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The Effects of Omega-3 Fatty Acids on Obesity-Related Chronic Inflammation and Metabolic Health

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Abstract. Obesity is widely recognized as a public health problem around the world. In the human body, it is not only shown by excessive accumulation of fat tissue, but is also closely related to a state of chronic low-grade inflammation. In recent years, studies have found that the abnormal function of fat tissue caused by obesity can promote the release of inflammatory factors, which can further lead to insulin resistance, abnormal lipid metabolism, and other metabolic problems. As a result, obesity and chronic inflammation can form a vicious cycle in which they continue to worsen each other. Omega-3 fatty acids, as essential unsaturated fatty acids, have the potential to regulate inflammatory responses and improve metabolic function. This paper uses a literature review to summarize the mechanisms behind obesity-related chronic inflammation and analyze the possible ways Omega-3 fatty acids may reduce inflammation and improve metabolic problems. Based on existing clinical trial results, this paper discusses whether Omega-3 can effectively improve obesity-related problems by reducing chronic inflammation, as well as whether it has a direct effect on weight loss. Research has found that Omega-3 fatty acids can improve the metabolic condition of people with obesity by lowering the levels of pro-inflammatory factors, improving the inflammatory environment of fat tissue, and increasing insulin sensitivity. However, current clinical evidence does not prove that Omega-3 has a significant direct effect on weight loss. Therefore, Omega-3 is more suitable as an additional nutritional intervention in obesity management rather than as a product directly used for fat loss.

Keywords: Omega-3, obesity, chronic inflammation, insulin resistance, metabolic disorders

1. Introduction

Obesity is currently one of the chronic metabolic diseases that receives global attention. Due to the presence of high-calorie diets and inactive lifestyles, the number of people who reach the obesity index continues to increase, which further raises the risk of developing diabetes, cardiovascular disease, and other metabolic diseases [1].

In recent years, more and more studies have started to explore the main causes behind obesity and have found that obesity is not only related to energy intake, but is also a state of fat accumulation accompanied by some chronic inflammatory metabolic diseases. When the fat tissue in the body remains overly expanded for a long time, fat cells become enlarged and attract a large number of

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immune cells into the fat tissue. These immune cells then release large amounts of pro-inflammatory factors, creating a vicious cycle that causes a continuous inflammatory environment in the body [2].

Chronic low-grade inflammation can also affect insulin signaling pathways, causing cells to become less sensitive to insulin and eventually leading to insulin resistance. At the same time, the inflammatory response can also affect fat metabolism and mitochondrial function, making abnormal fat accumulation more likely to occur. Therefore, obesity not only promotes inflammation, but inflammation can also further worsen obesity-related metabolic problems, creating a cycle between the two [3].

Omega-3 fatty acids are a type of unsaturated fatty acid that the human body cannot produce on its own. They mainly include EPA and DHA and usually come from deep-sea fish and fish oil supplements. In recent years, Omega-3 has received increasing attention because of its anti-inflammatory effects. Existing studies have shown that Omega-3 can regulate the production of inflammatory factors and reduce the development of inflammation [4].

Therefore, this paper mainly analyzes the chronic inflammation and metabolic problems caused by obesity, and then explores whether Omega-3 can reduce obesity-related metabolic abnormalities by improving inflammation. It also investigates whether Omega-3 can be used as a product for direct weight loss.

2. Health problems caused by obesity

2.1. The relationship between obesity and chronic low-grade inflammation

Obesity causes a large increase in fat tissue, but fat tissue is also an important organ with endocrine functions. When the body takes in too much energy for a long time, fat cells continue to expand, which can cause local problems such as a lack of oxygen inside the fat cells and increased cellular stress. These changes can promote the accumulation of immune cells in the fat tissue. Under obese conditions, these immune cells, such as macrophages, can gradually become pro-inflammatory and release inflammatory factors, such as TNF-α and IL-6 [5].

Importantly, these inflammatory factors can affect the function of fat cells and cause fat tissue to produce more inflammatory signals, which keeps the body in a state of chronic low-grade inflammation. This can affect the body's metabolic processes over a long period of time.

Therefore, obesity is not simply an increase in the amount of fat. It can also change the function of body tissues and become an important source of inflammation throughout the body.

2.2. Insulin resistance caused by obesity

Obesity can cause some metabolic problems, such as insulin resistance. When people eat food, insulin helps cells take in glucose, which helps keep blood sugar levels stable. However, under a long-term inflammatory environment, inflammatory factors can interfere with insulin signaling, causing cells to become less sensitive to insulin and respond less effectively. When insulin sensitivity decreases, the body needs to produce more insulin to keep blood sugar at a normal level, which can eventually lead to type 2 diabetes over time [6].

2.3. Various health problems and abnormalities caused by obesity

When the body is in an obese state, excess fat can enter some non-fat tissues, such as the liver, which can lead to abnormal fat accumulation.

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At the same time, chronic inflammation can affect mitochondrial function, causing cells to become less efficient at metabolism and making obesity even harder to improve.

Therefore, obesity-related problems are not just about an increase in body weight. They also include inflammation, abnormal insulin resistance, and many other diseases related to metabolic dysfunction.

3. Functions of Omega-3

3.1. The effects of Omega-3 on chronic low-grade inflammation

Omega-3 fatty acids mainly include eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are important polyunsaturated fatty acids for the human body. Since the human body cannot produce enough Omega-3 on its own, it is usually necessary to get the needed amount through additional nutritional supplements or other fish foods. In recent years, many studies have found that Omega-3 can help regulate immune responses and improve the inflammatory condition in the body [4].

Omega-3 can affect the production of inflammatory mediators by changing the ratio of fatty acids in the body. Under obese conditions, the body usually has higher levels of pro-inflammatory signals. When Omega-3 enters cell membranes, it can reduce the production of pro-inflammatory lipid mediators and promote the production of lipid molecules that have anti-inflammatory effects. For example, EPA and DHA can be converted into specialized pro-resolving mediators, such as resolvins and protectins. These substances can help regulate the activity of immune cells, allowing the inflammatory response to gradually improve and return to balance [7].

In addition, some experimental studies have found that taking Omega-3 supplements can lower the levels of inflammatory markers, such as TNF-α, IL-6, and CRP, which are important indicators of chronic inflammation related to obesity [8]. In contrast, in people with obesity, fat tissue remains in an inflammatory environment for a long time, which causes immune cells to stay activated. Omega-3 can help regulate the polarization of macrophages, reducing the proportion of pro-inflammatory M1 macrophages while promoting the formation of M2 macrophages, which have tissue-repair functions. In this way, Omega-3 can improve the inflammatory environment inside fat tissue [9].

Overall, Omega-3 does not improve obesity by directly reducing the amount of fat. Instead, it works by lowering inflammation and improving the internal environment of the body, which helps the body recover its normal metabolic functions.

3.2. How Omega-3 improves metabolic problems in obesity by reducing chronic inflammation

Lowering inflammation can be an important way to improve metabolic problems related to obesity because chronic inflammation has a major effect on these metabolic problems. Through its anti-inflammatory effects, Omega-3 can affect insulin sensitivity, lipid metabolism, and the regulation of fat cells.

First, Omega-3 can improve insulin resistance and reduce the effects of inflammatory factors on insulin sensitivity. In an obese state, inflammatory factors can interfere with insulin signaling, causing muscle and fat tissue to become less sensitive and less responsive to insulin. Omega-3 can reduce this interference with insulin signaling by lowering inflammatory factors such as TNF-α and IL-6 [10].

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Some studies have shown that people who take Omega-3 for a long time may have better insulin sensitivity and lower levels of inflammation in the body. However, the results of different studies are not always the same. This may be related to differences in the age of the participants, their level of obesity, the amount of Omega-3 they took, and the length of the intervention [11]. Therefore, the main value of Omega-3 in obesity management is to improve metabolic problems caused by obesity rather than to act as a direct fat-burning product.

4. Clinical studies on the effects of Omega-3

Although experimental studies have already shown that Omega-3 has anti-inflammatory and metabolic effects, its actual effects in people still need to be further tested through clinical studies. In recent years, several randomized controlled trials and meta-analysis studies have evaluated the effects of Omega-3 supplements on inflammatory markers, insulin sensitivity, and changes in body weight.

In terms of inflammation, several clinical studies have found that Omega-3 supplements can reduce some inflammation-related markers. For example, some people with obesity or metabolic problems showed a decrease in blood levels of CRP, IL-6, and other markers after taking Omega-3 supplements [12].

These results show that Omega-3 has some anti-inflammatory effects in people, and this effect may help improve the metabolic condition of people with obesity.

In terms of insulin sensitivity, some studies and experiments have found that Omega-3 can improve insulin-related measures, especially in people who already have metabolic problems. However, some clinical studies did not find this improvement, which shows that the effect of Omega-3 on insulin resistance may be affected by individual differences [13, 14].

For changes in body weight, the current research results are more limited. Most studies believe that Omega-3 does not have a stable or significant effect on weight loss [15]. This is because Omega-3 mainly improves the inflammatory environment and metabolic processes rather than directly affecting energy intake and energy expenditure. The basic way to lose weight is to change a person's diet and exercise habits. Therefore, simply increasing Omega-3 intake will not directly and significantly affect body weight.

Therefore, based on current clinical data, Omega-3 should be used more as an additional product for weight management. For example, while maintaining healthy habits, increasing Omega-3 intake may further help lower inflammation, improve metabolic health, and increase the overall effect of fat loss.

5. Conclusion

Obesity is not only a problem caused by excessive fat accumulation in the body. It is also a metabolic disease that is closely related to chronic low-grade inflammation. As fat tissue continues to increase, especially visceral fat, it attracts a large number of immune cells and causes the release of various pro-inflammatory substances, keeping the body in a low-level but long-lasting state of inflammation. This chronic inflammation not only affects the fat tissue itself but can also further lead to insulin resistance, abnormal blood lipid metabolism, and other metabolic problems. As a result, obesity and related metabolic diseases affect each other and gradually form a vicious cycle.

Omega-3 fatty acids have good anti-inflammatory effects. By regulating the release of inflammatory factors, promoting the reduction of inflammation, and improving the metabolic environment of fat tissue, Omega-3 can lower obesity-related chronic inflammation to some extent.

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At the same time, Omega-3 may also have some positive effects on insulin sensitivity and lipid metabolism, which can improve some metabolic problems related to obesity. Therefore, for people with obesity and related metabolic problems, Omega-3 has some value as an additional intervention.

However, current clinical studies still cannot prove that Omega-3 has a stable and direct effect on weight loss. Although some studies have found that Omega-3 may have certain effects on body fat percentage, lipid metabolism, and fat tissue function, its main effect is more focused on improving the body's metabolic environment and inflammatory state rather than directly causing a large reduction in body fat. Therefore, Omega-3 should not simply be considered a direct fat-loss product. Instead, it is more suitable as an additional intervention in obesity management. In the future, more long-term and large-scale clinical studies are still needed to further determine the best dosage of Omega-3 for different groups of people with obesity, its specific mechanisms, and its actual value in practice.

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