The Occurrence of Hyperlipidemia in Flying and Nonflying Subjects of the USAFSAM Cardiovascular Disease Study

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SUMMARY

Since some forms of mental stress are associated with elevations in serum cholesterol levels, it is relevant to ask whether the repeated acute stress periods encountered by pilots may eventuate in elevated serum levels of cholesterol and/or other lipids. The subjects of the USAFSAM Cardiovascular Disease Study were therefore separated into flying and nonflying groups, and the occurrence of elevated lipid levels in these groups tabulated. The means and standard deviations of the cholesterol, S_f 0-12, and S_f 20-400 lipoprotein levels were computed. No significant differences between the mean values were found for any of the years or for any of the three lipid fractions. The data therefore indicate that the stresses associated with flying, if they had any effect, had no more effect on the serum lipids than did the stresses experienced by the group of nonflying officers.

One of the factors thought to contribute to the development of atherosclerotic heart disease is psychological stress (1, 2). Examples of this stress and the response to it are seen in medical students whose serum cholesterol levels rose just before examinations (3), and in the tax accountants with elevated cholesterol levels just prior to deadlines for filing tax returns (4). Friedman and Rosenman (1) have classified individuals according to certain personality traits listed in Table 1. Competitive, agressive individuals, categorized as Type A, tend to have higher serum cholesterol levels and shorter blood clotting times than more passive individuals with Type B personalities.

Table I. Characteristics of Personality Types (5)

- Type A
  - Intense, sustained drive for achievement
  - Desire for recognition
  - Involvement in diverse functions
  - Sense of urgency to speed work and talk
  - Extra alertness, both mental and physical
- Type B
  - Essentially the obverse of Type A
- Type C
  - Anxiety (unemployed blind men)

Presumably, individuals with Type A personality experience more psychologic stress than Type B persons, since Type A individuals excrete larger amounts of catecholamines in their urine than do Type B individuals (5). The nature of this stress is rather specific, however, since a group of unemployed blind men who were studied did not have elevated serum cholesterol levels despite the fact that they presumably experienced chronic emotional stress (6). This specificity of stress response is further indicated by the fact that urinary excretions of corticosteroids were not different for the A and B personality types. Furthermore, Caganova, et al, (7) found an elevation of serum cholesterol levels in nonathlete students before examinations, but not in students tested for performance by a single physical load.

Studies of U.S. Air Force pilots have indicated that these men are subject to stressing factors associated with flying. Hale, et al., (8) reported that elevations of both urinary catecholamines and 17-hydroxysteroids occurred in pilots at various time during flights. The investigators interpreted these elevations to be reflections of the interaction of flight stresses on the natural circadian rhythms governing the excretion of these hormones.

The question of interest in this paper is whether the stresses of flight can elevate the serum cholesterol and predispose pilots to the development of atherosclerotic heart disease.

FINDINGS

An answer to the above question was sought in the data of the USAF School of Aerospace Medicine Cardiovascular Disease Study (9). This study was initiated in 1952, when serum cholesterol and lipoprotein levels were measured in many members of the entering class at the U.S. Military Academy at West Point. Figure 1 is a diagram summarizing the design of this study. Table II lists the lipids and lipoproteins measured and the years those measurements were initiated. Those measurements have been repeated once

Table II. USAFSAM Cardiovascular Disease Study. List of measurements made and the year in which the measurement was initiated.

Lipoproteins	
Low Density, including	
S_f 0-12	1952
S_f 12-20	1956
S_f 20-400	1956
High Density	1956
Cholesterol	1952
Phospholipids	1954

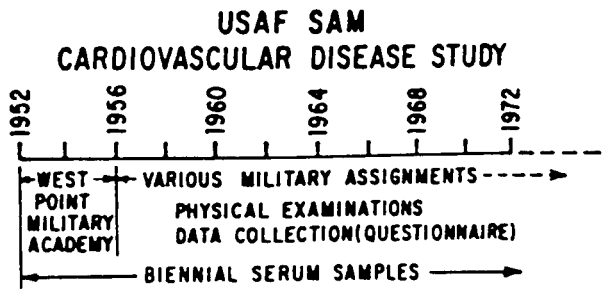

Fig. 1. Diagrammatic outline of the study.

every two years in as many of the subjects as possible. Consequently, serial measurements of serum cholesterol and lipoprotein levels are available on those officers for the years 1952-1970. Of the 479 officers in the study in 1956, 394 remained in the study through 1970. Among those 394 were 81 Air Force officers. All are classified as belonging to the flying population, although one is a flight medical officer and eight are navigators. The remaining 72 pilots include many who are or have been fighter pilots. The cholesterol and S_f 0-12 (low density) and S_f 20-400 (very low density) lipoprotein levels for the 81 flying subjects have therefore been compared with the corresponding levels for the 313 nonflying subjects. Some of the subjects could not provide blood for analysis during each of the sampling years. Consequently, the mean levels are not based on the same individuals during the various sample years. This variation in population makeup from one sample year to the next introduces some lack of confidence in the absolute values of the means and in their differences from year to year. Changes from one sample year to the next therefore have been ignored, and data analyses have been limited to comparing the mean values for the flying and nonflying groups in each of the sampling years.

The incidence of hyperlipidemia among the subjects is shown in Table III. The percentages listed in that table do not differ significantly between the two groups.

Table III. USAFSAM Cardiovascular Disease Study. Percentage of subjects in flying and nonflying groups having levels within the listed ranges.

	N	Percentage of Subjects with Maximum Levels				
		cholesterol		S_f 20-400 lipoprotein		
		275-350	>350	200-300	300-500	>500
Flying	81	31	2.5	12	7	1
Nonflying	313	36	7	16	6	0.3

A comparison was made to test the possibility that the two groups might differ in some years. Accordingly, the mean value and the standard deviation of the values about the mean were computed for each year for the flying and nonflying groups. Tables IV, V, and VI present the results of those computations.

Table IV. USAFSAM Cardiovascular Disease Study. Mean Serum Cholesterol Levels.

Year	Flyers			Non-Flyers		
	N	S	$\bar{X}$	$\bar{X}$	S	N
1952	73	37.5	177.3	184.2	39.2	260
54	79	36.5	217.3	217.9	36.4	295
56	81	42.8	231.6	234.4	40.8	313
58	81	40.0	246.7	249.2	40.6	308
1960	79	44.8	232.7	238.0	44.2	289
62	78	40.8	225.0	229.1	40.3	294
64	81	40.3	235.4	237.8	44.6	292
66	68	48.8	247.2	245.6	46.0	244
68	67	38.3	237.6	242.4	44.3	232
1970	74	35.2	242.4	249.8	44.2	261

N = number of subjects S = standard deviation $\bar{X}$ = mean value

Table V. USAFSAM Cardiovascular Disease Study. Mean S_f 0 - 12 Lipoprotein Levels.

Year	Flyers			Non-Flyers		
	N	S	$\bar{X}$	$\bar{X}$	S	N
1952	74	45.2	176.0	184.4	50.8	266
54	79	51.7	190.4	196.1	49.1	297
56	81	80.2	283.3	288.7	77.0	312
58	80	94.7	322.5	331.9	87.6	307
1960	78	97.4	302.0	308.9	83.7	288
62	78	93.2	346.2	327.5	86.0	293
64	81	99.1	321.0	316.9	85.7	292
66	69	94.2	335.2	327.8	91.4	242
68	67	82.5	366.2	366.6	96.5	236
1970	73	86.2	335.8	343.5	92.6	257

N = number of subjects S = standard deviation $\bar{X}$ = mean value

Table VI. USAFSAM Cardiovascular Disease Study. Mean S_f 20-400 Serum Lipoprotein Levels.

Year	Flyers			Non-Flyers		
	N	S	$\bar{X}$	$\bar{X}$	S	N
1956	81	65.4	51.8	46.6	36.2	313
58	81	62.3	88.4	90.7	57.1	309
1960	78	54.1	82.9	93.7	64.6	288
62	78	78.1	93.4	101.0	62.5	293
64	81	85.6	115.3	108.3	62.4	292
66	69	85.0	114.9	106.9	66.0	243
68	67	92.4	102.8	111.1	71.5	232
1970	73	78.8	114.9	125.4	86.8	258

N = number of subjects

S = standard deviation

$\bar{X}$ = mean value

It should be pointed out that for the years 1952-1956 there was no difference in the basic environment of the members of the flying and nonflying groups; all were cadets at the Military Academy. Only after the blood sampling of 1956 were the newly commissioned officers who became the flying group given assignments for flight training. Any differences between the two groups in 1952-1956, therefore, reflect some characteristic of individual members of the group before the individuals were assigned to flying or nonflying duty. Any such differences obviously could not be attributed to flying (or to not flying) per se.

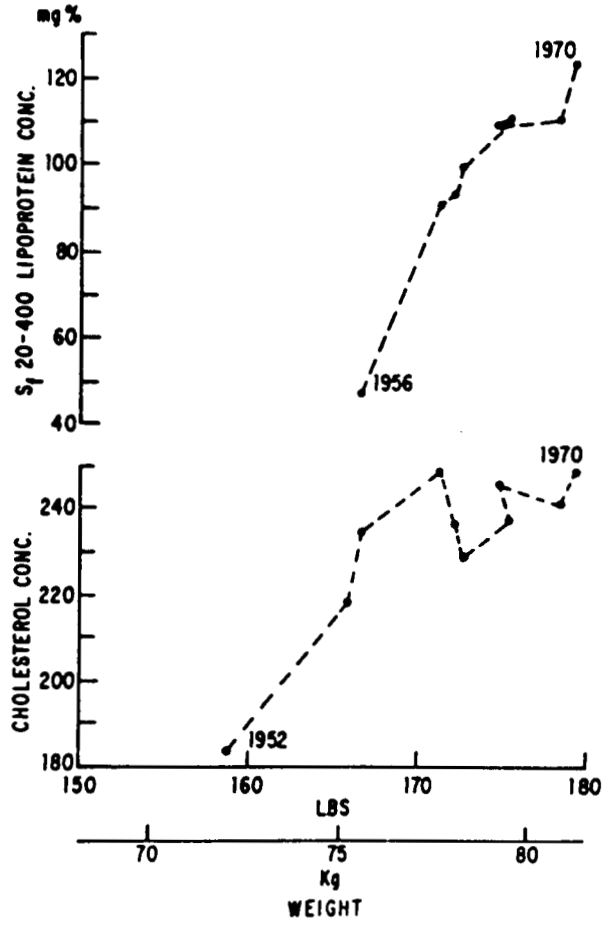

Fig. 2. Mean serum cholesterol and S_f 20-400 lipoprotein levels plotted against mean body weight for the various sampling years. Data from both flying and non-flying groups are included in the means. Earliest measurements (1952) are plotted at the left. The sequence of observed values is indicated by the lines connecting successive points.

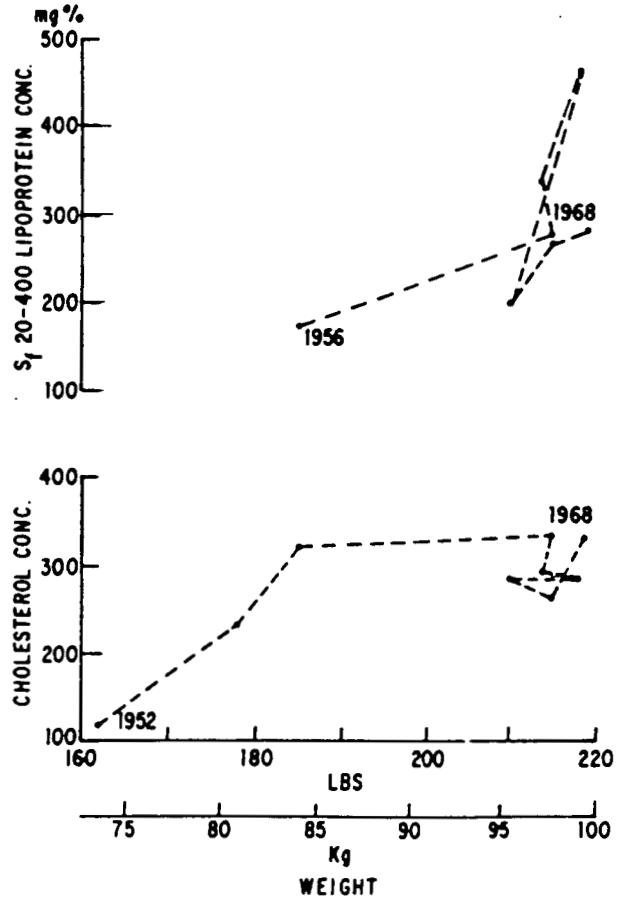

Fig. 3. Serum values plotted against body weight for subject A (height = 74 in, 188 cm). Earliest measurements (1952) are plotted at the left. The sequence of observed values is indicated by the lines connecting successive points.

In Tables IV, V, and VI, the differences between the mean values for the flying and nonflying groups are not significant, when evaluated by Student's t-test.

Because data on three parameters are not available for all sample years, subgroups were identified with complete data for all years. The same individuals were included in all years for these groups. A repeated measurements analysis of variance was performed using data for 1956, 1968, and 1970. No significant effect of flying on the means of the two groups was found.

To learn whether the distribution of values differed in the two large groups, their variances were compared by computing the F ration for each sampling year and for the three lipid parameters. There were no significant differences between the flying and nonflying in the variances of any of the cholesterol or S_f 0-12 lipoprotein data. However, in the S_f 20-400 lipoprotein levels, the variance for the flying group was significantly larger than for the nonflying group for all years except 1958 and 1970 ($P < 0.025$). This larger variance in the flying group resulted from certain members of the group who had relatively high S_f 20-400 lipoprotein levels in 1956, that have tended to persist throughout the study. This difference is an example of a characteristic of individuals that antedated their assignment to flight duty, and therefore cannot be attributed to stresses of flying.

The serum samples in which all lipid and lipoprotein levels were measured were not necessarily fasting sera. The S_f 20-400 lipoprotein levels, consequently, could be affected by the time elapsed since the last meal, by the amount of food included in that meal, and by its fat content. These uncertainties make it impossible to determine whether an elevated S_f 20-400 lipoprotein level represents a hypertriglyceridemia of metabolic or of postprandial origin. Nevertheless, some of the data are quite provocative.

Serum levels of the cholesterol and S_f 20-400 lipoproteins would be expected to correlate to some degree with weight (10). Therefore, in figure 2, the mean levels of those substances are plotted against the mean weight of the subjects at the time the lipid levels were measured. It is notable that the initial normal cholesterol level rose markedly with the first ten pounds of weight gain, but varied inconsistently with the further weight gains, as though the cholesterol levels were fluctuating below a metabolic ceiling. Meanwhile, the levels of the triglyceride-rich S_f 20-400 lipoproteins rose consistently as the weight increased, although the lipoprotein levels never became grossly elevated. These relationships suggest that the weight gain was the result of caloric intake in excess of metabolic needs. In such circumstances, the increase in triglyceride levels would be expected to accompany the increase in weight. As a possible cause of the observed increase in lipoprotein levels, hypertriglyceridemia secondary to basic metabolic abnormality seems to be an unlikely possibility.

For individual subjects, however, the possibility of primary metabolic abnormality is rather likely in some instances, although proof of such abnormality is lacking. Figures 3 and 4 are examples of data from individual subjects with hyperlipidemias.

Figure 3 shows data from subject A, who gained more than 50 pounds (22.7 kg) during the first six years of the study, and has maintained that weight ever since. Concomitantly, his serum cholesterol rose from its initial level of 120 mg % to values in excess of 300 mg %, and has remained near 300 mg % subsequently. The pronounced weight gain associated with the development of this hyperlipidemia suggests that excessive caloric intake may be the explanation of the elevated lipid and lipoprotein levels. However, this officer is 74 inches (188 cm) tall. For his height, his weight is not excessive by USAF standards. The basic cause of his hyperlipidemia therefore is not certain, but it would be highly interesting to determine how well it would respond to dietary control.

Figure 4 shows data from subject B, who gained 23 pounds (10.4 kg) during the first 6 years of study. Subsequently his weight decreased and remained below the maximum reached at the end of the first six years. Both the cholesterol and the lipoprotein levels varied erratically, sometimes by large amounts, throughout the period of observation.

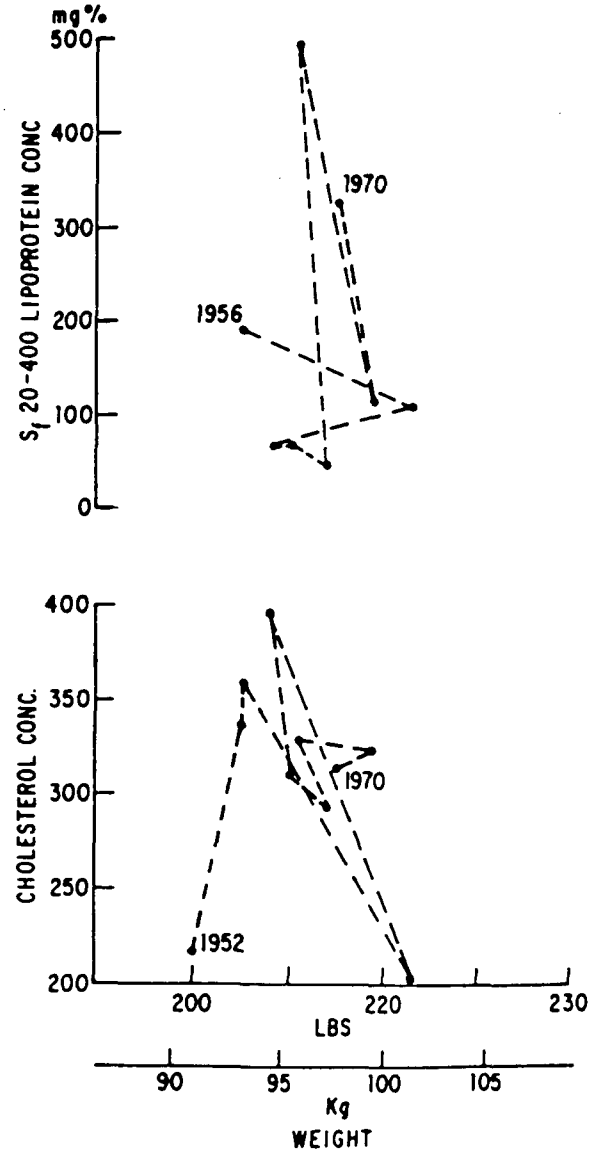

Fig. 4. Some values plotted against body weight for subject B (height = 73 in, 185 cm). Earliest measurements (1952) are plotted at the left. The sequency of observed values is indicated by the lines connecting successive points.

members of their group, but as examples of active and presumably physically fit officers with a range of hyperlipidemia that apparently has not interfered with their performance of duties up to the present time.

DISCUSSION AND CONCLUSIONS

Among the subjects of the USAFSAM Cardiovascular Disease Study, there is no evidence that the stresses of flying affect the serum lipid levels differently than those levels are affected by the stresses of life in the military nonflying subjects. Mean levels for serum cholesterol and for the S_f 0-12 (cholesterol-rich) and the S_f 20-400 (triglyceride-rich) lipoproteins did not differ significantly between the flying and nonflying groups. There were no significant differences, not only during the four-year period of schooling at West Point, but also during the subsequent fourteen years of flying or nonfling duty assignment. Further evidence of the absence of any effect of flying per se is provided by the similarity of the variances of the cholesterol and S_f 0-12 lipoprotein levels, which indicates that the flying and nonflying groups had a similar distribution of levels within the two groups. The variance for S_f 20-400 lipoprotein levels, however, was larger for the flying than for the nonflying group in most years. The reason is that the group who eventually became flyers included, even during the years of schooling at West Point, several individuals with elevated S_f 20-400 lipoprotein levels. Those elevations are possibly hereditary, although they could reflect eating habits. In any case, the elevations have generally persisted throughout the study and are not attributable to the stress of flying.

It is notable that various subjects, despite having had elevated serum lipid and lipoprotein levels while students at the Military Academy, went on to become rated pilots. Twenty years after entering the Military Academy, none of those men has had his flying career prematurely terminated by cardiovascular disease. Although the number of subjects, 81, is small, this absence of overt disease agrees with the absence of any significant differences in the serum lipid and lipoprotein levels of flying and nonflying officers.

The conclusion seems warranted that the streeses experienced by officers who fly planes do not affect serum lipids differently than the stresses experienced by nonflying officers. In other words, there is no evidence in these data of any effect on serum lipids that is peculiar to the stress of flying. The inference is that the stress of flying has no peculiar effects on susceptibility to atherosclerotic heart disease, despite the fact that evidence of physiologic stress associated with flying has been provided by studies of steroid and catecholamine excretion (8).

The absence of an observed effect on serum lipids in this population is significant. The studies of Friedman and Rosenman (1) showed that elevations of serum cholesterol levels were associated with Type A personality, and with the stress of meeting important deadlines. In the subjects of the USAFSAM study who are pilots, the acute stress of meeting critical performance requirements (takeoffs, landings, critical maneuvers) might be expected to approximate the stresses experienced by the accountants or students. The absence of any significant elevation in cholesterol levels in pilots could mean that (a) pilots become accustomed to such stresses, or (b) the stress tends to be chronic, as in the type C personality, and is not associated with an elevation of serum cholesterol, or (c) the nonflying group experiences other equivalent stresses.

The latter possibility cannot be adequately evaluated, but it is an attractive alternative explanation. It is notable that the mean cholesterol levels for the entire group of subjects are elevated above the means for U.S. males of comparable ages (11). This finding could be interpreted to mean that both flying and nonflying officers are subject to psychological stresses associated with elevation of serum cholesterol levels. Furthermore, it is a reasonable argument that selection and retention of men as military officers would favor those with competitive, aggressive type A personality chracteristics. Such selection could contribute to the elevation of mean cholesterol levels above those for U.S. males in general. If this selection factor does indeed play a significant role in the observed serum lipid and lipoprotein levels, it is apparently no more evident in the flying than in the nonflying officers.

The finding of high mean serum cholesterol levels in this population of subjects raises questions about possible increased relative risks of heart attack (12) among these officers. Such questions are among those that hopefully will be answered as the study continues.

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Summary of Discussion

Data are not yet available on a comparable civilian group similarly selected at a young age. The subjects in the Thousand Aviator Study of NAMI are now divided into military and civilian groups of approximately equal size. These two groups did not differ significantly in their serum cholestrol levels measured at the last sampling. The members of the civilian group, of course, were formerly members of the military group. The USAFSAM study is still unaware of any differences in serum lipids between military and civilian (former military) groups, but this question has not been analyzed using the most recent data.

Discussion speakers: Clark (US), Mitchell (US), Tredici (US), Troxler (US).

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The occurrence of hyperlipidemia in flying and nonflying subjects of the USAFSAM cardiovascular disease study
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The subjects of a cardiovascular disease study were separated into flying and non-flying groups, and the occurrence of elevated lipid levels in these groups was tabulated. The question of interest was whether the stresses of flight elevate serum cholesterol and predispose pilots to the development of atherosclerotic heart disease. None of the percentages obtained in this investigation differ significantly between the two groups. These data therefore indicate that the stresses associated with flying have no more effect on serum lipids than do the stresses experienced by a group of non-flying officers. A corollary inference is that the prognostic significance of a given serum lipid level is the same whether observed in a flying or a non-flying officer. (Author)

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THE OCCURRENCE OF HYPER LIPIDEMIA IN FLYING AND NONFLYING SUBJECTS OF THE USA AIR-FORCE SCHOOL OF AERO SPACE MEDICINE CARDIO VASCULAR DISEASE STUDY
CLARK D A ; NARAHARA K A ; ALLEN M F
AGARD (ADVIS GROUP AEROSP RES DEV) CONF PROC 129. 1973 19-1-19-6
CODEN: AGCPA
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