between fitness level or distance run in a certain time period, and the absolute amount of post-exercise change in serum cholesterol levels of normal individuals.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine whether a single period of aerobic exercise will cause a reduction in serum cholesterol levels.

Ten men and women, ranging in age from 17 to 46, were selected for the study from Salem, Illinois. All ten subjects had been active for several months prior to the study. Each subject was given an information sheet concerning the test one week prior to the test.

The test procedure consisted of a pre-exercise blood sample taken from each subject. The subjects then jogged at an aerobic pace for 30 minutes. Heart rates were taken at five minute intervals during the exercise to determine exertion levels. At the end of the 30 minute exercise period, a post-exercise blood sample was obtained. The pre-exercise and post-exercise blood samples were analyzed at the Salem Memorial Hospital Laboratory.

A t-test for correlated data was used to determine whether a significant difference between the pre-exercise and post-exercise serum cholesterol levels existed. A Pearson-Product Moment Correlation was used to determine whether a relationship existed between the fitness level, as measured by the distance run, and the absolute amount of post-exercise serum cholesterol change.

Conclusions

Based on the results of the study, it was concluded that a single period of aerobic exercise decreases the post-exercise concentration of serum cholesterol in normal individuals.

Recommendations

Based on the study, the following recommendations appear justified:

1. A study to determine the duration of post-exercise reductions in serum cholesterol would be beneficial. This study could also be performed on both sedentary and highly trained individuals to determine if the effects are the same on these groups as in moderately active groups.

2. More research is needed on the mechanism of serum cholesterol concentration decreases from the blood by exercise. Is it through orthostatic pressure on blood vessels, HDL levels, or increased cholesterol catabolism?

3. Certain forms of exercise may provide more of a cholesterol decreasing effect than other forms. Studies are needed in these areas to determine which, if any, is the best exercise for reducing levels of serum cholesterol after a single exercise period, and over a long term basis.

4. Research is needed in the area of serum cholesterol increases from either a single period of aerobic exercise, or a long term exercise program.

5. The most exciting area of cholesterol research appears to be

in the area of the lipoproteins, specifically LDL-cholesterol and HDL-cholesterol. Studies to determine the exact mechanism of LDL-cholesterol deposition of lipids on the tissues of the arterial intima would be of value. Of even greater value might be studies with HDL-cholesterol to determine what mechanism allows HDL-cholesterol to carry lipids away from the arterial intima and to the liver to be catabolized and excreted. A study to determine the best form of exercise to increase HDL-cholesterol levels and improve the ratio of HDL to LDL would also be welcomed.

6. On the forefront of research is the possibility that atherosclerotic lesions may even be dissolved by the reduction of serum cholesterol levels, or the increase in HDL-cholesterol. This has been shown to be possible in some nonhuman primates (Sabine, 1977: 270) (Cecil, 1979:1063) (DeBakey, 1977:160). The ability to reverse the atherosclerotic lesion in humans may be found through research. Research with a goal of finding the answer to the question of atherosclerotic reversal would be of the utmost importance to the entire coronary-prone human race.

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APPENDIXES

APPENDIX A

CHOLESTEROL RUN

Date: Wednesday, August 9, 1978
Time: 7:00 a.m. - Please be prompt.
Place: High School track (gymnasium in case of rain)

Purpose of Study

The purpose of this study is to determine whether one single jogging/walking workout will lower serum cholesterol.

Test Procedure

A blood sample will be taken prior to workout by a registered nurse. All subjects will start the run at the same time, however it is stressed that this is NOT A RACE. Each subject should jog or walk at a comfortable pace. Do not allow yourself to get out of breath. Six times during the exercise you will be required to take your heart rate and record it on the paper provided. Subjects must also record the number of laps traveled around the track. At the completion of the thirty minutes, recovery heart rates will be taken. Subjects will then rest for five minutes and the final blood samples will be drawn.

If this outline seems confusing, it probably is - don't worry - I will explain all details and answer all questions the morning of the run. If you have a need to contact me, my phone number is 548-1618.

I want to thank you for your time and effort. It is greatly appreciated. I will notify you of the study results as soon as they are available.

Stan Blank

ONE FINAL NOTE: IN ORDER TO GET THE MOST ACCURATE CHOLESTEROL VALUE, PLEASE FAST AND REMAIN RELATIVELY ACTIVE FOR 9-12 HOURS BEFORE THE RUN.

THANK-YOU

SALEM
MEMORIAL HOSPITAL

CHOLESTEROLS

	GROUP A	GROUP B
1.	170	181
2.	136	134
3.	189	189
4.	92	87
5.	209	209
6.	260	260
7.	117	111
8.	192	180
9.	135	116
10.	198	188

NORMAL CONTROL= 163
ABNORMAL CONTROL= 141

NORMAL CONTROL = 156
ABNORMAL CONTROL = 139

NORMAL RANGE FOR MALES = 138-294
normal range for females = 134-270

THESE CHOLESTEROLS WERE RUN ON 8-14-78, 1978 BY LARRY D. CLARK, MLT.

Larry D. Clark, MLT
Salem Hosp. Laboratory
Salem, Il.
62881