

Nutrition for Hypercholesterolemic Children

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Abstract

In the diet of hypercholesterolemic children, 10 to 18% of the total calorie intake should be protein, 50 to 60% carbohydrates, and 30% lipids, of which less than 10% should be saturated fatty acids, between 7 and 10% should be polyunsaturated fatty acids, and 10 to 20% should be monounsaturated fatty acids. Cholesterol intake should not exceed 300 mg/dL, and an adequate fiber intake of 8 to 28 g/day, according to the child's age, should be ensured. If a child is obese or overweight, the aim of the initial treatment should be to normalize weight through improved lifestyle habits, dietary recommendations, and increased physical activity. The healthy diet for cardiovascular disease prevention is similar to that advised for a healthy pediatric population: (1) reduced total fat intake, such as through eating less red meat and sausages and choosing skimmed milk, butter, skimmed-milk cheese, lean meat, skinless chicken, and rabbit, cooked using simple cooking processes; (2) increased intake of monounsaturated and polyunsaturated oils, such as fish oil and olive oil; (3) reduced cholesterol intake, such as through the reduced consumption of eggs, viscera, and industrial bakery products; and (4) higher intake of fish and complex carbohydrates, such as pasta, pulses, and whole-grain bread. In addition, fruits and vegetables should be recommended for their fiber, vitamins, minerals, and trace elements. The recommended culinary preparation is to grill, steam, or bake food and to avoid frying, especially with butter or animal fat, and to give preference to oils based on monounsaturated fats, such as olive and sunflower oil.

Keywords

- hypercholesterolemia
- nutrition
- dietary patterns
- children

Introduction

Increasing obesity worldwide has been accompanied by an increase in dyslipidemia among children. Obesity and dyslipidemia are both related to the metabolic syndrome and are associated with the premature development of cardiovascular disease (CVD).¹ It is therefore essential to identify pediatric dyslipidemia and to initiate measures to prevent, or at least slow, its development.

Atherosclerosis is one of the leading causes of death in adulthood and there is evidence that it can begin in childhood and progress throughout life. For example, fatty streaks in the arterial wall have been observed in children, and these can progress in adulthood to form the atherosclerotic pla-

ques responsible for arterial obstruction.² As well as genetic factors, lifestyle plays an important role in the progression of the disease, with unhealthy lifestyles and dietary habits promoting cardiovascular risk.³ Recognized risk factors include dyslipidemia, obesity, hypertension, smoking, and diabetes. The early identification of these factors in childhood or adolescence can reduce the risk of CVD in adulthood. Treating dyslipidemia can reduce low-density lipoprotein cholesterol (LDL-C) concentrations, improve endothelial function, substantially attenuate the progression of atherosclerosis, and ameliorate coronary outcomes.⁴

Dyslipidemia comprises a range of disorders of lipoprotein metabolism, with abnormal values of one or more blood lipid fractions. Hypercholesterolemia in children, defined as

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total cholesterol (TC) and LDL-C concentrations above the 95th percentile for a child's age and sex, has been shown to be associated with the development of early CVD. Lipid concentrations in healthy children vary with age: at birth they are very low, increasing slowly during the first 2 years of life, and then stabilizing by adolescence. TC and LDL-C concentrations subsequently decrease by 10 to 20% or more during adolescence, before increasing again during late adolescence and young adulthood to similar levels as those prior to adolescence.⁵

Lipid disorders are defined according to population norms. The Lipid Research Clinics prevalence studies used population distributions to determine age- and sex-specific cutoff levels for TC and LDL-C concentrations. The National Heart, Lung, and Blood Institute (NHLBI) and the American Academy of Pediatrics have adopted the National Cholesterol Education Program's recommended cutoff values for defining dyslipidemia in children (TC \geq 200 mg/dL and LDL-C \geq 130 mg/dL). These levels are commonly used in published studies and have been widely accepted in clinical practice, where they are used as the basis for initiating dietetic and other measures⁶ (► **Table 1**).

Types of Dyslipidemias

Dyslipidemias are classified as primary or secondary (► **Table 2**) according to different pathologies. In the latest, the treatment of the underlying disease is usually accompanied by improvement in, or resolution of, dyslipidemia.

Genetic factors are involved in the etiology of primary forms of dyslipidemia.⁷ They are classified as monogenic when only one gene involved in fat metabolism is altered or polygenic when several genes are involved (► **Table 3**). Monogenic primary dyslipidemias have the most severe pathologies and generally require pharmacological treatment because they are poorly modified by lifestyle and dietary changes.⁸

The most common type of genetically linked blood disorder is hypercholesterolemia, which, typically, is polygenic. It has been reported that plasma cholesterol levels are associated with nine single nucleotide polymorphisms located on nine different genes.⁹ Polygenic hypercholesterolemia is associated not only with alterations of the genes

Table 2 Causes of secondary hyperlipidemia

Pharmacological	<ul style="list-style-type: none"> – Corticoids – Alcohol – Oral contraceptives – Diuretics – Beta-blockers – Anabolic – Immunosuppressive drugs – Isotretinoin
Endocrine/metabolic	<ul style="list-style-type: none"> – Obesity – Hypothyroidism – Hypopituitarism – Mellitus diabetes – Cushing's syndrome – Idiopathic hypercalcemia – Pregnancy – Lipodystrophy – Acute intermittent porphyria
Liver diseases	<ul style="list-style-type: none"> – Hepatitis – Biliary atresia – Biliary cirrhosis – Alagille syndrome
Nephropathies	<ul style="list-style-type: none"> – Nephrotic syndrome – Hemolytic uremic syndrome – Chronic renal insufficiency
Infectious	<ul style="list-style-type: none"> – Acute viral/ bacterial infection – HIV – Hepatitis – Pancreatitis
Inflammatory disease	<ul style="list-style-type: none"> – Systemic lupus erythematosus – Juvenile rheumatoid arthritis
Storage disease	<ul style="list-style-type: none"> – Glycogenosis – Sphingolipidoses – Gaucher's disease – Cysteine storage disease – Juvenile Tay–Sachs disease – Niemann–Pick disease – Lipase acid deficiency
Other	<ul style="list-style-type: none"> – Kawasaki disease – Anorexia nervosa – Postsolid organ transplantation – Childhood cancer survivor – Progeria – Idiopathic hypercalcemia – Klinefelter syndrome – Werner's syndrome

Abbreviation: HIV, human immunodeficiency virus.

Table 1 Reference values of lipids and lipoproteins in children and adolescents

Parameter	Acceptable	Limit	High
Triglycerides (mg/dL)			
0–9 y	< 75	75–99	\geq 100
10–19 y	< 90	90–129	\geq 130
Total cholesterol (mg/dL)	< 170	170–199	\geq 200
LDL-C (mg/dL)	< 100	110–129	\geq 130
HDL-C (mg/dL)	> 45	40–45	< 40

Abbreviations: HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

involved in cholesterol metabolism, but also with obesity and unhealthy lifestyle behaviors, such as a poor diet and sedentary lifestyle.¹⁰

Multifactorial dyslipidemia is defined by elevated levels of LDL-C ($>$ 130 mg/dL) or TC ($>$ 200 mg/dL) that are not attributable to familial hypercholesterolemia. Several longitudinal studies have reported an association between childhood lipid levels in this range and indicators of atherosclerosis in adulthood. However, studies have shown that tracking lipid levels from childhood to adulthood cannot predict which individuals will have elevated LDL-C or TC as adults, although the tracking patterns of blood lipids from adolescence to adulthood are somewhat higher.¹¹

Table 3 Classification of primary dyslipidemias

Dyslipidemia	Default	Lipoproteins	Genetics	Incidence
Monogenic homozygote family hypercholesterolemia	– LDL-C receptor – Decreased LDL-C clearance	– TC 600–1,000 mg/dL – LDL-C >600 mg/dL	Autosomal dominant inheritance	1/1,000,000
Monogenic heterozygote family hypercholesterolemia	– LDL-C receptor – Decreased LDL-C clearance	– TC 300–400 mg/dL – LDL >200 mg/dL	Autosomal dominant inheritance	1/500
Polygenic family hypercholesterolemia (common hypercholesterolemia)	Unknown	TC < 300 mg/dL	Autosomal dominant inheritance	The most frequent in pediatrics (80%)
Family hypertriglyceridemia	– Lipoprotein lipase deficiency – Apo CII deficiency – Other mechanisms	Increased TG, VLDL-C, LDL-C, and HDL-C	Unknown	– Heterozygote 1/100 – Homozygote 2/1,000
Family disbetalipoproteinemia	Apo E	Increased TC and TG	Autosomal recessive inheritance	1/2,000
Family hipoalfalipoproteinemia	Apo A1	Decreased HDL-C	Autosomal dominant inheritance and recessive	
Apo B100 deficiency	Apo B	Increased LDL-C	Autosomal dominant inheritance	1/700–1,000

Abbreviations: Apo, apolipoprotein; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, cholesterol total; TG, triglycerides; VLDL-C, very low-density lipoprotein cholesterol.

Lifestyle changes, including improved diet and increased physical activity, are the first therapeutic measures to be initiated in children with this type of dyslipidemia. Dietary hygienic measures are essential and will sometimes be the only therapeutic interventions needed. However, in monogenic familial hypercholesterolemia, following the dietary recommendations alone is insufficient for achieving the intended therapeutic objective.¹² The decrease in LDL-C levels is closely related to the type of genetic mutation. However, it is indisputable that improving diet before commencing pharmacological treatment, or as an adjuvant to it, is essential when indicated.¹³

Selective Screening

Screening strategies for dyslipidemia in clinical practice are either selective or universal. Selective screening is based on a family history of dyslipidemia or premature CVD, whereas universal screening is based only on age. Universal screening is not indicated for children younger than 9 years because of a lack of conclusive studies that support its use. However, the most recent NHLBI expert recommendations advocate universal screening at ages 9 to 11 years, and again at ages 17 to 21 years, as well as selective screening at other ages because, to a greater or lesser extent, risk factors track from preadolescence and adolescence to adulthood.¹⁴

Treatment of Hypercholesterolemia in Children

The management of children with hypercholesterolemia focuses mainly on lowering blood cholesterol concentration and reducing other cardiovascular risk factors to prevent CVD.¹⁵ Recommendations for healthy living habits should be the first goal. Healthy lifestyles and dietary habits that promote cardiovascular health are advocated, including dietary changes, increased physical activity, and eliminating the breathing of tobacco smoke.¹⁶ For optimal compliance, the whole family should be involved. Obese children with hypercholesterolemia benefit from weight loss involving restriction of any excess energy intake. In general, fat contributes most to caloric excess, but food and drinks containing high levels of carbohydrates can be a major source of excess energy in overweight children who undertake very limited physical activity. Balancing energy intake and expenditure to maintain a healthy body weight is important; this includes controlling foods to avoid weight gain or assist with weight loss, maintaining adequate levels of physical activity, and minimizing the time spent in sedentary behaviors. Although data in children are limited, increased physical activity and a reduction in sedentary behavior may improve fasting lipid profiles and may even reduce the risk of CVD.¹⁷ Furthermore, there is strong evidence that increased

physical activity has a positive influence on other cardiovascular risk factors, such as blood pressure and glucose levels. The NHBLI guidelines recommend moderate to vigorous activity for 1 hour/day, and taking part in a sport or activity that the child enjoys. For children aged 5 years and older, vigorous physical activity on at least 3 days per week is advised. In addition, total screen time, including the time spent watching television and playing videogames, should be restricted to 2 hours or less per day.¹⁸

Dietary Recommendations

The basis of the intervention for children with hypercholesterolemia is dietary modification.¹⁹ Dietary interventions are not recommended to children younger than 2 years because, in this age group, limiting fat and calorie intake can cause nutritional deficiencies. Therefore, if there are risk factors, screening for childhood hypercholesterolemia is advisable between the age of 2 years and the start of puberty. Treatment should achieve a lasting decrease in cholesterol levels, thereby reducing the risk of premature cardiovascular morbidity and mortality. The diet should be as varied as possible to ensure the nutritional needs of the child are met while supporting a good quality of life and the child's enjoyment of eating. The caloric intake should be sufficient for growth and the level of physical activity undertaken should be appropriate for preventing the child becoming overweight.²⁰

Effective dietary change requires continued counseling and practical training, and the child's family should be provided with rigorous information to enhance motivation. Dietary change is essential and should be part of a way to eat more healthily. The parents should be encouraged to adapt the recommendations to their personal and cultural preferences.

The aim of dietary treatment is to reduce plasma lipid concentrations from their initial levels. For children with a normal high-density lipoprotein cholesterol (HDL-C) level (>45 mg/dL), a targeted dietary modification is indicated when the LDL-C concentration exceeds 130 mg/dL. This should be supported by an initial dietetic approach that includes restricting total fat intake to 30% of the total daily calorie intake and saturated fat intake to $<10\%$, and limiting the daily cholesterol intake to 300 mg or less. Polyunsaturated fatty acids should provide up to 10% of daily calories, and the target should be that monounsaturated fatty acids provide 10 to 15%. Trans fats should be avoided completely as they have been shown to increase LDL-C and reduce HDL-C.²¹ Because the diet will be maintained over a long period, assessment of nutritional status plays an important role in the follow-up of children with hypercholesterolemia.

Reduced Fat Intake

In most individuals, the total fat intake and, more importantly, the fatty acid composition of dietary fat affect plasma lipid and lipoprotein concentrations.²² Dietary fatty acids differ in their effects on plasma lipids and lipoproteins because of differences in their chemical structure, especially whether the fatty acid chains include one or more double bonds between carbon atoms, and the locations of those bonds in the chain.

Reduced Percentage of Calories from Saturated Fat

Saturated fatty acids are those without any double bonds in the chain of carbon atoms. The dietary saturated long-chain fatty acids associated with the greatest increase in cholesterol levels are myristic acid from milk fat (with a chain length of 14 carbon atoms) and palmitic acid from palm oil (with a chain length of 16 carbon atoms). Both reduce LDL receptor activity, impair the rate of removal of LDL from circulation, and raise the plasma concentrations of TC, LDL-C, and, to some extent, HDL-C.²³ They should be restricted in any hypolipemic diet. Relatively short-chain fatty acids with 6 to 12 carbon atoms (such as caproic, caprylic, capric, and lauric acids) and stearic acid (with 18 carbon atoms), produce little or no change in plasma cholesterol concentrations.

In general, reducing saturated fat intake lowers both LDL-C and HDL-C. Because the absolute effect tends to be greater for LDL-C than for HDL-C, reducing saturated fat intake has a beneficial effect on the lipid profile. Palmitic, myristic, lauric, and stearic saturated fatty acids are found in animal fats (such as those in butter, sausages, and cream) and in some vegetable oils, such as coconut and palm oil; these are widely used in the industrial manufacture of pastries and confectionery and to enrich or improve the taste of foods.²⁴ Foods with these saturated fatty acids have a high level of atherogenic effects and should be avoided. The current recommendation is to limit saturated fat intake initially to $<10\%$ of total energy intake.

Reduced Intake of Trans Fatty Acids

Trans fatty acids are unsaturated fatty acids where the double bond of unsaturation has been modified such that the adjacent carbon atoms have a trans arrangement, rather than the usual cis arrangement. The most commonly found trans fatty acid is elaidic acid. These acids have hypercholesterolemic effects, increasing LDL-C and reducing HDL-C concentrations, with some studies also reporting an increase in lipoprotein (a) concentration.²⁵ Reducing the intake of trans fatty acids therefore lowers LDL-C with little or no effect on HDL-C or triglyceride levels.

Trans fatty acids are present in dairy fat and the meat from some ruminants due to the fermentation of intestinal microbiota. In addition, polyunsaturated fatty acids in some vegetable oils change their spatial arrangement when heated to a high temperature such as during frying or in the technological solidification processes used to convert vegetable oils from a liquid to a semisolid state through hydrogenation. Trans fatty acids have been used in foods to prevent oxidation and improve flavor. The recommendation is that trans fatty acid intake should not exceed 2% of total calories.²⁶ Adhering to the recommendation to reduce dietary sources of saturated fat (such as meat and dairy fat) will result in additional reductions in trans fatty acid intake.

Intake of Monounsaturated Fatty Acids

Monounsaturated fatty acids reduce TC and LDL-C concentrations while maintaining or increasing HDL-C. The main monounsaturated fatty acid is oleic acid, which is obtained from olive oil and nuts such as hazelnuts, almonds, and peanuts. Because of their greater resistance to oxidation,

these oils are recommended for use in frying. However, the partial hydrogenation of oleic acid produces the trans fatty acid, elaidic acid, with the negative consequences described earlier. More recently, it has been shown that the replacement of saturated fatty acids with monounsaturated fatty acids has a hypocholesterolemic effect while minimizing the decrease in HDL-C concentration.²⁷ In addition, a diet rich in monounsaturated fatty acids compared with polyunsaturated fatty acids reduces susceptibility to the oxidative modification of plasma LDL-C.²⁸ The current recommendations suggest that monounsaturated fatty acids intake (such as rapeseed and olive oils) should form 10 to 15% of the total dietary energy intake.

Intake of Polyunsaturated Fatty Acids

Polyunsaturated fatty acids have two or more double bonds in the carbon chain. They are classified as omega-3 or omega-6 polyunsaturated fatty acids according to the position in the chain of the first double bond.

In omega-3 fatty acids, the first double bond is at position 3 in the carbon chain. Linolenic acid is the precursor of the omega-3 series and is present in vegetable oils such as soybean, olive, and canola oils, and in some legumes. Linolenic acid derivatives include eicosapentaenoic and docosahexaenoic acids, which are found in the fat of blue fish such as tuna, salmon, mackerel, or sardine. They reduce triglyceride concentrations whereas LDL-C and HDL-C concentrations are either increased or unchanged.²⁹ In addition, they exhibit anti-inflammatory and antithrombotic effects. Conversely, several studies have shown small increases in lipoprotein oxidation or in plasma levels of lipid peroxides after taking fish oil supplements.³⁰ Because of this concern, consuming a large amount of dietary polyunsaturated fatty acids is not recommended because it could result in a lower plasma HDL-C concentration and may increase the oxidability of lipoproteins.

In omega-6 fatty acids, the first double bond is at position 6 in the carbon chain. Linoleic acid, the precursor of the omega-6 series, is of vegetable origin and is present in the oil of some seeds, soybeans, sunflowers, corn, and nuts. It forms arachidonic acid, which is a precursor of prostaglandin E2 and leukotrienes, which exhibit an inflammatory effect and platelet aggregation action.³¹ A diet rich in omega-6 fatty acids is associated with a decrease in HDL-C and LDL-C

production.³² These fatty acids are more susceptible to oxidation and are therefore more atherogenic than oleic acid. In consequence, it is recommended that the diet of hypercholesterolemic children should include only a moderate amount of polyunsaturated fatty acids (7–10% of total energy), mainly in the form of vegetable oils, such as corn and sunflower seed oils. In summary, the current recommendation for fat intake is to reduce the intake of saturated fat and replace it with unsaturated fats, especially monounsaturated fats, to reduce the risk of CVD. Common sources of saturated and unsaturated fats are summarized in ►Table 4.

Cholesterol

Because increased dietary cholesterol leads to increased plasma cholesterol and an increased risk for atherosclerosis,³³ the amount of dietary cholesterol should be restricted. Current recommendations restrict the intake of dietary cholesterol to 300 mg/day. Meeting this target requires the avoidance of foods that are naturally rich in cholesterol, including eggs, liver, kidneys, and seafood such as prawns. In general, foods rich in saturated fat are also rich in cholesterol.

Protein Quality

Protein should provide 10 to 8% of the total calorie intake, particularly proteins of high biological value from meat and fish, which provide essential amino acids. In addition to providing high-quality protein, milk and dairy products are also the main source of calcium, which has been reported to have cholesterol-lowering properties.³⁴ Dairy foods are complex, however, and recent evidence indicates that the dairy food matrix may be just as important as the individual components.³⁵ Furthermore, calcium from dairy products has been implicated in fecal fat excretion. The intake of vegetable proteins, especially those derived from legumes (such as soybeans and beans), produces better results than animal proteins in lowering cholesterol concentration, as observed in animal studies.³⁶ To avoid deficiency, the lack of methionine in legumes should be compensated for by combining legumes with foods that contain methionine, such as rice or potatoes.

Fibers

Dietary fiber consists of the endogenous components of plants that are resistant to digestion by the digestive enzymes. It is

Table 4 Food sources of fat

Fat			
Saturated	Trans	Monounsaturated	Polyunsaturated
<ul style="list-style-type: none"> • Cheese • Red meats • Poultry skin • Full fat dairy products • Butter • Margarine • Lard • Pastries • Cookies • Processed foods 	<ul style="list-style-type: none"> • Fried or processed foods • Doughnut • Cakes • Pie crusts • Biscuits • Frozen pizza • Cookies • Crackers • Margarine 	<ul style="list-style-type: none"> • Olive oil • Safflower oil (high oleic) • Sunflower oil • Peanut oil and butter • Canola oil • Sesame oil • Nuts • Avocado 	<ul style="list-style-type: none"> • Walnuts • Sunflower seeds • Flax seeds or flax oil • Fish (salmon, mackerel, herring, albacore tuna trout) • Corn oil • Soybean oil • Safflower oil

classified as either soluble or insoluble in water. Soluble fiber, including pectins, gums, mucilages, β -glucans, and some hemicelluloses, is fermented by the bacteria of the colon. Insoluble fiber (celluloses and lignins) undergoes partial fermentation in the colon. Multiple clinical and epidemiological studies have demonstrated the benefits of soluble fiber, including a reduction in cardiovascular risk. Dietary fiber supplementation may lower plasma TC and LDL-C concentrations. In particular, water-soluble non-cellulose pectin, gums and mucilages, and lignin may have specific lipid-lowering effects through increasing the excretion of bile salts.³⁷ The beneficial effects of dietary fiber for hypercholesterolemia and plasma lipids are extensive: the consumption of nuts rich in soluble fiber results in a decrease in LDL-C, and insoluble fiber is able to retain water and thus to increase the fecal bolus by regulating intestinal movements.

The recommendation for dietary fiber is an intake of approximately 80% insoluble fiber and 20% soluble fiber. Foods rich in insoluble fiber include wheat bran, legumes, vegetables, cereals, and ripe fruit. Foods rich in soluble fiber include oats, carrots, and plums. It is advisable to ensure a diet rich in fiber by replacing refined cereals with whole-grain cereals and increasing the consumption of vegetables, fruit, and nuts. For children, the recommended daily intake of fiber in grams can be calculated as the child's age in years plus 5.

Plant Sterols and Stanols, and Other Supplements

Plant sterols (phytosterols) are molecules chemically similar to cholesterol, which are poorly absorbed. They are extracted from soybean oil and incorporated into some foods such as yogurt, milk, and margarines. They inhibit the absorption of dietary cholesterol and reduce endogenous cholesterol by competing with cholesterol in its aggregation with bile acids to form micelles; thus, some cholesterol will not be absorbed and will be eliminated in the feces.³⁸

The efficacy of esters of plant sterols and stanols, when taken at or before meals, has been demonstrated, with large daily doses (2 g) resulting in a decrease of TC and LDL-C of 10 to 20%. Higher doses are not recommended, as they do not result in a greater effect but they may interfere with the absorption of fat-soluble vitamins. Ensuring an adequate fruit and vegetable intake can compensate for the potential reduction in the levels of these vitamins and carotenoids. Currently, the use of foods enriched with vegetable sterols/stanols is not recommended for children under 6 years of age because of these nutritional concerns.³⁹ However, vegetable sterols may lower triglyceride levels through the decreased secretion of very LDL-C by the liver, although there is no evidence for this. Thus, vegetable sterols can improve the cardiovascular profile by their action on both LDL-C and triglycerides, with an excellent safety profile.⁴⁰ They can be used in schoolchildren and adolescents.

Other nutrients and supplements such as cereals enriched with psyllium, garlic extract, or canola oil have been evaluated only in small studies of children with high cholesterol; it is therefore not possible to make a firm recommendation about the use of any of these for children and adolescents.

Dietary Patterns

Different dietary patterns have been advocated to be useful in adults with hypercholesterolemia. The Mediterranean Diet comprises a high intake of fruit (particularly fresh fruit), vegetables (especially root and green varieties), whole grains (cereals, breads, rice, and pasta), and fatty fish (rich in omega-3 fatty acids). In addition, it involves a lower consumption of red meat (with an emphasis on lean meat), the substitution of higher-fat dairy foods with lower-fat or fat-free varieties, and the use of oils (olive or canola oil), nuts (walnuts, almonds, or hazelnuts), or spreads blended with rapeseed or flaxseed oils in place of butter and other fats. The Mediterranean Diet tends to include only a moderate level of total fat (32–35% of total calories) and is relatively low in saturated fats (9–10% of total calories), high in fiber, and high in polyunsaturated fatty acids (particularly omega-3). This dietary pattern is particularly recommended for hypercholesterolemic children.⁴¹

Conflict of Interest

None.

References

- 1 Kavey RE, Daniels SR, Lauer RM, Atkins DL, Hayman LL, Taubert K; American Heart Association. American Heart Association guidelines for primary prevention of atherosclerotic cardiovascular disease beginning in childhood. *Circulation* 2003;107(11):1562–1566
- 2 Rafeian-Kopaei M, Setorki M, Douidi M, Baradaran A, Nasri H. Atherosclerosis: process, indicators, risk factors and new hopes. *Int J Prev Med* 2014;5(08):927–946
- 3 Piepoli MF, Hoes AW, Agewall S, et al; ESC Scientific Document Group. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J* 2016;37(29):2315–2381
- 4 Canas JA, Ross JL, Taboada MV, et al. A randomized, double blind, placebo-controlled pilot trial of the safety and efficacy of atorvastatin in children with elevated low-density lipoprotein cholesterol (LDL-C) and type 1 diabetes. *Pediatr Diabetes* 2015;16(02):79–89
- 5 Eckel RH, Jakicic JM, Ard JD, et al; American College of Cardiology/American Heart Association Task Force on Practice Guidelines. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2014;63(25 Pt B):2960–2984
- 6 Downs JR, O'Malley PG. Management of dyslipidemia for cardiovascular disease risk reduction: synopsis of the 2014 U.S. Department of Veterans Affairs and U.S. Department of Defense clinical practice guideline. *Ann Intern Med* 2015;163(04):291–297
- 7 Ramasamy I. Update on the molecular biology of dyslipidemias. *Clin Chim Acta* 2016;454:143–185
- 8 Wiegman A, Gidding SS, Watts GF, et al; European Atherosclerosis Society Consensus Panel. Familial hypercholesterolaemia in children and adolescents: gaining decades of life by optimizing detection and treatment. *Eur Heart J* 2015;36(36):2425–2437
- 9 Kathiresan S, Willer CJ, Peloso GM, et al. Common variants at 30 loci contribute to polygenic dyslipidemia. *Nat Genet* 2009;41(01):56–65

- 10 Braamskamp MJ, Hutten BA, Wiegman A, Kastelein JJ. Management of hypercholesterolemia in children. *Paediatr Drugs* 2014; 16(02):105–114
- 11 Lozano P, Henrikson NB, Morrison CC, et al. Lipid screening in childhood and adolescence for detection of multifactorial dyslipidemia: evidence report and systematic review for the US Preventive Services Task Force. *JAMA* 2016;316(06):634–644
- 12 Watts GF, Gidding S, Wierzbicki AS, et al; International FH Foundation. Integrated guidance on the care of familial hypercholesterolaemia from the International FH Foundation: executive summary. *J Atheroscler Thromb* 2014;21(04):368–374
- 13 Yoon JM. Dyslipidemia in children and adolescents: when and how to diagnose and treat? *Pediatr Gastroenterol Hepatol Nutr* 2014;17(02):85–92
- 14 Bibbins-Domingo K, Grossman DC, Curry SJ, et al; US Preventive Services Task Force. Screening for lipid disorders in children and adolescents: US Preventive Services Task Force Recommendation Statement. *JAMA* 2016;316(06):625–633
- 15 Koletzko B. Hypercholesterolemia. In: Koletzko B, Bhatia J, Bhutta ZA, Cooper P, Makrides M, Uauy R, eds. *Pediatric Nutrition in Practice*. 2nd ed. Basel: Karger; 2015:234–238
- 16 Kelly RB. Diet and exercise in the management of hyperlipidemia. *Am Fam Physician* 2010;81(09):1097–1102
- 17 Robledo JA, Siccardi LJ. Relationship between genetic and environmental factors and hypercholesterolemia in children [in Spanish]. *Arch Argent Pediatr* 2016;114(05):419–425
- 18 Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. *Pediatrics* 2011;128(Suppl 5):S213–S256
- 19 Moráis López A, Lama More RA, Dalmau Serra J. Comité de Nutrición de la AEP. Hypercholesterolemia: a therapeutic approach [in Spanish] *An Pediatr (Barc)* 2009;70:488–496
- 20 Soran H, Adam S, Mohammad JB, et al. Hypercholesterolaemia - practical information for non-specialists. *Arch Med Sci* 2018;14(01):1–21
- 21 Gidding SS, Dennison BA, Birch LL, et al; American Heart Association; American Academy of Pediatrics. Dietary recommendations for children and adolescents: a guide for practitioners: consensus statement from the American Heart Association. *Circulation* 2005;112(13):2061–2075
- 22 Hammad S, Pu S, Jones PJ. Current evidence supporting the link between dietary fatty acids and cardiovascular disease. *Lipids* 2016;51(05):507–517
- 23 Sun Y, Neelakantan N, Wu Y, Lote-Oke R, Pan A, van Dam RM. Palm oil consumption increases LDL cholesterol compared with vegetable oils low in saturated fat in a meta-analysis of clinical trials. *J Nutr* 2015;145(07):1549–1558
- 24 Rosa CdeO, Dos Santos CA, Leite JL, Caldas AP, Bressan J. Impact of nutrients and food components on dyslipidemias: what is the evidence? *Adv Nutr* 2015;6(06):703–711
- 25 Lichtenstein AH. Dietary trans fatty acids and cardiovascular disease risk: past and present. *Curr Atheroscler Rep* 2014;16(08):433
- 26 Hadj Ahmed S, Kharroubi W, Kaoubaa N, et al. Correlation of trans fatty acids with the severity of coronary artery disease lesions. *Lipids Health Dis* 2018;17(01):52
- 27 Hannon BA, Thompson SV, An R, Teran-Garcia M. Clinical outcomes of dietary replacement of saturated fatty acids with unsaturated fat sources in adults with overweight and obesity: a systematic review and meta-analysis of randomized control trials. *Ann Nutr Metab* 2017;71(1-2):107–117
- 28 Qian F, Korat AA, Malik V, Hu FB. Metabolic effects of monounsaturated fatty acid enriched diets compared with carbohydrate or polyunsaturated fatty acid-enriched diets in patients with type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. *Diabetes Care* 2016;39(08):1448–1457
- 29 Nestel P, Clifton P, Colquhoun D, et al. Indications for omega-3 long chain polyunsaturated fatty acid in the prevention and treatment of cardiovascular disease. *Heart Lung Circ* 2015;24(08):769–779
- 30 Mason RP, Sherratt SCR. Omega-3 fatty acid fish oil dietary supplements contain saturated fats and oxidized lipids that may interfere with their intended biological benefits. *Biochem Biophys Res Commun* 2017;483(01):425–429
- 31 Innes JK, Calder PC. Omega-6 fatty acids and inflammation. *Prostaglandins Leukot Essent Fatty Acids* 2018;132:41–48
- 32 Drouin-Chartier JP, Tremblay AJ, Lépine MC, Lemelin V, Lamarche B, Couture P. Substitution of dietary ω -6 polyunsaturated fatty acids for saturated fatty acids decreases LDL apolipoprotein B-100 production rate in men with dyslipidemia associated with insulin resistance: a randomized controlled trial. *Am J Clin Nutr* 2018; 107(01):26–34
- 33 Goldstein JL, Brown MS. A century of cholesterol and coronaries: from plaques to genes to statins. *Cell* 2015;161(01):161–172
- 34 Michaëlsson K, Melhus H, Warensjö Lemming E, Wolk A, Byberg L. Long term calcium intake and rates of all cause and cardiovascular mortality: community based prospective longitudinal cohort study. *BMJ* 2013;346:f228
- 35 Mariotti F, Valette M, Lopez C, et al. Casein compared with whey proteins affects the organization of dietary fat during digestion and attenuates the postprandial triglyceride response to a mixed high-fat meal in healthy, overweight men. *J Nutr* 2015;145(12): 2657–2664
- 36 Carbonaro M, Maselli P, Nucara A. Structural aspects of legume proteins and nutraceutical properties. *Food Res Int* 2015;76:19–30
- 37 Surampudi P, Enkhmaa B, Anuurad E, Berglund L. Lipid lowering with soluble dietary fiber. *Curr Atheroscler Rep* 2016;18(12):75
- 38 Castellanos-Jankiewicz A, Del Bosque-Plata L, Tejero ME. Combined effect of plant sterols and dietary fiber for the treatment of hypercholesterolemia. *Plant Foods Hum Nutr* 2014;69(02):93–100
- 39 Gylling H, Plat J, Turley S, et al; European Atherosclerosis Society Consensus Panel on Phytosterols. Plant sterols and plant stanols in the management of dyslipidaemia and prevention of cardiovascular disease. *Atherosclerosis* 2014;232(02):346–360
- 40 Cabral CE, Klein MRST. Phytosterols in the treatment of hypercholesterolemia and prevention of cardiovascular diseases. *Arq Bras Cardiol* 2017;109(05):475–482
- 41 Nordmann AJ, Suter-Zimmermann K, Bucher HC, et al. Meta-analysis comparing Mediterranean to low-fat diets for modification of cardiovascular risk factors. *Am J Med* 2011;124(09):841–51.e2