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The Evolution of Omega-3 to Omega-6 Ratios: From Ancestral Diets to Modern Imbalances.

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ABSTRACT

The balance between omega-3 and omega-6 fatty acids plays a crucial role in maintaining human health. Historically, ancestral diets provided a near-optimal omega-6 to omega-3 ratio of approximately 1:1 to 2:1, contributing to anti-inflammatory and cardioprotective effects. The rise of industrialization, modern diets, particularly in Western societies, has experienced a drastic shift, with ratios increasing to 15:1 or higher. This imbalance is largely driven by increased consumption of omega-6-rich vegetable oils and processed foods, coupled with decreased intake of omega-3 sources such as fatty fish, flaxseeds, and walnuts. A high omega-6 to omega-3 ratio is associated with elevated risks of chronic inflammation, cardiovascular diseases, obesity, metabolic syndrome, and cognitive decline. Comparative analysis with previous studies confirms the evolutionary and clinical significance of restoring a healthier balance. Interventions aimed at increasing omega-3 intake while reducing excessive omega-6 consumption are essential for mitigating these risks. Strategies include adopting dietary patterns similar to Mediterranean or traditional Asian diets, incorporating omega-3-rich foods, and minimizing the use of refined vegetable oils. Aligning modern nutrition with ancestral dietary ratios may offer an effective approach to enhancing long-term health outcomes and preventing non-communicable diseases. This review underscores the need for public health policies and individual dietary choices that support a balanced omega fatty acid profile..

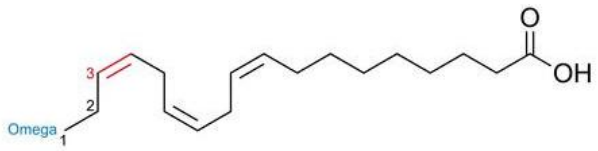
Keywords: *Omega-3 fatty acids, Omega-6 fatty acids, Inflammation, Dietary imbalance, Chronic disease prevention.*

INTRODUCTION

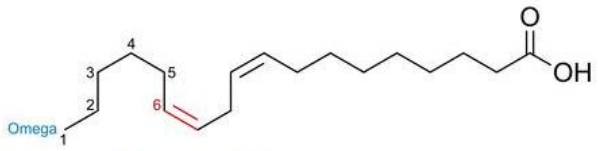
Omega fatty acids are essential polyunsaturated fats that play a crucial role in human health. Omega-3 and omega-6 fatty acids are the most significant, as they are vital for numerous physiological functions. These fatty acids must be obtained through diet since the human body cannot synthesize them. Understanding their biological roles and dietary sources is essential for maintaining optimal health. Omega-3 and omega-6 fatty acids belong to the class of polyunsaturated fatty acids (PUFAs). Their chemical structures are characterized by multiple double bonds, with the position of the first double bond from the methyl end defining their classification. Omega-3 fatty acids have the first double bond at the third carbon, while omega-6 fatty acids have it at the sixth carbon [1].Omega-3 fatty acids include alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). ALA, primarily found in plant sources like flaxseeds and walnuts, serves as a precursor for the synthesis of EPA and DHA, which are mainly found in marine sources [2].

Omega-6 fatty acids, such as linoleic acid (LA) and arachidonic acid (AA), are abundant in vegetable oils, nuts, and seeds [3]. Omega-3 fatty acids are well-known for their anti-inflammatory properties and their significant impact on cardiovascular and neurological health. EPA and DHA, in particular, play a crucial role in modulating inflammation by serving as precursors to specialized pro-resolving mediators (SPMs) such as resolvins and protectins [4]. Chronic inflammation is a key contributor to many diseases, including cardiovascular disease, arthritis, and neurodegenerative disorders. Omega-3 fatty acids help reduce inflammation by inhibiting the production of pro-inflammatory eicosanoids derived from omega-6 fatty acids. This action is particularly evident in diseases like rheumatoid arthritis, where omega-3 supplementation has been shown to reduce symptoms and disease activity [5]. Numerous studies have linked omega-3 intake with improved cardiovascular health. EPA and DHA contribute to heart health by lowering triglyceride levels, reducing blood pressure, and improving endothelial function. The American Heart Association (AHA) recommends regular consumption of fatty fish to maintain heart health due to its high omega-3 content [6].,..

Additionally, omega-3 fatty acids play a role in reducing the risk of atherosclerosis by decreasing platelet aggregation and vascular inflammation [7]. DHA is a critical component of neuronal membranes and is essential for cognitive function and brain development. Studies suggest that adequate DHA intake during pregnancy and early childhood enhances cognitive abilities and reduces the risk of neurodevelopmental disorders [8]. Furthermore, omega-3 fatty acids have been linked to a reduced risk of Alzheimer's disease and cognitive decline in aging populations [9]. While omega-6 fatty acids are often viewed in contrast to omega-3s, they also play essential roles in human physiology. Linoleic acid (LA), the primary dietary omega-6 fatty acid, is a precursor to arachidonic acid (AA), which contributes to various cellular processes. Omega-6 fatty acids serve as a significant energy source, especially in plant-based diets. LA is commonly found in vegetable oils such as soybean, corn, and sunflower oils, making it a predominant dietary fat in many populations [10]. These fatty acids contribute to overall caloric intake and support metabolic functions.

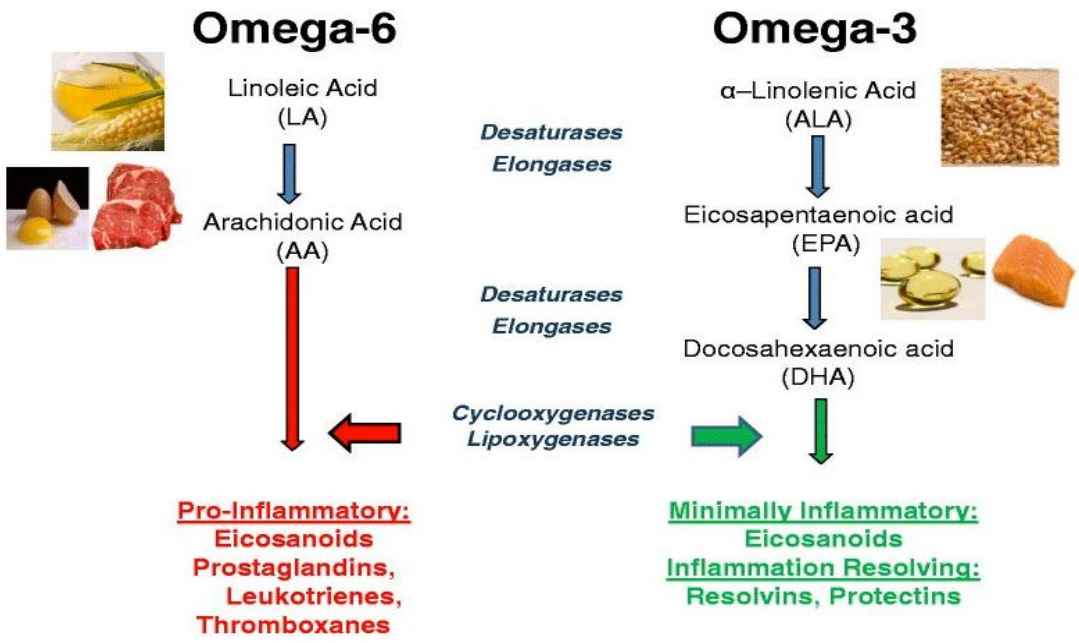


Omega-3 (Linolenic acid)



Omega-6 (Linoleic acid)

Arachidonic acid (AA), derived from LA, is a crucial component of cell membranes. It plays an essential role in maintaining membrane fluidity, which is vital for proper cellular signaling and function. Omega-6 fatty acids also participate in the synthesis of phospholipids, which are integral to cellular integrity [11]. Omega-6 fatty acids are precursors to eicosanoids, signaling molecules that regulate immune responses and inflammation. While AA-derived eicosanoids, such as prostaglandins and leukotrienes, contribute to inflammatory responses, they are also essential for wound healing and immune defense [12]. However, excessive omega-6 intake, particularly in relation to omega-3 intake, can promote chronic inflammation, which is associated with conditions such as obesity, cardiovascular disease, and metabolic syndrome [13].



2. The Historical Ratio of Omega-3 to Omega-6

2.1 Pre-Industrial Times: The Ideal Ratio

Before industrialized food processing, essential fatty acids were consumed in a well-balanced ratio. Historical evidence suggests that early human diets had an **Omega-3 to Omega-6 ratio of approximately 1:1 to 2:1**, supporting optimal health by regulating **inflammation, cardiovascular function, and cognitive processes** [14].

Natural Omega Balance (1:1 to 2:1) from Whole Foods: Traditional diets were rich in **wild game, fish, nuts, and seeds**, naturally keeping omega-6 intake lower while providing sufficient omega-3 fatty acids. The Industrial Revolution disrupted this balance, increasing omega-6 intake due to the widespread use of **vegetable oils and processed foods** [15].

Table 1: Estimated Omega-3 to Omega-6 Ratio in Pre-Industrial and Modern Diets

Diet Type	Omega-3:Omega-6 Ratio
Hunter-Gatherer	1:1 – 2:1
Mediterranean	1:2 – 1:4
Traditional Asian	1:3 – 1:6
Western Diet	1:15 – 1:20

2.2 The Role of Omega-3 and Omega-6 in Ancient Diets: Both **omega-3** and **omega-6** fatty acids are essential for health, but their balance is crucial: Omega-3 (α-linolenic acid, EPA, DHA): Anti-inflammatory, supports brain function, cardiovascular health. Omega-6 (Linoleic acid, Arachidonic acid): Pro-inflammatory in excess, necessary for immune response and skin health [16].

2.3 Primary Sources of Omega-3 and Omega-6

Ancient human diets consisted of **natural sources of both omega-3 and omega-6 fatty acids**. The primary sources of Omega-3 in ancient diets included fish, flaxseeds, walnuts, and chia seeds. Omega-6 was mainly derived from nuts, seeds, and unrefined plant oils. Ancient humans obtained omega-3 from fatty fish such as salmon, mackerel, and sardines, as well as plant-based sources like flaxseeds, chia seeds (rich in alpha-linolenic acid), and walnuts, which have a high omega-3 content. Meanwhile, omega-6 intake primarily came from nuts like almonds and walnuts, seeds such as sunflower and pumpkin, and less refined plant oils like cold-pressed olive oil[17].

3. Industrial Revolution and the Shift in Omega Ratios

3.1 Changes in Diet Post-Industrialization

The Industrial Revolution marked a significant shift in dietary patterns, particularly concerning the balance between omega-3 and omega-6 fatty acids. Before industrialization, diets were naturally rich in omega-3 due to the consumption of wild-caught fish, grass-fed animals, and unprocessed plant sources. The rise of agriculture and food processing industries, dietary habits changed drastically [18].

3.1.1 Increased Use of Vegetable Oils

With industrialization came the large-scale production of vegetable oils high in omega-6 fatty acids. Oils such as soybean, corn, and sunflower oil became dietary staples due to their affordability and long shelf life. As shown in Table 2, the global consumption of these oils increased significantly over the last century [19].

Table 2: Global consumption of these oils increased significantly over the last century

Vegetable Oil	Consumption (1900)	Consumption (2020)
Soybean Oil	0.02 million tons	57 million tons
Corn Oil	0.01 million tons	8 million tons
Sunflower Oil	0.005 million tons	18 million tons

3.1.2 Decrease in Omega-3-Rich Foods

Simultaneously, there was a decline in the consumption of omega-3-rich foods such as fatty fish, flaxseeds, and walnuts. Industrialized livestock production also played a role, as grain-fed animals contain lower omega-3 content compared to grass-fed counterparts [20].

3.2 The Shift in Omega-3 to Omega-6 Ratios

As a result of these dietary changes, the ratio of omega-6 to omega-3 in Western diets has increased dramatically. Historically, the ratio was approximately 1:1 to 2:1. However, modern diets now exhibit ratios between 15:1 and 20:1 [21].In the pre-industrial era, the Omega-6 to Omega-3 ratio was around 1:1 to 2:1. By the early 20th century, it increased to 4:1–6:1, while modern diets show a significantly higher ratio of 15:1–20:1.

3.3 Health Concerns Linked to High Omega-6 Intake

An imbalanced omega-6 to omega-3 ratio has been associated with numerous health concerns, including chronic inflammation, cardiovascular disease, and metabolic disorders [22].

Excessive omega-6 intake promotes pro-inflammatory pathways, which contribute to conditions such as:

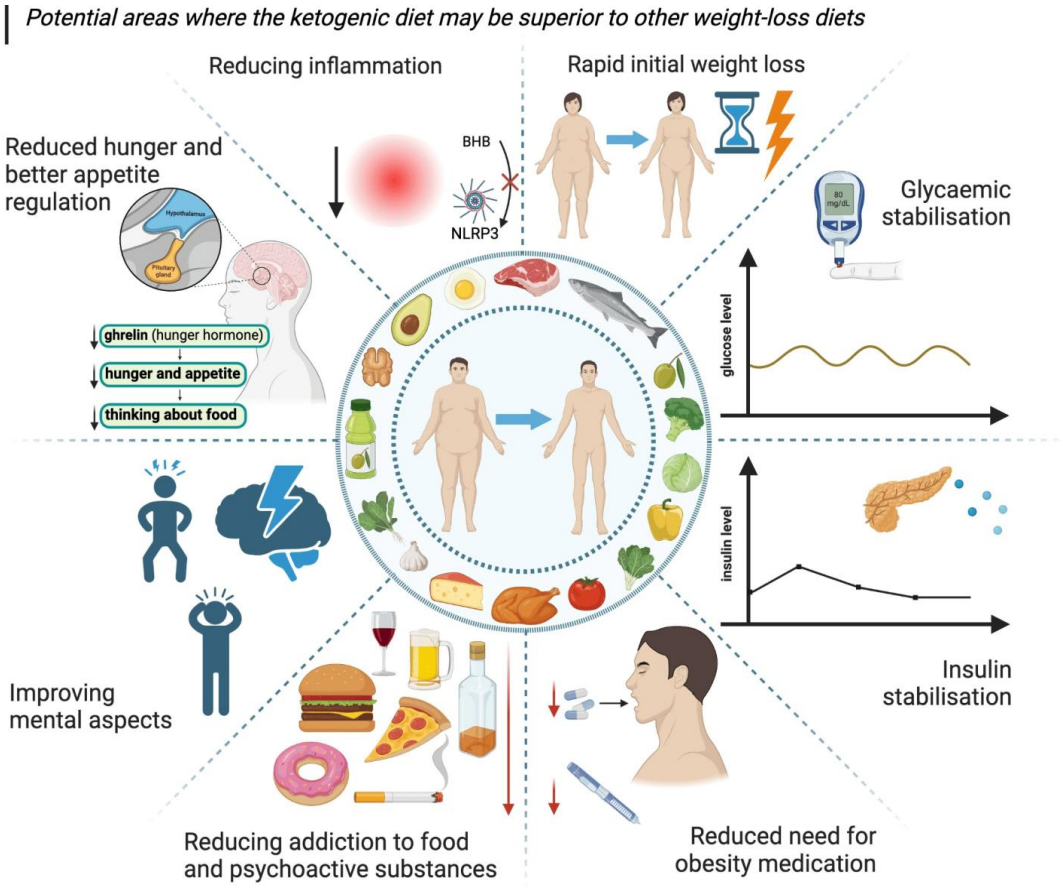
Cardiovascular disease (increased arterial inflammation and atherosclerosis risk)

Obesity and metabolic syndrome (due to altered lipid metabolism)

Neurodegenerative disorders (impairment of brain function and cognition)

Restoring dietary balance by increasing omega-3 intake and reducing excessive omega-6 consumption is crucial for preventing these health risks.

4. The Contemporary Omega Ratio and Health Implications



4.1 Current Trends in Omega-6 and Omega-3 Consumption

In modern diets, the ratio of **omega-6 to omega-3 has increased drastically**, reaching levels of **15:1 to 20:1** in Western diets, compared to the historically balanced **1:1 to 2:1** ratio [23]. The widespread consumption of processed foods, refined vegetable oils, and fast food has led to excessive omega-6 intake, while omega-3 consumption has declined significantly [24]. Different diets exhibit varying Omega-6 to Omega-3 ratios, with pre-industrial (1:1–2:1), Mediterranean (1:3–1:4), and

traditional Asian diets (1:3–1:6) maintaining a healthier balance. In contrast, the standard Western diet has a significantly higher ratio of 15:1–20:1.

Processed and Fried Foods: High in Omega-6

The overconsumption of **processed and fried foods** has become a major contributor to the high intake of omega-6 fatty acids. Vegetable oils such as **soybean, corn, sunflower, and safflower oil** commonly used in fast food and processed snacks contain high levels of omega-6 [25].

Omega-6 Content in Commonly Consumed Oils Vegetable oils vary in Omega-6 content, with safflower oil being the highest (70–75%), followed by sunflower (60–65%), corn (55–60%), and soybean oil (50–55%). In contrast, olive oil has a much lower Omega-6 content (8–20%).

Low Consumption of Omega-3-Rich Foods

While omega-6 consumption has skyrocketed, the intake of **omega-3-rich foods** such as **fatty fish, flaxseeds, and walnuts** has significantly declined. This has contributed to an imbalance that promotes inflammation and chronic diseases [26]. Decline in Omega-3 Intake Over Time: In the pre-industrial era, Omega-3 intake was around 3–4 g/day, decreasing to 2–3 g/day in the early 20th century. Present-day Western diets show a significantly lower intake of 0.1–0.5 g/day.

4.2 Health Risks of an Imbalanced Omega Ratio

An excessive **omega-6 to omega-3 ratio** has been linked to numerous health conditions. The imbalance promotes chronic inflammation, which is a root cause of various non-communicable diseases [27].

Table 3: Health Effects of High Omega-6 and Low Omega-3 Intake

Health Condition	Impact of High Omega-6	Impact of Low Omega-3
Cardiovascular Disease	Increases inflammation, raises LDL cholesterol	Reduces heart-protective EPA/DHA levels
Diabetes	Impairs insulin sensitivity	Decreases glucose metabolism efficiency
Obesity	Promotes fat accumulation and metabolic dysfunction	Reduces anti-inflammatory activity
Cognitive Decline	Increases neuroinflammation	Decreases brain DHA, leading to memory impairment
Autoimmune Diseases	Enhances inflammatory response	Reduces immune regulation

Excess Omega-6: Chronic Inflammation, Heart Disease, Diabetes

A high intake of omega-6 fatty acids—especially in the form of linoleic acid from vegetable oils—**promotes chronic inflammation**, increasing the risk of conditions such as:

Atherosclerosis and Heart Disease – Increased LDL oxidation and arterial inflammation.

Type 2 Diabetes – Impaired insulin signaling and metabolic dysfunction.

Obesity – Omega-6-induced fat accumulation.

Omega-3 Deficiency: Cognitive Decline, Cardiovascular Issues

A lack of **omega-3 fatty acids (EPA and DHA)** leads to several health problems, including:

Cognitive Decline – Essential for brain development and function; low levels associated with Alzheimer's and dementia.

Cardiovascular Diseases – Omega-3s reduce blood clotting, lower triglycerides, and decrease inflammation.

Mental Health Disorders – Omega-3 deficiency linked to depression and anxiety.

Table 4: Recommended Daily Omega-3 Intake for Health Benefits

Population Group	Recommended Omega-3 Intake (EPA + DHA)
General Adults	250-500 mg/day
Pregnant Women	300-600 mg/day
Cardiovascular Patients	1000 mg/day
Individuals with Cognitive Decline	1000-2000 mg/day

5. Restoring a Healthy Omega Ratio

5.1 Balancing the Ratio Through Diet

Modern diets have led to a drastic increase in the **omega-6 to omega-3 ratio**, reaching **15:1 to 20:1**, compared to the ideal **1:1 to 2:1** ratio [28]. Achieving a balanced ratio requires both **increasing omega-3 intake** and **reducing omega-6 consumption** through strategic dietary choices.To restore the omega ratio, increase omega-3 intake by consuming fatty fish, flaxseeds, walnuts, and chia seeds while reducing omega-6 intake by limiting processed vegetable oils, fried foods, and fast food. Additionally, opt for healthier oils like olive or avocado oil instead of soybean or corn oil, and consider fish oil or algae-based omega-3 supplements for added support.

5.2 Increasing Omega-3 Intake

Best Dietary Sources of Omega-3 Fatty Acids

Omega-3 fatty acids are essential for cardiovascular, brain, and overall health. The richest sources include:

Fatty Fish (salmon, mackerel, sardines, anchovies, herring)

Seeds & Nuts (flaxseeds, chia seeds, walnuts)

Algal Sources (seaweed, spirulina, algae-based omega-3 supplements)

Grass-fed Animal Products (grass-fed meat, eggs from pasture-raised chickens)

Mackerel (4.1 g), wild salmon (2.2 g), chia seeds (17.8 g), flaxseeds (22.8 g), walnuts (9.1 g), and grass-fed beef (0.9 g) are rich sources of omega-3 per 100g, with flaxseeds and chia seeds offering the highest content. Including these foods in the diet can help boost omega-3 intake and improve the omega ratio[29].

5.3 Reducing Omega-6 Intake

High Omega-6 Foods to Limit or Avoid

A major contributor to the omega-3/omega-6 imbalance is the excessive consumption of **refined vegetable oils and processed foods**.

Table 5: Omega-6 Content in Common Oils and Foods

Food/Oil Type	Omega-6 Content (% of total fat)
Soybean Oil	50-55%
Corn Oil	55-60%
Sunflower Oil	60-65%
Safflower Oil	70-75%
Fast Food Items	High due to fried oils

Steps to Reduce Omega-6 Intake

Replace high-omega-6 oils (e.g., soybean, corn) with **healthier options** like **olive oil, avocado oil, and coconut oil**.

Limit processed and fast foods, which are often fried in omega-6-rich oils.

Choose whole, unprocessed foods over packaged and convenience foods

The Importance of a Balanced Ratio

Maintaining a **1:1 to 2:1 omega-6 to omega-3 ratio** is essential for reducing inflammation and promoting overall health. The imbalance seen in modern diets contributes to numerous chronic conditions, including **heart disease, diabetes, obesity, and cognitive decline** [30].

Health Benefits of an Optimized Omega Ratio

Reduced Inflammation: Omega-3s lower inflammatory markers (CRP, IL-6).

Heart Disease Prevention: Omega-3s reduce triglycerides and improve HDL levels.

Brain Health: DHA supports cognitive function and mental well-being.

Metabolic Health: Enhances insulin sensitivity and reduces obesity risk.

Immune Function: A balanced ratio helps regulate immune responses.

Benefits of a 1:1 to 2:1 Ratio for Optimal Health

Achieving an **optimal omega-6 to omega-3 ratio** is associated with:

- ✅ Lower risk of cardiovascular disease
- ✅ Reduced inflammation-related disorders (arthritis, autoimmune diseases)
- ✅ Improved mental health and cognitive function
- ✅ Better weight management and metabolic balance

Reducing Chronic Disease Risks Through Dietary Adjustments

Long-term dietary adjustments can significantly **lower the risks of chronic diseases** by **reducing omega-6 and increasing omega-3 intake**.

Table 6: Impact of Omega Balance on Chronic Diseases

Condition	Effect of High Omega-6	Effect of Balanced Ratio
Cardiovascular Disease	Promotes arterial inflammation	Reduces LDL oxidation, improves heart health
Diabetes	Increases insulin resistance	Enhances glucose metabolism
Obesity	Increases fat storage, inflammation	Regulates metabolism, reduces obesity risk
Cognitive Decline	Promotes neuroinflammation	Protects brain function, reduces Alzheimer's risk
Arthritis & Inflammation	Exacerbates joint inflammation	Reduces pain and stiffness

DISCUSSION

The dramatic shift in the dietary omega-6 to omega-3 ratio over human history has significant implications for public health. Historically, ancestral diets provided these essential fatty acids in a balanced ratio of approximately 1:1 to 2:1, largely due to the consumption of wild game, fatty fish, and unprocessed plant sources. In contrast, the modern Western diet exhibits a highly skewed ratio ranging from 15:1 to 20:1, primarily due to the widespread consumption of omega-6-rich vegetable oils and the decline in omega-3-rich foods [31].

This shift aligns with the findings of Simopoulos (2002), who emphasized that evolutionary diets were rich in both omega-3 and omega-6 fatty acids in approximately equal proportions, contributing to optimal physiological function and low incidence of chronic diseases among early humans [32]. The imbalance in contemporary diets is primarily due to industrial food processing and agricultural practices that prioritize grain-fed livestock and processed oils, such as soybean, corn, and sunflower oils, all rich in linoleic acid (LA), an omega-6 fatty acid.

Several studies have highlighted the adverse health outcomes of an imbalanced omega ratio. A high intake of omega-6 fatty acids promotes the synthesis of pro-inflammatory eicosanoids derived from arachidonic acid (AA), which may aggravate inflammatory conditions such as atherosclerosis, rheumatoid arthritis, and neurodegenerative diseases [33]. On the contrary, omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), give rise to anti-inflammatory mediators such as resolvins and protectins, which are crucial in resolving inflammation and maintaining cellular homeostasis [34].

Calder (2015) demonstrated that marine omega-3 fatty acids reduce the production of pro-inflammatory cytokines and improve inflammatory markers in both healthy individuals and those with chronic inflammatory conditions [35]. This anti-inflammatory effect contrasts starkly with the outcomes of high omega-6 diets. For instance, Ailhaud et al. (2006) suggested that excessive omega-6 intake might contribute to increased adipogenesis and obesity through its influence on adipocyte differentiation and fat deposition [36].

Furthermore, cardiovascular risk is notably influenced by the omega fatty acid ratio. Kris-Etherton et al. (2002) and Harris et al. (2009) provided evidence that higher omega-3 intake is associated with lower triglyceride levels, reduced blood pressure, and decreased risk of cardiac events, while excessive omega-6 may elevate LDL oxidation and vascular inflammation, increasing cardiovascular risk [37]. These findings support current dietary guidelines that recommend regular intake of fatty fish and omega-3 supplements to improve lipid profiles and vascular health.

Cognitive health also reflects the consequences of this imbalance. DHA, the primary structural omega-3 fatty acid in the brain, is vital for neuronal membrane integrity and function. Lauritzen et al. (2001) and Cunnane et al. (2009) reported that lower dietary DHA intake is associated with neurodevelopmental issues in infants and increased risk of Alzheimer's disease in adults [38]. In contrast, high dietary omega-6 may disrupt membrane fluidity and neurotransmission, thereby impairing cognitive functions.

The current review confirms and expands upon these findings by illustrating the trajectory of dietary fatty acid intake from evolutionary diets to modern consumption patterns. It underscores how industrialization, while improving food availability, has inadvertently altered lipid nutrition, favoring omega-6 dominance at the expense of omega-3.

To address this imbalance, multiple strategies have been proposed in the literature and reaffirmed in this review. These include increasing the intake of omega-3-rich foods such as oily fish (salmon, sardines), flaxseeds, chia seeds, and walnuts, and simultaneously reducing consumption of omega-6-laden oils [39]. Substituting oils like soybean and sunflower oil with olive, avocado, or coconut oil can also help restore the optimal 1:1 to 2:1 ratio. Simopoulos (2002) strongly advocated for dietary reforms at both the individual and policy levels to reduce the burden of chronic diseases linked to fatty acid imbalance [40,41]. Moreover, the concept of nutrigenomics, as discussed by Calder (2011), offers a promising avenue for individualized dietary strategies based on genetic predispositions to metabolize and utilize omega fatty acids [42]. Future research should explore these personalized interventions and assess their efficacy in restoring fatty acid balance and mitigating disease progression.

CONCLUSION

The shift from balanced ancestral diets to modern omega-6-dominant patterns has significantly impacted human health. An optimal omega-6 to omega-3 ratio of 1:1 to 2:1 once supported anti-inflammatory and protective physiological functions. Today's typical ratio of 15:1 or higher contributes to chronic inflammation, cardiovascular diseases, obesity, and cognitive decline. Restoring this balance through increased omega-3 intake and reduced omega-6 consumption is crucial. Emphasizing whole foods, fatty fish, flaxseeds, and healthier oils while limiting processed foods and industrial vegetable oils can help achieve this. Aligning dietary practices with evolutionary needs offers a practical strategy to mitigate modern health challenges and promote long-term wellness..

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