



International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
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ARTICLE TITLE	DIET AND FRAILTY SYNDROME - WHAT DO WE KNOW? A LITERATURE REVIEW
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DOI	https://doi.org/10.31435/ijitss.3(51).2026.5830
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RECEIVED	18 June 2026
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ACCEPTED	22 September 2026
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PUBLISHED	25 September 2026
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DIET AND FRAILTY SYNDROME - WHAT DO WE KNOW? A LITERATURE REVIEW

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ABSTRACT

Introduction and purpose: Frailty syndrome is defined as a multidimensional degenerative process leading to a progressive loss of the body's homeostasis and a significant increase in susceptibility to health deterioration under the influence of even minor stressors (Arroyo-Huidobro et al., 2025). Due to the progressive aging of the population, this syndrome is becoming a growing demographic problem and one of the main challenges for modern public health and geriatric care. The aim of this study is to summarize the existing knowledge on the relationship between diet and the risk of frailty syndrome in older adults.

Materials and Methods: A narrative literature review was conducted using the PubMed, Scopus, and Web of Science databases. The analysis included observational and clinical studies as well as systematic reviews published up to 2025 that examined the association between the diet followed by older adults and their biological status, and consequently, the risk of frailty syndrome.

Results: It was demonstrated that strict adherence to the Mediterranean diet reduces the risk of frailty by 56% compared to a Western diet or an unhealthy plant-based diet (uPDI). Maintaining muscle mass in older adults, which has a protective effect against frailty syndrome, requires an increased protein intake (1.0–1.5 g/kg body weight/day) and reaching the leucine threshold (2.5–3.0 g per meal) to overcome anabolic resistance and stimulate muscle protein synthesis. Antioxidant supplementation supports the reduction of chronic inflammation—a component of the pathogenesis of frailty syndrome.

Conclusions: Optimizing dietary patterns and personalizing the daily intake of high-quality protein constitute a fundamental strategy for preventing the progression of frailty and sarcopenia in older adults.

KEYWORDS

Frailty Syndrome, Mediterranean Diet, Older Adults

CITATION

Piełuc, A., Brzózka, K., Ledwożyw, K., Krupska, A., Pyrka, Z., & Cionżyńska, W. (2026). Diet and frailty syndrome - what do we know? A literature review. *International Journal of Innovative Technologies in Social Science*, 3(51). [https://doi.org/10.31435/ijitss.3\(51\).2026.5830](https://doi.org/10.31435/ijitss.3(51).2026.5830)

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Introduction

Frailty syndrome is defined as a multidimensional degenerative process leading to a progressive loss of the body's homeostasis and a significant increase in susceptibility to health deterioration under the influence of even minor stressors (Arroyo-Huidobro et al., 2025). The type of diet recommended for and followed by the patient plays a key role in preventing the development of frailty syndrome and, when the patient is already affected, in alleviating its symptoms. This study analyzed recent research to consolidate and summarize existing knowledge on the association between the diet followed by older adults and the risk of developing frailty syndrome.

Research Objective

This study aims to conduct a comprehensive analysis of the current state of scientific knowledge regarding the impact of specific macro- and micronutrients, as well as overall dietary patterns, on the pathogenesis, progression, and potential for alleviating the symptoms of frailty syndrome in elderly patients.

Research Questions

The following research questions were formulated during the analysis.

To what extent does the Mediterranean diet model demonstrate an advantage over alternative dietary patterns (such as a plant-based diet or the Western diet) in terms of preventing frailty syndrome?

What role does not only total protein intake but also its diurnal distribution and source (animal vs. plant protein) play in maintaining muscle function?

Does supplementation with ingredients possessing antioxidant potential allow for a significant reduction in inflammatory biomarkers correlated with the occurrence of frailty syndrome?

Research Hypotheses

- The Mediterranean diet demonstrates greater clinical efficacy in preventing frailty syndrome than the Western diet and an unhealthy plant-based diet (uPDI).
- Increasing protein intake to 1.2–1.5 g/kg body weight per day and ensuring adequate leucine content in meals counteract anabolic resistance in the elderly.
- An adequate supply of antioxidants (e.g., curcumin) reduces levels of inflammatory biomarkers (IL-6, TNF- α), supporting the treatment of frailty syndrome.

Research materials and methods

Research materials and methods

The process of collecting research material was based on a systematic search of electronic databases: PubMed, Scopus, and Web of Science. The search strategy was formalized using precise keywords: “frailty,” “nutrition,” “Mediterranean diet,” “protein intake,” and “older adults.” Observational studies, clinical trials, and systematic reviews published up to and including 2025 were included in the final analysis, allowing for the inclusion of the latest scientific reports. The literature selection was a multi-stage process. First, titles and abstracts were analyzed for their relevance to the impact of macro- and micronutrients on the biological status of older adults and the risk of frailty syndrome. Next, a full-text review of the selected articles was conducted, with particular emphasis on the methodological quality of the studies, including the size of the study groups and the statistical models used. Data analysis was based on a qualitative and quantitative synthesis of results from large, multicenter epidemiological studies (e.g., PREDIMED-Plus, Seniors ENRICA-1) and prospective cohort studies, such as the Nurses’ Health Study. The comparative analysis incorporated validated dietary indices, such as the Mediterranean Diet Score (MDS), plant-based diet indices (hPDI, uPDI), and indices of dietary inflammation (DII) and redox balance (OBS scale). Regarding the assessment of protein metabolism, the analysis was expanded to include studies using advanced isotopic methods (e.g., Indicator Amino Acid Oxidation – IAAO), which allowed for the precise determination of amino acid requirements in individuals with sarcopenia and the establishment of physiological anabolic thresholds (e.g., the leucine threshold).

Table 1. Summary of studies examined in this paper, including their methodology, profile, and approximate quotations.

Study (Authors, Year)	Study type	Sample size and population	Intervention/ Factor Evaluated	Key findings in the context of the vulnerability syndrome
PREDIMED-Plus (Torrego-Ellacuría et al., 2025)	Multicenter clinical trial	Older adults with obesity and metabolic syndrome	Adherence to the Mediterranean diet (MD)	Strict adherence to the MD reduces the risk of weakness symptoms by nearly 52% (OR 0.479).
Nurses' Health Study (Sotos-Prieto et al., 2022)	Prospective cohort study	82,234 women (USA)	Assessment of the impact of a healthy (hPDI) and unhealthy (uPDI) plant-based diet	hPDI strongly reduces the risk of frailty (HR 0.77 for the highest quintile). An unhealthy plant-based diet (uPDI) increases the risk by 24%.
Seniors ENRICA-1 (Struijk et al., 2022)	Prospective cohort study	1,880 participants	Impact of plant-based diet indices (hPDI, uPDI)	Confirmation of the negative impact of a diet rich in processed plant-based foods on the risk of frailty.

Study (Authors, Year)	Study type	Sample size and population	Intervention/ Factor Evaluated	Key findings in the context of the vulnerability syndrome
DO-HEALTH (Gängler et al., 2022)	A multicenter observational study	2,157 adults (Europe, aged 70+)	Changes in the Mediterranean diet (MedDietScore scale)	A 5-point improvement in the diet score over 3 years of follow-up alone reduces the risk of developing <i>pre-frailty</i> by 23%.
Systematic reviews (Wang et al., 2018; Kojima, 2018)	Meta-analyses	Diverse populations (Asia, Europe, North America)	The impact of the Mediterranean diet depending on geographic region	The highest adherence to the diet (6–9 MDS) reduces the risk of frailty by 56%. Stronger protection was demonstrated in the West (RR 0.48) than in Asia (RR 1.06).
IAAO kinetic studies (Wu et al., 2025)	Quantitative isotopic studies	A small group of seniors diagnosed with sarcopenia	Assessment of actual amino acid requirements for muscle protein synthesis (MPS)	The Recommended Nutrient Intake (RNI) for this group is approximately 1.54 g/kg body weight/day, which significantly exceeds standard norms.
Protein distribution studies (Bouillanne et al., 2012)	Clinical study	Malnourished hospitalized seniors	"Pulse" vs. "Spread" protein distribution patterns	The "pulse" model (most of the daily protein intake in a single meal) proved more effective in improving the lean body mass index in malnourished individuals.

Statistical Software.

Data management and analysis were conducted using Microsoft Excel for data extraction and tabulation.

AI usage

It must be categorically noted that all AI technologies were used exclusively as auxiliary tools, subject to constant and strictly supervised by researchers. The final interpretation of data, classification of identified errors, and drawing of final conclusions remained the sole responsibility of human participants of this study. The role of artificial intelligence was limited to increasing data processing efficiency, pattern recognition, and linguistic optimization, without in any way replacing critical human judgment in the analytical process.

Statistical Methods

Given the nature of this work as a literature review, the present study draws on extensive epidemiological projects, cohort observations, and randomized clinical trials. In the included publications, researchers relied on a variety of statistical tools to verify the strength of the association between implemented dietary interventions and the incidence of frailty syndrome.

The PREDIMED-Plus, Nurses' Health Study, and Seniors ENRICA-1 (Dietary Patterns) studies assessed the impact of specific dietary patterns on the risk of frailty syndrome using multivariate regression models derived from large-scale studies such as PREDIMED-Plus, the Nurses' Health Study, and Seniors ENRICA-1. The effectiveness of interventions was reported using measures such as relative risk (RR), odds ratio (OR), and hazard ratio (HR). For example, the effectiveness of high adherence to the Mediterranean diet in patients with metabolic syndrome was reported as an OR of 0.479. Adherence to specific dietary patterns

was quantified in these studies using validated measures such as the Mediterranean Diet Score (MDS, scale 0–9), aMED, or plant-based diet indices (hPDI, uPDI), which were then analyzed by quintile or tertile, examining dose-dependent trends.

Studies of composite indices (DII and OBS) – publications based on composite indices assessing the biochemical profile of the diet were analyzed in a similar manner. The Oxidative Balance Score (OBS) was used for this purpose, with a cutoff threshold of >9.05 points, as well as the Dietary Inflammatory Index (DII).

A separate group consisted of studies assessing muscle protein synthesis (MPS) and anabolic resistance. These were based on quantitative isotopic methods, such as Indicator Amino Acid Oxidation (IAAO), used to determine the Estimated Average Requirement (EAR) and the Recommended Nutrient Intake (RNI) expressed in grams per kilogram of body weight per day (e.g., 1.54 g/kg bw/day for seniors with sarcopenia). These models also precisely determined physiological thresholds, such as the need to achieve a supply of 2.5–3.0 g of leucine in a single meal to activate the mTORC1 pathway.

Research results

Macronutrients with a special focus on protein

The choice of a dietary model is the foundation of preventive care in geriatrics. The Mediterranean diet (MD) has been positioned as a reference model for decades due to its unique combination of anti-inflammatory and antioxidant components (Capurso et al., 2020; Sofi et al., 2013; Rossi et al., 2025). However, contemporary scientific research compares the MD with alternative options, such as strictly plant-based diets (vegan, vegetarian) and the western dietary pattern prevalent in industrialized countries (Sotos-Prieto et al., 2022; Struijk et al., 2022; Morales-Brown, 2025). The superiority of the Mediterranean diet in reducing the risk of frailty has been confirmed in numerous meta-analyses. Adherence to the Mediterranean diet, assessed using the Mediterranean Diet Score (MDS) or aMED, correlates with a significant reduction in the likelihood of frailty (Wang et al., 2018; Kojima, 2018). According to data from a systematic review, individuals with the highest level of dietary adherence (MDS score of 6–9) have a 56% lower risk of developing frailty compared to those with the lowest adherence (MDS score of 0–3) (Wang et al., 2018; Kojima, 2018). It is important to note, however, that there are geographical differences: while in Western countries (Europe and North America) this protective effect is very strong (RR 0.48), studies of Asian populations have not shown such a clear association (RR 1.06), which may suggest the influence of genetic factors or the different composition of traditional Asian dishes (Wang et al., 2018). The mechanisms by which the Mediterranean diet slows the progression of biological aging include improvements in lipid profile, reduced insulin resistance, and blood pressure control, which directly translate to a lower risk of metabolic syndrome (MetS)—a condition strongly correlated with frailty (Torrego-Ellacuría et al., 2025; Bruna-Mejias et al., 2025). The PREDIMED-Plus study demonstrated that in older adults with MetS and obesity, adherence to the Mediterranean diet was associated with a nearly 52% lower risk of meeting frailty criteria (OR 0.479) (Torrego-Ellacuría et al., 2025).

Contrast between plant-based diets and the Western diet: hPDI vs. uPDI

In studies examining the impact of diet on senior health, plant-based diets are divided into subtypes: healthy (hPDI—healthful plant-based diet index) and unhealthy (uPDI—unhealthful plant-based diet index) (Sotos-Prieto et al., 2022; Struijk et al., 2022; Kahleova et al., 2025). This classification is based on the assumption that not every diet that excludes animal products is beneficial for maintaining physiological reserves (Sotos-Prieto et al., 2022). Results from the Nurses' Health Study cohort (82,234 women) and the Seniors ENRICA-1 cohort (1,880 participants) indicate dramatic differences in health outcomes depending on the quality of the plant-based diet followed (Sotos-Prieto et al., 2022; Struijk et al., 2022). A healthy plant-based diet, rich in whole grains, nuts, legumes, and fresh fruits, shows a strong inverse correlation with the risk of frailty (HR 0.77 for the highest quintile) (Sotos-Prieto et al., 2022). In contrast, the uPDI diet, characterized by high intake of refined carbohydrates, fruit juices, and sweetened beverages, is associated with a 24% increased risk of frailty (Sotos-Prieto et al., 2022).

Compared to a vegan diet, the Mediterranean diet appears to be more balanced in terms of preventing deficiencies in micronutrients critical for older adults, such as vitamin B12, vitamin D, and iodine (Morales-Brown, 2025). Although vegan diets may show an advantage in weight loss among overweight individuals (even when accounting for uPDI products), their potential for maintaining muscle mass in older age is

questionable due to lower leucine density and poorer digestibility of plant proteins (Kahleova et al., 2025; Physicians Committee, 2025; Reid-McCann et al., 2023).

The table below compares key parameters of the Mediterranean, plant-based, and Western diets in the context of preventing frailty.

Table 2. Key parameters of the Mediterranean, plant-based, and Western diets in the context of frailty prevention. Source: Author's own compilation based on

Characteristics of the dietary pattern	Mediterranean Diet (MD)	Healthy Plant-Based (hPDI)	Unhealthy Plant-Based (uPDI)	Western Diet
Main sources of protein	Fish, legumes, dairy, poultry	Legumes, nuts, tofu	No specific healthy sources	Red and processed meat
Dominant fats	MUFA (olive oil)	Vegetable oils, nuts	Trans fats, refined oils	Saturated fatty acids
Antioxidant content	Very high (polyphenols, vitamin E)	Very high	Low (processed juices)	Very low
Effect on frailty risk	30–56% reduction (Kojima, 2018)	15–23% reduction (Sotos-Prieto et al., 2022)	24–40% increase (Sotos-Prieto et al., 2022; Struijk et al., 2022)	Significant increase in risk (Struijk et al., 2022)
Effect on muscle mass	Protective (high amino acid profile)	Potentially protective	Adverse (risk of sarcopenia)	Negative (sarcopenic obesity)

(Wang et al., 2018; Sotos-Prieto et al., 2022; Struijk et al., 2022; Reid-McCann et al., 2025) A trend analysis in the DO-HEALTH study (2,157 adults over 70 years of age) showed that simply following a Mediterranean diet may not be sufficient if the quality of the diet does not improve over time. A 5-point increase in the MedDietScore over 3 years of follow-up was associated with a 23% reduction in the risk of developing pre-frailty, highlighting the dynamic nature of aging processes and the need for continuous optimization of nutrition (Gängler et al., 2022).

The Role of Protein in Maintaining Muscular Function: Intake, Sources, and Kinetics

Maintaining skeletal muscle mass and strength is a determining factor in preventing frailty. This process is regulated by a dynamic balance between muscle protein synthesis (MPS) and muscle protein breakdown (MPB). In older adults, a pathophysiological phenomenon known as anabolic resistance occurs, characterized by a reduced MPS response to standard amino acid intake and physical exercise (Paddon-Jones & Rasmussen, 2009; Kim et al., 2016; Tessier & Chevalier, 2018). Traditional recommendations for daily protein intake at 0.8 g/kg body weight per day are currently considered by expert panels (ESPEN, PROT-AGE) to be insufficient for the geriatric population (Tessier & Chevalier, 2018; Chevalier, 2025; Volkert et al., 2024). For healthy older adults, an intake of 1.0–1.2 g/kg body weight/day is recommended, whereas for those with diagnosed sarcopenia, frailty syndrome, or chronic diseases, this intake should be increased to 1.2–1.5 g/kg body weight/day (Chevalier, 2025; Heo & Yang, 2025). In acute conditions or severe malnutrition, doses of up to 2.0 g/kg body weight per day are permitted (Chevalier, 2025; Volkert et al., 2024). Kinetic studies using IAAO (Indicator Amino Acid Oxidation) technology specify these requirements even more precisely. In a small group of older adults with sarcopenia, it was shown that the Estimated Average Requirement (EAR) is 1.21 g/kg, and the Recommended Nutrient Intake (RNI) covering the needs of 97.5% of the population is 1.54 g/kg body weight per day (Wu et al., 2025). This represents a significant clash between theory and practice, as data from the NHANES study and studies of patients with type 2 diabetes show that actual protein intake often hovers around 0.9 g/kg body weight/day, placing most older adults in a state of chronic protein deficiency (Kim et al., 2016; Heo & Yang, 2025; Gatti et al., 2023). A key finding in the field of nutritional physiology is the role of leucine as a direct activator of the mTORC1 pathway in muscle cells (Katsanos et al., 2006; Verreijen et al., 2021; Lee et al., 2025). To initiate muscle protein synthesis in older adults, it is necessary to reach the so-called leucine threshold in a single meal, which is estimated at 2.5–3.0 g of pure leucine (Verreijen

et al., 2021; Verreijen et al., 2021). Lower doses of amino acids (e.g., 7.5 g of EAAs) do not elicit a significant anabolic response in older adults, whereas they are fully effective in young people (Paddon-Jones & Rasmussen, 2009). For this reason, dietary interventions should focus on providing 25–30 g of high-quality protein at each of the three main meals (Paddon-Jones & Rasmussen, 2009; Verreijen et al., 2021; Deer & Volpi, 2015). For example, 100 g of chicken breast provides approximately 1.96 g of leucine, meaning that consuming a typical serving of meat (approximately 150 g) is necessary to exceed the anabolic threshold (Verreijen et al., 2021).

Table. 3. Food product table showing macronutrients in grams per 100 grams. Source: Author's own work based on the literature

Food product (100 g)	Total protein (g)	Leucine (g)	Energy value (kcal)
Grana Padano cheese	33.9	2.82	406
Bresaola (a type of Italian cured meat)	32	2.65	152
Beef (leg)	22	1.89	111
Salmon	18.4	1.5	185
Eggs (whole, 2 pieces - approx. 100g)	12	1.2	140
Firm tofu	15	0.86	120
Cooked lentils	6.9	0.56	109

Distribution of daily intake: Spread vs. Pulse

There is some controversy regarding the optimal distribution of protein intake throughout the day. The "spread" model assumes an even distribution (e.g., 30g-30g-30g), which theoretically allows the anabolic threshold to be reached three times (Paddon-Jones & Rasmussen, 2009; Tessier & Chevalier, 2018; Deer & Volpi, 2015). In contrast, the "pulse" model involves consuming 70–80% of the daily protein intake in a single meal (usually lunch) (Tessier & Chevalier, 2018; Bouillanne et al., 2012; Dangin et al., 2003). Studies in older women suggest that pulsed protein intake may be more effective in overcoming anabolic resistance through high, transient blood amino acid concentrations, which saturate splanchnic sequestration and allow a greater amount of substrate to reach peripheral muscles (Bouillanne et al., 2012; Dangin et al., 2003). In one study, the "pulse" model (1.3 g protein/kg/day, with most consumed at noon) led to an improvement in the lean body mass index in malnourished hospitalized seniors, whereas the distributed model did not show such an effect (Bouillanne et al., 2012). Nevertheless, for healthy, active older adults, a balanced distribution remains the first-choice recommendation, as it better supports overall metabolic control and satiety (Deer & Volpi, 2015; Tieland et al., 2018). Animal proteins are traditionally considered superior due to their better digestibility and richer EAA profile, particularly leucine (Paddon-Jones & Rasmussen, 2009; Reid-McCann et al., 2025; Lim MT et al., 2025). Plant proteins (soy, wheat, peas) are characterized by a lower ability to stimulate MPS with the same amount of nitrogen (Reid-McCann et al., 2025; Lim MT et al., 2025). Whey protein has been shown to outperform soy protein in terms of stimulating MPS following resistance training (Lee et al., 2025). However, long-term observational studies indicate that a high intake of plant-based protein is associated with a significantly lower risk of frailty (RR 0.87), while animal protein showed a neutral or even slightly pro-frailty association in some cohorts (RR 1.07 in the Nurses' Health Study) (Huang et al., 2025; Ardisson Korat et al., 2022). The reason for this paradox may be that plant-based sources simultaneously provide anti-inflammatory compounds that reduce inflammaging—the main driver of frailty syndrome (Reid-McCann et al., 2025; Willett et al., 2021). A solution for seniors who prefer a plant-based diet is to use protein blends (e.g., rice + peas), technological processes that improve the digestibility of plant proteins, or simply increasing the portion size of the plant-based product to reach the leucine threshold (Volkert et al., 2024; Reid-McCann et al., 2025).

Supplementation regimens, dietary models, and their clinical value

The pathophysiological basis of frailty syndrome is chronic, low-grade inflammation, manifested by elevated levels of IL-6, TNF- α < 0.05, and CRP (Pan & Ma, 2024; Zhang et al., 2023). The IL-6 marker is a particularly strong predictor of 30-day and 1-year mortality in older patients (OR 1.75) (Wunderle et al., 2025). Supplementation interventions aim to reduce oxidative stress, which damages myocyte mitochondria and promotes tissue apoptosis (Pan & Ma, 2024; Monroy et al., 2025). Substances with the greatest documented potential for reducing inflammation include:

1. **Curcumin:** It has the ability to suppress the NF- κ B pathway, leading to a decrease in IL-6 and TNF- α (Monroy et al., 2025; Batsis et al., 2017). In clinical trials, a dose of 1000 mg/day was used to improve cognitive and physical function in at-risk seniors (Batsis et al., 2017; TrialX, 2025).

2. **Resveratrol:** Activates sirtuins and improves mitochondrial biogenesis. Despite promising results in animal models (improved muscle mass and strength), human studies are hampered by the compound's low bioavailability (Monroy et al., 2025).

3. **Quercetin:** Exhibits senolytic (removal of aging cells) and anti-inflammatory properties. Often studied in combination with curcumin for a synergistic anti-inflammatory effect in chronic conditions, e.g., in Long COVID syndrome among seniors (TrialX, 2025; Knepper, 2025).

4. **Selenium:** A key trace element that is a component of glutathione peroxidase. Meta-analyses indicate that selenium supplementation may lower CRP and IL-6 levels, with this effect being particularly pronounced with intravenous administration or in individuals with baseline deficiency (Kuria et al., 2023).

Instead of individual components, modern geriatric nutrition proposes composite indices. An example of such a tool is the OBS scale, which integrates antioxidant intake with pro-oxidant exposure.

1. OBS (Oxidative Balance Score) is an indicator assessing the body's overall redox balance resulting from diet and lifestyle. It typically includes approximately 16–20 variables, including:

2. Antioxidant factors: vitamins C and E, beta-carotene, selenium, zinc, copper, magnesium, and high fiber intake;

3. Pro-oxidative factors: high intake of iron, polyunsaturated fatty acids (PUFAs), as well as non-dietary factors such as smoking or a high BMI.

It has been shown that exceeding a threshold of 9.05 points on the OBS scale is associated with a sharp decrease in the risk of frailty (Wang et al., 2025). Similarly, a high DII (dietary inflammatory index) score, which is used to assess a diet's inflammatory potential. Its calculation takes into account up to 45 dietary parameters with a proven impact on markers of inflammation (e.g., CRP). Key variables include:

- pro-inflammatory components: energy, saturated fats, cholesterol, trans fats;
- anti-inflammatory components: fiber, vitamins A, C, D, E, B vitamins, magnesium, omega-3 fatty acids, as well as flavonoids and specific foods such as garlic, ginger, onions, and tea.

A positive score indicates a pro-inflammatory diet, while a negative score indicates an anti-inflammatory diet. A high DII score increases the risk of pre-frailty and frailty by approximately 50% (Shivappa et al., 2025). Magnesium is also an important factor, as higher intake is associated with lower levels of IL-6. Probiotics, in turn, show potential in reducing inflammatory cytokines, which may support the intestinal barrier in older adults and limit the translocation of bacterial endotoxins—another source of inflammaging (Noshadi et al., 2022).

The latest guidelines from ESPEN (European Society for Clinical Nutrition and Metabolism), a leading international scientific organization setting standards for clinical nutrition, place strong emphasis on personalized nutrition and early prehabilitation (ESPEN, 2025; ESPEN, 2024). Key recommendations include:

1. Energy intake: An average of 30 kcal/kg body weight/day, adjusted for activity level and inflammation (Volkert et al., 2024).

Early detection using the MNA-SF (Mini Nutritional Assessment - Short Form) is a validated screening tool (a shortened version of the full MNA test) designed for older adults. It consists of 6 questions regarding: decreased appetite, weight loss in the past 3 months, mobility, history of acute illnesses or psychological stress, neuropsychological problems, and BMI or calf circumference. It allows for rapid identification of malnutrition risk. An alternative is the FRAIL questionnaire used in primary care and during hospitalization (Volkert et al., 2024; Medycyna Praktyczna, 2021). The use of ONS (Oral Nutritional Supplements), i.e., high-protein oral nutritional supplements (so-called industrial/medical diets), often enriched with omega-3 fatty acids, has a positive impact on survival, including in oncology patients at risk of sarcopenia (Ryan et al., 2025; Delsoglio et al., 2025).

Table 4. Summary of recommendations for nutritional interventions at various stages of frailty syndrome.
Source: Author's own compilation based on the literature

Stage (according to Fried)	Goal of the intervention	Nutritional strategy	Recommended protein intake
Robust (0 criteria)	Primary prevention	MD or hPDI diet, regular activity	1.0–1.2 g/kg body weight
Pre-frail (1–2 criteria)	Reversal of deficiencies	MD, vitamin D supplementation, leucine in meals	1.2 g/kg body weight
Frail (3–5 criteria)	Stabilization, prevention of complications	High-protein diet, ONS, consider a "pulse" model	1.2–1.5 g/kg body weight
Severe Frailty / DRM	Treatment of malnutrition	ONS, enteral/parenteral nutrition (EN/PN), prehabilitation	1.5–2.0 g/kg body weight

DISCUSSION

This literature review confirms that nutritional interventions are a key, modifiable factor influencing the pathogenesis and progression of frailty syndrome in older adults. Analysis of the results indicates multidimensional links between diet quality, amino acid kinetics, and systemic inflammation, which collectively determine an older adult's physiological reserves and their ability to respond to external stressors.

Comparative analysis of dietary patterns

The dominance of the Mediterranean diet (MD) as a reference model in frailty prevention stems from its unique phytochemical profile. A 56% reduction in the risk of frailty among individuals adhering to the Mediterranean diet suggests that the synergistic action of polyphenols, MUFA fatty acids (found primarily in olive oil), and antioxidants outweighs the benefits of supplementation with individual components (Wang et al., 2018; Kojima, 2018). These components, found in foods such as leafy vegetables, nuts, and fatty fish, protect the endothelium of blood vessels and reduce oxidative stress at the cellular level, which directly translates to improved aerobic capacity and muscle strength.

An important observation, however, is the breakdown of plant-based diets into hPDI and uPDI models. The results point to a phenomenon known as the “vegetarian trap” among seniors. Eliminating animal products while simultaneously consuming high amounts of refined carbohydrates, fruit juices, and sweetened beverages (uPDI) drastically increases the risk of sarcopenia and weakness (by 24–40%). This is likely associated with low nutrient density, a high glycemic index that promotes insulin resistance, and an insufficient supply of essential amino acids necessary for tissue regeneration (Sotos-Prieto et al., 2022). In contrast, a healthy plant-based diet (hPDI) rich in fiber, legumes, and whole grains can support the gut microbiota, limiting the translocation of bacterial endotoxins, which provides an additional barrier against involutional processes and protects against so-called sarcopenic obesity.

Overcoming Anabolic Resistance

A key challenge in geriatrics is the phenomenon of anabolic resistance, which renders standard protein intake guidelines (0.8 g/kg) completely ineffective in stimulating muscle protein synthesis (MPS) in older adults. The debate over the “spread” vs. “pulse” model sheds new light on the nutritional strategy for hospitalized and malnourished patients. Although the model of uniform protein distribution supports satiety and stable metabolism in healthy individuals, the pulsed model (delivering ~80% of the daily protein intake in a single, large meal) appears to more effectively saturate *splanchnic* sequestration mechanisms.

This mechanism allows for the “overloading” of the liver and digestive system with amino acid substrates, enabling a greater amount of leucine to reach the systemic circulation and peripheral muscles, which is critical in individuals with advanced weakness (Bouillanne et al., 2012). It is important to emphasize the role of leucine as a direct molecular switch—without reaching a threshold of 2.5–3.0 g in a single meal, activation of the mTORC1 complex remains suppressed. This means that frequent but low-protein meals are ineffective from the perspective of preventing sarcopenia, and the lack of anabolic stimulation combined with a glycemic load may even accelerate muscle tissue degradation (Verreijen et al., 2021).

The "Inflammaging" Mechanism and Antioxidant Supplementation

The frailty syndrome is inextricably linked to a chronic, low-grade inflammatory state, referred to as *inflammaging*. The demonstrated efficacy of curcumin and selenium in reducing IL-6 and TNF-alpha levels suggests that targeted anti-inflammatory interventions may stabilize myocyte mitochondria and protect them from programmed cell death (apoptosis). An excess of pro-inflammatory cytokines leads to pathological degradation of muscle proteins through overactivity of the ubiquitin-proteasome pathway, which clinically manifests as a drastic decrease in walking speed and difficulties in performing activities of daily living (ADL).

The high correlation between the DII (Dietary Inflammatory Index) and the risk of frailty confirms that a pro-inflammatory diet, typical of the Western pattern (rich in saturated fatty acids, trans isomers, and highly processed foods), acts as an accelerator of biological aging. This leads to a condition in which, despite maintaining body weight, the body's physiological reserves are on the verge of depletion. This condition makes the patient extremely susceptible to complications following even minor stressors, such as a urinary tract infection or a short hospital stay, which in individuals with a high DII score often result in permanent loss of independence (Shivappa et al., 2025).

Clinical Implications

Personalizing energy intake (targeting 30 kcal/kg of body weight) and early supplementation with high-protein ONS-type formulations, particularly those enriched with omega-3 fatty acids and vitamin D, should become the standard of prehabilitation for individuals in the "pre-frail" stage. This approach not only improves the patient's prognosis and mobility but is also economically justified. Shorter hospital stays, fewer falls, and the prevention of complications resulting from immobility (e.g., pressure ulcers or pneumonia) significantly reduce the financial burden on budgets allocated for geriatric and long-term care (ESPEN, 2024; Volkert et al., 2024).

Limitations and Directions for Future Research

Despite strong evidence of the benefits of optimizing nutrition, most of the analyzed studies are observational in nature, which imposes limitations on drawing conclusions about direct causality. Differences in outcomes between Western and Asian populations suggest that the impact of diet may be significantly moderated by genetic factors (e.g., polymorphisms within magnesium or selenium metabolic pathways) and differing culinary traditions, which requires caution in uncritically transferring dietary models between regions of the world.

Future research directions should focus on long-term, randomized clinical trials evaluating the synergistic effects of personalized resistance training combined with targeted branched-chain amino acid (BCAA) supplementation. Another important area remains the study of the gut-muscle axis and the role of the microbiota as a mediator of the inflammatory response. Understanding how specific probiotic strains and prebiotics can reduce *inflammaging* may pave the way for a new generation of "nutraceutical" interventions that will allow for the effective reversal of the early stages of frailty and the preservation of autonomy in older adults (Noshadi et al., 2022).

Conclusions

A proper diet is a key factor in preventing frailty in older adults. The Mediterranean diet has been shown to be the most effective, reducing this risk by 56%, in contrast to the Western diet or unhealthy plant-based diets (uPDI), which significantly increase it. Due to the physiological phenomenon of anabolic resistance, standard protein intake is insufficient for seniors—they require an intake of 1.0–1.5 g/kg of body weight per day. To effectively stimulate muscle protein synthesis, it is also necessary to reach the so-called leucine threshold, i.e., to provide 2.5–3.0 g of this amino acid in a single meal. At the same time, chronic inflammation (*inflammaging*) should be combated through a diet with low inflammatory potential and antioxidants (e.g., curcumin or selenium).

Author Contributions: Conceptualization: A.P. and K.B.; methodology: K.B. and W.C.; check: K.B. and K.L.; formal analysis: A.K. and W.C.; investigation: A.P. and, Z.P.; data curation: A.P., K.L. and Z.P.; writing - rough preparation: A.P., A.K.; writing - review and editing: K.L. and W.C.; visualization: Z.P.; supervision: A.P.; project administration: A.P.

All authors have read and agreed with the published version of the manuscript.

Funding: The authors declare that this study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest: The authors declare no conflicts of interest.

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