COMPARISON OF TOTAL AND HIGH-DENSITY LIPOPROTEIN CHOLESTEROL IN MALE RECREATIONAL SWIMMERS AND SEDENTARY CONTROLS

by

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(ABSTRACT)

Total and high-density lipoprotein cholesterol (TC and HDL-C) and TC/HDL-C ratio were compared in 30 adult male recreational swimmers and 21 sedentary controls. Percentage of body fat, number of cigarettes smoked daily, and daily alcohol consumption were assessed for both groups. Maximum workout heartrate, weekly swim duration and weekly swim distance of the swimmers were also measured. Maximum workout heartrate (mean ± S.D.) was 140 ± 24 beats per minute. Mean weekly swim duration was 142 ± 84 minutes, and mean weekly swim distance was 5317 ± 3217 yards. Swimmers and controls were nonsignificantly different in age, number of cigarettes smoked daily, and percent body fat. In this sample, the swimmers consumed significantly higher levels of alcohol than the non-swimmers. TC and HDL-C concentrations of swimmers were not significantly different than controls, (204 vs 199 mg/dl, and 48 vs 47 mg/dl, respectively). TC/HDL-C ratio of

swimmers was 4.69, while that of controls was 4.65. This study showed that adult male recreational swimmers who train at low intensity do not differ significantly in total and HDL-C or TC/HDL-C ratio from male sedentary controls.

Key words: total cholesterol, high-density lipoprotein cholesterol, swimmers

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INTRODUCTION

Cardiovascular diseases (CVD) have been the leading cause of death in the United States during the second half of the 20th century. According to the National Center for Health Statistics (1982), the age-adjusted mortality rate from CVD increased from 50.6% in 1950 to a peak of 52.3% in 1958. Although there has been a gradual decline to 42.9% in 1982, the rate remains well above cancer, the second leading cause of death, which accounted for 21.9% of mortality in 1982.

The reason for the downturn in CVD mortality has been of great interest to health scientists and epidemiologists. Feinleib (1984) offered the following explanation for this improvement:

> Some evidence has been found linking better medical care with beneficial effects on CHD (coronary heart disease) mortality. These improvements have been attributed to advancements in available medical and surgical services, the widespread establishment of specialized coronary care units, improved diagnosis and followup capabilities and more sophisicated drug therapies. Improved surgical techniques have probably impacted CHD mortality rates.

While improved medical care has decreased the mortality rate, prevention of CVD is more desirable than treatment of the disease. Early steps toward prevention of CVD resulted from studies identifying relationships between spe-

cific physical and personality characteristics and occurrence of CVD.

The Framingham study is an important ongoing investigation of CVD incidence and mortality. This long-term study of the inhabitants of a small community sought to identify risk factors for cardiovascular disease, and document occurrences of the disease. Many risk factors were identified, though only two will be addressed in this study.

Plasma concentrations of total cholesterol (TC), a class of lipids found in blood and in cells were found to be positively related to CVD (Gordon et al.,1977). High TC concentrations were found in many subjects with existing CVD, and high TC concentrations were predictive of developing CVD. Low plasma TC concentrations were associated with low risk for developing CVD. There is much support for this association. In a recently completed study, the Lipid Research Coronary Primary Prevention Trials (Rifkind, 1984) it was found that males whose plasma TC concentrations were decreased through diet and drug therapy suffered less CVD than controls who did not lower their TC concentrations. The evidence continues to grow indicating the desirability of reduction of plasma TC concentrations.

In the Framingham study, high-density lipoprotein cholesterol (HDL-C) was shown to be negatively related to CVD. High plasma HDL-C concentrations were associated with a lower risk for developing CVD, while CVD risk was greater for in-

dividuals with low HDL-C concentrations (Gordon et al. 1977). Subsequent epidemiological studies have confirmed these relationships (Williams, Robinson, and Bailey, 1979), (Kannel 1983), (Lewis 1983). Current research is seeking to determine if increasing plasma concentrations of HDL-C can slow or prevent the disease process. At this time, it is not known if increasing plasma HDL-C concentrations decreases CVD risk.

Several studies reported that long-term (4 months or more) running programs resulted in increased plasma HDL-C concentrations of participants (Brownell et al. 1981), (Wood et al. 1983). The mechanism through which running causes elevation of HDL-C concentrations has not be identified. Current theory suggests that elevated HDL-C concentrations are a response to chronic aerobic exercise, and are not specific to running. However, research investigating the effects of training for sports other than running on plasma HDL-C concentrations is sparse.

THE PROBLEM

This study will investigate plasma concentrations of TC and HDL-C of long term recreational swimmers as an initial step in determining if swimming produces beneficial changes in the blood lipid profile similar to those produced by running.

HYPOTHESIS

The following null hypothesis will be tested: Mean plasma TC and HDL-C concentrations of male recreational swimmers are similar to mean plasma TC and HDL-C concentrations of sedentary males of similar age.

SIGNIFICANCE

Many individuals desire the possible cardiovascular risk reduction associated with running. However, running is not the exercise of choice for all. The stress of running irritates joints in in those burdened with arthritis or orthopedic problems. Obese individuals are often physically incapable of running. Some individuals do not enjoy running. Therefore, for these individuals, swimming is their primary aerobic exercise.

If long-term swimming programs decrease plasma TC and/or increase plasma HDL-C concentrations, discovery of threshold values for the factors of duration, frequency and intensity of exercise would be necessary. Exercise recommendations incorporating these threshold values would increase the health benefits of swimming for exercise and decrease CVD risk for individuals following this prescription.

DELIMITATIONS

Criteria for swim subjects:

1) males 17 or more years of age
2) were not on medications known to alter plasma concentrations of lipids or lipoproteins.
3) did not utilize interval training in their swim workouts.
4) had not swum competitively at high school or intercollegiate level in the two years prior to study participation
5) had been swimming their stated weekly mileage for at least one year
6) could not be training in aerobic sports other than swimming
7) were not on an active weight-loss program during their participation in the study.

The sedentary subjects met the first two criteria of swim subjects. In addition, these subjects had not participated in any regular exercise program for at least one year. Some sedentary subjects were active in pursuits such as softball and gardening.

LIMITATIONS

1) Subjects monitored their own heartrates during swim training by palpation. While providing a measure of maximum heartrate achieved, duration of training time at the maximum heartrate was not measured.
2) Study results may not be applicable to females or children.

DEFINITIONS

1) Recreational swimmers: individuals swimming two or more times weekly for exercise. These swimmers were not participating in competition at any level. The screening process did not specify ranges for duration and intensity of swim workouts, as a wide spectrum of values for these variables was desired.
2) Interval training: training at high levels of intensity that could not be maintained continously. Individuals utilizing this training method swim for short periods of high intensity followed by periods of low intensity or rest.

ASSUMPTIONS

1) The data recorded in the swimlogs by the swim subjects was assumed to be accurate and representative of their habitual swim training.
2) Subjects fasted for 12 hours as directed before blood was sampled.
3) The diets of the groups were equivalent, so diet was not a variable.

SUMMARY

Cardiovascular diseases have been the number one cause of death in the United States since 1950. The CVD mortality rate has decreased since 1958 due to improved medical care, but much remains to be done in prevention of CVD. Recent research reports have shown that lowering plasma TC concentrations decreases CVD risk. Research suggests, but has not proven, that increasing plasma HDL-C concentrations may also decrease the occurrence of CVD. Running has been shown to have little effect on plasma TC concentration, and to increase plasma HDL-C concentration. Due to elevated HDL-C concentrations, epidemiological data has suggested that runners are less likely to develop CVD than the population in general. This study will compare the plasma TC and HDL-C concentrations of male swimmers with those of sedentary males

to ascertain if swimmers have blood lipid profiles similar to those of inactive individuals.

LITERATURE REVIEW

INTRODUCTION

Cardiovascular disease (CVD) is an expression of a single disease process which can occur in various parts of the body. CVD results when fatty and fibrous materials build up in an artery to form an atherosclerotic plague. As the disease progresses, blood flow is increasingly restricted. At some time, the organ or body part supplied by this artery is stressed by inadequate blood flow. The limited blood flow is unable to supply sufficient oxygen and nutrients, or provide adequate removal of waste products. The organ ceases to function normally.

The CVD disease process is similar in all anatomical areas affected. When the heart is affected, it is termed coronary heart disease (CHD). CHD manifests itself in the form of angina, disturbances of normal heart rate and rhythm regulation, or myocardial infarction. If the kidneys are diseased, the result is renal impairment. Cardiovascular disease of the brain results in degradation of function, and ultimately, stroke.

Major factors which influence formation of atherosclerotic plague formation are: plasma concentrations of total and high-density lipoprotein cholesterol (TC and

HDL-C, respectively), blood sugar, blood pressure, smoking and personality type. This study will focus on plasma concentrations of TC and HDL-C. Although most blood lipid studies analyze both TC and HDL-C concentrations, they will be considered separately here for maximum clarity.

THE RELATIONSHIP BETWEEN TOTAL CHOLESTEROL AND CORONARY HEART DISEASE

Castelli (1983) stated that the Framingham study identified a linear relationship between total plasma cholesterol and risk of CHD. "The data show a progressive rise in risk as cholesterol values increased."

Keys (1980) reported the results of the Seven Countries Study. This study found a positive association between plasma TC levels of populations and incidence of both CHD and CHD deaths.

The Coronary Artery Surgery Study (CASS) (Vlietstra et al., 1980) was an investigation of the relationship between risk factors and the presence and severity of CHD as diagnosed from angiography. All subjects in the CASS study had been referred for the angiography as CHD was suspected. Results of CASS indicated that plasma TC concentration was the most powerful predictor of CHD and its severity in males less than 55 years old.

Intervention studies have reported decreased CHD when TC levels have been reduced. In the Oslo study, approximately 1200 men were randomly assigned to intervention or control groups (Leren, Helgeland, Hjermann, & Holme, 1983). Both groups were urged to stop smoking. The intervention group used dietary modification to achieve a mean plasma cholesterol concentration 13% lower than the control group. At the end of the 7-year observation the incidence of CHD in the intervention group was 47% lower than in the control group. A confounding factor was that 25% of the intervention group and 17% of the control group stopped smoking.

Castelli (1983) said, "...in virtually all diet and drug trials to date, the decrease in CHD rates is proportional to the fall in cholesterol." Additional support for this statement came in the results of the Lipid Research Clinics Coronary Primary Prevention Trial (LRC-CPPT). In the LRC-CPPT investigation (Rifkind 1984) 439,679 middle-aged males were screened to find men with TC concentrations greater than 265 mg/dl and without symptoms of CHD. A total of 3,806 men met these criteria. They were randomly divided into treatment and control groups. Baseline TC and HDL-C concentrations of the groups were almost identical. A lipid lowering diet was prescribed to both groups. The dietary intervention produced a small, significant reduction of 3.4 % in TC concentrations in both groups. The treatment group was given the cholesterol-lowering agent cholestyramine, and

the control group was given a placebo. Individuals were monitored for 7 to 10 years. The cholestyramine group achieved a total mean cholesterol decrease of 11.9 %, with a corresponding 19 % reduction in CHD risk relative to the placebo group. CHD risk was defined as diagnosed CHD, death, or nonfatal myocardial infarction.

Rates of CVD death are positively associated with TC levels in populations. Reduction of TC levels decreases incidence of CVD.

FACTORS INFLUENCING PLASMA TOTAL CHOLESTEROL

The major factors influencing TC concentrations are heredity, age, and diet. Heredity is considered to be a powerful source of variability in TC concentrations between individuals, but is not important in variability between populations. (American Health Foundation, 1979). TC concentrations tend to increase with age (Goldbourt & Medalie 1979). Results are inconclusive as to racial differences in TC concentration. Diet is the most powerful factor influencing TC concentrations in populations, but will not be addressed in this study. The effect of aerobic exercise on TC concentrations will be closely examined.

TOTAL CHOLESTEROL CONCENTRATIONS OF RUNNERS

Lehtonen & Viikari (1978) compared TC concentrations of 23 highly trained men (who ran or skiied at least 25 km per week) with 15 inactive male controls. The highly trained group had a mean TC concentration of 190.5 mg/dl compared to 201.6 mg/dl for the controls. This difference was non-significant.

Penny, Shaver, Carlton, & Kendall (1982) compared TC concentrations of marathoners, joggers, and inactive controls. All subjects were male. The average TC levels were 213.2, 189.1, and 194.7 mg/dl respectively. Although the mean TC concentrations were higher for the marathoners, TC concentrations were not significantly different between groups.

Thompson et al. (1983) compared plasma TC concentrations of male runners and sedentary males. His study included a detailed analysis of diet. The only significant differences in diet between groups was that runners consumed 20% more calories daily than the sedentary subjects, with the runners eating more carbohydrates. Runners and controls had nonsignificant differences in TC concentration of 204 and 198 mg/dl, respectively.

Hagan & Gettman (1983) compared 53 male runners with 53 sedentary males who were carefully matched by age, height, body weight, and body fat. No significant differences were

found between groups for the previous variables, but the runners did have greater maximal aerobic power. Mean TC concentrations of runners and controls of 189.7 and 196.5 mg/dl, respectively, were not significantly different.

Similar results have been published by Hartung & Squires (1980), Schnabel & Kinderman (1982), Hagan, Smith & Gettman (1983), and Nakamura, Uzawa, Maeda & Inomoto (1983).

Most studies comparing plasma TC concentrations between distance runners and inactive controls have failed to find significant differences between groups. However, Wood, Haskell, & Klein (1976) reported that plasma TC concentrations of male runners were significantly lower, though only by 10 mg/dl, than those of inactive males. The bulk of evidence suggests that runners are not unique in plasma TC concentrations, but are similar to the population from which they are derived.

THE EFFECT OF PHYSICAL TRAINING ON PLASMA TOTAL CHOLESTEROL

Horby-Petersen, Grande, & Christiansen (1982) trained 54 young male subjects. 35 were regular exercisers, and 19 were non-exercisers. Subjects trained three times weekly for 12 weeks, particpating in 45 minute bouts of jogging, gymnastics, swimming, and athletics. There was no significant difference in plasma TC concentrations between pre and post tests.

Wood et al. (1983) recruited 81 healthy, sedentary, middle-aged men. Random assignment was made to exercise or control groups. The exercise group trained 3-5 times per week for one year. Training consisted of running at 70-85% VO2 max. Blood was drawn every 3 months. The mean TC concentration of the exercise group displayed a nonsignificant decrease from 209.3 to 202.7 mg/dl at the end of the one year period.

Kiens, Lithell & Vessby (1984) placed six males on a program that progressively increased running distance and frequency. Blood was sampled and analyzed every six weeks for six months. The mean TC concentration of subjects decreased from 206.2 to 197.3 mg/dl, although the difference was not significant.

Physical training does not appear to be an effective method of decreasing plasma TC concentrations.

HDL-C AND CARDIOVASCULAR DISEASE

HDL-C may slow the progression of atheroslerosis in several ways. Miller & Miller (1984) described current theories detailing the mechanisms of this process. One function of HDL-C is a "reverse transport" mechanism. The HDL-C particle binds with cholesterol from the cellular components of the body, including the endothelium of the lumen of the arteries. This cholesterol is esterified in the HDL-C parti-

cle. Some of the cholesterol is passed to other lipoproteins, predominantly very-low density lipoprotein. As the HDL-C particle circulates in the plasma, some of the cholesterol is removed in the liver, and the particle continues to repeat the process. In the liver, the cholesterol is excreted in bile. A portion of the HDL-C particles are catabolized in the liver, and the components are resynthesized into new lipoproteins. In addition, endothelial cells in the arteries have receptors for low-density lipoprotein cholesterol (LDL-C). Excess concentrations of LDL-C in the plasma causes excess uptake of LDL-C molecules. LDL-C that is not required as a cellular component is deposited in the artery lining, the initial step in atherosclerosis. HDL-C molecules may compete with the LDL-C molecules at these receptor sites (Miller & Miller, 1984).

It is probable that relative concentrations of HDL-C and LDL-C govern the progression of atherosclerosis. Though it has not been proven that increasing HDL-C concentration reduces CVD risk, the association of high HDL-C levels and low CVD risk is documented (Gordon, Castelli, Hjortland, Kannel, & Dawber, 1977). Kannel (1983) provided the following summary:

> The protective effect of HDL is at least as strong as the atherogenic effect of LDL and is independent of lipids and other risk factors. Every change of 10 mg/dl in the HDL cholesterol is associated with a 50% change in risk. At any level of serum total cholesterol, risk varies widely, depending on the LDL/HDL ratio. A serum total cholesterol/HDL ratio of 5.0 is

associated with average risk; optimal ratios, around 3.5, correspond to half the average risk.

Support for this view is offered by Castelli (1983), who found that the lipid analysis offering the greatest predicitive ability (of CVD risk) at the lowest cost was the TC/HDL-C ratio.

It would appear that statements by Gordon et al (1977), Kannel (1983), and Castelli (1983) concerning the value of plasma HDL-C concentrations and the TC/HDL-C ratio in predicting CHD risk are contradictory to the results of the CASS study cited previously. Vlietstra et al., (1980) reported that the results of the CASS study implicated TC concentrations as the best predictor of the incidence and severity of CHD in males less than 55 years of age. This descrepency may be related to differences in sample characteristics. The Framingham study sampled from a cross-section of the population, whereas the CASS study sampled from patients referred for further assessment of suspected coronary heart disease.

Glueck, Gartside, Fallat, Sielski, & Steiner (1976) found that families who exhibit atypically high concentrations of HDL-C have lower incidence of CVD and live longer than the general population.

At any given plasma TC level, the greater the HDL-C level, the lower the risk of CVD.

FACTORS INFLUENCING PLASMA HDL-C

Plasma HDL-C increases with alcohol consumption, and decreases with smoking. HDL-C concentrations are negatively associated with percent body fat. Distance running for a period of 4 months or longer increases HDL-C concentrations.

Alcohol consumption has been shown to be positively correlated to plasma HDL-C concentration. Williams, Robinson, & Bailey, (1979) took physical measurements, and assessed the cigarette smoking and alcohol consumption of 2568 men in London, England. They divided subjects into 5 categories based on alcohol consumption. HDL-C concentrations increased corresponding to categories of increased alcohol consumption. At the extreme ends of the spectrum, individuals who were non-drinkers had mean HDL-C concentrations of 51.0 mg/dl. Individuals who drank more than 6 drinks per day had significantly higher HDL-C concentrations of 61.6 mg/dl.

Thorton, Symes & Heaton (1983) found 12 healthy individuals with low initial alcohol consumption. The subjects drank 39 grams of alcohol daily for six weeks. Subjects underwent a second six week period completely abstaining from alcohol consumption. Normal physical activity and diet were maintained throughout the 12 weeks. Blood was sampled at the beginning of the study, and at the end of each six week period. HDL-C concentration rose from baseline after the pe-

riod of alcohol intake, and fell below baseline with abstention. All changes in HDL-C were significant.

Crouse & Grundy (1984) hospitalized 12 patients on a metabolic ward and fed them controlled diets. The subjects were fed a alcohol-free diet for 4 weeks to establish baseline blood lipid values. For the next 4 weeks, approximately 3.4 ounces (90 grams) of alcohol was added to the daily diet. The plasma HDL-C levels of all patients increased significantly during the alcohol feeding period.

In the study previously mentioned, Williams et al., (1979) divided subjects into 7 categories based on their smoking habits. HDL-C concentrations were inversely related to number of cigarettes smoked daily. Nonsmokers had a mean plasma HDL-C concentration of 57.2 mg/dl. Individuals who smoked more than 40 cigarettes per day had a significantly lower mean HDL-C concentration of 49.4 mg/dl.

In a similar study investigating the effects of smoking on blood lipid profiles, Brischetto, Connor, Connor & Matarazzo (1983) divided 214 men and 236 women into 5 categories based on their smoking habits. In presenting their results, males and females were assimilated into the smoking behaviour categories, and not treated as separate groups. Mean plasma HDL-C values for nonsmokers was 54 mg/dl, and 45 mg/dl for individuals smoking more than 25 cigarettes per day. These differences were significant.

Pader & Leiken (1983) studied the effects of cigarette smoking and weight on 158 male patients. Cigarette smoking was inversely related to plasma HDL-C concentrations, and its negative effect on HDL-C is dose-dependant.

Glueck et al. (1980) reported significant associations between body mass indices and plasma HDL-C concentrations even when corrected for smoking, alcohol intake, and age.

Pader & Leiken (1983) reported a significant negative relationship between plasma HDL-C and weight. Two years later, a repeat study was conducted with the same individuals. Loss of weight caused a significant increase in concentration of HDL-C.

Concentrations of HDL-C are inversely related to percent body fat. Sustained weight loss results in increased plasma HDL-C.

HDL-C CONCENTRATIONS OF RUNNERS

Lehtonen & Viikari (1978) compared HDL-C concentrations 23 highly trained men (who ran or skiied at least 25 km per week) with 15 inactive male controls. The highly trained group had a significantly higher mean HDL-C concentration of 68.5 compared to 54.9 mg/dl for the controls.

Thompson et al. (1983) compared HDL-C concentrations 20 male runners and 14 sedentary males. The mean HDL-C concen-

tration of runners was 66 mg/dl, significantly greater than the 46 mg/dl of the sedentary group.

Hagan & Gettman (1983) compared 53 male runners to 53 sedentary males who were carefully matched by age, height, body weight, and body fat. No significant differences were found between groups for the previous variables, but the runners exhibited greater maximal aerobic power. Runners' mean HDL-C concentration of 50.9 mg/dl was significantly greater than controls 46.5 mg/dl.

Hartung, Foreyt, Mitchell, Vlasek, & Gotto (1980) and Rotkis, Cote & Coyle (1982) placed experienced runners in groups according to their habitual weekly running mileage. In both studies, the mean plasma HDL-C concentration of the running group was significantly higher than nonrunning controls. Among runners, HDL-C concentrations increased stepwise by group with running mileage. Differences between all groups were significant.

There is almost universal agreement that endurance athletes, whether distance runners or cross country skiers, have higher HDL-C levels than sedentary individuals. In studies that contained an intermediate running group (grouped by running mileage), the HDL-C concentrations of the intermediate group were greater than sedentary controls but less than subjects who ran more.

HDL-C CONCENTRATIONS OF SWIMMERS

Schnabel & Kindermann (1982) compared plasma TC and HDL-C concentrations of elite male athletes withmale sedentary controls. Twenty-six of these elite athletes were swimmers. The workout routine was not described, though it was noted that swimmers had been in regular competive training for several years and trained more than five times per week. The swimmers' mean HDL-C value of 45 mg/dl was not significantly different than 42 mg/dl of controls.

Smith, Mendez, Bruckenmiller, & Kris-Etherton (1982) compared HDL-C concentrations of competitive swimmers, synchronized swimmers, and sedentary controls. All subjects were female. Competitive swimmers

> ...swam 6 days a week, averaging 8000 yards a day. The synchronized swimmers swam an average of 3 days a week for 2 hours, with a total of 1500 yards per session.

Swimmers had mean HDL-C concentrations of of 82.0 mg/dl, synchronized swimmers 70.0 mg/dl, and controls 67.2 mg/dl. HDL-C concentrations of the competitive swimmers were significantly higher than those of controls, but the HDL-C of the synchronized swimmers were not.

As expected, the absolute HDL-C concentrations of female subjects were higher than those reported for males. It is difficult to explain why male competitive swimmers had no significant elevation of plasma HDL-C, and female competitive swimmers did. Additional studies of swimmers with detailed

descriptions of training routines may resolve this discrepency. The results of Smith et al. (1982) were similar to the studies of male runners previously mentioned, with the athletes having significantly higher concentrations of HDL-C than sedentary controls. The synchonized swim team cannot be considered an intermediate group as the aerobic requirements of this sport are low, and not directly comparable to swim team training.

THE EFFECT OF PHYSICAL TRAINING ON PLASMA HDL-C

Some studies investigating the effects of physical training on plasma HDL-C have demonstrated positive effects. Huttunen et al. (1979) had 100 asymptomatic middle aged men whom were randomly divided into exercise and control groups. Subjects were given an individualized training program that consisted of walking, jogging, swimming, skiing, or cycling. The first 8 weeks of training was conducted at low intensity (maximum heartrate - resting heartrate x .40). The last 8 weeks of training was conducted at moderate intensity (maximum heartrate - resting heartrate x .66). Blood was sampled and analyzed for HDL-C initially and after the 16-week training period was completed. Mean HDL-C concentration of the exercise group increased significantly. Mean HDL-C levels for the control group increased nonsignificantly.

Kiens et al. (1980) recruited a group of 37 healthy, sedentary, middle aged men. Random assignment to an exercise or control group was made. The exercise group participated in gymnastics, swimming, running or games. Subjects in groups A - C trained 3 times per week, 45 minutes per bout, for 12 weeks. "The training was usually performed intermittently, i.e. 1-4 min of exercise followed by rest period of 15-60 s." This intermittent program allowed exercise intensity to be maintained at 80-85% of VO2 max. Activity level of the control group did not change. Mean HDL-C concentration in the exercise group increased significantly. There was no significant change in the HDL-C concentration of the control group.

Brownell, Bachorik & Ayerle (1982) reported similar results in a 10 week study with subjects of both sexes. HDL-C concentrations of males increased significantly, but those of females dropped nonsignificantly.

Sutherland, & Woodhouse (1980) enrolled 23 normal, healthy untrained men in a self regulated running program that lasted for 4 months. The training program culminated with the running of a marathon. HDL-C values were determined before and after the program. Mean initial values were 49.5 mg/dl,and mean post-training HDL-C values were 63.4 mg/dl. This elevation was significant.

Wood et al. (1983) recruited 81 healthy, sedentary, middle-aged men. Random assignment was made to exercise or

control groups. The exercise group trained 3-5 times per week for 1 year. Training consisted of running at 70-85% VO2 max. Blood was sampled and analyzed every 3 months. Subjects differed in ability and willingness to run, but all miles run were recorded. The entire exercise group did not show significant increases in HDL-C concentration. However, the HDL-C concentrations of subjects who ran 8 miles or more per week increased significantly from 50.2 to 54.9 mg/dl. Wood stated that this increase did not appear until the 9th month.

Kiens et al. (1984) recruited six trained males. The investigation revealed initially high HDL-C concentrations in the subjects. Subjects were placed on a program that progressively increased running distance and frequency. Blood was sampled and analyzed every six weeks for six months. Mean HDL-C concentraions increased significantly from 64.2 to 74.3 mg/dl.

Some studies have produced no increase in HDL-C from physical training. Ready & Quinney (1982) placed 21 healty young men into exercise or control groups. The exercise group trained on a bicycle ergometer for 30 minutes per bout, 4 times per week, at an intensity of 80% of VO2 max. Training lasted for 9 weeks. No significant changes in mean HDL-C concentration occurred in either group.

Thomas, Adeniran, & Etheridge (1984) investigated the impact of three running programs on the HDL-C concentrations

of 59 untrained college-age men and women. Subjects were randomly assigned to training groups as specified below:.

Group A - ran 4 miles per bout at 75% VO2 max.

Group B - ran 2 miles per bout at 75% VO2 max.

Group C - ran intervals at 90% VO2 max with rest periods between runs.

Group D - untrained controls who remained untrained.

Subjects trained three times per week for 12 weeks. All running programs were ineffective in altering HDL-C concentrations of subjects.

Studies monitoring the effects of physical training on HDL-C values have yielded inconsistent results. These discrepencies may be partially explained by the length of the training programs in each study. All studies reviewed in which training lasted four months or more reported significant increases in plasma HDL-C of the treatment group. Studies which were shorter than four months yielded varied results.

In addition, there is apparently a mileage threshold required to elicit the HDL-C elevating response. Lehtonen & Viikari (1978) reported supernormal HDL-C concentrations only individuals running more than 70 km per week. However, Hartung & Squires (1980) suggested that this threshold was running approximately 11.2 miles per week. The longitudinal study of Wood et al (1983) reported HDL-C was elevated in

runners who ran eight or more miles per week. The consensus seems to be approximately 10 miles per week.

Although both TC and HDL-C were evaluated, few studies have shown TC concentrations of distance runners to be significantly different than those of sedentary individuals. Cross-sectional studies have reported elevated HDL-C concentrations in runners (Lehtonen & Viikari, 1978, Hartung & Squires, 1980, Schnabel & Kindermann, 1982, Hagan & Gettman, 1983, and Nakamura, Uzawa, Maeda, & Inomoto, 1983), skiers (Enger, Kirsten, Erikssen & Fretland, 1977, Myhre, Mjoes, Bjorsvik, & Stromme, 1981), female competetive swimmers (Smith et al., 1982, and tennis players (Howley et al., 1982) relative to sedentary controls.

Elevated plasma HDL-C of runners may have several causes.

a) Individuals who have high concentrations of HDL-C may choose distance running as an activity. If this is true, self-selection rather than running is the cause of the differences.
b) Running causes elevations of plasma HDL-C concentrations when running mileage surpasses a threshold value.
c) Factors other than running, such as alcohol consumption, cigarette smoking, medications, fatness, diet or other factors are substantially different between runners and

sedentary individuals, and thus responsible for the difference in HDL-C concentrations.

d) A composite model containing elements of the models above.

The self selection model has some support. Individuals tend to choose a physical activity in which they have physical ability. A recognized measure of physical capacity important to distance running is maximum oxygen consumption (VO2 max). Some studies have shown significant associations between VO2 max and HDL-C concentrations. Sutherland & Woodhouse (1980) reported a correlation of r= 0.41 in 21 men. These men ran less than 20 miles per week. Schnabel & Kindermann (1982) reported correlations of 0.51 to 0.66 for athletes participating in rowing, skating, handball, soccer, and middle and long distance running, but no significant correlations between plasma HDL-C and sprint runners or inactive controls. Haskell et al., (1980) reported no significant correlations between VO2max and HDL-C concentrations. Looking at another aspect of self-selection, Wood et al (1983) placed previously sedentary individuals on a running program of increasing distance and frequency. He reported that individuals with initially high HDL-C concentrations ran more miles than those with lower concentrations. The self-selection process occurred even in a controlled study. However, Wood's study also reported after one year a correlation of 0.48 between changes in HDL-C concentrations and miles

run. Loss of body fat was associated with increased HDL-C concentrations for a correlation of -0.47.

Wood's report of a dose-dependent response to mileage supports documentation of the same phenomenon in established runners. As detailed previously, virtually every study comparing plasma lipoproteins of runners to sedentary controls has found runners have higher HDL-C concentrations than controls. Intermediate running groups have exhibited intermediate HDL-C concentrations, in between those of the high mileage runners and controls. Kiens et al. (1984) analyzed the blood of six trained distance runners before and after placing them on a progressive running program. Subjects gradually increased distance and frequency of training. After six months, mean HDL-C concentration increased from an initial value of 64.1 mg/dl to 74.1 mg/dl. Rotkis et al (1981) ran a similar study on 22 moderately trained females. Initial values for blood lipids and lipoproteins were establised. Subjects were retested individually after each subject had increased her weekly running mileage by 30 miles per week. Subjects took between four and seven months to achieve this increase. Mean HDL-C concentration increased significantly from an initial value of 53.5 mg/dl to a final value of 58.5 mg/dl. Elevation of plasma HDL-C concentrations has been shown to be a function of running mileage for chronic runners with habitually run a particular distance, for runners who increase their running mileage, and

for sedentary individuals who begin to run. In sedentary individuals, a threshold value of approximately 10 miles per week for four to nine months is required before HDL-C elevation begins.

The possibility that runners had higher HDL-C concentrations than controls because of differences in diet, alcohol consumption, cigarettes smoked, or weight was investigated by Hartung et al,(1980). The dietary analysis in this study was limited to correlations between specific foods and plasma HDL-C concentrations. No attempt was made to analyze the nutrient content of specific foods. Hartung reported that distance run was the best predictor of HDL-C concentrations, followed by egg consumption, wine consumption, cigarettes smoked, and hard liquor consumption. Percent body fat was not significantly associated with HDL-C concentration. Hagan et al., (1983) reported almost identical results. Predictors of HDL-C concentrations were distance run, wine consumption, and soft drink consumption. In his study, only one individual was a smoker, so smoking did not exert any appreciable effect on HDL-C concentrations. Percent body fat again failed to show significant association with HDL-C concentrations.

From a number of detailed studies about runners, several conclusions can be drawn. The most powerful predictor of HDL-C concentrations of runners is distance run, while other

factors such as diet, alcohol consumption, cigarette smoking, body fat and self selection contribute less.

SUMMARY

The incidence of CVD is positively related to plasma TC concentrations, and negatively related to plasma HDL-C concentrations.

Runners have been found to have TC concentrations statistically similar to those of sedentary persons. Longitudinal studies using running as a training method have not produced significantly different TC concentrations between intervention and control groups.

Runners have been found to have higher plasma HDL-C concentrations than sedentary individuals. Many longitudinal studies using running as a training method reported significant elevations in HDL-C concentrations. Other studies have found contradictory results, with little or no increase in plasma HDL-C from training. The duration of training appears to be a critical factor influencing HDL-C increases. The studies in which training lasted for four months or more reported significantly increased plasma HDL-C concentrations in the intervention groups.

In a study of female swimmers, competitive swimmers had significantly higher HDL-C concentrations than either synchonized swimmers or sedentary controls. In a study of

male athletes, competitive swimmers did not have significantly higher HDL-C concentrations compared to sedentary controls.

JOURNAL MANUSCRIPT

COMPARISON OF TOTAL AND HIGH-DENSITY LIPOPROTEIN CHOLESTEROL IN MALE RECREATIONAL SWIMMERS AND SEDENTARY CONTROLS

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(abbreviated title for running head)
TC and HDL-C Levels in Male Swimmers

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ABSTRACT

Total and high-density lipoprotein cholesterol (TC and HDL-C) and TC/HDL-C ratio were compared in 30 adult male recreational swimmers and 21 sedentary controls. Percentage of body fat, number of cigarettes smoked daily, and daily alcohol consumption were assessed for both groups. Maximum workout heartrate, weekly swim duration and weekly swim distance of the swimmers were also measured. Maximum workout heartrate (mean ± S.D.) was 140 ± 24 beats per minute. Mean weekly swim duration was 142 ± 84 minutes, and mean weekly swim distance was 5317 ± 3217 yards. Swimmers and controls were nonsignificantly different in age, number of cigarettes smoked daily, and percent body fat. In this sample, the swimmers consumed significantly higher levels of alcohol than the non-swimmers. TC and HDL-C concentrations of swimmers were not significantly different than controls, (204 vs 199 mg/dl, and 48 vs 47 mg/dl, respectively). TC/HDL-C ratio of swimmers was 4.69, while that of controls was 4.65. This study showed that adult male recreational swimmers who train at low intensity do not differ significantly in total and HDL-C or TC/HDL-C ratio from male sedentary controls.

Key words: total cholesterol, high-density lipoprotein cholesterol, swimmers

INTRODUCTION

Cardiovascular diseases (CVD) are the number one cause of death in the United States. Plasma total cholesterol (TC) concentrations are positively associated with incidence of CVD (1) while high-density lipoprotein cholesterol (HDL-C) concentrations are negatively associated with CVD incidence (2).

Numerous studies (3-7) have reported that distance runners who have normal concentrations of TC have elevated HDL-C concentrations when compared to sedentary controls. Reported mileage thresholds range from 8 miles per week for one year (8) to 11.2 (9) miles per week for six months before an elevation of HDL-C concentrations occur. Elevated HDL-C concentrations were also reported (10) in female competitive swimmers who swam 48,000 yards per week.

This study compared the TC and HDL-C concentrations of adult male recreational swimmers and sedentary controls.

METHODOLOGY

Subjects

Fifty-three adult males from the Blacksurg, Virginia area participated in this study. The Swim group consisted of 31 recreational swimmers who swam at the Virginia Tech pool. Swim distance of individuals in the Swim group ranged

from 800 to approximately 15,000 yards per week. Swim group participants swam at least twice per week, and had been swimming for at least one year. No individuals in this group were current or former competitive swimmers, utilized interval training while swimming, or trained in additional aerobic sports. Swim group ages ranged from 17 to 71 years, with a mean age of 37. The sedentary group was comprised of 22 males who did not exercise regularly. Sedentary group ages ranged from 23 to 53 years, and a mean age of 34. Age difference between groups was not significant. Individuals were apparently healthy and were not taking medication known to affect plasma lipid or lipoprotein concentrations.

Procedures

Prospective subjects filled out a health behaviour questionaire that sought detailed information on medications, cigarette smoking, quantity and type of alcoholic beverages consumed, and exercise habits.

Swimmers kept a one-week log of swim duration, swim distance, and maximum heartrate achieved for each workout. A lab visit was scheduled within two weeks of completion of the first swim log. A second swim log was maintained for the week after the lab visit. Mean values for each individual were computed from the figures reported in the two swim logs.

Skinfold measurements were taken when subjects reported to the lab for blood sampling. Body fat values were obtained

by skinfold measurement of three sites (chest, abdomen, and thigh) in accordance with procedures and equations detailed by Jackson & Pollock (11). Each site was measured five times, and the mean value for each site was used in the equation.

Subjects fasted for 12-14 hours before blood specimens were collected. Samples were obtained from the antecubetal vein in 7 ml vacutainers containing dry ethylenediamine tetraacetic acid. Vacutainers were inverted for thorough mixing, and placed in wet ice for 30 minutes. Samples were then placed in a Sorvall RT 6000 refrigerated centrifuge set at 4 degrees C and spun for 30 minutes with an 1880 g force. The plasma was drawn off the packed cells and stored at 4 degrees C for later analysis of TC. A portion of the plasma was transferred to 5 ml test tubes. Addition of a heparin-manganese chloride solution caused precipitation of the very-low-density and low-density lipoprotein cholesterol fractions (12). These samples were spun in the centrifuge for 30 minutes at 4 degrees C at 1880 g's. TC of whole plasma and HDL-C concentrations in the supernatent were determined in duplicate using a colormetric procedure (13). Test-retest association was r=0.90.

Statistical analysis

Group differences between mean values for all variables were assessed using analysis of variance. A Duncan post hoc

test was performed if F-ratios were significant. The relationships between plasma TC and HDL-C concentrations and all independent variables were evaluated with Pearson product-moment correlations. These variables were age, number of cigarettes smoked, ounces of alcohol consumed, percentage body fat, weekly swim duration, weekly swim distance, and maximum heartrate achieved during swim workout. Statistical significance was determined at the $p < .05$ level. All statistics were analyzed using the SAS Institute's computer package (14).

RESULTS

All variables measured are shown in Table 1. Though statistically nonsignificant, swimmers were older and leaner than sedentary controls. Only one individual in each group smoked cigarettes, so this was not a differentiating factor between groups. The swimmers consumed significantly more alcohol than controls.

TC was positively associated with age, $r= 0.57$ for the swimmers, and $r= 0.55$ for controls. A significant positive relationship of $r= 0.39$ between TC and percentage body fat was noted in swimmers but not in controls. In swimmers, a significant negative relationship of $r= -0.39$ was found between TC and weekly swim duration. There were no significant

relationships between HDL-C concentrations and any of the measured variables in either group.

Concentrations of TC and HDL-C of swimmers and controls were similar. The values were 204 vs 199 mg/dl, and 48 vs 47 mg/dl, respectively. The TC/HDL-C ratios of the groups were almost identical. The mean TC/HDL-C ratio of the swimmers was 4.69, and the controls 4.65.

To investigate the effects of intensity, the swimmers were subdivided by maximum heartrate achieved into low and moderate intensity groups. The low-intensity group achieved a mean maximum heartrate less than 140 beats per minute (bpm) during swim training. The moderate intensity group group achieved a mean maximum heartrate equal to or greater than 140 bpm during swim training. There were no significant differences between controls and either intensity swim group for TC or HDL-C concentrations or TC/HDL-C ratio. Comparisons between groups are shown in Table 2.

Table 1 : Characteristics of Swimmers and Sedentary Males

	Swimmers	Sedentary
NUMBER	31	22
AGE (years)	37.0 ± 14.9	34.1 ± 8.8
TC (mg/dl)	204.0 ± 34.5	198.8 ± 23.8
HDL-C (mg/dl)	48.4 ± 14.4	46.6 ± 13.8
CIG (# per day)	0.4 ± 2.7	0.1 ± 0.2
AL (oz per day)	0.6 ± 0.5*	0.1 ± 0.2
BODY FAT (%)	14.2 ± 5.5	17.2 ± 6.6
DURATION (mins per week)	141.7 ± 84.5	
SWIM YARDS (per week)	5240.6 ± 3216.6	
MAX HR	140.2 ± 24.3	

* indicates significant difference between groups, $p < .05$
TC = Total cholesterol in mg/dl
HDL-C = High-density lipoprotein cholesterol in mg/dl
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
MAX HR = Maximum heartrate achieved during workout
DURATION of swim workouts in minutes per week

Table 2 : Characteristics of Low and Moderate Intensity Swimmers and Sedentary Males

	Mod-Intensity Swimmers	Low-Intensity Swimmers	Sedentary
NUMBER	17	14	22
AGE (years)	34.1 ± 10.4	40.6 ± 18.8	34.1 ± 8.8
TC (mg/dl)	207.1 ± 32.5	200.3 ± 37.7	198.8 ± 23.8
HDL-C (mg/dl)	52.2 ± 16.8	43.7 ± 9.7	46.6 ± 13.8
TC/HDL-C ratio	4.50	4.93	4.65
CIG (# per day)	0	1.1 ± 4.0	0.1 ± 0.2
AL (oz per day)	0.5 ± 0.5	0.7 ± 0.4	0.1 ± 0.2
BODY FAT (%)	13.0 ± 5.5	15.7 ± 5.3	17.2 ± 6.6
SWIM DURATION (mins per week)	143.5 ± 86.4	139.6 ± 85.3	
SWIM YARDS (per week)	6159.5 ± 3537.1	4523.4 ± 2626.3	
MAX HR	157.0 ± 13.9*	119.8 ± 17.5	

* indicates significant difference between MOD and LOW intensity groups, $p < .05$
MOD = Moderate, mean max hr ≥ 140 beats per minute
LOW = Low, mean max hr < 140 beats per minute
TC = Total cholesterol in mg/dl
HDL-C = High-density lipoprotein cholesterol in mg/dl
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
MAX HR = Maximum heartrate achieved during workout

DISCUSSION

The lack of significant difference in HDL-C concentrations between groups agrees with previously published results of Schnabel & Kindermann's (17) study of elite male athletes. Twenty-six male swimmers were among the larger group of athletes. HDL-C concentrations of the swimmers were not significantly different from inactive controls. Smith et al (10) reported significant elevations in plasma HDL-C concentrations in female competitive swimmers (82.0 mg/dl), compared to synchonized swimmers (70.0 g/dl) and sedentary controls (67.2 mg/dl).

Smith et al (10) reported nonsignificant plasma TC concentration differences between groups. The present study found no significant differences in plasma TC concentrations between groups.

Similar results have been reported in studies (3,4,6,7) comparing male runners with sedentary controls finding nonsignificant differences in TC concentrations between groups.

The negative relationship between weekly swim duration and TC concentrations has no parallel in the studies of swimmers previously mentioned. Similar correlations have not been reported in studies of runners. However, Wood et al (14) reported that runners had significantly lower TC concentrations than controls. A possible explanation for TC concentrations decreasing with increasing swim time in the

present study may be that increasing duration of training was sufficient to cause a decrease in LDL-C concentration, but inadequate for causing an elevation in HDL-C concentration.

A positive relationship between age and TC is well supported. The Lipid Research Clinic Program Prevalence Study (15) reported this relationship in analysis of plasma lipids and lipoproteins of 4756 adults of both sexes. This relationship has also been confirmed in studies (16,4,5) comparing athletes to sedentary controls.

SUMMARY

Results of this study indicate that plasma TC and HDL-C values of recreational swimmers who train at low intensities (with maximum training heartrates of 140 bpm or less) are similar to inactive controls.

Additional studies with greater numbers of subjects with an intensity of 75 to 90% of VO2 max, training four days per week for 45 minutes per bout are suggested before definite conclusions can be made as to the ability or inability of swimming to elevate plasma concentrations of HDL-C.

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SUMMARY AND RESEARCH RECOMMEDATIONS

SUMMARY

Numerous studies have demonstrated that plasma HDL-C concentrations of distance runners are higher than the HDL-C concentrations of sedentary controls (Lehtonen & Viikari, 1978, Hartung & Squires, 1980, Schnabel & Kindermann, 1982, Hagan & Gettman, 1983, and Nakamura et al, 1983). According to epidemiological studies (Gordon et al., 1977, Kannel, 1983, and Glueck et al., 1976) high concentrations of HDL-C are associated with low incidence of CVD. Results of a cross-sectional study by Hartung & Squires (1980) of joggers who trained for six months or more, closely agrees with results of a year long longitudinal study by Wood et al., (1983). Both studies identified a running threshold of approximately 10 miles per week to achieve elevation of plasma HDL-C concentrations in runners.

The primary goal of this study was to ascertain if male recreational swimmers exhibited plasma HDL-C, TC concentrations, and TC/HDL-C ratios which were significantly different from those of inactive males. A secondary goal was dependent upon the outcome of the primary goal. If the HDL-C concentrations of swimmers was significantly higher, or the TC concentrations significantly lower than those of sedentary

controls, threshold values of weekly swim distance, swim duration, intensity or frequency would be evaluated.

Prospective subjects filled out a health behaviour questionaire that sought detailed information on medications, cigarette smoking, quantity and type of alcoholic beverages consumed, and exercise habits.

Swimmers kept a one-week log of swim duration, swim distance, and maximum heartrate achieved for each workout. A lab visit was scheduled within two weeks of completion of the first swim log. A second swim log was maintained for the week after the lab visit. Mean values for each individual were computed from the figures reported in the two swim logs.

Skinfold measurements were taken when subjects reported to the lab for blood sampling. Body fat values were obtained by skinfold measurement of three sites (chest, abdomen, and thigh) in accordance with procedures and equations detailed by Jackson & Pollock (1978). Each site was measured five times, and the mean value for each site was used in the equation.

Subjects fasted for 12-14 hours before blood specimens were collected. Samples were obtained from the antecubetal vein in 7 ml vacutainers containing dry ethylenediamine tetraacetic acid. Vacutainers were inverted for thorough mixing, and placed in wet ice for 30 minutes. Samples were then placed in a Sorvall RT 6000 refrigerated centrifuge set at 4 degrees C and spun for 30 minutes with an 1880 g force.

The plasma was drawn off the packed cells and stored at 4 degrees C for later analysis of TC. A portion of the plasma was transferred to 5 ml test tubes. Addition of a heparin-manganese chloride solution caused precipitation of the very-low-density and low-density lipoprotein cholesterol fractions (Albers et al., 1978) These samples were spun in the centrifuge for 30 minutes at 4 degrees C at 1880 g's. TC of whole plasma and HDL-C concentrations in the supernatent were determined in duplicate using a colormetric procedure (Schoenheimer & Warren, 1934). Test-retest association was r=0.90.

Group differences between mean values for all variables were assessed using analysis of variance. A Duncan post hoc test was performed if F-ratios were significant. The relationships between plasma TC and HDL-C concentrations and all independent variables were evaluated with Pearson product-moment correlations. These variables were age, number of cigarettes smoked, ounces of alcohol consumed, percentage body fat, weekly swim duration, weekly swim distance, and maximum heartrate achieved during swim workout. Statistical significance was determined at the $p < .05$ level. All statistics were analyzed using the SAS Institute's computer package.

RESULTS

Though statistically nonsignificant, swimmers were older and leaner than sedentary controls. Only one individual in each group smoked cigarettes, so this was not a differentiating factor between groups. The swimmers consumed significantly more alcohol than controls.

TC was positively associated with age, r= 0.57 for the swimmers, and r= 0.55 for controls. A significant positive relationship of r= 0.39 between TC and percentage body fat was noted in swimmers but not in controls. In swimmers, a significant negative relationship of r= -0.39 was found between TC and weekly swim duration. There were no significant relationships between HDL-C concentrations and any of the measured variables in either group.

Concentrations of TC and HDL-C of swimmers and controls were similar. The values were 204 vs 199 mg/dl, and 48 vs 47 mg/dl, respectively. The TC/HDL-C ratios of the groups were almost identical. The mean TC/HDL-C ratio of the swimmers was 4.69, and the controls 4.65.

To investigate the effects of intensity, the swimmers were subdivided by maximum heartrate achieved into low and moderate intensity groups. The low-intensity group achieved a mean maximum heartrate less than 140 beats per minute (bpm) during swim training. The moderate intensity group group achieved a mean maximum heartrate equal to or greater than

140 bpm during swim training. There were no significant differences between controls and either intensity swim group for TC or HDL-C concentrations or TC/HDL-C ratio. Comparisons between groups are shown in Table 2. The following trends were noted:

1) The moderate-intensity swim group had slightly higher concentrations of TC than either of the other groups.
2) The moderate-intensity swim group had higher HDL-C concentrations than either of the other groups.
3) The moderate-intensity swim group had a lower TC/HDL-C ratio than either of the other groups.

Since there were not significant differences in TC or HDL-C concentrations between groups, there were no threshold values.

RESEARCH IMPLICATIONS

Nonsignificant differences between TC in swimmers and sedentary controls were expected. Schnabel & Kindermann, (1982) reported that swimmers had significantly lower TC concentrations than controls, but the majority of cross-sectional studies have not supported this finding. Smith et al., (1982) failed to find significant differences in plasma TC concentrations between female competitive swimmers and sedentary controls. Many studies (Hagan & Gettman, 1983,

Hartung & Squires, 1980, Hartung et al., 1980, Penny et al., 1982) comparing male runners with sedentary controls have not reported significant differences in TC levels between groups.

A positive relationship between age and TC is well supported. The Lipid Research Clinic Program Prevalence Study (Heiss et al. 1980) reported this positive association in analysis of plasma lipids and lipoproteins of 4756 adults of both sexes.

Possible reasons for nonsignificant differences in HDL-C concentrations in swimmers and controls could be:

1) The intensity of training of the swim group was inadequate to cause elevation of HDL-C.
2) The duration of training of the swim group was inadequate to cause elevation of HDL-C.

Comparing the results of the threshold value of running to swimming, several parameters of exercise were evaluated. Several assumptions are needed in the conversion process. If aerobic activity is the key element in elevation of HDL-C, conversion to a common denominator for different physical activities is nessecary to compare them. Caloric requirements per unit time are available for many sports and physical activities, and will allow comparison of various activities by estimating energy output. All values stated will be for 150 pound males from McCardle & Katch (1981). Caloric expenditure to run at the easily attainable pace of nine minutes per mile is 13.1 kcal/min. Running the thresh-

old 10 miles per week would require an output of 1179 kcal and would take 90 minutes of actual activity. The energy expenditure for a slow crawl stroke (most commonly employed by the subjects in the present study is 8.7 kcal/ minute. Thus the mean caloric expenditure for the swimmers in this study was 1233 kcal per week, slightly higher than the runners. Correcting to equalize the slight difference in output, it took the swimmers in this study 49% longer to expend the same amount of energy. Even allowing for errors in conversion, it is evident that the swimmers trained at a much lower intensity than the runners.

Howley et al., (1982) reported elevated HDL-C concentrations in senior tennis players. Tennis is a sport of intermittent activity, not the continuous activity of running or swimming. According to McCardle & Katch, tennis requires 7.4 kcal/min, less than swimming at the pace of the swimmers in the present study. However, the tennis players in Howley's study consumed 3002 kcal/week more than sedentary controls. Howley stated that his subjects played competitive tennis four to five times per week. Expending the 3002 kcal would require four hour-and- forty minute matches per week, a reasonable assumption. So in this case, elevation of HDL-C levels was achieved at a relatively low output intermitent activity, but with a weekly duration of 400 minutes, compared to the 141 minutes of the swimmers in the present study.

HDL-C elevation cannot be predicted from energy expenditure alone.

Evidence does not suggest that extremely high intensity training produces HDL-C elevations. Myhre et al.(1981) studied the HDL-C concentrations of six male competitive cross-country skiers over an eight month period prior to the competitive season. The training regimen of the skiers was divided into two four month periods characterized by sharply different training emphasis. The first period required many hours of moderate-intensity training, defined by Myhre as 70-80% of VO2 max. The second period sharply decreased the amount of moderate-intensity training, which was replaced with high-intensity training (80-95% VO2 max). The monthly samples revealed peak HDL-C at the end of the moderate-intensity period, and HDL-C concentrations decreased in the high-intensity period. HDL-C concentrations of skiers, even at the lowest point, were significantly higher than those of sedentary controls. There is also evidence that power or speed athletes exhibit normal or subnormal concentrations of HDL-C (Farrell, Maksud, & Pollock, 1982, Schnabel & Kindermann, 1982). Power and speed athletes utilize very-high intensity anaerobic training, which appears to be ineffective in increasing HDL-C concentrations.

The female competitive swimmers in the study by Smith et al., (1982) swam at a higher intensity than the recreational swimmers here, covering 8000 yards per day (more than

the mean weekly distance of the recreational swimmers) in two hours. In the same time, the recreational swimmers would have covered approximately 4400 yards. The competitive swimmers also trained for 720 minutes a week, compared to the 141 of the recreational swimmers in the present study. Based on these values, the 15 mg/dl difference in HDL-C concentration between competitive swimmers and inactive controls was not surprizing, while the recreational swimmers in the present study did not train at sufficient intensity and/or duration to produce HDL-C concentrations significantly higher than those of inactive controls.

Results comparable to those of other investigators cited here and in the literature review were found in the present study when swimmers were divided into low and moderate-intensity training groups based on training heartrate. The low-intensity swimmers (<140 bpm) had a mean HDL-C concentration of 43.7 mg/dl, compared to 52.2 mg/dl of the moderate-intensity (>140 bpm) swimmers. Although this difference was not significant, it suggests that swimmers who maintain a training heartrate greater than 140 bpm for 2-3 hours per week will experience elevations of plasma HDL-C.

The following hypotheses are suggested from the results of the studies cited and the present study. Exercise prescriptions to raise VO2 max will cause elevation of HDL-C concentrations, if the threshold value is met. (Increases in VO2 max can result from running less than 10 miles per

week). Elevation of HDL-C will lag behind exercise-induced increases of VO2 max. Very-high-intensity anaerobic training is ineffective in increasing HDL-C concentrations. High-intensity aerobic training produces some elevation of HDL-C concentrations. Moderate intensity aerobic training produces the greatest amount of HDL-C elevation in the least amount of training time. Low-intensity aerobic training requires extended training duration to produce the elevation in HDL-C concentrations reported from training at moderate or high intensities.

RECOMMENDATIONS FOR FUTURE STUDY

1) A one year longitudinal study featuring aerobic swim training at an intensity range of 75 to 90% VO2 max, 4 or 5 days per week, for 45 minutes per swimming bout.
2) Record diet to facilitate measurement of caloric expenditure and allow evaluation of dietary influences on plasma lipids and lipoproteins.

APPENDIX A. METHODOLOGY

SUBJECT SELECTION

Swim subjects were recruited at the VA Tech swimming pool. Sedentary subjects were recruited from the primary investigator's church.

Prospective subjects were given the Health Questionaire (Appendix B). Individuals were screened according to their answers on this questionaire.

Criteria for swim subjects were:

1) males 17 or more years of age
2) were not on medication known to alter plasma concentrations of lipids or lipoproteins
3) did not utilize interval training in their swim workouts
4) had not swum competitively at high school or intercollegiate level in the two years prior to participation in the study
5) had been swimming their stated weekly mileage for at least one year

The sedentary subjects met the first two criteria of swim subjects. In addition, these subjects had not participated in any regular exercise program for at least one year. Some

sedentary subjects were active in pursuits such as softball and gardening.

PROCEDURES

Cigarette smoking and alcohol consumption were quantified through questionaire. Swimmers kept a detailed log of their swim workouts for two one-week periods. Swim time, swim distance, and maximum heartrate achieved during workouts were recorded in the swim log.

Swim subjects kept a one-week log of their swim workouts before and after blood was drawn. Subjects reported to Gym 230, the Human Performance Laboratory after a 12-hour fast. The fasting condition was verbally verified. Informed consent forms (Appendix C) were read and signed. Subjects were weighed in gym clothes without shoes. Sites on the chest, abdomen and front thigh were measured to allow estimation of body fat percentage. Each site was measured five times, and a mean value from each site was calculated and entered into the equation. Collection of skinfold measurements and calculation of percent body fat were in accordance with procedures stated by Jackson and Pollock (1978).

Blood was collected in 7 ml vacutainers containing dry ethylenediamine tetraacetic acid (EDTA). Vacutainers were inverted for thorough mixing, and placed in wet ice for 30 minutes. Samples were then placed in a Sorvall RT 6000 re-

frigerated centrifuge set at 4 degrees C and spun for 30 minutes with an 1880 g force. The plasma was drawn off the packed cells. One ml of the plasma was transferred to 5 ml test tubes, the remainder was stored at 4 degrees C for later analysis of plasma total cholesterol. Addition of a heparin-manganese chloride solution caused precipitation of the very-low-density lipoprotein and low-density lipoprotein cholesterol fractions. These samples were also spun in the centrifuge at an 1880 g force for 30 minutes at a temperature of 4 degrees C. HDL-C concentration in the supernatent was determined using a colormetric procedure. Contents of test tubes were transferred to cuvettes. Sigma cholesterol standards 350-50, 350-100, 350-200 and 350-400 were used. Samples and standards were read against reagent blank in a spectrophotometer set a 625 nm. All samples were run in duplicate. Duplicate values of the same sample were within 10% for HDL-C, and 5% for TC. Samples that did not meet these requirements were processed again. Test-retest assosiation was r=0.90

DETERMINATION OF HDL-C

Plasma samples were allowed to warm to room temperature.

Sigma standard solutions 350-50 and 350-100 were used for 50 and 100 mg/dl standard curve. The 50 mg/dl standard was diluted with distilled H20 to make a 25mg/dl standard. These were used to create the standard curve.

Plasma samples were mixed well. A calibrated volumetric pipet was used to transfer duplicate 1 ml plasma samples to 5 ml centrifuge tubes.

The HDL-C reagent was vortexed well. A calibrated micropipet was used to transfer 0.1 ml HDL-C reagent to each centrifuge tube. Each tube was vortexed lightly and covered with Parafilm, and allowed to stand at room temperature for 10 minutes.

A refrigerated centrifuge was precooled to 4 degrees C. Samples were spun at a force of 1880 gs for 30 minutes.

Most of the supernatant from each tube was removed and transfered into clean test tubes. Analysis was completed by using total cholesterol procedures below.

DETERMINATION OF TOTAL CHOLESTEROL

0.100 ml each of distilled water (blank), plasma and cholesterol standards of 100, 200, and 400 mg/dl, were transferred into appropriately labeled test tubes. Sigma standards 350-100, 350-200, and 350-400 were used in undiluted state for the TC standard curve. The standard curve described in the preceding section was used for HDL-C determinations.

6.0 ml of cholesterol reagent* was added to each test tube and mixed well. All test tubes were placed in a 37 degree C. water bath for 20 minutes.

All test tubes were removed from the water bath and mixed thoroughly. Contents of each tube were transferred to cuvettes. The spectrophotometer was set at a wavelength of 625 nm, and appropriate filter selected. Specimens and standards were read against the reagent blank on the spectrophotometer within 30 minutes after removal from the water bath.

* A cholesterol reagent consisting of 41.5% acetic acid, 41.5% acetic anhydride, 13.6% sulfuric acid, and 3.4% phosporic acid was added to both HDL-C and TC samples.

STATISTICAL ANALYSIS

Group differences between mean values for all variables were assessed using multiple analysis of variance procedures. The Duncan post hoc test was also applied to groups with significant differences between means. The relationship between plasma concentrations of TC and HDL-C concentrations and all independent variables (age, weekly swim time, weekly swim distance, maximum heartrate, cigarette smoking, percent body fat and alcohol consumption) were evaluated using Pearson product-moment correlation analysis. Statistical significance was determined at the $p < .05$ level.

HEALTH QUESTIONAIRE

Factors other than exercise are known to influence HDL-C levels. Your answers to this questionaire will allow accurate assessment of relevant factors and their contribution to your HDL-C level. Answers will also be used to screen subjects for elgibility for the study. This information is strictly confidential and will be used for research purposes only.

NAME _____

PHONE NUMBER _____

AGE _____

Please circle answers and fill in blanks as indicated.

1. Are you on any medications? Yes No
   If so, please specify.
   a)
   b)
   c)
   d)

2. Do you smoke? Yes No

   a) If so, please circle type: Cigarettes Cigars Pipe

   b) How many cigarettes or cigars do you smoke per day? _____

   c) How often do you light your pipe? _____

3. Do you consume alcoholic drinks? Yes No

   a) What type of beverage do you normally drink? Please place a number in the appropriate column estimating your weekly intake of alcoholic beverages.

	# of drinks per week	oz. per drink
1) beer	_____	_____
2) wine	_____	_____
3) sherry	_____	_____
4) liquor	_____	_____
5) other(please specify)	_____	_____

4. Do you participate in any sport or fitness activity on a regular basis.
   Yes _____ No _____

5. Aerobic exercise may be defined as rythmic, continous, repetitive exercise which causes increased heart and breathing rate and lasts for at least 5 minutes. Common examples besides swimming are jogging, cycling, racquet sports and aerobic dance.

   Do you regularly participate in aerobic exercise other than swimming? If so, please specify.
   What exercise(s)?_____
   How long? (duration of each workout)_____mins
   How many times per week?_____

6. Have you swum competitively (at the high school or intercollegiate level) within the past 2 years?

7. When you swim, do you regularly do interval work (repeated sprints and rest periods)?

Table 3 : Data Table: Swimmers

SUB	TC	HDL	AGE	CIG	AL	BF	SD	SY	XHR
1	193	61	20	0	1.1	4.2	195	6600	163
2	201	59	31	0	.4	4.8	260	11475	167
3	176	56	21	0	.5	18.5	150	5400	137
4	269	56	37	0	.2	14.7	83	3900	151
5	170	67	20	0	0	10.7	215	15500	142
6	178	33	24	0	.2	6.6	112	4425	161
7	188	51	44	0	.8	21.3	116	5033	160
8	206	46	35	0	.9	16.8	100	3775	100
9	203	50	51	0	.8	21.9	88	3213	134
10	240	46	43	0	.7	22.2	166	8000	150
11	212	57	71	0	.7	17.9	40	800	108
12	195	22	33	0	0	9.6	104	5040	167
13	162	38	22	0	.3	7.0	208	8450	129
14	228	87	35	0	.8	9.6	76	3000	145
15	207	42	22	0	.4	10.4	122	2925	122
16	212	41	63	0	.7	18.8	138	5450	139
17	173	49	21	0	1.7	17.6	180	8100	200
18	228	22	44	0	.9	10.7	128	6575	160
19	170	48	33	0	.3	11.5	59	1613	152
20	237	29	63	0	1.3	20.3	91	4550	132
21	153	51	18	0	.9	18.2	390	9750	97
22	141	56	18	0	.1	8.0	165	3750	127
23	226	62	39	0	0	17.4	73	4050	144
24	236	46	47	0	1.8	18.8	60	1333	79
25	275	70	45	0	0	16.2	112	6275	155
26	200	38	53	15	.8	17.3	165	6850	130
27	284	28	53	0	.5	20.0	89	1481	119
28	175	34	31	0	.3	6.2	148	5600	124
29	203	56	18	0	.6	18.6	395	9250	155
30	200	39	52	0	.3	15.9	100	3675	157
31	183	60	40	0	.1	8.8	65	2200	140

SUB = Subject number
TC = Total cholesterol in mg/dl
HDL = HDL-C in mg/dl
AGE = In years
CIG = Number of cigarettes smoked daily
AL = Ounces of alcohol consumed daily
BF = Percent body fat
SD = Swim duration in minutes per week
SY = Swim yards per week
XHR = Mean maximum heartrate for swim workout

Table 4 : Data Table: Sendentary Males

SUB	TC	HDL	AGE	CIG	AL	BF
32	250	58	29	0	.1	20.4
33	163	52	26	0	.1	4.7
34	168	49	30	0	.3	22.0
35	194	56	28	0	0	9.1
36	180	42	33	0	0	27.2
37	187	42	26	0	0	13.9
38	166	47	25	0	.8	13.9
39	196	35	46	0	0	9.8
40	179	47	25	0	0	13.1
41	204	53	34	0	.2	21.0
42	196	59	27	0	.1	22.0
43	217	86	40	0	.1	28.5
44	190	42	23	0	0	8.5
45	240	25	50	0	0	21.1
46	169	30	27	1	.4	19.0
47	193	45	40	0	0	20.8
48	205	23	53	0	0	18.2
49	219	36	43	0	.3	21.3
50	203	48	38	0	0	26.3
51	231	43	43	0	0	17.9
52	221	51	37	0	0	7.7
53	203	57	27	0	.1	13.1

SUB = Subject number
TC = Total cholesterol in mg/dl
HDL = HDL-C in mg/dl
AGE = In years
CIG = Number of cigarettes smoked daily
AL = Ounces of alcohol consumed daily
BF = Percent body fat

Table 5 : Correlation Table: All Swimmers

	TC	HDL	RATIO	AGE	CIG	AL	BF	SD	SY	XHR
TC	1.00 0.00	-0.01 0.95	0.48 0.01	0.57 0.01	-0.02 0.91	0.09 0.63	0.39 0.02	-0.39 0.03	-0.30 0.10	-0.05 0.79
HDL	-0.01 0.95	1.00 0.00	-0.81 0.01	-0.23 0.22	-0.13 0.47	-0.11 0.54	-0.06 0.72	0.09 0.63	0.14 0.46	0.06 0.76
RATIO	0.48 0.015	-0.81 0.01	1.00 0.00	0.42 0.02	0.05 0.79	0.10 0.59	0.13 0.48	-0.26 0.16	-0.21 0.25	0.01 0.99
AGE	0.57 0.01	-0.23 0.22	0.42 0.02	1.00 0.00	0.20 0.28	0.19 0.30	0.51 0.01	-0.57 0.01	-0.46 0.01	-0.22 0.24
CIG	-0.02 0.91	-0.13 0.47	0.05 0.79	0.20 0.28	1.00 0.00	0.09 0.65	0.10 0.58	0.05 0.78	0.08 0.66	-0.08 0.68
AL	0.09 0.63	-0.11 0.54	0.10 0.59	0.19 0.30	0.09 0.65	1.00 0.00	0.39 0.02	0.05 0.78	-0.08 0.69	-0.16 0.38
BF	0.39 0.03	-0.06 0.73	0.13 0.48	0.51 0.01	0.10 0.59	0.39 0.03	1.00 0.00	-0.07 0.69	-0.17 0.37	-0.23 0.22
SD	-0.39 0.03	0.09 0.63	-0.26 0.16	-0.57 0.01	0.05 0.78	0.05 0.78	-0.07 0.69	1.00 0.00	0.76 0.01	0.08 0.66
SY	-0.30 0.10	0.14 0.46	-0.21 0.25	-0.46 0.01	0.08 0.66	-0.08 0.69	-0.17 0.36	0.76 0.01	1.00 0.00	0.31 0.08
XHR	-0.05 0.79	0.06 0.76	0.01 0.99	-0.22 0.24	-0.08 0.68	-0.16 0.38	-0.23 0.21	0.08 0.66	0.31 0.08	1.00 0.00

TC = Total cholesterol in mg/dl
HDL = High-density lipoprotein cholesterol in mg/dl
RATIO = TC/HDL
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
BF = Percent body fat
SD = Swim duration in minutes per week
SY = Swim yards per week
XHR = Mean maximum heartrate (beats per minute)

Table 6 : Correlation Table: Sedentary Males

	TC	HDL	RATIO	AGE	CIG	AL	BF
TC	1.00 0.00	0.07 0.76	0.40 0.07	0.55 0.01	-0.28 0.21	-0.38 0.08	0.26 0.25
HDL	0.07 0.76	1.00 0.00	-0.81 0.01	-0.38 0.08	-0.28 0.21	0.01 0.98	0.14 0.53
RATIO	0.40 0.07	-0.81 0.01	1.00 0.00	0.71 0.01	0.13 0.57	-0.17 0.44	0.08 0.71
AGE	0.55 0.01	-0.38 0.08	0.71 0.01	1.00 0.00	-0.18 0.43	-0.30 0.17	0.39 0.14
CIG	-0.28 0.21	-0.28 0.21	0.13 0.57	-0.18 0.43	1.00 0.00	0.33 0.13	0.06 0.79
AL	-0.38 0.08	0.01 0.98	-0.17 0.44	-0.30 0.17	0.33 0.13	1.00 0.00	0.06 0.79
BF	0.26 0.25	0.14 0.53	0.08 0.71	0.33 0.14	0.06 0.79	0.06 0.79	1.00 0.00

TC = Total cholesterol in mg/dl
HDL = High-density lipoprotein cholesterol in mg/dl
RATIO = TC/HDL
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
BF = Percent body fat

Table 7 : Correlation Table: Low-Intensity Swimmers

	TC	HDL	RATIO	AGE	CIG	AL	BF	SD	SY	XHR
TC	1.00 0.00	-0.54 0.05	0.85 0.01	0.70 0.01	-0.01 0.99	0.47 0.09	0.58 0.02	-0.65 0.01	-0.64 0.01	-0.15 0.61
HDL	-0.54 0.05	1.00 0.00	-0.86 0.00	-0.27 0.35	-0.17 0.56	-0.08 0.79	0.05 0.86	0.12 0.68	-0.08 0.79	-0.20 0.49
RATIO	0.85 0.01	-0.86 0.01	1.00 0.00	0.50 0.07	0.05 0.88	0.22 0.45	0.30 0.28	-0.38 0.18	-0.31 0.28	0.08 0.79
AGE	0.70 0.01	-0.26 0.35	0.50 0.07	1.00 0.00	0.19 0.51	0.45 0.10	0.61 0.01	-0.61 0.02	-0.47 0.09	0.05 0.86
CIG	-0.01 0.99	-0.17 0.56	0.05 0.87	0.19 0.51	1.00 0.00	0.06 0.85	0.08 0.77	0.09 0.77	0.25 0.38	0.17 0.57
AL	0.47 0.09	-0.08 0.79	0.22 0.45	0.45 0.10	0.06 0.85	1.00 0.00	0.64 0.01	-0.22 0.44	-0.21 0.48	-0.57 0.03
BF	0.58 0.03	0.05 0.86	0.31 0.29	0.61 0.02	0.08 0.77	0.64 0.01	1.00 0.00	-0.23 0.43	-0.26 0.37	-0.13 0.67
SD	-0.65 0.01	0.12 0.69	-0.38 0.18	-0.61 0.02	0.09 0.77	-0.22 0.44	-0.23 0.43	1.00 0.00	0.87 0.01	-0.03 0.92
SY	-0.64 0.01	-0.08 0.79	-0.31 0.28	-0.47 0.09	0.25 0.38	-0.21 0.48	-0.26 0.36	0.87 0.01	1.00 0.00	0.24 0.41
XHR	-0.15 0.61	-0.20 0.49	0.08 0.79	0.05 0.86	0.17 0.57	-0.57 0.03	-0.12 0.66	-0.03 0.92	0.24 0.41	1.00 0.00

TC = Total cholesterol in mg/dl
HDL = High-density lipoprotein cholesterol in mg/dl
RATIO = TC/HDL
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
BF = Percent body fat
SD = Swim duration in minutes per week
SY = Swim yards per week
XHR = Mean maximum heartrate (beats per minute)

Table 8 : Correlation Table: Moderate-Intensity Swimmers

	TC	HDL	RATIO	AGE	CIG	AL	BF	SD	SY	XHR
TC	1.00 0.00	0.22 0.40	0.19 0.47	0.49 0.04	0.00 1.00	-0.18 0.50	0.30 0.23	-0.16 0.53	-0.14 0.58	-0.27 0.30
HDL	0.22 0.39	1.00 0.00	-0.84 0.01	-0.15 0.57	0.00 1.00	-0.03 0.92	-0.01 0.98	0.08 0.77	0.12 0.65	-0.37 0.14
RATIO	0.19 0.47	-0.84 0.01	1.00 0.00	0.32 0.21	0.00 1.00	-0.03 0.91	-0.04 0.88	-0.17 0.52	-0.13 0.62	0.19 0.46
AGE	0.50 0.04	-0.15 0.57	0.32 0.21	1.00 0.00	0.00 1.00	-0.26 0.32	0.36 0.16	-0.60 0.01	-0.48 0.05	-0.30 0.24
CIG	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00	0.00 1.00
AL	-0.18 0.50	-0.03 0.92	-0.03 0.91	-0.26 0.32	0.00 1.00	1.00 0.00	0.14 0.60	0.27 0.30	0.10 0.70	0.66 0.01
BF	0.30 0.23	-0.01 0.98	-0.04 0.88	0.36 0.16	0.00 1.00	0.14 0.59	1.00 0.00	0.05 0.84	-0.02 0.93	0.02 0.93
ST	-0.16 0.53	0.08 0.77	-0.17 0.52	-0.60 0.01	0.00 1.00	0.27 0.29	0.05 0.84	1.00 0.00	0.74 0.01	0.24 0.36
SY	-0.14 0.58	0.12 0.65	-0.13 0.62	-0.48 0.05	0.00 1.00	0.10 0.70	-0.02 0.93	0.74 0.01	1.00 0.00	0.16 0.53
XHR	-0.27 0.30	-0.37 0.14	0.19 0.46	-0.30 0.24	0.00 1.00	0.66 0.01	0.02 0.93	0.24 0.36	0.16 0.53	1.00 0.00

TC = Total cholesterol in mg/dl
HDL = High-density lipoprotein cholesterol in mg/dl
RATIO = TC/HDL
CIG = Cigarettes smoked per day
AL = Ounces of alcohol consumed per day
BF = Percent body fat
SD = Swim duration in minutes per week
SY = Swim yards per week
XHR = Mean maximum heartrate (beats per minute)

APPENDIX C. INFORMED CONSENT

HUMAN PERFORMANCE LABORATORY

Division of Health, Physical Education and Recreation
Virginia Polytechnic Institute and State University

I, _____, do hereby voluntarily agree and consent to participate in a study conducted by the personnel of the Human Performance Labratory of the HPER Division of VPI & SU.

TITLE OF STUDY:

THE RELATIONSHIP BETWEEN WEEKLY SWIMMING TIME, PLASMA TOTAL CHOLESTEROL AND HIGH-DENSITY LIPOPROTEIN-CHOLESTEROL IN MALE RECREATIONAL SWIMMERS

The purposes of this study include:

The purpose of this study is to determine if recreational swimmers have lower plasma levels of of TC and higher plasma levels of HDL-C than sedentary controls.

I voluntarily agree to participate in this study. It is my understanding that my participation will include:

1) Filling out a personal health habits questionaire to determine my elgibility for the study.
2) Swim subjects: filling out logs detailing their swim activity during the first and third weeks of the study. Logs will be given to the investigator upon completion.
3) Having 25 ml of blood drawn and skinfold measurements taken in the Human Performance Lab.
    a) Subjects will be required to fast for 12 hours before reporting to the lab to have blood drawn.

I understand that participation in this study may produce certain discomforts and risks. These risks are those normally associated with the drawing of blood, and include the possibility of hematoma and bruising at the point of blood withdrawl. A registered nurse will be drawing the blood to minimize this risk.

Certain personal benefits may be expected from participation in this study. These include:

1) Comparison of individual plasma levels of TC and HDL-C to normal values and their contribution to CHD risk.
2) Comparison of individual percentage of body fat to normal values and its relationship to CHD risk. Percentage body fat will be estimated by skinfold measurements which are non-invasive and painless.
3) Instruction in counting heartrate through palpation.
4) A possible exercise prescription for swimmers that will aid them in decreasing the CHD risk factors of high plasma TC and low plasma HDL-C.

I understand that any data of a personal nature will be held confidential and will be used for research purposes only. I also understand that these data may only be used when not identifiable with me.

I understand that I may abstain from participation in any part of the experiment or withdraw from the experiment should I feel the activities might be injurious to my health. The experimenter may also terminate my participation should he feel the activities might be injurious to my health.

I understand that it is my personal responsibility to advise the researchers of any preexisting medical problem that may affect my participation or of any medical problems that might arise in the course of this experiment and that no medical treatment or compensation is available if injury is suffered as a result of this research. A telephone is available which would be used to call the local hospital for emergency service.

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

Your participation in this experiment provides the investigator the opportunity to conduct meaningful scienfific observations designed to make significant educational contribution.

If you would like to receive the results of this investigation, please indicate this choice by marking in the appropriate space provided below. A copy will then be distributed to you as soon as the results are made available by the investigator. Thank you.

_____ I request a copy of the results of this study.

Date _____ Time_____ a.m./p.m.

Participant Signature_____

Witness _____(HPL Personnel)

Project Director _____ Phone # _____

HPER Human Subjects Chairman: Dr. Don Sebolt
Phone # 961-5104

Dr. Charles Waring, Chairman, Institutional Review Board for Research Involving Human Subjects.

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