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Cholesterol in Childhood
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Committee on Nutrition

Cholesterol in Childhood

ABSTRACT. This updated statement reviews the scientific justification for the recommendations of dietary changes in all healthy children (a population approach) and a strategy to identify and treat children who are at highest risk for the development of accelerated atherosclerosis in early adult life (an individualized approach). Although the precise fraction of risk for future coronary heart disease conveyed by elevated cholesterol levels in childhood is unknown, clear epidemiologic and experimental evidence indicates that the risk is significant. Diet changes that lower fat, saturated fat, and cholesterol intake in children and adolescents can be applied safely and acceptably, resulting in improved plasma lipid profiles that, if carried into adult life, have the potential to reduce atherosclerotic vascular disease.

ABBREVIATIONS. LDL, low-density lipoprotein; HDL, high-density lipoprotein.

Although the focus of this statement by the Committee on Nutrition is on cholesterol levels in children, other risk factors for atherosclerosis originate in childhood and should be addressed with equal attention. Specifically, smoking should be discouraged, hypertension should be identified and treated, obesity should be avoided and reduced, regular exercise should be encouraged, and diabetes mellitus should be identified and treated.¹

This statement, for the most part, is in concert with statements of other experts and expert panels, including the National Cholesterol Education Program, the American Heart Association's Council on Cardiovascular Disease in the Young and Committee on Nutrition, the US Department of Agriculture and the US Department of Health and Human Services Dietary Guidelines for Americans, the US Surgeon General, the National Research Council, and the National Cancer Institute.

DIET AND ATHEROSCLEROSIS

Studies in animals have demonstrated that high blood cholesterol levels promote atherosclerosis.²⁻⁴ Atherosclerosis develops in many species fed diets that raise the total and low-density lipoprotein

(LDL)-cholesterol levels. Vascular fatty streaks and fibrous plaques develop in adolescent nonhuman primates fed diets high in saturated fatty acids and cholesterol.^{5,6} In monkeys with severe atherosclerosis, regression of the process occurs when the blood cholesterol level is lowered with diet and drugs.^{2,7,8}

In adults, the major nutritional determinant of differences in serum cholesterol levels between countries appears to be the proportion of saturated fat in the diet.⁹⁻¹¹ This also is observed in childhood populations.¹¹⁻¹³ Total blood cholesterol levels in children vary geographically. In countries such as the Philippines, Italy, and Ghana, saturated fat constitutes approximately $\leq 10\%$ dietary intake, and the serum cholesterol level in boys 8 to 9 years of age is generally below 160 mg/dL.¹³⁻¹⁵ In boys from countries such as the Netherlands, Finland, and the United States, the saturated fat intake varies from 13.5% to 17.7% of energy intake, and serum cholesterol levels are generally >160 mg/dL. Although blood cholesterol levels are lowest in countries in which nutrition is not optimal and growth is delayed, there are many industrialized countries in which children have lower cholesterol levels than children in the United States and in which normal growth is maintained (eg, Portugal, Israel, and Italy). A range of serum cholesterol levels is found in industrialized countries, with the United States in the top half of the range.^{13,15-23}

CLINICAL TRIALS

Clinical trials in adult populations have shown that lowering cholesterol levels reduces coronary risk.²⁴⁻²⁶ Aggregate analysis of many clinical trials shows that lowering cholesterol levels by diet or drugs and by primary or secondary prevention reduces fatal and nonfatal myocardial infarction.²⁷ Initially, some controversy occurred about the effectiveness of lowering cholesterol levels because a number of trials did not find a significant reduction in total mortality after treatment to lower the cholesterol level.² These findings have been clarified recently by several studies with large samples of subjects and of long duration showing a decrease not only in the incidence of coronary heart disease but also in mortality from all causes.^{28,29}

In addition, the Dietary Intervention Study in Children, a recent study of the safety and efficacy of lower fat diets in pubertal children, was reported by a collaborative multicenter group. In this study of 663 children 8 to 10 years of age who were followed for 3 years, an intervention group receiving a diet with 28% of calories from total fat, $\sim 10\%$ of calories

Material in this statement is adapted from the *Report of the Expert Panel on Blood Cholesterol in Children and Adolescents* of the National Cholesterol Education Program.⁵² It has been modified to reflect additional considerations of the Committee on Nutrition of the American Academy of Pediatrics.

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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from saturated fat, and 95 mg per day of cholesterol was compared with a group that consumed 33% to 34% of calories as total fat, 12.7% of calories as saturated fat, and 112 mg per day of cholesterol. There were no differences in height, weight, or serum ferritin levels in the two groups, and the intervention group had significant, but modestly lower, levels of LDL-cholesterol levels and maintained psychologic well-being.³⁰

SIGNIFICANCE OF BLOOD CHOLESTEROL LEVELS IN CHILDREN AND ADOLESCENTS

High blood cholesterol levels clearly play a role in the development of premature coronary heart disease in adults. This has been established by many laboratory, clinical, pathological, and epidemiologic studies. It has also been shown that lowering blood cholesterol levels in adults results in a significant lowering of coronary heart disease rates and mortality. Because no long-term studies of the relationship of blood cholesterol levels measured in childhood to coronary heart disease in later life have been conducted, the relationship of childhood cholesterol levels to the atherosclerotic process must be inferred from less direct evidence.

These lines of evidence are summarized as follows:

1. Compared with their counterparts in many other countries, US children and adolescents have higher blood cholesterol levels and higher intakes of saturated fatty acids and cholesterol, and US adults have higher rates of coronary heart disease morbidity and mortality.^{13,15}
2. Autopsy studies demonstrate that early coronary atherosclerosis or precursors of atherosclerosis often begin in childhood and adolescence and are related to high serum total cholesterol levels, LDL-cholesterol plus very low-density lipoprotein-cholesterol levels, and low high-density lipoprotein levels.
3. Children and adolescents with elevated serum cholesterol levels, particularly LDL-cholesterol levels, often come from families in which there is a high incidence of coronary heart disease in the adult relatives.^{32,33}
4. A strong familial aggregation of total, LDL-, and HDL-cholesterol levels exists in children and parents.^{34,35} Familial aggregation of blood cholesterol levels results because of shared environments and genetic factors.³⁶ The monogenetic factors that cause high cholesterol levels include familial hypercholesterolemia and familial-combined hypercholesterolemia. Polygenic disorders that result from the expression of a number of genes, each with a small but additional effect, combined with environmental contributions such as a diet high in saturated fat and cholesterol are likely the most frequent causes of high cholesterol levels during childhood.^{37,38}
5. Children and adolescents with high cholesterol levels are more likely than the general population to have high levels as adults.³⁹⁻⁴⁵ However, a substantial number of children with high cholesterol

levels become adults with desirable cholesterol levels without intervention.⁴⁶

STRATEGIES TO LOWER CHOLESTEROL LEVELS IN CHILDREN AND ADOLESCENTS

To lower blood cholesterol levels in children and adolescents, two complementary approaches are recommended: a population approach and an individualized approach.

The Population Approach

The population approach is designed as the primary means for preventing coronary heart disease. It aims to lower the average level of blood cholesterol in all children and adolescents through population-wide changes in nutrient intake and eating patterns. These recommendations are directed to groups that influence the eating patterns of children and adolescents, including schools, health professionals, government agencies, the food industry, and the mass media. The advantage of this approach is that even a small reduction of the mean total and LDL-cholesterol levels in children and adolescents, if carried into adult life, could decrease substantially the incidence of coronary heart disease.

The US Department of Agriculture 1987 to 1988 Food Consumption Survey indicated that children and adolescents consume 35% to 36% of calories from total fat; 14% from saturated fat, and 193 to 296 mg per day of cholesterol.^{47,48} More recent US population-based data from the National Health and Nutrition Examination Survey III for persons 2 to 19 years of age indicate that mean intakes of total fat and saturated fat are 34% and 12%, respectively, and the mean cholesterol intake is ~270 mg per day.⁴⁹

Nutrient Recommendations

No restriction of fat or cholesterol is recommended for infants <2 years when rapid growth and development require high energy intakes. A precise percentage of dietary intake from fat that supports normal growth and development while maximally reducing atherosclerosis risk is unknown. Therefore, a range of appropriate values, averaged over several days for a child or adolescent, is recommended based on the scientific information available. Because concerns have been expressed that some parents and their children may overinterpret the need to restrict their fat intakes, a lower limit of fat intake is suggested by this Committee. The Committee recognizes that children 2 to 5 years of age are selective in their food choices. After 2 years of age, children and adolescents should gradually adopt a diet that, by ~5 years of age, contains ≤30% of calories and ≤20% from fat. As they begin to consume fewer calories from fat, children should replace these calories by eating more grain products, fruits, vegetables, low-fat milk products or other calcium-rich foods, beans, lean meat, poultry, fish, or other protein-rich foods. These recommendations are for average intakes over several days, so that if foods high in total fat, saturated fat, and cholesterol are eaten, they can be compensated for by eating less of these nutrients at other times. Because no single food item provides all the

essential nutrients in the amounts needed, choosing a wide variety of food from all the food groups will ensure an adequate diet.

Specific nutrient recommendations are as follows: 1) nutritional adequacy should be achieved by eating a wide variety of foods; and 2) caloric intake should be adequate to support growth and development and to reach or maintain desirable body weight.

For a child or adolescent (2 to 18 years of age), the following pattern of nutrient intake is recommended: 1) saturated fatty acids <10% of total calories; 2) total fat over several days of $\leq 30\%$ of total calories and no less than 20% of total calories; and 3) dietary cholesterol <300 mg per day.

Because saturated fatty acids raise blood cholesterol levels,⁵⁰ a major emphasis should be placed on reducing saturated fat intake to <10% of calories. A sufficiently low saturated fat intake can be achieved with a total fat intake of $\sim 30\%$ of calories from fat. A lower fat intake is usually not necessary and, for some children and adolescents, may make it difficult to provide enough calories and minerals for optimal growth and development.

THE INDIVIDUALIZED APPROACH

The individualized approach to lowering cholesterol levels calls on the cooperative effort of health

care professionals to identify and treat children and adolescents at highest risk of having high blood cholesterol levels as adults and increased risk of coronary heart disease.

Selective Screening

Figures 1 and 2 present the algorithms for selective screening.

Children and adolescents who have a family history of premature cardiovascular disease or have at least one parent with a high blood cholesterol level are at increased risk of having high blood cholesterol levels as adults and increased risk of coronary heart disease and, therefore, are recommended for selective screening in the context of regular health care. This focus is supported by strong evidence of familial aggregation of coronary heart disease, high blood cholesterol levels, and other risk factors.

The following are specific recommendations for selective screening of children and adolescents in the context of their continuing health care.

1. Screen children and adolescents whose parents or grandparents, at ≤ 55 years of age, underwent diagnostic coronary arteriography and were found to have coronary atherosclerosis. This in-

Fig 1. Risk assessment. Positive family history is defined as a history of premature (≤ 55 years of age) cardiovascular disease in a parent or grandparent (from the National Cholesterol Education Program⁵²).

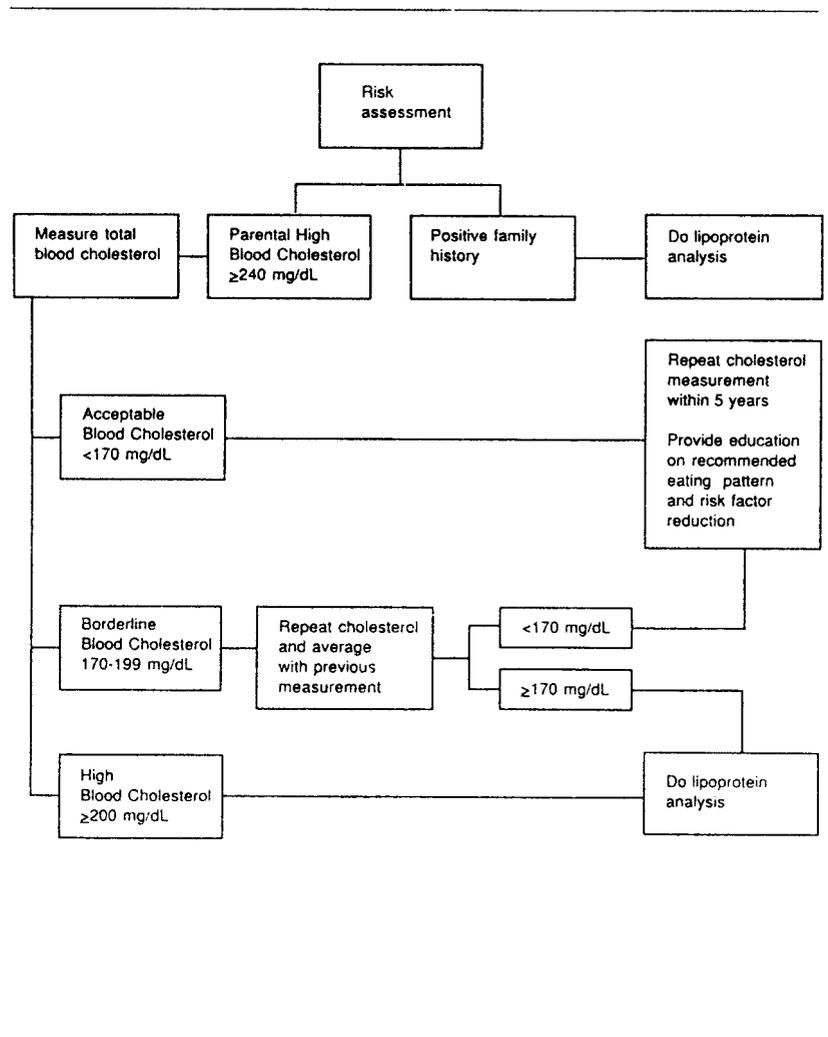
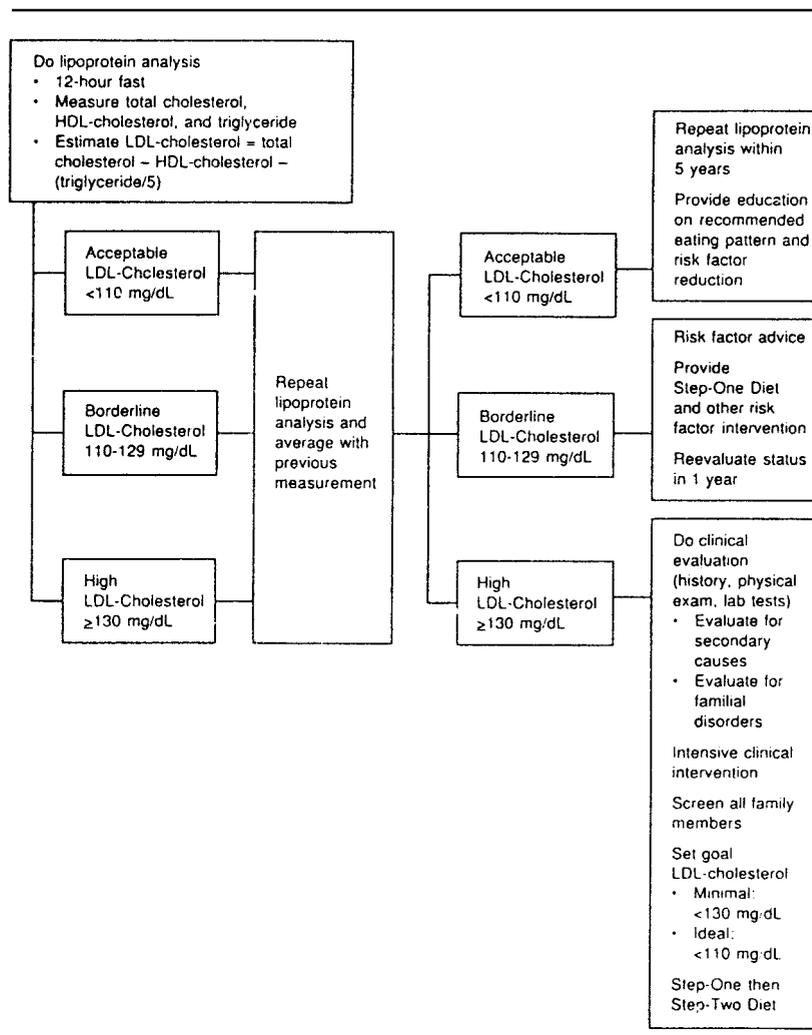


Fig 2. Classification, education, and follow-up based on low-density lipoprotein-cholesterol (from the National Cholesterol Education Program⁵²). HDL indicates high-density lipoprotein; LDL, low-density lipoprotein.



- cludes those who have undergone balloon angioplasty or coronary artery bypass surgery.
2. Screen children and adolescents whose parents or grandparents, at ≤ 55 years of age, had a documented myocardial infarction, angina pectoris, peripheral vascular disease, cerebrovascular disease, or sudden cardiac death.
 3. Screen the offspring of a parent with an elevated blood cholesterol level (240 mg/dL or higher).
 4. For children and adolescents whose parental history is unobtainable, particularly for those with other risk factors, physicians may choose to measure cholesterol levels to identify those in need of nutritional and medical advice.

Optional cholesterol testing by practicing physicians may be appropriate for children who are judged to be at higher risk for coronary heart disease independent of family history (Table 1). For example, adolescents who smoke, consume excessive amounts of saturated fats and cholesterol, or are overweight may also be tested at the discretion of their physician. For parents who do not know their cholesterol levels, pediatricians should strongly encourage them to have their levels measured.

What Should Be Measured

The focus of the individualized approach is to detect and treat the child or adolescent with hypercholesterolemia whose elevated LDL-cholesterol level is likely to indicate increased risk in adulthood. The screening protocol varies according to the reason for testing. This protocol is suggested to limit the need for more sophisticated analyses. If screening is performed because a parent has a cholesterol higher than 240 mg/dL, the initial test should be a measurement of total cholesterol. If the child's level is higher than 200 mg/dL, a fasting lipoprotein analysis should be obtained to measure HDL-cholesterol and LDL-cholesterol levels. If the total cholesterol is borderline (170 to 199 mg/dL), a second measurement should be obtained and averaged with the first result. If the average is borderline or high, a fasting lipoprotein analysis should be obtained.

If the patient is being tested because of a documented family history of premature cardiovascular disease, the initial test should be a lipoprotein analysis that requires a 12-hour fast to obtain accurate triglyceride levels, which are necessary for the computation of LDL-cholesterol levels. The acceptable

TABLE 1. Other Risk Factors That Contribute to Earlier Onset of Coronary Heart Disease

Family history of premature coronary heart disease, cerebrovascular disease, or occlusive peripheral vascular disease (definite onset before the age of 55 years in siblings, parent, or sibling of parent)
Cigarette smoking
Elevated blood pressure
Low HDL-cholesterol concentration (<35 mg/dL)
Severe obesity (\geq 95th percentile weight for height)
Diabetes mellitus
Physical inactivity

borderline and high levels for total and LDL-cholesterol are given in Table 2.

Management

Because there is considerable variability in some children, once a lipoprotein analysis is obtained, it should be repeated so that an average LDL-cholesterol level can be calculated. The average LDL-cholesterol level determines the steps for risk assessment and treatment. Follow-up of the averaged LDL-cholesterol determinations is as follows:

1. Acceptable LDL-cholesterol level (<110 mg/dL)—Provide education on the eating pattern recommended for all children and adolescents and on other risk factors; repeat lipoprotein analysis in 5 years.
2. Borderline LDL-cholesterol (110 to 129 mg/dL)—Provide advice about risk factors for cardiovascular disease; initiate the American Heart Association Step-One diet and other risk factor intervention; reevaluate in 1 year.
3. High LDL-cholesterol (\geq 130 mg/dL)—Examine for secondary causes (thyroid, liver, and renal disorders) and familial disorders, screen all family members, initiate Step-One diet, followed by the Step-Two diet, if necessary.

Step-One and Step-Two Diets

The Step-One diet calls for the same nutrient intake recommended for the population approach to lower cholesterol levels, ie, \leq 30% and no less than 20% of calories from total fat; <10% of total calories from saturated fat; \leq 10% of calories from polyunsaturated fat; and no more than 300 mg per day of cholesterol. What makes the diet therapeutic is prescription in a medical setting with monitoring and follow-up by a health professional. If careful adherence to this diet for at least 3 months does not result in a lower LDL-cholesterol level to the acceptable range, the Step-Two diet should be prescribed. Often children who have been determined to have high LDL-cholesterol levels have instituted a diet similar

TABLE 2. Classification of Total and LDL-Cholesterol Levels in Children and Adolescents From Families With Hypercholesterolemia or Premature Cardiovascular Disease

Category	Total Cholesterol (mg/dL)	LDL-Cholesterol (mg/dL)
Acceptable	<170	<110
Borderline	170–199	110–129
High	\geq 200	\geq 130

to the Step-One diet and require counseling to adopt the Step-Two diet.⁵¹

The Step-Two diet requires detailed assessment of current eating patterns and instruction by a physician, registered dietitian, registered nurse, nutritionist, or other appropriately trained health professional. It aims to induce an eating pattern that includes no more than 30% and no less than 20% of calories from total fat; <7% of total calories from saturated fat; \leq 10% of calories from polyunsaturated fat; and no more than 200 mg per day of cholesterol. This eating pattern requires careful planning to ensure adequacy of nutrients, vitamins, and minerals, and often requires the services of a registered dietitian or other qualified nutrition professional.

Drug Therapy

Drug therapy should be considered only for children >10 years of age after an adequate trial of diet therapy (for 6 to 12 months) and whose LDL-cholesterol level remains \geq 190 mg/dL or whose LDL-cholesterol level remains \geq 160 mg/dL and there is a family history of premature cardiovascular disease (\leq 55 years of age) or two or more other risk factors (Table 1) are present in the child or adolescent after vigorous attempts have been made to control these risk factors.

The recommended drugs for the treatment of hypercholesterolemia and high LDL-cholesterol levels in children are the bile acid sequestrants cholestyramine and colestipol, which bind bile acids in the intestinal lumen. They have documented efficacy, relative freedom from adverse effects, and are apparently safe when administered to children. Other pharmacologic agents are not recommended for routine use in children and adolescents except in consultation with a lipid specialist.

CONCLUSION

To promote lower cholesterol levels in all healthy children (2 to 18 years of age) in the United States, the following pattern of nutrient intake is recommended.

1. Saturated fatty acids <10% of total calories.
2. Total fat over several days of no more than 30% of total calories and no less than 20% of total calories.
3. Dietary cholesterol <300 mg per day.

Pediatricians should identify children at highest risk for the development of accelerated atherosclerosis by screening cholesterol levels in children who have a parental or grandparental history (\leq 55 years of age) of a documented myocardial infarction, angina pectoris, peripheral vascular disease, cerebrovascular disease, or sudden cardiac death, or a parent with a high blood cholesterol level (\geq 240 mg/dL). In addition, for children and adolescents whose parental history is unobtainable, particularly those with other risk factors, physicians may measure cholesterol levels to determine those in need of nutritional and medical advice.

A precise percentage of dietary intake from fat that supports normal growth and development while

maximally reducing atherosclerosis risk is unknown. Therefore, a range of appropriate values, averaged over several days for a child or adolescent, is recommended based on the scientific information available.

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Section on Cardiology

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