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SCIENTIFIC REVIEW: OMEGA-3s & IMMUNE HEALTH

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Omega-3s & Immune Health

The immune system plays a critical role in shielding the body while maintaining tissue homeostasis (balance). Nutrition is increasingly recognized as an important factor influencing immune function, and omega-3 fatty acids, particularly EPA and DHA from marine sources, including fish and microalgae, have attracted significant scientific interest due to their effects on healthy inflammation response, immune-cell function, and the production of specialized pro-resolving mediators (SPMs).^{1,5} This review summarizes current evidence regarding the role of omega-3 fatty acids in immune health.



Immune Function and Healthy Inflammation Response

The immune system shields the body while maintaining tissue homeostasis. It consists of innate and adaptive defense mechanisms that work together to recognize and eliminate harmful microorganisms, damaged cells, and other threats. Innate immunity provides a rapid first-line response, whereas adaptive immunity generates specific responses and long-term immunological memory through the actions of B- and T-cells.⁶

A healthy inflammatory response is a fundamental component of the immune system. When tissues are damaged or exposed to pathogens, the body initiates an inflammatory response characterized by increased blood flow, recruitment of immune cells, and production of signaling molecules that help eliminate harmful agents and promote healing. Once the threat has been resolved, inflammation must return to its healthy levels through a highly regulated process known as the resolution of inflammation, thereby restoring normal tissue function. Failure to adequately restore normal tissue function may result in chronic, low-grade inflammation.⁷⁻¹⁰

Mechanisms of EPA and DHA

As important structural components of cell membranes, EPA and DHA are incorporated into immune cell membranes, where they influence membrane organization, fluidity, cell signaling, gene expression, and the production of bioactive lipid mediators. Through these mechanisms, omega-3 fatty acids can affect both innate and adaptive immune responses. Studies have reported effects on several immune cell populations, including macrophages, neutrophils, B cells, and T cells, suggesting that omega-3 fatty acids may influence multiple aspects of immune function.^{2-5,11,12}

EPA and DHA also affect intracellular signaling pathways and gene expression. Research suggests that omega-3 fatty acids can modulate healthy inflammatory signaling by inhibiting activation of nuclear factor kappa B (NF- κ B), a key transcription factor involved in the production of pro-inflammatory mediators, while simultaneously influencing pathways involved in immune regulation and healthy inflammatory resolution.^{1,3-5} A key mechanism by which EPA and DHA influence immune function is through their conversion into

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SPMs, including resolvins, protectins, and maresins. These bioactive compounds actively coordinate the resolution of inflammation and support the restoration of tissue homeostasis after an immune response. Experimental and clinical research suggests that SPMs may contribute to immune regulation by modulating inflammatory signaling, cellular responses, and host defense mechanisms. As a result, the resolution of inflammation has become a major area of interest in omega-3 research.¹³⁻¹⁷

In addition, incorporation of EPA and DHA into cell membranes occurs partly at the expense of omega-6 fatty acids, particularly arachidonic acid. This shift influences the profile of lipid mediators produced during immune responses and generally favors the generation of less inflammatory and more pro-resolving mediators, thereby contributing to inflammatory homeostasis.^{2-4,9,10,16,17}

Omega-3s & Immune Health

Evidence Across Life Stages and Clinical Settings

Research indicates that omega-3 fatty acids influence diverse immune-cell functions, as well as cell membrane structure, cytokine production, cellular signaling, and adaptive immune responses. The emerging field of immunometabolism has further advanced this understanding by examining how metabolic processes interact with immune regulation.^{4,5,11,12,18}

Early life represents a particularly important period for immune development. During pregnancy and lactation, maternal intake of EPA and DHA influences the fatty-acid composition of breast milk and may affect immune-related outcomes in infants. Some studies and meta-analyses suggest that maternal omega-3 supplementation may reduce the risk of certain immune-related outcomes, particularly food allergy, whereas other reviews conclude that evidence remains inconsistent.¹⁹⁻²²

Emerging evidence also suggests a potential role for omega-3 fatty acids in supporting healthy immune aging, although further studies are needed to establish clinical relevance.^{1,18}

Clinical studies investigating omega-3 fatty acids have reported effects on inflammatory biomarkers, immune-cell activity, and recovery from physiological stress. However, findings are not always consistent. Differences between studies may reflect variations in dose, EPA:DHA composition, intervention duration, health status, age, baseline omega-3 status, and study design.^{1,4}

Current evidence, however, supports a role for omega-3 fatty acids in immune regulation and inflammation resolution, while highlighting the need for continued research in targeted populations and clinical conditions.

Intake, Sources and Practical Relevance

EPA and DHA are important dietary nutrients that are often consumed below recommended levels in many populations. Increasingly, researchers recognize that tissue or blood levels of EPA and DHA, often referred to as omega-3 status, may be as important as dietary intake when evaluating potential health effects.^{1,23,24}

EPA and DHA can be obtained from both fish-derived and algae-derived sources. Marine fish accumulate omega-3 fatty acids through the marine food web, ultimately originating from microalgae. Consequently, algae-derived oils provide a direct source of EPA and DHA. Evidence indicates that algae-derived omega-3 oils effectively increase omega-3 status and represent a scalable, non-marine-catch-dependent source of these physiologically important fatty acids. As the biological effects described in this review are linked to EPA and DHA themselves, both fish- and algae-derived omega-3 oils may contribute to supporting normal immune function and healthy inflammatory responses when consumed in appropriate amounts.^{1,25-28}

Increasing intake of EPA and DHA raises their levels in tissues and cell membranes, providing substrates for the production of bioactive lipid mediators involved in immune regulation.^{2-5,13-17}

Health authorities and scientific organizations typically recommend regular intake of EPA and DHA as part of a balanced diet. EPA and DHA have been extensively studied in both healthy individuals and clinical populations and are generally considered safe when consumed within established intake recommendations.^{4,23-25}

Assessment of omega-3 status may provide additional insight into an individual's exposure to EPA and DHA beyond dietary intake alone.^{1,23}



EPA and DHA themselves, both fish- and algae-derived omega-3 oils may contribute to supporting normal immune function.

Omega-3s & Immune Health

Summary of Current Evidence

Topic	Current Understanding	Strength of Evidence
Immune-cell membranes	EPA and DHA are incorporated into immune-cell membranes and influence signaling and mediator production ²⁻⁴	Established mechanism
Immune-cell function	Studies have reported effects on macrophages, neutrophils, B-cells and T-cells ^{4,5,11,12}	Moderate evidence
Specialized pro-resolving mediators (SPMs)	EPA and DHA are precursors to resolvins, protectins and maresins involved in healthy inflammation response ¹³⁻¹⁷	Strong mechanistic evidence
Early-life immunity	Maternal omega-3 status may influence breast milk DHA and selected immune-related outcomes ¹⁹⁻²²	Mixed, population-dependent
Healthy immune aging	Omega-3 fatty acids may support healthy immune aging ^{1,18}	Emerging evidence
Clinical immune outcomes	Effects on inflammatory biomarkers and selected clinical outcomes have been reported ¹	Promising
Dietary intake and sources	Fish oil and algae-derived oils are important and biologically relevant sources of EPA and DHA for supporting omega-3 status ^{1,24-28}	Well established

Conclusion

Omega-3 fatty acids, particularly EPA and DHA, play important roles in immune function through their effects on immune-cell membranes, cellular signaling pathways, and the production of bioactive lipid mediators. A growing body of evidence supports their involvement in the regulation and resolution of inflammation, which is essential for maintaining

tissue homeostasis and overall health. While research continues to refine our understanding of the clinical implications of omega-3 supplementation, current evidence supports a role for EPA and DHA in immune regulation and a healthy inflammatory response.

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