

Analysis of the Mediterranean Diet's Impact on Sarcopenia among Older Adults

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Abstract. Background: As the aging process in China continues to intensify, Sarcopenia has emerged as a critical public health issue that impacts the welfare of elderly individuals. Sarcopenia primary symptoms, which have a significant impact on older people's independence and quality of life, consist of deteriorated physical functions, decreased muscular mass, and decreased muscle strength. Current Situation: Currently, there are no specific drugs for treatment. Nutritional intervention has become one of the core measures of non-drug management. In recent years, the Mediterranean diet, as a dietary pattern that emphasizes natural foods, diverse nutrition, anti-inflammatory and antioxidant properties, has received extensive attention in the prevention and control of sarcopenia. This article focuses on six key nutritional components of the MD—olive oil, fish, whole grains, vegetables and fruits, dairy products, and moderate wine intake—to systematically review their effects on deteriorated physical functions, decreased muscular mass, and decreased muscle strength. Conclusions: Considering one consensus's analysis, one yearbook, two clinical guidelines, and ten meta-analyses and controlled trials, the findings suggest that the synergistic action of nutrients in the MD can reduce the risk of sarcopenia by improving inflammation, oxidative stress, and protein metabolism. Clarifying the dose-response connections of important nutrients will require future high-quality, long-term intervention research and explore their combined effects with exercise, providing theoretical support for the development of standardized non-pharmacological strategies against sarcopenia in older adults.

Keywords: Mediterranean diet, sarcopenia, elderly

1. Introduction

Muscle wasting syndrome, another name for sarcopenia, is a skeletal muscle disease marked by a progressive decrease of muscular mass, strength, and/or function with aging [1]. It is closely associated with aging, nutritional deficiency, sedentary lifestyle, and various chronic diseases. Sarcopenia may be as common as 46% in China, according to data from the China Health and Retirement Longitudinal Study (CHARLS) [2]. Rates among individuals 60 and older range from 12.0% to 30.7% [2-5], and among those over 80, rates increase to 50% to 60% [6]. With the deepening of population aging, the prevalence of sarcopenia has become increasingly concerning. Consensus [6,7] unanimously states that a reasonable dietary nutrition prescription and exercise

intervention can help improve the standardization and scientificity of non-pharmacological treatment for sarcopenia in the elderly, and early intervention is of significance for promoting healthy aging.

Due to the decline in physical functions, damage to the satiety nervous system, decreased taste or smell functions, and increased cellular factors in the elderly, their appetite decreases, and insufficient intake of nutrients can lead to many diseases, which is also a major cause of sarcopenia. Further worsening of the elderly's physical condition may also result from their declining muscle strength and condition [6]. Clinical research has confirmed that some nutrients and dietary patterns can reduce muscle loss, prevent muscle function decline, and delay the onset of sarcopenia [7]. Currently, there is no specific treatment for sarcopenia, and the main non-drug management methods are dietary nutrition and exercise [8]. The Mediterranean diet has gained recognition as a healthful eating pattern as nutritional therapy continues to advance. This diet, which mainly consists of olive oil and is supplemented with grains, dairy products and fish, has been gradually applied in dietary guidance for various diseases. Studies have shown that the MD pattern can reduce the risks of cardiovascular diseases, diabetes, and certain cancers, and has a positive effect on the prognosis of chronic diseases in the elderly [9]. In order to serve as a guide for the development of non-pharmacological management strategies for sarcopenia in individuals over 60, this study aims to investigate the impact of the Mediterranean diet pattern on sarcopenia in the elderly population.

2. The relationship between the MD and sarcopenia

Seniors who have sarcopenia, a prevalent chronic syndrome, exhibit a progressive decline in skeletal deterioration, physical functions, decreased muscular mass, and decreased muscle strength. Its pathogenesis involves multiple factors, including age-related hormonal decline, chronic inflammation, oxidative stress, neuromuscular degeneration, and inadequate nutritional intake, etc. [1]. Sarcopenia significantly increases the risks of falls, disability, hospitalization, and mortality, making it a key concern in the pursuit of healthy aging [4].

The MD is a dietary pattern based on the traditional diets of the Mediterranean coastal regions such as Greece, Italy, and southern Spain [10]. Its core features include using olive oil as the main source of fat; a high proportion of vegetable and fruit intake; a large amount of coarse-grain cereals, beans, nuts; moderate intake of dairy products, fish, and poultry; limited intake of red meat and processed foods; and regular consumption of moderate amounts of red wine [11]. A meta-analysis on different dietary patterns and the risk of sarcopenia found that the MD, anti-inflammatory diet, and high plant-based food intake pattern were significantly negatively correlated with the risk of sarcopenia (overall OR = 0.65, 95% CI: 0.54 - 0.77) [12]. Among them, the MD showed the most significant protective effect (OR = 0.53). Additionally, this study emphasized that key components in the diet, such as antioxidants, high-quality proteins, vitamin D, and omega-3 fatty acids, could reduce the risk of sarcopenia through mechanisms such as anti-inflammatory, reduction of oxidative stress, and promotion of muscle synthesis.

At present, there are numerous studies on the correlation between the MD pattern and sarcopenia. In general, the nutrients in the MD have a certain association with delaying the occurrence of sarcopenia and can reduce the incidence of sarcopenia. A systematic review indicates that adherence to the Mediterranean diet is negatively correlated with the risk of sarcopenia, which involves progressive loss of skeletal muscle. Multiple studies have applied the "MD score" (such as aMED, MEDAS), which scores based on the degree of conformity of an individual's dietary structure to the typical MD (generally ranging from 0 to 9), to quantify the diet pattern. The study found that for every 2-point increase in the MD score, the risk of sarcopenia or frailty decreases by approximately 20%-30%, indicating a dose-dependent protective effect [13]. In terms of intervention research, the

outcomes of a 24-week randomized controlled study with 80 senior sarcopenia patients revealed that the group that received a combination of the MD, resistance training, and aerobic exercise had significantly better maximum grip strength (HGS), 6-meter walking speed (UGS), short physical performance test score (SPPB), daily living ability score (ADL), and serum nutritional indicators (albumin, hemoglobin, 25-hydroxyvitamin D3) in contrast to the control group, which was given simply standard care. ($P < 0.05$). This experiment also confirmed that the MD can improve muscle metabolism and inflammatory environment by providing abundant high-quality protein, unsaturated fatty acids, and antioxidants, thereby enhancing muscle strength and functional levels [14].

However, there were also a few studies that did not observe a significant correlation. For instance, the individual study mentioned by Papadopoulou et al. did not show statistical significance between grip strength and MD, thus different assessment tools or research methods may affect the consistency of the results [9]. In a meta-analysis that included 7 observational studies, it was pointed out that when the dietary structure has high fat and high calorie characteristics, even if protein intake is adequate, the risk of sarcopenia may still increase [10]. A study based on the traditional "British diet" showed that although the total protein met the standard, the risk of sarcopenia in the subjects did not decrease after 3 years, suggesting that the combined effect of dietary quality and structure on muscle health is more crucial than a single nutrient [11]. Community-based surveys have also shown that greater dietary diversity is associated with lower sarcopenia risk. Specifically, consuming 12 or more food categories daily was significantly inversely associated with sarcopenia (OR = 0.916, 95% CI: 0.840–0.998) [4]. In summary, the MD pattern, with its rich nutritional composition and anti-inflammatory and antioxidant mechanisms, shows positive effects in reducing the risk of sarcopenia in the elderly, enhancing muscle strength and functional levels. It should be noted that the synergistic effect of multiple nutrients in the MD is more conducive to improving the muscle synthesis environment and enhancing the overall nutritional status.

3. The effects of the main nutrients in the MD on sarcopenia

The MD's effectiveness in preventing sarcopenia is largely attributed to its rich content of functional nutrients, which work in synergy across various physiological pathways such as antioxidation, anti-inflammation, and muscle protein synthesis [4]. Based on the current research evidence's validity and the targeting of sarcopenia intervention, the five most representative core nutrients in the MD are: The primary ingredients are olive oil, fish, cereals, vegetables, and fruits; dairy products should be consumed in moderation; and alcohol, saturated fats, and red meat should be consumed in moderation [7]. These nutrients respectively undertake different physiological regulatory functions and are of great significance for preventing the occurrence of sarcopenia.

3.1. Oil from olives

The main source of fat in the Mediterranean diet is extra-virgin olive oil, which is high in monounsaturated fatty acids (MUFAs) and a variety of antioxidative polyphenols such as hydroxytyrosol, oleic acid, and squalene. These make it a central lipid with both antioxidant and anti-inflammatory properties [9]. In a clinical observational study, older male participants in the high olive oil intake group demonstrated a significant decrease in low inflammatory indicators (like Interleukin-7) levels, a 28% decrease in the risk of falls (IRR: 0.72, 95% CI: 0.54 - 0.96), and a significant increase in muscle mass over a 5-year follow-up period [10]. Mechanistically, the hydroxytyrosol in olive oil can activate the AMPK and SIRT1 signaling pathways, thereby enhancing mitochondrial function and muscle cell metabolic activity, which helps maintain the

number and quality of muscle fibers [12]. Therefore, olive oil effectively inhibits the expression of inflammatory factors, reduces oxidative stress levels, decreases the production of inflammatory mediators, reduces apoptosis and protein breakdown of skeletal muscle cells, and thereby reduces the occurrence of sarcopenia.

3.2. Fish

The MD emphasizes consuming 2-3 servings of fish per week, especially fatty deep-sea fish (such as salmon, tuna, and mackerel), which are important sources of protein and omega-3 polyunsaturated fatty acids (PUFAs). The omega-3 fatty acids EPA and DHA not only have significant anti-inflammatory effects but also promote muscle protein synthesis. According to studies, By activating the muscle synthesis signal through the mTOR pathway, omega-3 fatty acids can stop protein breakdown, hence preventing the prevalent pathological condition known as "anabolic resistance" in the aged [13]. Elderly participants in a double-blind randomized controlled research who received a daily supplement of 1.5 g of DHA and 1.86 g of EPA for six months shown notable gains in deteriorated physical functions, decreased muscular mass, and decreased muscle strength when in contrast to the control group [12]. This helps to preserve the structural integrity of the skeletal muscles and metabolic function. High-quality proteins, vitamin D, and trace minerals like selenium are also abundant in fish. A cross-sectional cohort study in South Korea showed that the serum vitamin D content was negatively correlated with the occurrence of sarcopenia and could inhibit the expression of myostatin [13]. Therefore, fish are regarded as a dual guarantee of high-quality protein and omega-3 fatty acids.

3.3. Whole grains

These foods are rich in complex carbohydrates, dietary fiber, B vitamins, and trace elements like magnesium. Compared to refined grains, the low glycemic index characteristic of whole grains can prevent excessive insulin fluctuations and help maintain the endocrine environment necessary for long-term muscle synthesis [12]. Some cohort studies have found that the higher the intake of whole grains in the diet, the better the muscle mass is maintained. The mechanism may be related to reducing insulin resistance, regulating sugar and lipid metabolism, and maintaining the glycogen content in muscles [13]. In addition, the dietary fiber contained in whole grains can improve the structure of the intestinal flora, enhance the absorption efficiency of amino acids by the intestine, and indirectly promote the improvement of protein utilization in the elderly.

3.4. Fruits and vegetables

Vegetables and fruits are the main components of the MD. They not only provide the body with vitamins C,E, polyphenols and other antioxidants, but also improve the body's acid-base balance with their rich potassium, magnesium and other alkaline minerals, thereby reducing the rate of protein breakdown in skeletal muscles [6]. Elderly adults who regularly ate fruits and vegetables had a considerably lower chance of developing sarcopenia, based on a meta-analysis and comprehensive review that comprised 14 observational researches using a total sample size of 33,801 participants (summarized OR = 0.61, 95% CI: 0.48 - 0.79) [10]. The more fruits and vegetables consumed, the lesser the sarcopenia risk. Furthermore, the examination of several dietary patterns also showed that whether it was individual vegetables, individual fruits, or the MD pattern, all were linked to a decreased likelihood of developing sarcopenia [11]. B vitamins are cofactors in the process of

muscle synthesis and also neurotrophic agents involved in biological energy and nutrient pathways [15]. Vitamin C is an important antioxidant that can resist muscle damage caused by reactive oxygen [14]. Plant polyphenols can inhibit the generation of ROS, activate antioxidant pathways, reduce inflammatory damage and oxidative stress accumulation in muscle tissues, and protect muscle mitochondrial function. In addition, the intake of potassium, which is abundant in fruits and vegetables, can reduce the acid load of the kidneys, lower the negative nitrogen balance, and be beneficial for muscle protein preservation.

3.5. Dairy products

Dairy products are one of the components of the MD and can be consumed in moderation. By increasing muscle mass, dairy products can lower the incidence of sarcopenia, according to a meta-analysis of 11 research, muscle function, and physical function of middle-aged and elderly people [3]. Among dairy products, whey protein or casein is the main component [3]. A controlled study involving 60 middle-aged and elderly people with low bone mineral index, which included health education, supplementation of whey protein, and resistance exercise intervention, confirmed that whey protein can effectively increase the muscle mass of people with muscle loss. Whey protein contains abundant leucine [5], which can be metabolized into β -hydroxy- β -butyric acid methyl ester (HMB), activating the mTOR1 complex, thereby increasing protein synthesis and delaying sarcopenia [10]. In addition to containing a large amount of protein, dairy products also contain a large amount of calcium. Calcium interacts with calcium-binding proteins to affect the contraction function of muscles [12]. A cross-sectional study involving 386,283 participants showed that the occurrence of sarcopenia is closely related to calcium intake, and the more calcium is consumed, the lower the risk of sarcopenia [7].

3.6. Wine

The MD allows for the moderate consumption of red wine, and particularly emphasizes natural wines containing polyphenols such as resveratrol [3]. This compound can activate the SIRT1/PGC-1 α signaling pathway, thereby enhancing the generation of mitochondrial structures in skeletal muscles and their antioxidant capacity [8]. In animal experiments, resveratrol significantly delays muscle deterioration and improves exercise endurance and neuromuscular conduction functions. Although in population intervention studies, the direct evidence of the impact of moderate alcohol consumption on sarcopenia is not yet sufficient, Bertozzi et al. found that in groups with a high MD score, a moderate use of red wine was linked to a decreased risk of sarcopenia complications and frailty, indirectly indicating that the polyphenols in red wine have a positive regulatory effect in the overall anti-aging mechanism [15]. It should be emphasized that the intake of red wine should be strictly limited to no more than 150 mL per day to avoid the reverse effect caused by the burden of alcohol metabolism [11].

The above six major nutrients work together to form a stable nutritional metabolic network. Olive oil and fish jointly establish the anti-inflammatory lipid foundation, whole grains provide a continuous low-GI energy supply, fruits and vegetables provide antioxidant and acid-base regulation, dairy products increase protein synthesis, and red wine activates the mitochondrial repair pathway through polyphenols. This multi-channel and multi-mechanism combined defense structure can cover multiple key nodes of the occurrence and development of sarcopenia, including oxidative stress, protein synthesis resistance, energy metabolism imbalance, and muscle function decline, etc. Therefore, the MD, as a comprehensive dietary pattern with the core characteristics of naturalness,

diversity, and balanced structure, not only has a functional basis for preventing sarcopenia in the overall structure, but its various nutritional components jointly construct a systematic nutritional network to have a positive effect on the occurrence of sarcopenia in the elderly [15].

4. Conclusion

This article demonstrates through the analysis of the relationships between various nutrients in the MD and sarcopenia that this dietary pattern has a certain effect in preventing the occurrence of sarcopenia. The combined structure of olive oil, fish, whole grains, vegetables and fruits, dairy products, and a small amount of red wine in the MD model possesses multiple functions such as anti-inflammatory, antioxidant, and promoting protein synthesis. Multiple studies have confirmed that it can effectively improve the muscle mass, muscle strength, and physical function of the elderly, and help to delay or reduce the risk of sarcopenia. However, most current studies are of cross-sectional design and lack longitudinal studies for long-term follow-up, which limits the strength of causal inference. In the future to further understand how nutrients work in the MD, high-quality, suitably sized randomized controlled trials should be carried out and the synergistic relationship of exercise intervention, providing more reference basis for comprehensive non-pharmacological therapeutic methods for sarcopenia in the elderly.

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