International Journal of Medical Science and Research
www.medicaljournals.in
Online ISSN: 2664-8768
Received: 07-03-2026, Accepted: 07-04-2026, Published: 22-04-2026
Volume 8, Issue 2, 2026, Page No. 11-13

Omega-3 Fatty Acids and Cardiovascular Health: Mechanisms and Clinical Benefits

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Abstract
Omega-3 fatty acids are essential polyunsaturated fatty acids widely recognized for their cardioprotective properties. The principal omega-3 fatty acids—alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA)—play crucial roles in maintaining cardiovascular health through multiple physiological mechanisms. These fatty acids help regulate lipid metabolism, reduce inflammation, improve endothelial function, decrease blood pressure, and prevent arrhythmias. Epidemiological studies have demonstrated that populations with higher omega-3 intake, particularly from marine sources, show reduced incidence of coronary heart disease and cardiovascular mortality. Clinical trials also suggest that omega-3 supplementation can lower triglyceride levels, reduce platelet aggregation, and improve vascular elasticity. In addition, omega-3 fatty acids modulate gene expression and influence cell membrane fluidity, contributing to improved cardiac function. Despite some variations in clinical outcomes, the overall evidence supports the beneficial role of omega-3 fatty acids in reducing cardiovascular risk. This review summarizes the mechanisms underlying the cardioprotective effects of omega-3 fatty acids and highlights their clinical benefits in preventing and managing cardiovascular diseases.

Keywords: Omega-3 fatty acids, cardiovascular disease, EPA, DHA, triglycerides, inflammation, endothelial function, heart health

Introduction

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality worldwide, accounting for a significant proportion of global deaths (Tewari *et al*., 2025) [23]. Risk factors such as dyslipidemia, hypertension, inflammation, obesity, and atherosclerosis contribute to the development of cardiovascular complications (Poznyak *et al*., 2022) [18]. Nutritional strategies have gained increasing importance in the prevention and management of cardiovascular diseases, and among these, omega-3 fatty acids have attracted considerable attention due to their cardioprotective effects (Lee and Lip, 2003) [13]. Omega-3 fatty acids are long-chain polyunsaturated fatty acids that cannot be synthesized efficiently in the human body and must be obtained through diet (Calder, 2014) [3]. The major omega-3 fatty acids include alpha-linolenic acid (ALA), mainly found in plant sources such as flaxseed, chia seeds, and walnuts, and the marine-derived fatty acids EPA and DHA, which are present in fatty fish such as salmon, sardines, and mackerel (Saidaiah *et al*., 2024) [21].

Omega-3 fatty acids exert beneficial effects on cardiovascular health through several mechanisms. They reduce serum triglyceride levels by decreasing hepatic very-low-density lipoprotein (VLDL) synthesis and enhancing fatty acid oxidation (Samanta *et al*., 2022) [22]. Additionally, omega-3 fatty acids exhibit anti-inflammatory properties by reducing pro-inflammatory cytokines and promoting the formation of specialized pro-resolving mediators such as resolvins and protectins (Biełach-Bazyluk *et al*., 2025) [2]. These mediators help control chronic inflammation associated with atherosclerosis. Omega-3 fatty acids also improve endothelial function by increasing nitric oxide production, leading to vasodilation and improved blood flow (Zehr and Walker, 2018) [26].

Another important mechanism is their anti-thrombotic effect. Omega-3 fatty acids reduce platelet aggregation and inhibit thromboxane A2 synthesis, thereby lowering the risk of clot formation (Adili *et al*., 2018) [1]. They also stabilize cardiac cell membranes, which may reduce the risk of arrhythmias and sudden cardiac death. Clinical studies have reported that omega-3 supplementation reduces triglyceride levels significantly, improves HDL cholesterol, and lowers blood pressure (Liu *et al*., 2023) [14]. Furthermore, omega-3 fatty acids may slow the progression of atherosclerosis by decreasing plaque formation and improving arterial compliance (Ververiotis *et al*., 2018) [24].

Several large-scale clinical trials and observational studies have supported the role of omega-3 fatty acids in cardiovascular protection (Rizos *et al*., 2012) [20]. Dietary intake of fish or omega-3 supplements has been associated with reduced risk of coronary artery disease, myocardial infarction, and stroke. Although some recent trials have shown mixed outcomes, particularly regarding low-dose supplementation, high-dose EPA-based therapies have demonstrated significant reductions in cardiovascular events in high-risk populations. Therefore, omega-3 fatty acids remain an important component of dietary strategies aimed at improving cardiovascular health (Elagizi *et al*., 2018) [9].

Clinical Benefits of Omega-3 Fatty Acids in Cardiovascular Health

Reduction in Triglyceride Levels: Omega-3 fatty acids significantly reduce triglyceride levels, particularly in individuals with hypertriglyceridemia. EPA and DHA decrease hepatic triglyceride synthesis and increase lipid clearance. Studies have reported that omega-3 supplementation can reduce triglycerides by 20–30%, which contributes to lower cardiovascular risk (Mozaffarian & Wu, 2011; Calder, 2017) [4, 17].

Anti-Inflammatory Effects: Omega-3 fatty acids reduce systemic inflammation by decreasing inflammatory markers such as C-reactive protein, interleukin-6, and tumor necrosis factor-alpha. Reduced inflammation helps slow the progression of atherosclerosis and improves vascular health (Calder, 2017; Kris-Etherton *et al*., 2002) [4, 12].

Blood Pressure Regulation: Omega-3 fatty acids have modest blood pressure-lowering effects. They improve arterial compliance and reduce vascular resistance, which contributes to improved blood pressure control. Regular intake of omega-3 fatty acids is associated with reduced risk of hypertension (Mozaffarian & Wu, 2011; Kris-Etherton *et al*., 2002) [12, 17].

Improvement in Lipid Profile: Omega-3 fatty acids help improve lipid profile by reducing triglycerides and slightly increasing high-density lipoprotein (HDL) cholesterol. Although their effect on low-density lipoprotein (LDL) cholesterol may vary, the overall impact supports cardiovascular protection (Mozaffarian & Wu, 2011) [17].

Anti-Thrombotic Properties: Omega-3 fatty acids reduce platelet aggregation and decrease clot formation. These effects help reduce the risk of thrombosis, myocardial infarction, and stroke (Kris-Etherton *et al*., 2002; Calder, 2017) [4, 12].

Prevention of Arrhythmias: Omega-3 fatty acids stabilize cardiac membranes and regulate ion channels. These actions help reduce the risk of arrhythmias and sudden cardiac death, particularly in patients with existing cardiovascular disease (Mozaffarian & Wu, 2011) [17].

Reduction in Atherosclerosis: Omega-3 fatty acids reduce plaque formation and improve endothelial function. They also decrease oxidative stress and vascular inflammation, which slows the progression of atherosclerosis (Calder, 2017; Kris-Etherton *et al*., 2002) [4, 12].

Dietary Sources of Omega-3 Fatty Acids: Omega-3 fatty acids are obtained from both plant and marine sources. Marine sources include fatty fish such as salmon, mackerel, sardines, tuna, and herring. Plant sources include flaxseeds, chia seeds, walnuts, soybean oil, and canola oil. Fish oil supplements and algal oil supplements are also commonly used to increase omega-3 intake (Mozaffarian & Wu, 2011) [17].

Recommended Intake: Health organizations recommend consuming fatty fish at least two times per week. For individuals with cardiovascular disease, omega-3 supplementation may be recommended under medical supervision. The typical recommended intake ranges from 250–500 mg/day of EPA and DHA for general health, while higher doses may be used for therapeutic purposes (Kris-Etherton *et al*., 2002; World Health Organization, 2023) [12, 25].

Table 1: Summary of Published Studies on Omega-3 Fatty Acids and Cardiovascular Health: Mechanisms and Clinical Benefits

Author(s) & Year	Study Type	Population/Model	Key Mechanism(s)	Major Findings	Conclusion
Chaddha *et al*., 2015 [5] (AHA)	Review	Human clinical data	Lipid metabolism, anti-thrombotic effect	Reduced triglycerides, increased HDL, decreased platelet aggregation	Omega-3 improves lipid profile and reduces CVD risk
Mozaffarian *et al*., 2011 [17]	Review	Human studies	Anti-arrhythmic, BP regulation	Lower heart rate, reduced blood pressure, improved cardiac efficiency.	Cardioprotective effects via multiple pathways
Innes & Calder, 2020 [10]	Review	Clinical & experimental	Anti-inflammatory, endothelial function	Reduced inflammation, improved vascular function.	Important for primary & secondary CVD prevention
Khan *et al*., 2021 [11]	Meta-analysis	RCTs	Lipid lowering, anti-inflammatory	Reduced cardiovascular mortality and improved outcomes.	Strong evidence for mortality reduction
Rawat *et al*., 2024 [19]	Systematic Review	Human studies	Cardiac function modulation	Reduced cardiac events, improved heart function (mixed consistency).	Benefits present but not always consistent
Malik *et al*., 2024 [15]	Review	Human & experimental	Anti-atherogenic, platelet modulation	Reduced platelet aggregation, improved lipid profile.	Prevents thrombosis and atherosclerosis
Mason *et al*., 2023 [16]	Review	Human studies	Triglyceride reduction	Lower triglycerides but inconsistent CV risk reduction.	Mechanistic benefit clear; outcomes variable
Covington, 2004 [7] (AAFP)	Clinical review	Human trials	Anti-arrhythmic, anti-inflammatory	Reduced sudden cardiac death and mortality.	Effective in secondary prevention of CHD
Chen *et al*., 2024 [6] (BMJ)	Cohort study	Human population	Non-lipid mechanisms	Cardiovascular benefits beyond triglyceride reduction.	Suggests additional protective pathways
Djuricic *et al*., 2025 [8]	Review	Human & molecular	Endothelial function, anti-inflammatory	Improved endothelial function and reduced hypertension.	Emerging mechanisms support cardio protection

Conclusion

Omega-3 fatty acids play a significant role in promoting cardiovascular health through multiple biological mechanisms, including reduction of triglycerides, anti-inflammatory effects, improved endothelial function, anti-thrombotic activity, and stabilization of cardiac rhythm. Both dietary intake and supplementation of omega-3 fatty acids have shown beneficial effects in reducing cardiovascular risk factors and preventing heart disease. While variability exists among clinical trials, the overall evidence supports the cardioprotective role of omega-3 fatty acids, particularly EPA and DHA from marine sources. Incorporating omega-3-rich foods such as fatty fish, flaxseeds, walnuts, and chia seeds into the daily diet can contribute to improved heart health. Further research is needed to determine optimal dosage, formulation, and long-term benefits; however, omega-3 fatty acids remain a valuable nutritional strategy for the prevention and management of cardiovascular diseases.

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