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Obesity-related inflammation: Nutritional modulators of adipose tissue function.

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Introduction

Adipose tissue was once considered a passive fat storage site but is now recognized as a dynamic endocrine organ that regulates systemic metabolism. In the context of obesity, adipose tissue undergoes significant structural and functional changes that lead to **chronic inflammation**, characterized by immune cell infiltration and cytokine overproduction.This inflammatory state is a key driver of **metabolic syndrome**, linking excess fat to cardiovascular and endocrine complications. However, nutritional strategies—especially those rich in anti-inflammatory components have shown promise in improving adipose tissue homeostasis and reducing disease risk [1].

In lean individuals, adipose tissue maintains metabolic balance by storing lipids, releasing adipokines (e.g., adiponectin), and regulating energy homeostasis. In obesity, this balance is disrupted due to this altered adipose microenvironment fuels systemic inflammation and impairs insulin signaling, contributing to insulin resistance and metabolic dysfunction.Nutritional Modulators of Adipose Tissue Function. Diet is a crucial environmental factor that can either aggravate or alleviate adipose tissue inflammation. Several nutrients and dietary patterns have been shown to directly influence adipose biology and immune activity. Found in fatty fish (e.g., salmon, sardines), omega-3 polyunsaturated fatty acids (PUFAs)—especially EPA and DHA—exhibit potent anti-inflammatory effects [2].

They reduce the expression of inflammatory genes in adipocytes.Promote a shift in macrophage phenotype from pro-inflammatory M1 to anti-inflammatory M2. Inhibit the activation of NF-κB, a key transcription factor in cytokine production. Supplementation with omega-3s has been shown to reduce markers of inflammation (e.g., CRP) in obese individuals. High-fiber diets, rich in fruits, vegetables, legumes, and whole grains, improve gut health and modulate systemic inflammation. Enhancing gut microbiota diversity rooting production of short-chain fatty acids (SCFAs) like butyrate. Improving gut barrier integrity and reducing endotoxin (LPS) translocation. These effects collectively reduce inflammation in adipose tissue and improve insulin sensitivity.Plant-derived compounds such as flavonoids, resveratrol, and curcumin have been shown to inhibit oxidative stress and inflammation [3].

Resveratrol suppresses inflammatory gene expression in adipocytes.Curcumin inhibits the JNK and NF-κB pathways. Green tea catechins reduce fat accumulation and adipocyte size in animal models. Regular intake of polyphenol-rich foods (berries, green tea, turmeric) can improve adipose tissue function and reduce pro-inflammatory cytokines. Vitamin D deficiency is common in obesity and has been linked to increased adipose inflammation. It suppresses pro-inflammatory cytokines in adipocytes. Enhances insulin receptor expression. May regulate adipogenesis and fat distribution. Restoring adequate vitamin D levels through diet or supplementation may help control inflammatory responses in adipose tissue. Reducing caloric intake, even without weight loss, has been shown to downregulate inflammatory markers. Intermittent fasting also alters adipokine profiles favorably and

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enhances autophagy in fat cells.Both methods improve metabolic outcomes and reduce adipose tissue inflammation by inducing metabolic flexibility and reducing oxidative stress.Dietary Patterns and Adipose Health [4].

Characterized by high consumption of fruits, vegetables, nuts, olive oil, and fish, the Mediterranean diet is consistently associated with lower inflammatory markers in obese individuals. Plant-Based Diet vegetarian and vegan diets, which emphasize whole plant foods, tend to be low in saturated fats and rich in fiber and antioxidants, contributing to reduced adipose inflammation. Western diet high in sugar, refined grains, and saturated fats, the Western diet promotes adipocyte hypertrophy, macrophage infiltration, and chronic inflammation [5].

Conclusion

Obesity-related inflammation originates in dysfunctional adipose tissue and underpins many chronic metabolic diseases. Nutritional interventions provide a **non-pharmacological, low-risk** approach to modulating adipose tissue function. Specific nutrients such as omega-3s, polyphenols, and fiber—as well as broader dietary patterns like the Mediterranean diet, have the potential to reduce inflammation, improve insulin sensitivity, and restore adipose homeostasis. Future research should continue to clarify the molecular mechanisms through which diet influences adipose immune activity and explore personalized nutrition strategies for effective prevention and management of obesity-related complications.

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