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**SERUM LIPID AND LIPOPROTEIN CONCENTRATIONS IN
MILITARY ACADEMY GRADUATES-TRENDS FROM
1952 THROUGH 1960**

TECHNICAL DOCUMENTARY REPORT NO. SAM-TDR-63-28

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**USAF School of Aerospace Medicine
Aerospace Medical Division (AFSC)
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FOREWORD

This report was prepared by the following personnel at the USAF School of Aerospace Medicine:

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The authors are grateful to the Cardiovascular Group, especially Fredrick H. Wilson, Jr., and Mrs. Dorothy N. Ball, for their help in obtaining and analyzing these data.

ABSTRACT

Biennial measurements of serum cholesterol, phospholipid, low and high density lipoprotein concentrations, and body weight are recorded for a group of more than 400 men who have been followed from average age 19.6 through 27.5 years. In general, serum lipid and low density lipoprotein concentrations increased between 1952 and 1958, and either remained unchanged or decreased slightly between 1958 and 1960. The high density lipoprotein concentration decreased in each sample year since first measured in 1956.

This technical documentary report has been reviewed and is approved.


ROBERT B. PAYNE
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Chief, Operations Division

SERUM LIPID AND LIPOPROTEIN CONCENTRATIONS IN MILITARY ACADEMY GRADUATES—TRENDS FROM 1952 THROUGH 1960

1. INTRODUCTION

Previous communications (1, 2) from this laboratory have reported a longitudinal study of blood lipids and lipoproteins in the individuals who graduated from the United States Military Academy in 1956. This continuing study was designed to evaluate serum lipid and lipoprotein levels (a) as indices of the presence of atherosclerosis in Air Force personnel at any age, and (b) as predictors of subsequent occurrence of clinical manifestations of cardiovascular disease. The subjects of this study are still young (average age, 27.5 years in 1960); no objective clinical evidence of atherosclerosis has been observed. Since no statement can be made at the present time about possible associations between clinical manifestations and other parameters, attention has been given to those associations between variables, or trends in variables, that are demonstrable. Such associations, though present in one sample year, may not be observed in adjacent sample years. They will be reported when observed, and the associations and trends which persist will be evaluated for their usefulness in predicting atherosclerosis. Meanwhile, periodic reports will present group averages and any other findings that seem to be of interest.

2. METHODS

As in previous sample years, a blood sample was obtained from each subject. Since many of the subjects were stationed overseas in 1960, the serum rather than whole blood was usually forwarded to this laboratory for analysis. Cholesterol concentration was determined by

the method of Robinson and Pugh (3). Phospholipid phosphorus was measured by a modification (4) of a method of Youngsburg and Youngsburg (5), using the colorimetric method of Fiske and Subbarow (6). Lipoprotein analyses were performed by the method of deLalla and Gofman (7), except that potassium bromide was added to increase the density to 1.20 for determination of high density lipoproteins (8). The double sector cell described by Milch et al. (9) was used.

At the time the blood was drawn, a physical examination was performed which included ECG tracings and four chest x-rays with barium swallow.

All but 12 of the 451 subjects reported on in 1958 continued in the study during 1960. However, lipid data were obtained for only 400 men. About 10% of the subjects were no longer on active duty, but approximately 75% of this group have remained in the study.

3. RESULTS

The mean, standard deviation, and range of the blood serum components, age, height, weight, and height-weight ratio for each of the 5 study years are given in table I. The change in the mean levels of the low density lipoproteins between 1958 and 1960 was less than between 1956 and 1958. The mean level for S_r 0-12 was lower in 1960 than in 1958 while the levels for S_r 12-20 and S_r 20-400 did not change. The mean level for cholesterol in 1960 was about the same as in 1956, but was lower than the level for 1958. The mean level of the high density lipoproteins (1.2) was still decreasing in 1960. The mean level for

TABLE I
*Physical measurements and blood serum components for the
 USMA class of 1956*

Variable	Year	Number of subjects	$\bar{X}$	S.D.	Range
Age (yr.)	1952	593	19.6	1.2	17 - 22
	1954	485	21.5	1.2	19 - 24
	1956	459	23.5	1.2	21 - 26
	1958	447	25.5	1.2	23 - 28
	1960	405	27.5	1.3	25 - 30
Height (in.)	1952	608	70.5	2.2	65 - 77
	1954	499	70.7	2.3	61 - 76
	1956	479	70.6	2.2	62 - 76
	1958	433	70.8	2.1	65 - 76
	1960	391	70.7	2.2	64 - 76
Weight (lb.)	1952	608	158.3	16.9	120 - 220
	1954	499	165.5	16.7	105 - 220
	1956	478	166.2	16.7	109 - 220
	1958	432	171.2	20.1	120 - 230
	1960	387	171.8	19.9	130 - 240
(Height/weight) 100	1952	608	45.0	4.0	35 - 56
	1954	499	43.1	3.6	33 - 58
	1956	478	42.8	3.7	33 - 57
	1958	431	41.8	4.2	32 - 56
	1960	387	41.6	4.2	31 - 53
Cholesterol (mg./100 ml.)	1952	511	184.8	39.2	39 - 371
	1954	483	219.3	36.8	111 - 353
	1956	479	235.3	41.5	127 - 448
	1958	447	249.1	41.5	125 - 396
	1960	405	236.9	45.3	126 - 435
Phospholipid phosphorus (mg./100 ml.)	1954	144	8.7	1.2	5.2 - 11.2
	1956	479	9.6	1.2	6.3 - 13.7
	1958	447	9.6	1.4	5.4 - 14.2
	1960	399	10.0	1.7	4.0 - 16.4
Lipoproteins (mg./100 ml.)					
Low density ($\rho \leq 1.063$)					
S_r 0-12	1952	394	183.8	48.9	36 - 375
	1954	486	195.8	49.4	71 - 376
	1956	478	288.5	76.9	76 - 716
	1958	447	331.6	90.2	85 - 609
	1960	402	306.1	87.5	83 - 686
S_r 12-20	1952	521	21.0	10.7	1 - 56
	1956	472	20.6	15.6	3 - 110
	1958	447	30.6	15.8	4 - 90
	1960	402	30.8	20.1	0 - 266
S_r 20-400	1956	475	47.7	43.4	4 - 399
	1958	447	90.5	57.1	4 - 399
	1960	402	90.9	68.0	0 - 649
S_r 12-400	1954	486	43.5	30.3	3 - 301
	1956	478	67.7	54.6	3 - 476
	1958	447	121.0	65.8	8 - 456
	1960	402	121.6	82.2	0 - 915
High density ($1.063 < \rho < 1.2$)					
	1956	475	272.8	67.2	31 - 515
	1958	438	245.5	69.1	11 - 594
	1960	400	208.0	60.1	0 - 456

phospholipid phosphorus rose in 1960 to a level higher than for any of the previous years.

To study the effect of weight and levels of measured variables, the subjects were grouped according to the deviation of their weight from a standard weight. The standard weight employed was that listed as "standard" in table V, Air Force Manual 160-1. The number and the mean age of subjects in each group are given in table II.

There appears to be a mild age effect in these data, especially in the earlier sampled years; for example, in 1952 the overweight subjects are, on the average, slightly older than the normal and the underweight subjects. However, the range in age for all subjects is so small that this effect, if real, is of slight importance.

The mean level for each variable for each weight group and for each sample year is given in table III. Within a sample year, there is generally an increase in mean level of all variables with an increase (algebraic) in weight deviation from standard, except for the high density lipoproteins. For the latter serum

component, there is usually a decrease with algebraic increase in weight. For the weight group showing deviations of 15 pounds or less from standard, there is occasionally a reversal from the above-mentioned trends. But these means are relatively unstable, owing to the small numbers of subjects in this category.

A somewhat clearer picture of trends is obtainable by regressing level of variable on algebraic weight deviation for each variable for each year. The results of these analyses are shown in table IV. Listed are the average changes for each variable, for the years 1956, 1958, and 1960, for each 10 pounds' (algebraic) deviation from the standard. Only those changes in level of variable significantly related to weight deviations are shown. From the table we observe that, on the average, for each 10 pounds of overweight, one can expect a 5.4 mg./100 ml. increase in cholesterol (or for 10 pounds underweight, a 5.4 mg./100 ml. decrease could be expected). By 1960 the level of all variables was significantly related to weight deviation. However, this was the first year that weight deviation and high density lipoprotein were significantly correlated.

TABLE II
Deviation from standard weight with number and mean ages of subjects in each weight group*

Year blood sample drawn	Pounds deviated from standard weight						
	≤ -15	-5 to -14	± 4	5 to 14	15 to 24	≥ 25	Total
	Number of subjects						
1952	15	62	84	108	46	30	345
1954	7	44	83	134	95	36	399
1956	7	41	76	139	97	42	402
1958	16	32	57	112	75	110	402
1960	18	36	66	109	74	99	402
	Average age of subjects (years)						
1952	19.2	19.1	19.3	19.7	19.6	19.7	19.4
1954	22.4	21.2	21.2	21.4	21.6	21.8	21.5
1956	23.9	23.5	23.3	23.4	23.6	23.7	23.5
1958	25.5	25.5	25.3	25.4	25.5	25.7	25.5
1960	27.4	27.3	27.4	27.3	27.5	27.7	27.5

*Weight employed was "standard" from table V, Air Force Manual 160-1, 30 April 1953.

TABLE III
*Means of blood serum components and of weight as a function of weight deviation from standard weight**

Variable	Year	Pounds deviated from standard weight						S.D.†
		-15	-5 to -14	± 4	5 to 14	15 to 24	> 25	
Weight (lb.)	1952	138.3	141.2	150.3	161.5	170.7	187.1	8.9
	1954	143.3	147.8	154.4	165.4	175.4	189.3	10.3
	1956	145.1	146.7	155.2	164.6	176.6	190.4	10.2
	1958	141.9	147.3	154.7	164.1	174.8	193.5	11.0
	1960	142.4	147.9	158.8	165.7	176.8	196.5	10.5
Cholesterol (mg./100 ml.)	1952	175.4	183.9	178.9	190.9	187.1	187.0	40.1
	1954	231.0	213.3	215.9	217.9	220.6	232.4	36.8
	1956	221.6	219.9	233.3	232.8	243.0	245.5	42.2
	1958	246.9	219.8	250.0	245.6	250.9	262.1	40.7
	1960	223.3	220.2	233.6	237.4	239.4	246.1	45.0
Phospholipid phosphorus (mg./100 ml.)	1956	9.78	9.35	9.56	9.49	9.66	9.80	1.28
	1958	9.80	8.89	9.48	9.65	9.66	10.01	1.36
	1960	9.66	9.50	10.01	10.02	10.18	10.28	1.65
Lipoproteins (mg./100 ml.) Low density ($\rho < 1.063$) S_r 0-12	1952	187.6	180.6	179.2	181.3	188.5	185.6	52.3
	1954	213.0	189.6	202.4	195.2	195.6	209.6	54.4
	1956	268.0	269.3	282.6	283.4	294.5	320.2	78.2
	1958	307.9	286.0	318.2	326.2	342.0	355.7	90.1
	1960	284.2	269.7	302.2	300.2	314.8	325.8	86.6
	S_r 12-20	1952	18.3	17.3	21.4	21.3	23.5	10.4
		1956	16.7	15.6	17.5	19.5	23.8	15.6
		1958	23.9	25.4	27.7	29.0	32.0	15.4
		1960	23.6	24.2	30.1	29.7	30.9	19.9
	S_r 20-400	1956	34.0	34.0	39.0	45.1	55.9	44.1
		1958	79.0	66.2	87.1	79.8	86.7	55.2
		1960	71.7	74.2	77.9	86.8	91.4	67.0
	S_r 12-400	1954	32.0	36.8	37.9	46.6	44.9	31.6
		1956	50.7	49.6	56.5	64.6	79.7	55.2
		1958	102.9	91.6	114.5	108.6	118.4	63.3
		1960	95.3	98.5	108.0	116.5	122.3	80.8
	High density ($1.063 < \rho < 1.2$)	1956	287.4	274.8	291.3	263.7	272.0	67.2
		1958	242.7	236.2	244.1	248.9	247.4	68.7
		1960	238.7	225.6	220.0	208.9	205.8	59.2

*See table II for source of standard weight and for number of subjects in each group.

†Standard deviation was estimated from within each weight deviation group and pooled over groups.

Rank correlation coefficients for each variable for subjects on whom data were available for each pair of sample years are recorded in table V. The degree of association is not of sufficient size to suggest strong stability in relative position of subjects between two indicated years for any of the listed variables.

The percentage of the subjects with levels of a variable in the upper 10% in a given year who maintain levels of the variable in the upper 10% in subsequent sample years is given in table VI. Again one concludes that relative rank ordering is not maintained on any of the measured variables with any degree of predictability.

4. DISCUSSION

Obviously, the direction of trends in lipid levels during future years remains to be discovered. However, the smaller increases in mean levels of S_r 12-20 and S_r 20-400 lipoproteins and the decreases in mean levels of S_r 0-12 and cholesterol may indicate that there is a

TABLE IV

Average change in level of variable for each 10 pounds' deviation from standard weight†*

Variable (mg./100 ml.)	Year		
	1956	1958	1960
Cholesterol	5.40	5.65	4.84
Phospholipid phosphorus		0.14	0.14
Lipoproteins Low density ($\rho \leq 1.063$)			
S_r 0-12	10.38	12.15	10.62
S_r 12-20	2.67	2.45	2.51
S_r 20-400	6.15	7.70	9.32
S_r 12-400	8.82	10.13	11.83
High density ($1.063 < \rho < 1.2$)			-7.94

*Only significant changes tabulated for indicated years. All listed changes were significantly different from zero at the .01 level.

†See table II for number of subjects and the weight standard employed.

TABLE V

Rank correlation coefficients between the different years for blood serum components for subjects for whom all measurements were available in 1954, 1956, 1958, and 1960

Variable (mg./100 ml.)	Number of subjects	Correlation coefficient for					
		1954-56	1954-58	1954-60	1956-58	1956-60	1958-60
Cholesterol	377	.69	.56	.65	.58	.64	.59
Phospholipid phosphorus		.72*	.53*	.47*	.46†	.42†	.40†
Lipoproteins Low density ($\rho \leq 1.063$)							
S_r 0-12	377	.57	.48	.44	.60	.58	.58
S_r 12-400	377	.43	.35	.38	.37	.32	.39

*114 subjects.

†372 subjects

TABLE VI
*Percent of subjects who ranked in the upper 10% at "first" sampling
 who also ranked in the upper 10% at later samplings*

Variable (mg./100 ml.)	In upper 10 percent			Percent of subjects		
	Number of subjects	Year in which sampled		In upper 10% in first and a later sample year	In upper 10% in first and all later years	In upper 10% in first and in at least n-1 of n later sample years
		First	Later			
Cholesterol	32	52	54	34.4	12.5	21.9
			56	34.4		
			58	28.1		
			60	37.5		
	54	56	56	65.6	25.0	56.2
			58	43.8		
			60	46.9		
			58	53.1	28.1	81.2
	56	58	60	56.2		
			60	31.2		
			60			
			60			
Lipoproteins Low density ($\rho \leq 1.063$) S_r 0-12	33	52	54	33.3	15.2	24.2
			56	36.4		
			58	27.3		
			60	36.4		
		54	56	36.4	18.2	39.4
			58	33.3		
			60	42.4		
			58	33.3	24.2	51.5
	56	58	60	42.4		
			60	39.4		
			60			
			60			
	32	52	56	21.9	6.2	15.6
			58	21.9		
			60	15.6		
		56	58	31.2	12.5	50.0
			60	31.2		
			60	18.8		
			60			
	38	54	56	36.8	13.2	26.3
			58	26.3		
			60	36.8		
			56	28.9	23.7	39.5
			60	34.2		
			60	36.8		
			60			
			60			

plateauing of the level of these blood serum concentrations in these subjects.

Change in level of the lipoprotein parameters per 10-pound change in weight (table IV) in absolute amounts, was smallest for S_r 12-20. If this change in level is expressed as a percent of the mean level for the variable, then the percent change in S_r 12-20 is one of the larger changes and similar to the percent change in S_r 20-400. The S_r 12-20 fraction is the one which Gofman et al. (10) originally reported

as being most closely associated with cardiovascular disease.

The decreasing trend in high density lipoprotein concentration probably is the descending limb of a curve that may reach a minimum in the near future and may rise somewhat thereafter. Such a sequential change in this fraction would not be predicted from recent population surveys (11), but it is suggested in a somewhat attenuated form by the early published data of deLalla et al. (12).

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Unclassified Report

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1. Lipids
 2. Lipoproteins
 3. Cholesterol
 4. Phospholipids
- I. AFSC Task 775301
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