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Elevated Cholesterol Levels Present Major Risk for Cardiovascular Disease

Civil aviation authorities differ in their methods of addressing the problem, but individual pilots can use the results of cholesterol tests to develop personal methods of controlling their cholesterol levels and reducing their health risks.

FSF Editorial Staff

An elevated level of cholesterol in the blood is a major risk factor for cardiovascular disease — a risk factor that often can be reduced with or without medication.

Cholesterol is a waxy substance found among fats in the bloodstream and in all cells throughout the body. Cholesterol is required for the body's normal formation of cell membranes, other body tissues and some hormones. The liver typically produces as much cholesterol as the body needs — about 1,000 milligrams a day. Individuals consume additional cholesterol when they eat foods derived from animals, especially egg yolks, meats, poultry, fish and shellfish, and whole-milk dairy products.

Cholesterol becomes a health risk when it is carried by low-density lipoproteins (LDL) in the blood at elevated levels. Health authorities generally agree that desirable total cholesterol levels are less than about 200 milligrams per deciliter (200 mg/dL; 5.17 millimoles per liter [5.17 mmol/L]) of blood.[1] Cholesterol levels from 200 mg/dL to 239 mg/dL [6.18 mmol/L] of blood are considered borderline high, and levels of 240 mg/dL (6.20 mmol/L) of blood are considered high. An individual with a cholesterol level of 300 mg/dL (7.76 mmol/L) of blood has a heart attack risk more than double that of an individual with cholesterol in the desirable range.[2]

A number of factors affect an individual's cholesterol levels, including:

- Diet — Cholesterol in the diet and saturated fat (found in foods derived from animals, including meat, butter and cheese, and in palm oil and coconut oil) are associated with increases in blood cholesterol levels. Reducing the amount of saturated fat and cholesterol in the diet helps lower cholesterol levels;

- Weight — Being overweight increases cholesterol levels. (See "Sedentary Lifestyles and High-fat, High-calorie Diets Blamed for Worldwide Increases in Overweight, Obesity." *Human Factors & Aviation Medicine* Volume 48 [March–April 2001].) Losing weight can help lower total cholesterol; LDL cholesterol, sometimes known as "bad" cholesterol; and triglycerides, the other major form of fat in the blood, which, like cholesterol, has been associated with cardiovascular disease. Weight loss also helps to increase high-density lipoprotein (HDL) cholesterol, sometimes known as "good" cholesterol; and,

- Physical activity — Regular physical activity can help decrease LDL cholesterol and increase HDL cholesterol

and contribute to weight loss. Thirty minutes of physical activity is recommended each day.

Other factors cannot be modified, including:

- Age — Cholesterol levels tend to increase with age;
- Gender — Before menopause, women typically have lower total cholesterol levels than men. After menopause, women's LDL cholesterol levels increase. After age 50, women often have higher total cholesterol levels than men of the same age; and,
- Heredity — Elevated blood cholesterol can be a familial trait.

Civil aviation authorities differ in their methods of addressing the problem of elevated cholesterol levels among pilots.

For example, the Joint Aviation Authorities (JAA) require applicants for an initial Class 1 (professional pilot) medical certificate to undergo a blood test to determine cholesterol levels. The blood tests sometimes are known as lipid profiles because they measure lipids (fats) in the blood or as lipoprotein profiles because they measure lipoproteins — combined fat-and-protein particles in the bloodstream. The test must be repeated during the examination for the first medical certificate issued after the pilot reaches age 40.

"Treatment of a lipid disorder is not a bar to certification, and no restriction, per se, is required on the medical certificate unless the overall vascular risk is considered to be too great," the JAA *Manual of Civil Aviation Medicine* says. "From the point of view of overall risk, a European in his 50s probably has a median risk of major coronary event of one every [3 million] flying hours, but the presence of hypertension [high blood pressure], lipid abnormality and/or smoking may increase this."[3]

Christopher Schenk, MBBS (bachelor of medicine and bachelor of surgery), a medical officer in the aeromedical section of the U.K. Civil Aviation Authority, said that cholesterol testing has been required for U.K. professional pilots since July 1999, when the relevant JAA regulations were implemented.

"The aim of testing for lipid levels is to assist in the general assessment of the cardiovascular risk factors for individual pilots," Schenk said. "While an elevated cholesterol [level], per se, is not a bar to certification, it does prompt a closer look at other coronary risk factors such as weight, smoking, glucose intolerance and hypertension, as, in combination, these factors increase the likelihood of a coronary event."[4]

He said that pilots whose cholesterol level exceeds 5.5 mmol/L (213 mg/dL) of blood are advised to adjust their diets and, perhaps, to lose weight; cholesterol levels of more than 6.5 mmol/L (251 mg/dL) may require medication.

In Australia, professional pilots with Class 1 medical certificates and air traffic controllers with Class 3 medical certificates undergo cardiovascular risk assessment — including estimates of their levels of cholesterol and triglycerides — as part of their annual/biannual medical certificate renewal.

Dave Emonson, MBBS, acting director of aviation medicine for the Australian Civil Aviation Safety Authority (CASA), said that results of the cholesterol tests and related information "help provide designated aviation medical examiners with an estimate of the risk of professional aviators (and air traffic controllers) developing significant cardiovascular disease. High-risk individuals are asked to undergo further testing to exclude significant disease."[5]

Treatment of elevated cholesterol levels typically involves changes in diet and exercise and often includes the prescription of medication to lower cholesterol and/or triglycerides, Emonson said.

"Many of the more modern … medications are compatible with aircrew [duties] and air traffic control duties," he said. "Pilots and [air traffic controllers] taking acceptable … medications should only return to their flying/controlling duties after a period of ground-testing has established that they do not suffer side effects from the medications, and CASA has given approval for their use."

Similarly, in New Zealand, the total cholesterol level and HDL cholesterol level are among the factors considered in calculating a medical-certificate applicant's risk of an incapacitating cardiovascular event, said Martyn Gosling, communications coordinator for the Civil Aviation Authority of New Zealand.[6]

If the risk-assessment procedure determines that the pilot's risk exceeds 1 percent, then further medical examination is required and medical intervention — including treatment with cholesterol-reducing medication — may be necessary, Gosling said. In many instances, the medication does not interfere with a pilot's continuation of flying duties, he said.

The U.S. Federal Aviation Administration (FAA) considered — but, in 1996, rejected — a proposal that would have required a cardiovascular evaluation of a pilot whose total cholesterol level was more than 300 mg/dL of blood. FAA medical requirements do not include routine blood testing, and a medical certificate cannot be denied because of an elevated cholesterol level. Nevertheless, most cardiovascular conditions for which FAA requests further evaluation require reports on the pilot's cholesterol levels, as measured in lipid profiles.

Lipid profiles typically are conducted after an individual refrains from eating for between nine hours and 12 hours.

Results reveal not only the total cholesterol level but also:

- The level of LDL cholesterol — A low level of LDL cholesterol indicates a lower risk of cardiovascular disease.

  The American Heart Association, in its assessment of the cholesterol risks, says, "If too much LDL cholesterol circulates in the blood, it can slowly build up in the walls of the arteries feeding the heart and brain. Together with other substances, [LDL cholesterol] can form plaque, a thick, hard deposit that can clog those arteries. This condition is known as atherosclerosis. A clot (thrombus) that forms in the region of this plaque can block the flow of blood to part of the heart muscle and cause a heart attack. If a clot blocks the flow of blood to part of the brain, the result is a stroke."[7]

  Health authorities typically consider LDL cholesterol levels of more than 160 mg/dL (4.14 mmol/L) of blood to be high; desirable levels are 130 mg/dL (3.36 mmol/L) or lower.

  Studies have shown that the size of LDL particles also is a factor in development of cardiovascular disease. Researchers say that, generally, individuals with relatively small, dense LDL particles have a greater risk of heart attack than individuals with larger LDL particles because small particles are more likely to damage blood vessel linings and to cause cholesterol to accumulate;[8]

- The level of HDL cholesterol — HDLs carry as much as one-third of the cholesterol through the bloodstream, collecting some of the cholesterol from the arteries and carrying it to the liver, where it is recycled or eliminated from the body. A high level of HDL cholesterol indicates a lower risk of cardiovascular disease.

  In recent years, health authorities have considered HDL levels too low if they are less than 35 mg/dL (0.88 mmol/L) of blood. The NHLBI standards issued in May 2001 said that desirable HDL levels are 40 mg/dL (1.03 mmol/L) or more; and,[9]

- The level of triglycerides — Just as an elevated level of cholesterol can increase the risk of cardiovascular disease, so can an elevated level of triglycerides. Health authorities generally say that normal triglyceride levels are less than 200 mg/dL (2.26 mmol/L) of blood, borderline-high levels are between 200 mg/dL and 400 mg/dL (4.52 mmol/L), high levels are between 400 mg/dL and 1,000 mg/dL (11.29 mmol/L), and very high triglyceride levels are more than 1,000 mg/dL.

Information obtained from a lipid profile can be used to calculate the ratio of total cholesterol to HDL cholesterol, a number considered useful in predicting atherosclerosis. An average ratio (obtained by dividing total cholesterol by HDL cholesterol) is 4.5-to-1; the desirable ratio is 3.5-to-1.[10]

If a lipid profile reveals elevated levels of total cholesterol or LDL cholesterol, several methods, primarily involving changes in diet, can lower cholesterol.

NHLBI and most health authorities recommend weight management (weight loss for those who are overweight), 30 minutes of physical activity a day, no smoking and a diet designed to reduce cholesterol levels.

The NHLBI diet, known as the therapeutic lifestyle changes (TLC) diet, recommends:[11]

- Enough calories to maintain a desirable weight, with a maximum of 30 percent of those calories from fat and less than 7 percent of those calories from saturated fat. Polyunsaturated fat (from cold-water fish such as tuna, cod and halibut, and from some vegetable oils such as safflower, corn, sunflower and soybean) and monounsaturated fat (from olive oil and peanut oil) may add calories but help reduce cholesterol;

- Less than 200 milligrams of cholesterol a day; and,

- If reducing consumption of cholesterol and saturated fat does not lower an individual's LDL cholesterol, an increase in the amount of soluble fiber in the daily diet. Soluble fiber — found in fruits, vegetables and grains — interferes with the absorption of cholesterol in the intestines. Recommendations typically call for consumption of 25 grams to 35 grams of fiber a day.

Quay C. Snyder, M.D., associate aeromedical adviser to the Air Line Pilots Association, International, said that an individual who consumes 30 grams of fiber a day has 55 percent less chance of experiencing a heart attack than someone who consumes 12 grams of fiber a day.[12]

NHLBI also recommends adding to the diet such foods as margarine and salad dressings made with cholesterol-lowering ingredients known as plant sterol esters or plant stanol esters. Both substances are found in small amounts in many fruits, vegetables and other plants, and both substances are considered effective in reducing cholesterol.[13]

Other health authorities and health specialists also recommend:

- Increasing the intake of antioxidant vitamins, including vitamin C and vitamin E, which decrease the oxidation of LDL. Oxidated LDL is deposited in the walls of blood vessels and causes formation of plaque. The vitamin compounds are found in many fruits and vegetables; vitamin supplements also may be useful;[14]

- Increasing intake of vitamin B_{12}, vitamin B_6 and folate, all of which help to break down homocysteine, an amino acid that is considered a vascular toxin responsible for between 5 percent and 10 percent of cardiovascular-disease risk.

The vitamins and folate are found in fruits, vegetables and beans; the benefits of vitamin supplements have not been proved; and,[15]

- Eating two servings to three servings a week of fish, a source of omega-3 fatty acids, which lower levels of blood cholesterol and triglycerides and may reduce the premature death rate among people who have survived one heart attack. Omega-3 fish-oil supplements taken in large doses, however, can increase LDL cholesterol levels, increase blood-sugar levels among people with diabetes, decrease blood-clotting and increase the toxicity of vitamin A and vitamin D.[16] As an alternative, flax-seed oil also contains substantial amounts of omega-3 fatty acids.[17]

NHLBI recommends an overall assessment of an individual's risk of developing cardiovascular disease or experiencing a heart attack (see "Four Steps to Reducing Cholesterol and Reducing the Risk of Heart Attack") as the first step in reducing elevated cholesterol levels.

"In general, the higher your LDL level and the more risk factors you have (other than LDL), the greater your chances of developing [cardiovascular] disease or having a heart attack," NHLBI said. "Some people are at high risk for a heart attack because they already have heart disease. Other people are at high risk for developing heart disease because they have diabetes (which is a strong risk factor) or a combination of risk factors for heart disease."[18]

The major risk factors include cigarette smoking, high blood pressure, low HDL cholesterol, age and a family history of early heart disease.

The more risk factors an individual has, the more his or her chances of experiencing a heart attack increase — and the more he or she will benefit from reducing the LDL cholesterol level. For example, NHLBI says, an individual with a low risk to moderate risk of experiencing a heart attack should reduce LDL cholesterol below 160 mg/dL of blood, either by making

Continued on page 6

Four Steps to Reducing Cholesterol and Reducing the Risk of Heart Attack

The risk of developing cardiovascular disease or having a heart attack increases along with increases in low-density lipoprotein (LDL) cholesterol, also known as "bad" cholesterol, and with increases in the number of risk factors. This is one method of assessing risk, based on recommendations published in May 2001 by the U.S. National Heart, Lung and Blood Institute (NHLBI). Similar risk-assessment programs — many of them based on different values — have been developed by other health authorities; this one is presented here because it represents some of the most current thinking on cholesterol reduction. Cholesterol measurements are presented in milligrams per deciliter of blood, the value used in the United States, and they also have been converted to millimoles per liter of blood, the value used in other countries.

The following is based on NHLBI recommendations. The first step is to add the number of major risk factors, with a value of one point each:

- Cigarette smoking;
- High blood pressure (140/90 millimeters of mercury or higher or on blood pressure medication);
- Low high-density lipoprotein (HDL) cholesterol, also known as "good" cholesterol, (less than 40 milligrams per deciliter [40 mg/dL; 1.03 millimoles per liter [1.03 mmol/L)]);
- Family history of early heart disease (heart disease in father or brother before age 55; heart disease in mother or sister before age 65); and,
- Age (men 45 years or older; women 55 years or older).

If your HDL cholesterol is 60 mg/dL (1.55 mmol/L) or higher, subtract one point from your total count. (Although obesity and physical inactivity are not included in this list, they are conditions that should be corrected. [See "Sedentary Lifestyles and High-fat, High-calorie Diet Blamed for Worldwide Increase in Overweight, Obesity," *Human Factors & Aviation Medicine* Volume 48 (March–April 2001)].)

The second step is to use the risk-scoring tables. If you have two or more risk factors from Step 1, use Tables 1–5 to add your points. Then use Table 6 to determine your risk score — your chance of experiencing a heart attack in the next 10 years, reported as a percentage. For example, a risk score of 20 percent means that 20 of every 100 people in the category will have a heart attack within 10 years. If you have zero or one risk factor, proceed to Step 3.

The third step is to determine the risk category. If you have:

- Heart disease, diabetes, or a risk score of more than 20 percent, you are in category 1 (highest risk);
- Two or more risk factors and a risk score of 10 percent to 20 percent, you are in category 2 (next-highest risk);
- Two or more risk factors and a risk score of less than 10 percent; you are in category 3 (moderate risk); and,
- Zero or one risk factor; you are in category 4 (low-to-moderate risk).

The fourth step is to determine the LDL-cholesterol-reduction goal.

The goal is to reduce the LDL cholesterol level enough to achieve a reduction in the risk of developing cardiovascular disease or a heart attack. The higher your risk, the lower your LDL goal. NHLBI identifies two primary methods of reducing cholesterol: therapeutic lifestyle changes (TLC), including the TLC cholesterol-reduction diet (which limits daily consumption of cholesterol to 200 milligrams and saturated fat to 7 percent of total calories), physical activity and weight management, and use of cholesterol-reducing medications.

Goals differ for each category:

- **Category 1 (highest risk)** — Your LDL goal is less than 100 mg/dL (2.95 mmol/L) of blood. If your LDL is 100 mg/dL or more, begin the TLC diet. If your LDL is 130 mg/dL (3.36 mmol/L) or more, begin drug treatment at the same time as the TLC diet. If your LDL is 100 mg/dL to 129 mg/dL (3.34 mmol/L), you also may need medication along with the TLC diet. Even if your LDL is below 100 mg/dL, you should follow the TLC diet to keep your LDL as low as possible;

- **Category 2 (next-highest risk)** — Your LDL goal is less than 130 mg/dL. If your LDL is 130 mg/dL or more, begin the TLC diet. If your LDL is 130 mg/dL or more after three months on the TLC diet, you may need medication along with the TLC diet. If your LDL is less than 130 mg/dL, consumption of saturated fat and cholesterol may be increased slightly, but you still should adhere to a healthy diet;

- **Category 3 (moderate risk)** — Your LDL goal is less than 130 mg/dL. If your LDL is 130 mg/dL or more, begin the TLC diet. If your LDL is 160 mg/dL or more after three months on the TLC diet, you may need medication along with the TLC diet. If your LDL is less than 130 mg/dL, adhere to a healthy diet; and,

- **Category 4 (low-to-moderate risk)** — Your LDL goal is less than 160 mg/dL. If your LDL is 160 mg/dL or more, begin the TLC diet. If your LDL is 160 mg/dL or more after three months on the TLC diet, you may need medication along with the TLC diet, especially if your LDL is 190 mg/dL (4.91 mmol/L) or more. If your LDL is less than 160 mg/dL, adhere to a healthy diet.♦

Table 1
Age Points for Calculating Heart-attack Risk

	Points	
Age	**Men**	**Women**
20–34	–9	–7
35–39	–4	–3
40–44	0	0
45–49	3	3
50–54	6	6
55–59	8	8
60–64	10	10
65–69	11	12
70–74	12	14
75–79	13	16

Note: Table 1 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

Source: U.S. National Heart, Lung and Blood Institute

Table 2
HDL-cholesterol Points for Calculating Heart-attack Risk

HDL		Points	
Milligrams per Deciliter	**Millimoles per Liter**	**Men**	**Women**
60+	1.55+	–1	–1
50–59	1.29–1.53	0	0
40–49	1.03–1.27	1	1
<40	<1.03	2	2

Note: Table 2 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

HDL = high-density lipoprotein

Source: U.S. National Heart, Lung and Blood Institute

Table 3
Total-cholesterol Points for Calculating Heart-attack Risk

Total Cholesterol		Points									
		Age 20–39		**Age 40–49**		**Age 50–59**		**Age 60–69**		**Age 70–79**	
Milligrams per Deciliter	**Millimoles per Liter**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
<160	<4.14	0	0	0	0	0	0	0	0	0	0
160–199	4.14–5.15	4	4	3	3	2	2	1	1	0	1
200–239	5.17–6.18	7	8	5	6	3	4	1	2	0	1
240–279	6.20–7.21	9	11	6	8	4	5	2	3	1	2
280+	7.24+	11	13	8	10	5	7	3	4	1	2

Note: Table 3 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

Source: U.S. National Heart, Lung and Blood Institute

Table 4
Smoking Points for Calculating Heart-attack Risk

	Points									
	Age 20–39		Age 40–49		Age 50–59		Age 60–69		Age 70–79	
Smoking Status	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Nonsmoker	0	0	0	0	0	0	0	0	0	0
Smoker	8	9	5	7	3	4	1	2	1	1

Note: Table 4 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

Source: U.S. National Heart, Lung and Blood Institute

Table 5
Blood-pressure Points for Calculating Heart-attack Risk

	If Untreated		If Treated	
Systolic Blood Pressure*	Men	Women	Men	Women
<120	0	0	0	0
120–129	0	1	1	3
130–139	1	2	2	4
140–159	1	3	2	5
160+	2	4	3	6

Note: Table 5 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

*Systolic blood pressure is recorded when the heart contracts and is higher than diastolic blood pressure, recorded when the heart relaxes. Blood pressure is reported as systolic pressure/diastolic pressure.

Source: U.S. National Heart, Lung and Blood Institute

Table 6
Ten-year Heart-attack Risk

Point Total, Men	10-year Risk, Men	Point Total, Women	10-year Risk, Women
< 0	<1%	< 9	<1%
0–4	1%	9–12	1%
5–6	2%	13–14	2%
7	3%	15	3%
8	4%	16	4%
9	5%	17	5%
10	6%	18	6%
11	8%	19	8%
12	10%	20	11%
13	12%	21	14%
14	16%	22	17%
15	20%	23	22%
16	25%	24	27%
17 or more	≥ 30%	25 or more	≥ 30%

Note: Table 6 is one of six tables to be used in determining risk of a heart attack during the next 10 years.

Source: U.S. National Heart, Lung and Blood Institute

changes in diet and lifestyle or by adding treatment with cholesterol-reducing medications. An individual with the highest risk of experiencing a heart attack, however, should reduce LDL cholesterol below 100 mg/dL (2.59 mmol/L) of blood and maintain that level.[19]

Several types of medication exist to help reduce cholesterol levels. These include:[20,21]

- Statins, the most widely used cholesterol-reduction medications. They function by blocking an enzyme that converts fat in the diet into cholesterol in the liver. Besides reducing LDL cholesterol levels, they also help increase levels of HDL cholesterol. They have few side effects, but in some cases, they may elevate liver enzymes, which can indicate a rare adverse effect on the liver. Typically, regular blood

tests are conducted to ensure that there is no harm to the liver.

Because the side effects of statins are considered infrequent, their use by pilots has been approved by many civil aviation authorities, including FAA, which allows pilots to use the medications without prior approval;[22]

- Niacin, or nicotinic acid, a B vitamin that, when administered in sufficient doses, increases HDL cholesterol levels and lowers levels of LDL cholesterol, total cholesterol and triglycerides. The most common side effects are itching and flushing of the skin after the medication is administered; an aspirin tablet administered 30 minutes before the niacin usually relieves those symptoms. In some forms, niacin may damage the liver, and liver function should be monitored;

- Bile acid sequestrants, which function by binding bile acids in the intestine to allow fat and cholesterol to be eliminated in the stool, thereby lowering LDL cholesterol levels in the blood. Side effects may include bloating, nausea, indigestion, constipation and an increase in triglyceride levels; and,

- Fibric acid derivatives, which lower triglyceride levels and raise HDL cholesterol levels. Side effects may include gallstones and gall bladder disease.

Typically, pilots with elevated cholesterol levels can find treatment — either dietary changes or medication — that causes no side effects and that meets the requirements of civil aviation authorities.♦

Notes and References

1. In the United States, the measurements of blood cholesterol are reported as milligrams per deciliter. Most other countries use Systeme International d'Unites (SI units), which report hematological values and clinical chemistry values in molar concentrations per liter. Milligram amounts refer to weight; molar concentration refers to the concentration of molecules. Conversion factors differ for different substances.

   The University Extension of Iowa State University in Ames, Iowa, U.S., in defining the differences between the measurements, said, "Molar concentration refers to numbers of molecules, for example, the number of cholesterol molecules in blood. Biological reactions occur on a molecular basis, and molar concentrations reflect the proportional amounts of various components within the body that are available to participate in reactions. Milligram [amounts] or gram amounts are based on the weight of a substance present in the body. Large molecules that are heavy may appear to be present in larger amounts than small, lightweight molecules. Yet, in reality, there may be very few of the heavy molecules and vast numbers of the lightweight molecules. It is the actual number of molecules of a substance that determines the potential for action in the body."

   These are the conversion factors for lipids and some examples:

   - Example: Total cholesterol 5.20 millimoles per liter (mmol/L) = 201.08 milligrams per deciliter (mg/dL), 250 mg/dL = 6.465 mmol/L. Conversion factor: 0.02586. To convert mmol/L to mg/dL, divide mmol/L by the conversion factor; to convert mg/dL to mmol/L, multiply mg/dL by the conversion factor;

   - Example: LDL cholesterol 3.36 mmol/L = 129.93 mg/dL. Conversion factor: 0.02586;

   - Example: HDL cholesterol 0.9 mmol/L = 34.80 mg/dL. Conversion factor: 0.02586; and,

   - [T]riglycerides 1.80 mmol/L = 159.43 mg/dL. Conversion factor: 0.01129.

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