Naval Submarine Medical Research Laboratory

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NUTRITION EDUCATION AND DIET MODIFICATION ABOARD SUBMARINES

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NSMRL Report 1201

Naval Medical Research and Development Command
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Summary Page

Problem

To determine whether nutrition education and a menu designed to decrease the percentage of caloric intake from saturated fats and cholesterol would improve coronary heart disease (CHD) risk.

Findings

Regardless of nutrition education or menu intervention, submariners showed some reduction in CHD risk factors during deployment. There was an additional beneficial effect for those submariners who received the education and menu intervention.

Application

The use of nutrition education and menu intervention in the reduction of coronary heart disease risk factors.

Administrative Information

This work was conducted under NMRDC Work Unit 63706N 0096.002-5206, Nutrition education and diet modification aboard submarines. Both authors contributed equally to the report; order of authors does not reflect degree of involvement. The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U. S. Government. This report was approved for publication on 27 June 1996 and designated NSMRL Report 1201.

Abstract

During a one year period, 534 male, US Navy submariners participated in a nutrition research project designed to reduce coronary heart disease (CHD) risk. The research was carried out on board USN Trident Submarines before, during, and following actual patrols. Subjects from six submarine crews were assigned to either the education / diet group (E) or the control group (C). Group E was provided nutrition education and a modified 5 week cycle menu which focused on decreasing the percentages of caloric intake derived from fat and high cholesterol food. Group C received NO intervention. Measurements of cholesterol (TC), high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL), triglycerides (TG), Ratio (TC/HDL), blood pressure (BP), and body fat (BF%) were taken before and after deployment and again after the off crew period. Age, height, and weight data were also gathered. The data were analyzed with the MANOVA procedure using a mixed multivariate model with repeated measures on the two groups. Following the patrol one of the three control crews demonstrated statistically and clinically significant decreases in TC, HDL, LDL, and Ratio and another crew showed a significant decrease in BP (systolic). Within the education group (3 crews) several significant decreases occurred during deployment: TC declined (3 crews), LDL and HDL declined (2 crews), ratio declined (one crew), and TG declined (2 crews). All six crews demonstrated a statistically significant decrease in BF% during deployment. Changes were noted following the off crew period. Both groups demonstrated increases in most variables.

The experiment demonstrated that regardless of education or menu intervention, subjects showed some reduction in CHD risk factors during deployment.

The results also demonstrated that the nutrition education and diet modification intervention had a greater beneficial effect on reducing CHD risk factors when compared to no intervention.

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In the United States, cardiovascular disease is the leading cause of death, with coronary heart disease (CHD) accounting for two thirds of all heart disease (Kannel, Dawber, Kagan, Revotskie, & Stokes, 1961; Klang, et al., 1993; Garber, Sox, & Littenberg, 1989). Epidemiological studies indicate that both genetic and acquired factors increase the risk for CHD (Garber, et al., 1989; Manson, et al., 1992; Ornish, et al., 1990). Some of these, such as age, gender, and familial predisposition are irreversible risk factors. However, many of the other risk factors for CHD are reversible (e.g. elevated serum cholesterol, elevated low density lipoprotein cholesterol, low level of high density lipoprotein cholesterol, smoking, high blood pressure, obesity) (Kannel, et al., 1961; Klang, et al., 1993; Garber, et al., 1989).

For instance, there is overwhelming evidence that identifies hypercholesterolemia as a major risk factor for CHD (Kannel, et al., 1961; Klang, et al., 1993; Garber, et al., 1989; Schuler, et al., 1992). Both dietary cholesterol and saturated fats raise serum cholesterol and other lipid fractions (Kannel, et al., 1961; Klang, et al., 1993; Garber, et al., 1989; Schuler, et al., 1992; Stehbens, 1990). In most cases, abnormal or unhealthy levels of these lipids can be modified with a diet outlined for sound nutrition (Thom, Kannel, & Feinleib, 1985; Banta, 1979; Hoiberg, Bernard, & Watten, 1980; Graham & Good, 1987). Research suggests that improving dietary habits and consequently reducing percent body fat (%BF) may improve cardiovascular health, physical performance, and job productivity (Thom, et al., 1985; Banta, 1979; Hoiberg, et al., 1980; Graham & Good, 1987).

Improvement or maintenance of health and physical fitness of military personnel is a major concern of the US Navy as they impact on performance and it reduces the risk for CHD. Because excess %BF incurs a health risk, the Department of Defense (DOD) has set a maximum acceptable %BF level of 22% for males (using the circumference method). Excess body fat has been shown to be associated with high blood pressure, diabetes, and heart disease as described by the National Institute of Health Conference on Obesity (National Institute of Health [NIH], 1985). Therefore, the relationship between risk factors and coronary heart disease is of importance to the DOD and the U.S. Navy from both a health and financial standpoint.

U.S. Navy shipboard conditions such as confinement, lack of exercise equipment, and the lack of time to exercise are barriers to increasing cardiovascular health in the operational Navy (Marcinik, Hodgdon, & O'Brien, 1988). In general, the lack of physical activity is related to CHD (Paffenberger, 1985). Due to confinement, this lack of activity is frequently the case aboard submarines. Reduced physical activity, coupled with the usual 35-percent-of-calories from fat and high cholesterol diet typically served onboard submarines, may put submariners at higher risk for CHD while on active submarine duty (Carson, 1986; Tappan, Mooney, Jacey, & Heyder, 1979). These circumstances suggest that nutritional modification and/or an exercise program could be beneficial.

Very few studies on submariners are available in the open literature; however, significant results are reported in Navy publications. In a study of CHD risk on crew members on one submarine, Carson (1986) examined the nutrient intake of the submariners and the implications for CHD. He reported that the crew

members subsisted on a highly atherogenic diet.

Carson (1986) states that the submarine fleet has seen increased incidence of CHD in highly trained members. Missions have been jeopardized in order to conduct highly dangerous and expensive medivac operations (Tansey, Wilson, & Schaefer, 1979). These occurrences could be reduced with an increase in physical activity, modification of the diet, and implementation of preventive medicine measures (Carson, 1986; Trent & Conway, 1988).

The purpose of this research is to demonstrate that a nutrition education program combined with improved menu choices during submarine deployment can have a beneficial effect on CHD risk factors by reducing serum cholesterol, other lipid fractions, blood pressure, and percent body fat.

Method

Subjects

The research was carried out on board U.S. Navy Trident Submarines before, during, and following actual patrols. Subjects were male, U.S. Navy submarine volunteers (N=534) from six Trident submarine crews stationed at either of two Naval submarine bases (Kings Bay, GA or Bangor, WA). Some subjects did not complete all phases due to transfer of crew members off the submarine and scheduling conflicts with mission related training.

Procedure

Data were collected before (pre-patrol) and after a deployment (post-patrol) of at least 60 days, and immediately before a second deployment (final). Three submarine crews were assigned to the control group (C) and three crews to the education/diet group (E). One submarine participated in both groups (C first, E last). The control group was provided a diet consisting of menus prepared as usual by their cooks (Mess Management Specialists) who were not given any additional nutrition education. The experimental crews received nutrition education and were offered a modified diet which was lower in fat and cholesterol than the normal menu. The experimental menu offered meals which were approximately 30% fat, while the control submarines provided meals which ranged from 34-36% fat.

Time of year varied for the patrol. Two of the control submarines began the study in the winter of 1992 and finished in the summer of 1993. The third control submarine had the first set of measurements taken in early May, 1993, post-patrol measurements in August, and final measurements in November 1993. All three experimental submarines began pre-patrol measurements in the summer of 1993 and completed post-patrol and final measurements in the winter of 1993 - 1994.

Education. The food service personnel in the experimental group attended two days of nutrition education lectures several weeks prior to deployment. They received specific instructions on how to order foods, prepare menus, and prepare foods which are nutritionally and medically sound.

Prior to deployment, the experimental submarine crew members also attended 4 hours of nutrition education lectures and were further provided with nutrition education via lectures and video media during deployment. The education provided during the patrol was presented by a hospital corpsman from the NSMRL research staff who acted also as a research monitor during the patrol.

During the educational lectures, the crews of the experimental group received specific instructions on how to decrease their risk for CHD by choosing foods which are nutritionally and medically sound. They also received

information regarding the specific risk factors associated with CHD, and how to modify their own particular risk.

Modified menu. The modifications to the submarine menu were planned under the supervision of a registered dietitian (RD). The experimental menu focused on decreasing the percentage of caloric intake that was derived from fat and high cholesterol food. The menu was intended to provide menu choices with an overall percentage of fat of 30% and to include nutritionally sound recommendations such as modifying cooking methods, keeping fat content to a minimum, offering low calorie desserts, and using whole wheat flour. All subjects were allowed to choose what and how much they wanted to eat.

Cost comparisons for the menus were made between the control and the experimental groups. No appreciable difference was found between the lower fat menu and menus typically used by each submarine.

Analysis

With few exceptions, two measurements of total cholesterol (TC), high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL calculated), triglycerides (TG), and blood pressure (BP) were made at each of the three time periods (pre-patrol, post-patrol, and final). At each time period, blood was drawn with the subject in a sitting position in the morning after a 12-hour fast (Segal, et al., 1984). Analyses for TC, HDL, LDL, and TG, were performed at the Naval Hospital Groton, CT using the Boehringer Mannheim Corp Hitachi 911 clinical analyzer (Diagnostic Laboratory Systems Division, Indianapolis, IN). Low density lipoprotein cholesterol was derived from a standard calculation (TC-HDL-(TG/5)) (Bakermann, 1984). Any measurements with greater than 14% difference between the two measurements were re-analyzed (National Institute of Health [NIH], 1990). A single measurement for percent body fat (%BF) was made at each time period using the Navy's body circumference measurement method (Beckett & Hodgdon, 1984).

Investigators gathered initial data on height, weight and age. Height was recorded and rounded to the closest half-inch while weight was recorded to the closest half-pound using scales available on the submarines.

The data were analyzed with the MANOVA procedure using a mixed multivariate model with repeated measures on the two groups. All physiological data were analyzed in this manner. A calculation of percent change was then performed for each group followed by a paired *t*-test to compute the differences in percent change for the control group versus the experimental group. Pre-planned apriori *t*-tests were conducted separately for each group (C&E) across time, for all variables. Except where noted, all comparisons were significant at the .01 level or greater. Other factors (e.g. family history of CHD, diet, exercise, alcohol, and nicotine habits) were included and will be summarized in a subsequent report.

A concern in a study of this magnitude is the probability of Type I errors (rejecting the null hypothesis, when in fact it is true) due to the large number of significant tests conducted. In particular, the family wise error rate for the experiment must be considered. Two common ways of addressing this issue are using significance tests which take into account the number of comparisons being made or secondly, to simply adopt a more stringent α level when performing the tests (Howell, 1993).

In the present design, for each variable, there are nine comparisons that will be made. Within each group there are three compari-

Table 1
Pre-Deployment: Mean physiological values for male US Navy submarine crew members

Variable	Control			Experimental		
	Mean	SD	CV	Mean	SD	CV
Age (yrs)	27.0	5.6	.20	27.6	5.7	.20
Height (in)	69.7	2.7	.04	70.1	2.6	.04
Weight (lbs)	182.5	27.8	.15	181.1	27.0	.15
TC (mg/dl)	182.1	34.3	.19	187.5	38.5	.20
HDL (mg/dl)	45.1	10.3	.23	41.3	11.4	.28
LDL (mg/dl)	113.5	29.4	.26	119.5	33.4	.28
TG	122.6	76.8	.63	137.4	79.0	.57
Ratio (TC/HD)	4.3	1.4	.32	4.9	1.9	.39
Systolic BP (mmHg)	121.7	9.1	.07	121.9	8.7	.07
Diastolic BP (mmHg)	76.3	7.7	.10	77.9	7.8	.10
BF (%)	19.1	6.0	.31	18.8	5.7	.30

Table 2
Comparison of control (C) and experimental (E) groups for pre-patrol, post-patrol, and final measurement

Variable	C/E	n	Pre		Post		Final	
			Mean	SD	Mean	SD	Mean	SD
TC (mg/dl)	C	296	182.1	34.3	174.5	31.9	187.4	35.3
	E	238	187.5	38.5	176.6	37.3	193.1	34.3
HDL (mg/dl)	C	285	45.1	10.3	42.9	9.4	49.3	14.6
	E	236	41.3	11.4	37.9	8.3	43.4	9.1
LDL (mg/dl)	C	287	113.5	29.4	107.8	28.7	111.8	31.7
	E	234	119.5	33.5	112.2	34.5	120.0	30.5
TG (mg/dl)	C	285	122.6	76.8	126.7	69.3	136.8	83.4
	E	233	137.4	79.0	125.8	70.0	143.8	89.8
Ratio (TC/HDL)	C	285	4.3	1.4	4.3	1.2	4.2	1.3
	E	236	4.9	1.9	4.9	1.5	4.6	1.2
Systolic BP (mm Hg)	C	281	121.7	9.1	121.6	10.1	120.0	9.0
	E	246	121.9	8.7	114.9	10.1	118.3	9.2
Diastolic BP (mm Hg)	C	280	76.3	7.7	75.1	8.0	76.2	7.0
	E	246	77.9	7.8	71.8	7.9	74.7	7.1
BF (%)	C	266	19.1	6.0	17.9	5.3	18.9	5.5
	E	244	18.8	5.7	17.8	5.7	18.8	6.0

sons for the interval (pre to post, post to final, pre to final), a total of six for the two groups. Between groups there are comparisons at each interval (three comparisons). For each variable, therefore, there are nine comparisons of simple effects being made in the MANOVA. Since the degrees of freedom in the numerator for the F tests is 1 for each of these comparisons, the resulting F value is equal to t squared. This relationship permits the use of the Bonferroni t (Dunn's test) to control the family-wise error rate (Howell, 1993). The critical value of t for nine comparisons and df > 100 is 2.77. An F value (t^2), therefore, must be above 7.7 to control for family wise error at the $p < .05$ level.

Another way to control family wise error is to use a more conservative level of α, such as .01, .005, or .001. This is equally acceptable as the Bonferroni adjustment of t (Howell, 1993), but may yield slightly different results. In the tables that follow, we have included the F value and the level of significance resulting from the MANOVAS. We have noted in the test instances in which the Bonferroni correction would alter the significance of a comparison.

Results

Table 1 presents the mean physiological values and standard deviations (SD) pre-patrol for each group. It includes columns for the coefficient of variation (CV - standard deviation divided by mean), which is a scaled measure of the relative variability. Table 2 shows the physiological values for both groups across the three time periods. Figures 1, 2, and 3 show the direction of change for interval comparisons for the physiological measures. "Better" means the change was in the direction of reduced risk, "worse" is toward increased risk. Significant changes are depicted with arrows, an equal sign indicates no change across the time interval.

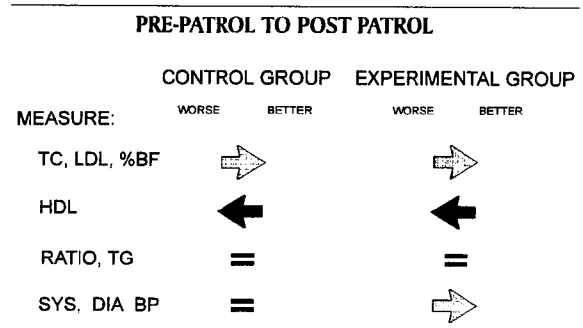

Figure 1

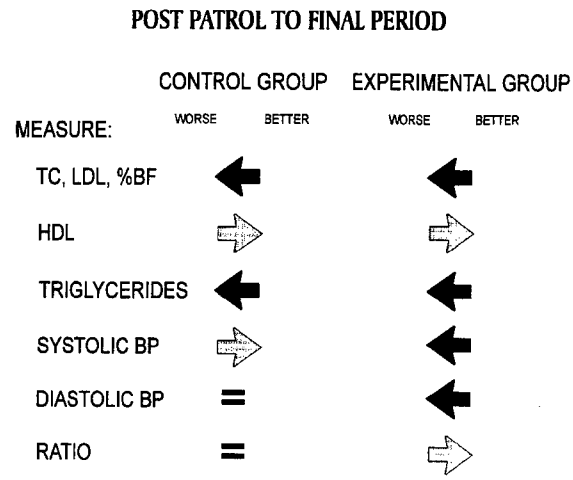

Figure 2

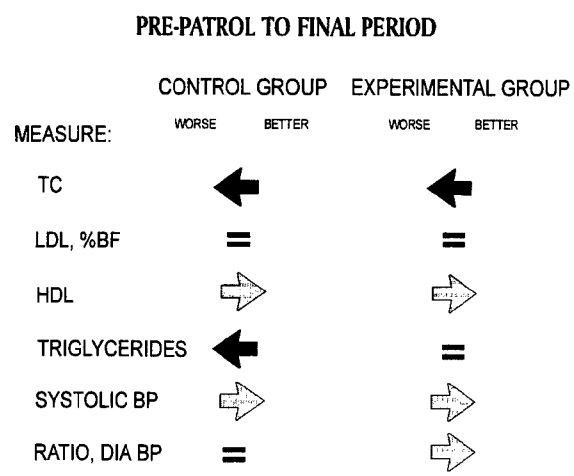

Figure 3

Appendix A shows the results of the repeated measures MANOVAs and simple effects tests for each variable. It also includes the paired *t* tests for within group comparisons for the three intervals. Table 3 shows percent changes for each group from pre- to post-patrol and Table 4 the post-patrol to final measurement.

Appendix B displays individual crew results from pre- to post-patrol and from post-patrol to final measurement. The number of subjects included in the various means differs throughout because not all subjects completed all phases.

In the following sections, pre- to post-patrol results are discussed first, then post-patrol to final measurement results follow.

Total Cholesterol (TC) (mg/dl)

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. There was no difference between groups in pre-patrol TC values or at the other two intervals (Appendix A-2). Both groups showed a significant lowering of total cholesterol from pre- to post deployment, followed by an increase during the off-crew period (Appendix A-3). There was no significant difference found between groups for percent change in TC (Table 3). One control boat (crew 3) showed a significant decrease in TC, while all three experimental crews had significant decreases in TC during the patrol (Appendix B).

From post-patrol to the final measurement, both groups had significant increases in TC (Appendix A-3), and no significant difference was found in the percent change in TC values between groups (Table 4). Final TC values were significantly higher than pre-patrol values for both groups (Appendix A-3). All six crews demonstrated significant increases in TC during the off crew period (Appendix B).

HDL (mg/dl)

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. Values for HDL were significantly different between the two groups and across the three measurement intervals (Appendix A-1). The difference between groups was significant at each of the three time intervals (Appendix A-2). Both groups showed similar decreases in HDL values from pre- to post-deployment, followed by an increase during the off crew period to a level higher than pre-deployment values (Appendix A-3).

From pre- to post-patrol measurement, each group showed significant decreases in HDL values (Table 2 and Appendix A-3), and no difference was found in the percent change between the two groups (Table 3). Two control crews (1 and 3) and two experimental crews (4 and 5) displayed significant decreases in HDL during the patrol period (Appendix B).

During the off crew period, each group demonstrated significant increases in HDL and there was no difference in percent change found between the groups (Tables 2 and 4). Individually, four of the crews (2, 3, 4, 6) showed significant increases ($p < .05$) in HDL levels during the off crew period (Appendix B).

LDL (mg/dl)

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. The results for LDL revealed a significant difference in low density lipoproteins across time and between groups (Table 2 and Appendix A-1). There were no differences between groups in LDL values at the pre- or the post measurement intervals, only at the final (Appendix A-2). The effect of interval was significant for the experimental

Table 3
Mean percent change for Control and Experimental Groups for pre-patrol to post-patrol

Variable	Control Group				Experimental Group				Groups Diffferent
	M(%)	SD	*N*	Increase ↑ or Decrease ↓	*M* (%)	*SD*	*N*	Increase ↑ or Decrease ↓	*p**
Total Cholesterol (TC) (mg/dl)	3.1	14.5	296	↓	4.9	14.8	238	↓	NS
HDL (mg/dl)	3.6	14.6	285	↓	5.0	19.8	236	↓	NS
LDL (mg/dl)	3.1	20.7	287	↓	4.7	21.0	234	↓	NS
Ratio (TC/HDL)	2.8	20.0	285	=	3.6	24.5	236	=	NS
Triglycerides (TG) (mg/dl)	14.3	44.6	285	=	.5	48.9	233	=	.001
Systolic Blood Pressure (SBP) (mmHg)	.2	8.3	289	=	5.4	8.8	246	↓	.001
Diastolic Blood Pressure (BP) (mmHg)	.9	11.1	280	=	7.0	13.0	246	↓	.001
Percent Body Fat (BF) (%)	3.3	19.6	266	↓	4.7	15.1	244	↓	NS

* NOTE: Column marked *p* indicates whether the percent change was different in the two groups and the level of significance.

Table 4
Mean percent change for Control and Experimental Groups for post-patrol to final measurement

Variable	Control Group				Experimental Group				Groups Different
	M(%)	SD	*N*	Increase ↑ or Decrease ↓	*M* (%)	*SD*	*N*	Increase ↑ or Decrease ↓	*p**
Total Cholesterol (TC) (mg/dl)	8.3	14.8	296	↑	11.8	20.5	238	↑	NS
HDL (mg/dl)	17.7	39.3	285	↑	17.7	27.2	236	↑	NS
LDL (mg/dl)	5.6	24.8	287	↑	14.0	38.3	234	↑	.01
Ratio (TC/HDL)	1.4	22.5	285	=	.2	28.1	236	↓	NS
Triglycerides (TG) (mg/dl)	17.5	59.2	285	↑	22.7	22.7	233	↑	NS
Systolic Blood Pressure (SBP) (mmHg)	1.0	8.1	280	↓	3.5	9.2	246	↑	.001
Diastolic Blood Pressure (BP) (mmHg)	2.1	11.3	280	=	5.0	13.4	246	↑	.01
Percent Body Fat (BF) (%)	5.9	14.7	266	↑	7.0	17.3	244	↑	NS

* NOTE: Column marked *p* indicates whether the percent change was different in the two groups and the level of significance.

group, while for the control group, the effect of interval was not significant by the Dunn's test criteria of $F = 7.7$.

Each group demonstrated a significant decrease in LDL during deployment (Table 2), and no difference in percent change between the groups was evident (Table 3). One control crew (2) showed a significant increase in LDL while crew 3 showed a significant decrease (Appendix B). Two of the experimental crews (4 and 5) showed significant decreases in LDL during deployment (Appendix B).

During the off-crew period, each group demonstrated a significant increase in LDL (Appendix A-3). There was a difference in the percent change between the groups, but final LDL values were not different than pre-patrol values for either group (Table 4 and Appendix A-3). There was a significant difference between groups at the final interval with the control group showing lower LDL values (Appendix A-2). One control crew (1) and two experimental crews (4 and 5) had significant increases in LDL during the off-crew period, while one experimental crew (6) displayed a significant decrease (Appendix B).

Ratio

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. Significant differences were noted in the ratio of TC to HDL across time and between groups (Appendix A-1). The differences between groups were significant at the pre- and the post interval with ratios higher in the experimental group (Table 2 and Appendix A-2).

From pre- to post-patrol, no significant change in Ratio occurred in either group (Table 2 and Appendix A-3) and no difference in percent change was noted (Table 3). Two of the control crews showed significant changes in ratios during deployment (crew 2 increased, crew 3 decreased). One experimental crew (6) showed a significant decrease in Ratio (Appendix B).

During the post-patrol period, the experimental group displayed a significant decrease in Ratio (Table 2) and no difference was found between groups when comparing percent change (Table 4, and Appendix A-3). The final ratio measure was lower than the pre-patrol value for the experimental group only. Specifically, one control crew (1) and one experimental crew (5) displayed increases in Ratios during off-crew while one control crew (3) and one experimental crew (6) showed significant decreases (Appendix B).

Triglycerides (mg/dl)

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. Triglycerides measures showed more variability than the other measures. This is evidenced by the coefficient of variation, which for TG is twice as large as that of any other variable (Table 1). The basic MANOVA on TG data revealed a significant difference across time for both groups (Appendix A-2); only the experimental group, however, met the significance level on the Dunn's test (Appendix A-2).

During deployment, neither group revealed a significant change in TG values, but the direction of change was an increase for the control and a decrease for the experiment (Table 2 and Appendix A-3). There was a significant difference between the two groups for percent change in TG values (Table 3). While no changes were noted for any of the control crews during deployment, two of the experimental crews (5 and 6) displayed significant declines in TG values (Appendix B).

During the off-crew period, both groups displayed significant increases in TG values with no difference in percent change between groups (Table 4). For the control group only, the final TG measure was significantly higher than the pre-patrol value (Appendix A-3). Individually, one control crew (2) and two experimental crews (4 and 6) demonstrated significant increases in TG values during off crew (Appendix B).

Blood Pressure (mm Hg)

Systolic (SBP). Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. The MANOVA (Appendix A-1) revealed significant differences across interval and between groups. An interaction was also found for interval by group. The change over intervals was significant for the experimental group, but not the control group by the Dunn's criteria (Appendix A-2).

During the patrol period, only the experimental group showed a decrease in SBP (Appendix A-3). A significant difference was found between the two groups for percent change in SBP during the patrol (Table 3) with the experimental group showing an 8% decrease in SBP. Individually, a significant decrease in SBP was demonstrated by one control (1) and one experimental (4) crew (Appendix B).

Both groups showed a significant change in SBP during the off-crew period with the control group demonstrating a decrease and the experimental group displaying an increase. Both groups showed significantly lower final SBP than pre-patrol, but the magnitudes of these differences were small (Table 2 and Appendix A-3). A significant difference was found between the groups for percent change in SBP during this time with the larger increase found for the experimental group (Table 4). Whereas one control crew (3) demonstrated a significant decline in SBP, two of the experimental crews (4 & 6) displayed significant increases (Appendix B).

Diastolic (DBP). Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in Appendix A. The results for DBP were somewhat similar to those for SBP. As with SBP, there was a significant difference found for DBP across time. There was, however, no difference between groups. An interaction was revealed for interval by group (Table 2 and Appendix A-1). There was no difference in diastolic BP between groups at the pre-patrol or final measure, but there was for the post-patrol measure (Appendix A-2).

During the deployment, only the experimental group showed a decrease in DBP (7%), and a significant difference was found between groups for percent change with the experimental group showing a larger decrease (Table 3). One control crew (1) and two experimental crews (4 and 6) demonstrated a significant decline in DBP during the deployment (Appendix B).

The experimental group demonstrated significant increases ($p < .05$) in DBP during the off-crew period. The difference in percent change found between the groups was also significant with the experimental group change, again, larger (Table 4). Final DBP measure was lower than pre-patrol for the experimental group only (Appendix A-3). Two control (1 and 3) and two experimental crews (4 and 6) displayed significant increases in DBP during the off-crew period while one experimental crew (5) showed a decrease. (Appendix B)

Body Fat (%)

Means and standard deviations for both groups at each time interval are shown in Table 2 and statistical results are shown in

Appendix A. Multivariate analysis of variance showed no overall difference between groups in BF % levels (Table 2 and Appendix A-1). There was a significant difference among the three time periods for BF%.

During the patrol cycle, both groups demonstrated significant declines in BF% and no difference in percent change was evident between groups (Tables and Appendix A-3). Each of the six crews demonstrated a significant decline in BF%.

Both groups displayed significant increases in BF% during the off crew period and again no difference between groups was found in percent change (Tables and Appendix A-3). Percent body fat at the end of the patrol was not different than the pre-patrol for either group (Appendix A). Four individual crews revealed significant increases in BF% during the off crew, two from each group (1 and 3; 4 and 5) (Appendix B).

Within Submarine Comparison of the Effect of Education and Menu Modification

One of the submarines participated in the study first as a control crew and then as an experimental crew. The control crew had the first set of measurements taken in March, the second set in May, and the final set in August of 1993. The experimental crew had the first set of measurements taken in August of 1993, the second set in December 1993, and the final set in February 1994. During the research, several subjects were lost and some were gained due to rotation of men off and onto submarine duty. Following are results for comparison of those subjects who completed both patrols (Control and Experimental).

Control Patrol

Lipid Profiles Immediately following the control patrol, subjects showed a significant increase in total cholesterol (6.1 mg/dl) and LDL cholesterol (6.5 mg/dl) above pre-patrol values. This change was also reflected in a small increase in the TC/HDL ratio (.17). There were no changes in triglycerides or HDL cholesterol. At the final measurement, LDL levels were the same as those of the post-patrol. Total cholesterol levels were further increased over the post-patrol levels (6.3 mg/dl) at the final measurement, but there was no accompanying change in ratio.

Blood pressure and percent body fat. The only significant change in any blood pressure measure was a 6.0 mm Hg mean rise in systolic pressure from pre-patrol to post-patrol. There was also a significant drop in percent body fat (.8%) from pre-patrol to post-patrol.

Experimental Patrol

Lipid Profiles. When these same subjects participated in a patrol including menu modification and nutrition education, a different pattern of change was observed. Both total cholesterol (11.2 mg/dl) and LDL cholesterol (5.6 mg/dl) decreased at the post-patrol measurements.

These values both increased over the post-patrol values at the final measurement (cholesterol 17.7 mg/dl; LDL 15.1 mg/dl). HDL values decreased from pre-patrol to post-patrol by 4.7 mg/dl and rose again by 2.5 mg/dl for the final measurement. This final measurement was 4.6 mg/dl lower than the pre-patrol level. There was no change in ratio from pre- to post-patrol, but there was a significant increase from post-patrol to the final measurement (.46) . Triglyceride levels did not change.

Blood pressure and percent body fat. There were no changes in any of the blood pressure measurements for the experimental patrol. Percent body fat decreased by .7% during the patrol and increased again by .8% at the final measurement. Pre-patrol percent

body fat was no different from the final measurement.

Within Submarine Comparison Across Control and Experimental Conditions

Because these are the same men, it is possible to compare the initial measurements taken before the first control patrol to the final measurements taken following the experimental patrol to determine any lasting changes for these men. Final measurements for total cholesterol were 18.9 mg/dl greater than the pre-patrol measures for the control patrol, 17.4 mg/dl for LDL and 17.2 mg/dl for triglycerides. HDL levels were 2.3 mg/dl lower at the final measurements across the same time period. Percent body fat was .7% lower at the final measurement. Note that these sets of samples were all taken after approximately 3 months ashore, in a non-deployed status.

Discussion

The experiment demonstrated that both groups showed some degree of decrease in CHD risk factors from pre- to post-patrol.

Specifically, the control group displayed significant decreases in three variables (TC, LDL, BF%), while the experimental group displayed significant decreases in five (TC, LDL, SBP, DBP, BF%). Concurrently, both groups also demonstrated significant declines in HDL values during deployment, typifying an increase in CHD risk (Garber, et al., 1989; Hunninghake, et al., 1993). Decreases in the levels of all CHD risk related variables (except HDL) are considered positive with respect to lowering CHD risk (Manson, et al., 1992; Stehbens, 1990).

During the off-crew period, both groups demonstrated significant increases in four variables (TC, LDL, TG, BF%). Increases in these levels are associated with greater risk for CHD (Garber, et al., 1989; Manson, et al., 1992; Stehbens, 1990). Systolic blood pressure was the only variable for which the two groups showed opposite changes. The control group displayed a decline, and the experimental group showed an increase. There was no change in DBP for the control group while there was an increase for the experimental group. The experimental group demonstrated significant declines in Ratio (TC/HDL) during the off-crew, but there was no difference in perent change between the groups.

Some of these results demonstrate that nutrition education and diet modification had a small additional beneficial effect on reducing CHD risk when compared to no intervention. When considering CHD risk factors, the results also demonstrate that the deployment cycle was healthier for all submarine crews than was the off crew period.

Percent Change

Comparison of the percent changes that occurred during deployment provided a clearer view of what occurred between the two groups (Table 3). No differences were found between the two groups for five variables (TC, HDL, LDL, Ratio, BF%). The control group fared better when comparing changes in HDL values, because, although both groups displayed statistically significant decreases, the control group's decline (3.6% = 2.2 mg/dl) was significantly less than that of the experimental group (5.0% = 3.4 mg/dl). Data suggest that a 2 to 3 percent increase in CHD risk is associated with a 1 mg/dl decrease in HDL for an individual (NIH, 1992). Therefore, these results might be considered clinically important even though the decline in HDL appears small for both groups.

The experimental group, however, did much better during deployment than the control group with respect to percent difference (pre- and post-patrol) for SBP, and DBP. The experimental group had a significant decrease in both variables, while the control group

showed no change. Similarly, the experimental group had a smaller increase in TG level than shown by the control group. This suggests less risk for CHD in the experimental group (Garber, et al., 1989; Manson, et al., 1992; Stehbens, 1990).

Of the three control submarines, crew 3 had by far the best pre- to post-patrol results with respect to lowering CHD risk. This crew lowered their TC, LDL, Ratio, and BF% significantly during deployment, thereby decreasing overall risk for CHD.

Subjectively, it appeared that crew 3 was definitely more nutrition and health conscious prior to their participation than other crews. This observation is based on several pre-study interviews and briefings with the Commanding Officer, Food Service Officer, and Mess Management Specialists. It is also based on reviews and nutrition analysis of their menu used during the study. If this is true, this variable confounds the results.

Crew 6 was the only submarine crew to demonstrate an improvement (4.6% increase) in HDL values during deployment. This change, if significant, would be considered clinically important. In the Lipid Research Clinic's Coronary Primary Prevention Trial, a 3% increase in HDL was correlated with a 2% decline in CHD risk (NIH, 1992). Crew 6 also displayed significant improvement with decreases in five other variables (TC, Ratio, TG, DBP, BF%). Overall, crew 6 demonstrated the best results with respect to lowering CHD risk. This crew, in particular, had an extremely involved nutrition educator/research monitor on board during the patrol. This individual played an integral part in furthering the subjects' education while deployed. He was a working member of the Food Service Division and was involved in preparing and serving food. This allowed him daily one-on-one contact with all test subjects as they came through the serving line and asked for advice on choosing lower fat foods. Research monitors on the other two experimental boats were not actively involved with the preparation or serving of food.

Only one of the control crews showed improvement from pre- to post-patrol. However, all three of the experimental crews did as well or better and appear to have benefited from the intervention.

In general, CHD risk increased for both groups during the off-crew period, since values for six variables increased during this time. A significant difference was noted between groups for only three variables (LDL, SBP, DBP) during the off-crew interval. Possible reasons for this pattern of results: a) the diets of the experimental group during the off crew period were worse than with the experimental menu, and/or b) nutrition education had no lasting effect on subjects' dietary choices.

It appears that the off-crew period was less conducive to maintaining or improving risk factors for CHD compared to the patrol period.

The results from the single within boat comparison indicate that the men benefited from the study intervention when comparing values for CHD risk factors displayed from their control deployment period to their experimental deployment period. The results suggest a positive temporary effect of diet modification but no lasting effect of nutrition education.

Risk Factors

The hypothesis of this study was that nutrition education and diet modification would have a beneficial effect on CHD risk factors. The mechanisms underlying these effects,

however, vary. They are discussed below in relation to the findings of this study.

Lipids

It has been stated that a 10% to 15% reduction in serum cholesterol level resulting from the diet modification should reduce CHD risk by 20 to 30%, especially for those who have levels in the 250-300 mg/dl range (NIH, 1988). In light of this information, the 7.6% decline of TC observed in the experimental group during deployment would be considered beneficial. This decline in TC values, however, could also have been caused in part by the decrease in BF% observed (NIH, 1992).

In addition, decreases in HDL levels are also encountered, both following weight loss and in response to diets which are lower in total fat, saturated fat, and cholesterol. These decreases in HDL levels brought about by lower total fat intake, however, can be prevented or attenuated by aerobic exercise (NIH, 1992; Hunninghake, et al., 1993; Miller, Seidler, Kwierovich, & Pearson, 1992). It is also known that exercise increases HDL values and decreases plasma TG and the risk of CHD (NIH, 1990; Manson, et al., 1992; NIH, 1992; National Cholesterol Education Program [NCEP], 1993). Active smoking decreases HDL and is itself a risk factor for CHD. The Consensus Development Conference Statement on triglyceride, high density lipoprotein and CHD reported that recent data suggests that passive smoking also decreases HDL levels (NIH, 1992). Use of alcohol increases HDL levels in some individuals (NIH, 1992).

In this study, HDL values declined during deployment in all but one of the crews. These decreases may have been caused by: a) decreases in the amount of aerobic exercise performed, b) exposure to second hand smoke, c) lower total fat or saturated fat intake, or d) a combination of the above.

Other factors besides exercise can also cause changes in TG values. It is known that alcohol increases plasma TGs in some people. On the other hand, plasma triglycerides will decrease in response to a lower intake of total fat and saturated fat, and frequently weight loss will help to lower plasma TG values (NIH, 1992).

The decreases in TG observed following deployment may be related (at least partially) to the prohibition of alcohol consumption during deployment. The effect of a lack of alcohol during patrol on HDL values is unclear since HDL actually declined in 5 crews. All crews lost BF% during the patrol, and this may have been what brought about the decreased in TG observed.

The results revealed that LDL values decreased in five of the crews during deployment which is an improvement since decreases in LDL levels are associated with decreased CHD risk. However, HDL values also decreased during this time which increases CHD risk. Both declines could have been caused by the change in diet, yet the net effect on the risk of CHD of reduction of both LDL and HDL levels is still not clear (Sacks & Willet, 1991).

Blood Pressure:

Hypertension is a consistent and modifiable cause of CHD (Stokes, Kannel, Wolf, D'Agostino, & Cupples, 1989). Data confirm that systolic blood pressure is a better predictor than is diastolic pressure. This finding is consistent with the fact that isolated systolic blood pressure can predict the incidence of CHD, stroke, and coronary heart failure for those with a diastolic pressure less than 90 mm Hg (Stokes, et al., 1989).

In this study, SBP declined significantly during deployment in one control and one experimental crew. DBP declined significantly

in three crews (one control, two experimental). For CHD risk level, these changes are considered positive. During the off-crew period, however, no consistent changes were observed within groups or between groups for either SBP or DBP, therefore it is difficult to assess whether risk for CHD was affected for either group.

Seasonal Variations of Lipids

To make matters more complicated, not only are lipid levels affected directly by factors such as diet and exercise, it is known that seasonal variations in cholesterol of approximately 3-5% exist. Cholesterol tends to be higher in the winter and lower in the summer months. Levels for HDL follow a similar pattern. Researchers believe that seasonal changes in physical activity, diet, and/or other factors may contribute to some extent to these changes (NIH, 1990). Ideally, pre-, during-, and post- patrol data should have occured at the same time(s) of year. This could be a confounding factor in the present results.

Summary

In summary, this study reveals that CHD risk factors appear to be favorably modified during at sea periods, even in the absence of dietary change or education. U.S. Navy submarine personnel benefit from nutrition education and diet modification by decreasing risk for CHD. Nutrition education and dietary changes during a submarine patrol had a small additional benefit on CHD risk by lowering triglycerides and blood pressure.

What remains unclear is the relative roles of diet modification and the nutrition education in reducing or modifying the CHD risk factors.

Our findings show that submariners are at somewhat greater risk for CHD during the off-crew period than they are during deployment. We were unable to find any reports that addressed how long term cyclic increases and decreases (like those observed) in CHD risk factors affect the health of the general population and specifically of submariners. To improve CHD risk, lasting changes in personal health and eating habits are required; education may assist in this process.

The total cost of CHD in the U.S. is staggering, costing the nation between $50 and $100 billion each year for medical treatment and lost wages (NCEP, 1993). Prevention of CHD, therefore, could reduce this economic burden (Garber, et al., 1989; NCEP, 1993). One inexpensive way to reduce CHD may be through education targeted at preventing or reducing the major risk factors for CHD, especially high blood cholesterol, lack of exercise, high blood pressure, and smoking (NCEP, 1993).

Conclusions

1. Coronary heart disease risk factors appear to be favorably modified during at-sea periods.

2. A nutrition education program followed up by dietary modification during submarine deployment had a small additional beneficial effect on CHD risk factors.

3. Broader use of the nutrition education program throughout the U.S. Navy and Department of Defense is not strongly supported by these results.

4. Implementation of a low fat menu and storage of the required food aboard TRIDENT submarines can be easily accomplished with no additional expense and with strong crew acceptance.

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APPENDIX A

Table A-1
Multiple analysis of variance for CHD risk variables

Source	*df*	*F*
Between Subjects - Group		
TC (mg/dl)	1,532	2.50
HDL (mg/dl)	1,519	40.00**
LDL (mg/dl)	1,519	6.44*
TG (mg/dl)	1,516	1.30
Ratio (TC/HDL)	1,519	27.70**
SBP (mmHg)	1,524	18.31**
DBP (mmHg)	1,524	4.52
BF (%)	1,508	.09
Within Subjects - Interval (Pre, Post, Final)		
TC (mg/dl)	2,1064	85.50**
HDL (mg/dl)	2,1038	78.49**
LDL (mg/dl)	2,1038	20.92**
TG (mg/dl)	2,1032	13.38**
Ratio (TC/HDL)	2,1038	8.55**
SBP (mmHg)	2,1048	34.43**
DBP (mmHg)	2,1048	46.98**
BF (%)	2,1016	74.61**
Within Subjects - Group x Interval		
TC (mg/dl)	2,1064	1.59
HDL (mg/dl)	2,1038	2.51
LDL (mg/dl)	2,1038	1.52
TG (mg/dl)	2,1032	3.90
Ratio (TC/HDL)	2,1038	1.16
SBP (mmHg)	2,1048	32.68**
DBP (mmHg)	2,1048	24.44**
BF (%)	2,1016	.90

* $p < .01$
** $p < .001$

Table A-2
Multiple analysis of variance and simple effects for physiological data

Variable	df	Education Group F	Interval (Pre,Post, Final)	Education for interval (EXI)	Group at Pre	Group at Post	Group at Final	Interval for Control Group	Interval for Experimental Group
TC (mg/dl)	1	2.50	85.5**	NS	2.94	4.6	3.5	36.35**	49.24**
HDL (mg/dl)	2	40.0**	78.49**	NS	15.98**	40.81**	29.48**	51.86**	31.1**
LDL (mg/dl)	2	6.44*	20.92**	NS	4.72	2.51	9.0*	7.68**	14.10**
TG (mg/dl)	3	1.3	13.38**	NS	4.65	.02	.85	7.5**	9.58**
Ratio (TC/HDL)	2	27.7**	8.55**	NS	20.47**	23.97**	18.47	2.01	7.22**
SBP (mm Hg)	4	18.31**	34.43**	32.68 .001	.03	58.43**	4.13	5.46*	58.24**
DBP (mm Hg)	4	4.52	46.98**	22.44 .001	5.79	23.38**	5.65	3.0	62.58*
BF (%)	5	.09	74.61**		.31	.06	.01	41.97**	33.89**

** $p < .001$
* $p < .01$

Degrees of freedom	Code	Group and Group at Interval	Interval and Interval for Group
	1	1,532	2,1064
	2	1,519	2,1038
	3	1,516	2,1032
	4	1,524	2,1048
	5	1,508	2,1016

Table A-3
T test results for within group comparisons for the control and experimental groups for three intervals (pre to post, post to final, pre to final)

	Pre to Post Patrol		Post to Final		Pre to Final	
Variable	Control *t*	Exp t	Control *t*	Exp *t*	Control *t*	Exp *t*
TC (mg/dl)	4.96**	6.38**	-9.14**	-8.31**	-3.67**	-3.43**
HDL (mg/dl)	5.55**	6.22**	-7.87**	-8.71**	-5.39**	-2.96*
LDL (mg/dl)	4.14**	4.95**	-3.06*	-3.87**	1.14	-.31
TG (mg/dl)	-1.17	2.98	-2.61*	-3.92**	-4.02**	-1.44
Ratio (TC/HDL)	-.14	.7	2.21	-2.50*	1.76	2.62*
SBP (mmHg)	-.14	10.07**	2.63*	-5.31**	3.26**	5.72**
DBP (mmHg)	2.36	9.15**	-2.11	-5.31**	.27	5.74**
BF (%)	7.80**	7.94**	-7.08**	-7.09**	1.86	-.06

** $p < .001$
* $p < .01$

APPENDIX B

Appendix B-1

Pre-patrol versus post-patrol measurement comparison by paired t-tests for Control submarines

		Submarine One				Submarine Two				Submarine Three			
Variable	Draw	n	Mean	SD		n	Mean	SD		n	Mean	SD	
TC (mg/dl)	Pre	101	183.5	34.0		105	179.0	31.5		129	184.8	38.1	*
	Post	101	180.1	30.4		105	183.2	30.8		129	161.6	29.6	
HDL (mg/dl)	Pre	101	45.8	9.1	*	103	43.6	10.7		120	47.0	11.2	*
	Post	101	43.2	8.9		103	42.9	9.4		120	43.2	10.1	
LDL (mg/dl)	Pre	101	118.0	29.5		105	110.1	26.1	*	120	111.8	32.7	*
	Post	101	113.8	27.8		105	114.3	26.7		120	94.6	27.6	
Ratio (TC/HDL)	Pre	101	4.2	1.2		103	4.3	1.2	*	120	4.2	1.6	*
	Post	101	4.4	1.1		103	4.5	1.2		120	3.9	1.2	
TG (mg/dl)	Pre	101	111.7	59.6		103	125.9	69.0		120	132.1	89.6	
	Post	101	115.8	46.1		103	135.5	80.7		120	129.8	71.5	
SBP (mm Hg)	Pre	103	120.0	13.3	*	104	116.5	16.5		127	119.8	14.7	
	Post	103	115.1	16.7		104	118.7	18.1		127	119.1	19.3	
DBP (mm Hg)	Pre	103	76.4	6.8	*	104	76.3	6.9		126	76.2	8.7	
	Post	103	72.4	7.5		104	75.6	7.6		126	76.9	8.0	
BF (%)	Pre	102	19.5	6.4	*	104	19.7	6.3	*	127	18.3	5.5	*
	Post	102	18.5	5.3		104	18.9	5.4		127	16.9	4.9	

(* = $p < .05$)

Appendix B-2

Pre-patrol versus post-patrol measurement comparison by paired t-tests for Experimental submarines

Variable	Draw	Submarine Four n	Submarine Four Mean	Submarine Four SD		Submarine Five n	Submarine Five Mean	Submarine Five SD		Submarine Six n	Submarine Six Mean	Submarine Six SD	
TC (mg/dl)	Pre	101	176.5	39.1	*	109	185.6	33.2	*	84	198.4	39.5	*
	Post	101	162.3	36.7		109	174.6	31.4		84	192.0	37.2	
HDL (mg/dl)	Pre	101	44.1	9.5	*	109	44.6	11.2	*	83	30.8	7.2	
	Post	101	38.6	9.2		109	40.7	7.2		83	32.3	5.6	
LDL (mg/dl)	Pre	99	107.0	31.9	*	109	114.5	27.7	*	83	139.7	34.1	
	Post	99	96.0	29.9		109	108.6	28.4		83	135.8	32.9	
Ratio (TC/HDL)	Pre	101	4.2	1.3		109	4.4	1.2		83	6.7	2.0	*
	Post	101	4.4	1.3		109	4.4	1.0		83	6.1	1.6	
TG (mg/dl)	Pre	99	135.6	90.9		109	140.0	82.0	*	83	135.3	73.2	*
	Post	99	132.2	72.6		109	126.7	75.8		83	113.4	62.3	
SBP (mm Hg)	Pre	101	118.3	18.6	*	109	118.3	15.1		84	116.3	20.6	
	Post	101	102.5	18.5		109	115.7	18.2		84	114.1	17.2	
DBP (mm Hg)	Pre	101	81.8	7.6	*	109	75.2	7.3		84	76.8	6.2	*
	Post	101	65.0	6.9		109	76.0	7.0		84	73.4	4.2	
BF (%)	Pre	101	19.7	5.4	*	104	18.5	5.8	*	84	17.5	5.3	*
	Post	101	18.4	5.1		104	17.9	5.8		84	16.8	5.2	

(* = $p < .05$)

Appendix B-3

Post-patrol versus final measurement comparison by paired t-tests for Control Submarines

		Submarine One				Submarine Two				Submarine Three			
Variable	Draw	n	Mean	SD		n	Mean	SD		n	Mean	SD	
TC (mg/dl)	Post	86	180.1	30.4	*	105	183.2	30.8	*	107	162.1	30.3	*
	Final	86	187.6	34.2		105	189.1	33.7		107	185.8	37.5	
HDL (mg/dl)	Post	86	43.0	9.0		103	42.9	9.4	*	100	42.6	9.8	*
	Final	86	43.1	9.3		103	44.9	12.0		100	58.8	15.9	
LDL (mg/dl)	Post	86	114.0	28.2	*	105	114.3	26.7		100	96.1	27.8	
	Final	86	121.2	31.5		105	115.8	29.3		100	100.3	30.5	
Ratio (TC/HDL)	Post	86	4.4	1.1	*	103	4.5	1.2		100	4.0	1.2	*
	Final	86	4.6	1.2		103	4.5	1.4		100	3.5	1.0	
TG (mg/dl)	Post	86	115.4	45.0		103	135.5	80.7	*	100	127.8	72.1	
	Final	86	121.0	67.4		103	148.6	86.6		100	138.5	89.6	
SBP (mm Hg)	Post	85	115.4	13.5		95	119.5	17.8		103	119.7	19.5	*
	Final	85	115.9	17.9		95	118.2	14.7		103	112.5	20.0	
DBP (mm Hg)	Post	85	72.4	7.5	*	95	75.8	7.8		102	76.7	8.0	*
	Final	85	74.6	6.2		95	75.2	7.3		102	78.4	6.6	
BF (%)	Post	85	18.0	5.3	*	91	18.9	5.2		92	16.9	5.2	*
	Final	85	19.4	5.6		91	19.0	5.6		92	18.2	5.2	

(* = $p < .05$)

Note: "Post" averages may not be the same as in the Pre/Post tables because only crew members having each pair of measurements were used for averages.

Appendix B-4

Post-patrol vs final measurement comparison by paired t-tests for Experimental Submarines

Variable	Draw	Submarine Four n	Submarine Four Mean	Submarine Four SD		Submarine Five n	Submarine Five Mean	Submarine Five SD		Submarine Six n	Submarine Six Mean	Submarine Six SD	
TC (mg/dl)	Post	81	163.6	38.4	*	94	175.4	31.5	*	63	194.9	36.7	*
	Final	81	194.4	34.8		94	195.4	34.7		63	188.1	33.1	
HDL (mg/dl)	Post	81	38.4	9.1	*	94	40.8	7.2		62	32.5	6.0	*
	Final	81	43.0	7.3		94	41.1	8.5		62	47.0	11.0	
LDL (mg/dl)	Post	80	96.8	31.5	*	93	109.0	28.8	*	61	139.6	34.3	*
	Final	80	119.7	31.6		93	126.5	28.9		61	110.7	29.3	
Ratio (TC/HDL)	Post	81	4.4	1.4		94	4.4	1.0	*	62	6.3	1.7	*
	Final	81	4.7	1.2		94	4.9	1.1		62	4.3	1.5	
TG (mg/dl)	Post	80	133.1	75.1	*	93	128.3	79.0		61	117.5	58.1	*
	Final	80	159.9	109.9		93	137.6	83.3		61	138.1	78.8	
SBP (mm Hg)	Post	81	104.4	13.7	*	98	115.3	19.0		67	115.1	13.8	*
	Final	81	114.2	11.5		98	117.4	12.4		67	120.2	12.2	
DBP (mm Hg)	Pre	81	65.2	7.0	*	98	76.2	7.0	*	67	73.4	4.1	*
	Post	81	73.6	8.2		98	74.2	6.0		67	76.9	7.0	
BF (%)	Pre	81	18.7	5.4	*	99	17.9	5.8	*	67	16.7	5.6	
	Post	81	20.8	5.5		99	18.6	5.9		67	16.7	5.8	

(* = $p < .05$)

Note: "Post" averages may not be the same as in the Pre/Post tables because only crew members having each pair of measurements were used for averages.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

During a one year period, 534 male, US Navy submariners participated in a nutrition research project designed to reduce coronary heart disease (CHD) risk. The research was carried out on board USN Trident Submarines before, during, and following actual patrols. Subjects from six submarine crews were assigned to either the education / diet group (E) or the control group (C). Group E was provided nutrition education and a modified 5 week cycle menu which focused on decreasing the percentages of caloric intake derived from fat and high cholesterol food. Group C received NO intervention. Measurements of cholesterol (TC), high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL), triglycerides (TG), Ratio (TC/HDL), blood pressure (BP), and body fat (BF%) were taken before and after deployment and again after the off crew period. Age, height, and weight data were also gathered. The data were analyzed with the MANOVA procedure using a mixed multivariate model with repeated measures on the two groups. Following the patrol one of the three control crews demonstrated statistically and clinically significant decreases in TC, HDL, LDL, and ratio and another crew showed a significant decrease in BP (systolic). Within the education group (3 crews) several significant decreases occurred during deployment: TC declined (3 crews), LDL and HDL declined (2 crews), ratio declined (one crew), and TG declined (2 crews). All six

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19. cont.

crews demonstrated a statistically significant decrease in BF% during deployment. Changes were noted following the off crew period. Both groups demonstrated increases in most variables.

The experiment demonstrated that regardless of education or menu intervention, subjects showed some reduction in CHD risk factors during deployment.

The results also demonstrated that the nutrition education and diet modification intervention had a greater beneficial effect on reducing CHD risk factors when compared to no intervention.