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The Role of Nutrition in Managing Sarcopenia in Aging and Cancer

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Abstract
Purpose of the research:
This review aims to examine the role of nutrition and supplementation in the prevention and management of sarcopenia, particularly among the elderly and oncology patients. It explores how targeted dietary strategies can influence muscle mass, strength, and function.
Materials and methods:
The study is based on a review of the scientific literature, including clinical and experimental studies on nutritional interventions for sarcopenia in aging and cancer-related conditions.
Results:
Adequate protein intake, especially leucine-rich sources, alongside key nutrients such as vitamin D, omega-3 fatty acids, creatine, and antioxidants, has shown benefits in preserving muscle mass and improving physical function. In oncology patients, nutritional support is crucial to mitigate treatment-induced muscle loss and to improve therapy tolerance.
Conclusions:
Nutrition plays a vital role in mitigating sarcopenia and related complications in aging and cancer. Early screening and individualized nutritional strategies, combined with physical activity, offer a promising approach to improving patient resilience, treatment outcomes, and quality of life.

Keywords: nutrition, supplementation, sarcopenia, cachexia, elderly, oncology patients

Introduction

Sarcopenia is a progressive loss of muscle strength (dynapenia), mass, and function. The condition is often exacerbated by chronic comorbidities such as cardiovascular disease, chronic kidney disease, and cancer.

Originally introduced as a medical concept in the late 1980s, sarcopenia refers to the progressive loss of skeletal muscle mass and strength, primarily affecting older adults. However, subsequent research has highlighted that muscle function, rather than mass alone, is a more reliable predictor of negative outcomes.

The pathogenesis of sarcopenia is believed to involve multiple interrelated biological mechanisms, including nerve degeneration, impaired mitochondrial function, and alterations in inflammatory and hormonal signaling pathways. These changes contribute to a reduction in lean body mass and are associated with negative health consequences such as falls, decreased physical function, increased frailty, and elevated mortality risk.

Material and Methods

A comprehensive review of the literature was conducted using PubMed, Google Scholar. The review focused on studies exploring the role of nutrition and supplementation in the prevention and management of sarcopenia among elderly individuals and oncology patients. For the bibliographic search, the following keywords and their combinations were used: sarcopenia, nutrition, malnutrition, dietary strategies, supplementation, oncology, aging, and muscle health.

Pathophysiology and epidemiology

Sarcopenia affects up to 29% of older adults in community-dwelling settings and between 11–50% of individuals aged 80 years and older. Compared to individuals in their twenties, older adults experience a decline of approximately 25–30% in skeletal muscle mass and 30–40% in muscle strength. Moreover, after the age of 50, muscle mass typically decreases at an annual rate of 1–2%.

Aging disrupts skeletal muscle homeostasis by shifting the balance between muscle protein synthesis and degradation. This imbalance leads to a reduction in both the size and number of type II (fast-twitch) muscle fibers, accompanied by increased fat infiltration within and between muscle tissues. In addition, satellite cells, responsible for muscle repair and regeneration, decline in both number and function. Their regenerative capacity may be impaired by systemic factors such as transforming growth factor-β (TGF-β), myogenin, and components of the muscle stem cell niche. TGF-β, myostatin, and bone morphogenetic proteins (BMPs) are key signaling molecules regulating muscle tissue homeostasis.

Additional contributors to muscle atrophy include neuromuscular junction degradation, loss of motor units, chronic low-grade inflammation, insulin resistance, mitochondrial dysfunction, and oxidative stress. Denervation further exacerbates muscle degeneration by promoting the loss of type II fibers, which are frequently replaced by type I fibers and intramuscular fat [2,4].

Risk Factors

Although sarcopenia is commonly regarded as a physiological consequence of aging, its severity varies significantly depending on individual risk factors:

- **Lack of Physical Activity:** Muscle loss typically begins around the age of 50 and progresses more rapidly in sedentary individuals. Even trained athletes experience gradual declines in muscle mass and function with age.
- **Hormonal and Inflammatory Dysregulation:** Reduced levels of anabolic hormones such as testosterone and growth hormone, along with elevated concentrations of

inflammatory cytokines (e.g., TNF-α, IL-6), accelerate muscle catabolism and impair regeneration.

- **Impaired Protein Synthesis:** Aging decreases the efficiency of muscle protein synthesis, resulting in impaired muscle remodeling and the accumulation of dysfunctional proteins within muscle tissue.
- **Motor Unit Decline:** Age-related decline in motor units and neuromuscular junction integrity impairs satellite cell activation, thereby limiting muscle regeneration and functional capacity.
- **Evolutionary Mismatch:** An evolutionary mismatch between our genetic predisposition for physically demanding environments and today's sedentary lifestyles contributes to reduced muscle maintenance and adaptability.
- **Early Life Influences:** Suboptimal early growth, often reflected by low birth weight, has been associated with reduced muscle mass and strength in later life. [5]

In summary, while aging is the primary driver of sarcopenia, modifiable factors such as physical activity, diet, and hormonal balance significantly influence its progression.

Nutritional Interventions

Sarcopenia frequently coexists with malnutrition in older adults, and inadequate nutritional status is a major contributor to frailty development. Therefore, regular nutritional screening and early identification of malnutrition are essential in both community and clinical settings, including primary care and hospital environments.

Aging is often accompanied by a reduction in food intake, which contributes to weight loss and negatively affects muscle mass, strength, and overall physical performance. Although the role of adequate nutrition in older adults has been long recognized, research specifically linking dietary factors to muscle health and function has gained significant attention in recent years. Interventions range from general dietary support to targeted nutrient supplementation. The nutrients most consistently linked to improved muscle outcomes include protein, vitamin D, antioxidants (such as carotenoids, selenium, and vitamins E and C), and long-chain polyunsaturated fatty acids.

Older adults have increased protein requirements due to age-related metabolic changes, including reduced anabolic sensitivity and greater splanchnic amino acid extraction. This increased demand is further exacerbated by the "anorexia of aging"—a physiological decline in appetite and energy intake—which accelerates muscle wasting. Moreover, acute and chronic diseases induce systemic inflammation and catabolic stress, further raising protein requirements. Together, these factors contribute significantly to the onset and progression of sarcopenia [6, 7].

Protein and Amino Acids

Skeletal muscle accounts for approximately 40% of total body weight, stores 50%–75% of total body protein, and is responsible for 30%–50% of overall protein turnover. Dietary strategies incorporating high-quality protein may positively influence muscle aging biomarkers and delay sarcopenia onset.

Bovine whey protein, for instance, is highly digestible, provides all essential amino acids, and is rich in branched-chain amino acids (BCAAs) that activate the mTOR signaling pathway. It also contains numerous bioactive peptides. The main constituents of bovine whey include β-lactoglobulin (50–60%), α-lactalbumin (15–25%), bovine serum albumin (6%), lactoferrin (<3%), and immunoglobulins (<10%). It is available in various forms, liquid whey, whey protein concentrate, isolate, and hydrolysate, each differing in protein content and degree of hydrolysis [8].

Muscle protein synthesis is regulated by multiple anabolic factors, with physical activity and dietary intake playing major roles. A systematic review and meta-analysis demonstrated that leucine enhances muscle protein synthesis in older adults and may help counteract age-related muscle loss [9]. Among essential amino acids (EAAs), leucine is the most potent stimulator due to its capacity to activate the mTOR pathway and suppress proteasomal degradation. Older adults demonstrate a blunted anabolic response to lower EAA doses (<10 g), but larger doses (10–15 g, including ≥3 g leucine) can restore synthesis rates comparable to younger individuals. A daily leucine intake of at least 78.5 mg/kg is considered beneficial [10].

Accordingly, older adults should prioritize protein sources rich in EAAs and leucine, such as lean meat and leucine-dense plant foods including soybeans, peanuts, cowpeas, and lentils.

Emerging evidence suggests that intake above the current Recommended Dietary Allowance (RDA) of 0.8 g/kg/day may be required to maintain muscle health in older adults. A daily intake of 1.0–1.2 g/kg is commonly recommended for healthy older individuals, while those with acute or chronic illnesses may require 1.2–1.5 g/kg. In cases of severe illness or established malnutrition, needs may rise to 2.0 g/kg/day.

As for protein source, current evidence does not definitively favor animal- over plant-based proteins; however, animal proteins contain more EAAs and have greater digestibility. In contrast, plant proteins often undergo greater splanchnic extraction and urea conversion, potentially limiting their anabolic effect. Even when consumed in larger quantities, soy protein appears less effective than whey in stimulating muscle protein synthesis in older men, possibly due to higher oxidation rates. Moreover, meat provides additional bioactive compounds—such as creatine, carnitine, iron, and vitamin B12—that support muscle metabolism. Regular intake of lean meat (e.g., 4–5 servings per week) is recommended to help preserve muscle mass in older adults.

The form in which protein is consumed also influences its anabolic potential. Liquid protein sources (e.g., meal replacements) may result in higher plasma amino acid availability compared to solid foods with equivalent nutritional value, potentially enhancing muscle protein synthesis in older adults [11]. Overall, ensuring adequate intake of high-quality protein, especially rich in leucine, is critical for preserving muscle mass in older adults.

Vitamin D

Vitamin D deficiency represents a widespread global health concern, particularly among older adults. This fat-soluble vitamin plays a crucial regulatory role in multiple physiological systems, including the musculoskeletal system. An increasing body of evidence indicates that vitamin D supports skeletal muscle health by stimulating muscle fiber proliferation and differentiation, thereby enhancing strength and physical performance.

Age-related factors, such as decreased dietary intake and reduced skin exposure to ultraviolet radiation, contribute to the high prevalence of vitamin D deficiency in this population. Consequently, older adults with suboptimal vitamin D levels face a heightened risk of developing sarcopenia.

Vitamin D acts on muscle tissue primarily by binding to the vitamin D receptor (VDR) expressed on muscle fibers, promoting fiber hypertrophy and improving functional outcomes. However, aging is associated with a decline in VDR expression in muscle tissue, which reduces responsiveness to vitamin D and contributes to muscle atrophy.

Numerous studies demonstrate a positive correlation between serum 25-hydroxyvitamin D [25(OH)D] concentrations and muscle function. Levels below 30 ng/mL (75 nmol/L) are considered insufficient, and those below 20 ng/mL (50 nmol/L) are classified as deficient. For example, Okuno et al. reported that 89% of elderly Japanese women (aged >65 years) had insufficient vitamin D status, with 28% showing deficiency. Among those with inadequate levels, over half experienced falls within a three-month period.

A meta-analysis of five randomized controlled trials evaluating the impact of vitamin D supplementation (800 IU/day or 20 μg/day) in older adults revealed a 22% reduction in fall risk compared to calcium alone or placebo. Furthermore, supplementation at 20 μg/day significantly reduced fracture incidence compared to lower doses (10 μg/day or 400 IU/day). These findings underscore the protective effect of adequate vitamin D levels in preserving musculoskeletal integrity and reducing sarcopenia risk.

The age-related decline in serum 25(OH)D levels is further exacerbated by physiological changes. These include increased expression of CYP24A1 (an enzyme responsible for deactivating 1,25-dihydroxyvitamin D), diminished cutaneous synthesis due to reduced sun exposure, and a decline in renal production of active vitamin D metabolites.

Vitamin D deficiency is also commonly observed in individuals with sarcopenic obesity, a condition characterized by low muscle mass coexisting with increased fat mass. This may be partly explained by the inverse relationship between serum 25(OH)D concentrations and body fat. Additionally, vitamin D inhibits the differentiation of preadipocytes into adipocytes; thus, low levels may promote fat accumulation and contribute to obesity.

Interventional studies show that vitamin D supplementation can significantly improve muscle strength, particularly in individuals with deficient baseline levels. In one study, elderly women receiving 100 μg/day (4000 IU/day) of vitamin D for four months showed a 30% increase in muscle nuclear VDR content and a 10% enlargement in muscle fiber size. Maintaining serum 25(OH)D concentrations within the optimal range of 50–75 nmol/L is therefore critical for preserving peripheral muscle strength and promoting anabolic protein processes in older

adults. Overall, maintaining adequate vitamin D levels appears to be a cost-effective and safe intervention to support muscle health in older adults. [12, 13, 14]

Other Nutrients

Omega-3 Fatty Acids

Omega-3 polyunsaturated fatty acids (PUFAs) are regarded as a promising adjunctive strategy in sarcopenia management, primarily due to their anti-inflammatory properties, particularly in mitigating "inflammaging", a chronic, low-grade inflammation associated with aging that is believed to contribute to the development of sarcopenia. Supplementation with omega-3s has been shown to significantly reduce pro-inflammatory cytokines such as IL-6, IL-1β, and TNFα after four weeks of use, with more pronounced effects reported following eight weeks of supplementation.

The primary dietary sources of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are fatty fish such as salmon and mackerel, as well as other types of seafood. Alpha-linolenic acid (ALA) is found in plant-based sources such as nuts, chia seeds, and vegetable oils (e.g., soybean oil). The Academy of Nutrition and Dietetics recommends consuming two to three servings of fatty fish per week, which is estimated to provide approximately 500 mg of EPA and DHA daily.

Beyond their anti-inflammatory effects, omega-3 PUFAs may also exert anabolic effects on skeletal muscle by activating the mTOR signaling pathway and enhancing insulin sensitivity [15].

Creatine

Creatine monohydrate is among the most extensively studied ergogenic aids, consistently shown to enhance muscle mass and strength, especially when combined with resistance training. These effects are primarily attributed to increased phosphocreatine availability and improved cellular energy metabolism. In older adults, creatine supplementation may help attenuate muscle loss and improve functional outcomes.

Creatine may contribute to sarcopenia prevention not only by supporting muscle performance but also through its antioxidant properties. Given that oxidative stress is a recognized factor in muscle degradation, maintaining redox balance is essential. Experimental studies suggest that

creatine may neutralize reactive oxygen species via both direct and indirect mechanisms, thus offering potential protection against muscle atrophy. [16]

Antioxidants

Oxidative stress is a key contributor to sarcopenia, particularly in older individuals, who often exhibit impaired antioxidant defenses and mitochondrial dysfunction. Various dietary antioxidants, including vitamin C, vitamin E, carotenoids, and polyphenols, have been explored for their potential to mitigate muscle loss.

Vitamins C and E protect muscle cells by preventing lipid peroxidation and regenerating each other's antioxidant functions. Polyphenols (e.g., quercetin, resveratrol, curcumin) show promise in reducing inflammation, supporting mitochondrial function, and improving muscle performance—mainly in animal models and when combined with physical activity. However, findings from human studies remain inconclusive. While some trials report improvements in muscle mass and strength, others suggest that prolonged antioxidant supplementation may impair exercise-induced adaptations by interfering with endogenous antioxidant signaling.

Overall, antioxidant-rich diets may support muscle health, particularly when paired with regular physical activity, although the type, dosage, and timing of supplementation remain critical factors requiring further investigation [17].

Physical Activity and Exercise Interventions

Combining whey protein, leucine, and vitamin D supplementation with regular physical activity has been shown to significantly enhance muscle strength and physical performance in individuals with sarcopenia. Notably, the appendicular muscle mass index increased more substantially when supplementation was paired with exercise (SMD = 0.45) compared to supplementation alone (SMD = 0.21). These findings highlight that physical activity should be considered a fundamental component of sarcopenia treatment. Relying solely on nutritional supplementation without incorporating exercise offers only limited therapeutic benefit for these patients [12].

The Importance of nutrition in oncology therapy

Sarcopenia, malnutrition, and cachexia frequently occur in older cancer patients and are associated with poorer health outcomes. While they share some characteristics, their causes, effects, and treatment approaches differ. Malnutrition significantly impairs cancer treatment and outcomes by reducing tolerance to therapy, increasing toxicity, diminishing quality of life, and lowering survival rates. Since nutritional status evolves throughout cancer treatment, regular assessments are essential to address changes influenced by tumor stage, treatment type, comorbidities, and individual risk factors.

Malnutrition affects 15–40% of cancer patients at diagnosis and rises to 40–80% during treatment. It is closely linked to sarcopenia, contributing to muscle dysfunction, loss of lean body mass, and reduced muscle performance. Sarcopenia has been observed in 14% to 74% of cancer patients prior to treatment and is linked to complications like increased surgical risks, chemotherapy toxicity, and poorer survival in various malignancies (e.g., lung, breast, colorectal). Chemotherapy drugs such as 5FU, capecitabine, and cisplatin, as well as targeted agents like sorafenib and sunitinib, exacerbate sarcopenia via oxidative stress and fat deposition in muscle. This creates a vicious cycle where sarcopenia exacerbates drug toxicity, and treatment further accelerates muscle loss. Additionally, chemotherapy-induced nausea can lower protein intake, further aggravating sarcopenia.

Cancer cachexia is a distinct form of malnutrition linked to chronic inflammation and should not be mistaken for end-stage malnutrition. Cachexia Consensus Conference (Washington DC, December 2006) defined cachexia as “a complex metabolic syndrome associated with underlying illness and characterized by loss of muscle with or without loss of fat mass.” In adults, weight loss was highlighted as the central defining feature of this condition. [18, 19, 20]

Tools to identify nutritional issues and sarcopenia

Early identification of malnutrition is crucial for effective cancer patient management. Nutritional screening should be conducted at the time of diagnosis, ideally before initiating cancer treatments. There are several validated screening tools to assess malnutrition or the risk of malnutrition, including the Nutritional Risk Screening 2002 (NRS 2002), the Malnutrition Universal Screening Tool (MUST), and the Mini Nutritional Assessment (MNA).

Nutritional assessment for malnutrition and sarcopenia should involve:

- Anthropometric measurements: Current body weight, height, and body mass index (BMI).
- Weight loss assessment: Unintentional weight loss exceeding 5% in the past six months is considered significant.
- Body composition evaluation through bioelectrical impedance vector analysis (BIVA), dual-energy X-ray absorptiometry (DXA).
- The gold standard for body composition assessment includes computed tomography (CT) and magnetic resonance imaging (MRI).
- Biochemical markers related to inflammation and metabolic status: serum albumin, prealbumin, total lymphocyte count, cholesterol, C-reactive protein (CRP), transferrin, interleukin-6 (IL-6), and fibrinogen.
- Assessment of nutritional intake, appetite, resting energy expenditure (REE) via indirect calorimetry, and physical activity levels using metabolic holters.
- Sarcopenia evaluation: muscle strength via handgrip dynamometer and chair stand test; physical performance measured by gait speed, short physical performance battery, timed-up-and-go test, and 400-meter walk.
- Quality of life and functional capacity through specialized quesstionnaires [18, 21].

To complement the assessment of nutritional issues and sarcopenia, it is essential to consider the criteria of sarcopenia established by leading international organizations. The EWGSOP2 emphasizes low muscle strength and muscle mass as primary diagnostic markers, with physical performance indicating the severity of sarcopenia. In contrast, the SDOC suggests prioritizing physical performance alongside muscle strength while placing less emphasis on muscle mass. These distinctions highlight the variability in defining sarcopenia, which can impact its diagnosis and management. For example, the cut-off values for grip strength differ between these definitions: EWGSOP2 defines low grip strength as less than 16 kg for women and less than 27 kg for men, while SDOC uses stricter thresholds of less than 20 kg for women and less than 35.5 kg for men. Such differences significantly influence the prevalence of sarcopenia diagnosed in clinical settings.

The AWGS1 definition of sarcopenia, tailored to the Asian population, combines low muscle mass as a primary criterion with additional components such as low muscle strength and low physical performance (e.g., gait speed). This multi-dimensional approach underlines the

importance of adapting diagnostic criteria to specific populations and contexts, which can further complicate the standardization of sarcopenia assessments globally. [22]

Despite these variations, aligning sarcopenia evaluations with nutritional assessments can offer a more comprehensive understanding of a patient's overall health. Integrating these approaches ensures that malnutrition and sarcopenia are effectively addressed in a unified framework, enhancing the identification of at-risk individuals and guiding tailored interventions.

Interconnection of sarcopenia, cachexia, and malnutrition in cancer

The key difference between weight loss in cancer cachexia and starvation is that cachexia-induced weight loss cannot be reversed with nutrition alone. Tumor-related metabolic changes contribute to this, affecting disease outcomes, symptoms, and survival [21]. Sarcopenia and cachexia frequently coexist, particularly in older cancer patients, and both involve muscle wasting driven by distinct mechanisms. Cachexia arises from systemic inflammation and malnutrition, whereas sarcopenia is a progressive muscle disorder that can develop independently of inflammatory processes. Despite shared traits like reduced muscle mass, mitochondrial disfunction, impaired regeneration of muscles, differentiating these conditions can be challenging due to overlapping symptoms and a lack of specific diagnostic tools. Older cancer patients experiencing cachexia or sarcopenia often exhibit similar physical characteristics, and both conditions can lead to comparable complications. Malnutrition significantly increases the risk of sarcopenia, underscoring the importance of clear clinical definitions to guide prevention and treatment strategies, particularly in oncological settings. [19, 23, 24]

Factors in cancer-related malnutrition

The degree of malnutrition in cancer patients depends on the type of cancer, its stage, and the treatment modality; however, the etiology of cancer-related weight loss is multifactorial and complex. Changes in nutritional status can occur at any stage of diagnosis, treatment, or supportive care. These changes may arise from metabolic disturbances, mechanical obstructions or abnormalities, side effects of treatment, or psychosocial challenges.

Decreased food consumption and insufficient energy intake

Various factors directly contribute to a decrease in food consumption, leading to insufficient energy intake. These include conditions such as dysphagia, nausea, xerostomia, and alterations in taste and smell. Indirectly, factors like pain, fatigue, and psychological issues, often linked to tumor-related mechanisms, can further reduce appetite and the desire to eat. Eating difficulties, including disturbed chewing, vomiting, and abdominal pain, as well as gastrointestinal motility issues, impaired digestion, and absorption (e.g., mucositis, stenosis, diarrhea), can significantly hinder nutrient absorption and contribute to energy deficiency.

Tumor-related mechanisms

Tumor-related mechanisms, such as gastrointestinal tract obstruction, can cause symptoms like dysphagia or odynophagia, particularly in cancers of the esophagus and head and neck. These issues often lead to weight loss, which is frequently associated with physiological changes caused by the tumor, including malabsorption, vomiting, diarrhea, and anorexia. Side effects from cancer treatments such as chemotherapy, radiotherapy, and surgery also contribute to weight loss. Additionally, tissue destruction from invasive cancer, wounds, or therapeutic interventions can further exacerbate metabolic derangements. Oral and gastrointestinal symptoms, which may occur independently of nutritional status or treatment, also play a role in this weight loss. Patients often report increased depression, abdominal fullness, taste alterations, dry mouth, dysphagia, and a decreased appetite, making it difficult to maintain adequate nutrition.

Host response to tumor

Systemic inflammation plays a critical role in cancer-associated metabolic disturbances. This chronic inflammatory response originates from the tumor microenvironment, where cancer cells and stromal immune cells release pro-inflammatory mediators such as cytokines (e.g., IL-6, TNF) and inflammatory proteins (e.g., C-reactive protein). These mediators not only sustain local inflammation but also spill over into systemic circulation, driving metabolic and catabolic changes that significantly impact the host’s physiology.

During inflammation, the body's effort to restore homeostasis or repair tissues often depletes its energy and protein stores, redirecting them toward the healing process. However, when this inflammatory state becomes chronic, as seen in cancer, it leads to maladaptive outcomes, including persistent catabolism and tissue degradation.

- **Muscle:** Chronic inflammation triggers proteolysis, leading to the breakdown of muscle proteins and the loss of muscle mass, mediated by pathways such as the ubiquitin-proteasome system.
- **Fat:** Inflammatory signals stimulate lipolysis, causing depletion of fat stores and a reduction in white adipose tissue, which is further converted to a metabolically active brown-like phenotype. This transformation exacerbates energy expenditure and lipid mobilization.
- **Liver:** The synthesis of acute-phase proteins and increased glucose production contribute to systemic dysmetabolism, adding to the energy imbalance.
- **Brain and Appetite Regulation:** Inflammatory mediators influence the brain, resulting in symptoms like anorexia, fatigue, and listlessness, which suppress appetite and reduce energy intake.

Energy expenditure in cancer patients

Resting energy expenditure (REE) in cancer patients can vary depending on the type of tumor, with some patients experiencing an increase or decrease in REE compared to predicted values. While REE may be elevated in some cases, total energy expenditure often decreases due to reduced physical activity levels (PAL). This reduction in PAL, particularly in weight-losing patients, contributes to a lower total energy expenditure, which, combined with inadequate energy intake and metabolic disturbances, exacerbates the negative energy balance. This necessitates the utilization of body stores to maintain resting energy expenditure and vital organ functions, while supporting essential daily activities.

During caloric restriction, autophagy increases, aiding in repurposing cell components, while anabolic pathways are suppressed, resulting in decreased ATP consumption and reduced cell growth. Hepatic ketogenesis is activated to minimize protein losses, enabling brain and nerve tissues to consume ketones, thereby reducing the need for amino acids to produce glucose. These adaptations, controlled by low insulin levels in a setting of high insulin sensitivity,

characterize a typical starvation metabolism that allows the body to sustain prolonged periods of caloric restriction while preserving alertness and physical performance.

However, in cancer patients with weight loss, the reduction in physical activity not only limits energy expenditure but also initiates a cycle of deconditioning. Low activity levels, comparable to those seen in patients with spinal cord injuries or cerebral palsy, exacerbate muscle wasting and further reduce the ability to exercise. In the presence of systemic inflammation, protein-sparing mechanisms fail, and neuroendocrine mediators induce insulin resistance, leading to increased glucose and insulin levels. This maladaptive response contributes to muscle degradation, fat loss, and metabolic derangements. [21, 25]

Nutritional management in cancer care

Effective cancer treatment demands a collaborative, multidisciplinary approach involving oncologists, surgeons, dietitians, psychologists, and other healthcare professionals to meet the diverse and evolving needs of patients. Comprehensive care plans should be designed and regularly updated to address critical aspects such as malnutrition, pain management, and psychological well-being, ensuring personalized support throughout the treatment journey. Nutritional care in oncology presents unique challenges, particularly in cases like head and neck cancers (HNCs), where treatment often impairs oral intake. Guidelines advocate for tailored dietary counseling, with the addition of oral nutritional supplements (ONS) or tube feeding as required. The reliance on tube feeding in HNC patients underscores the complexities of managing malnutrition in cancer care, reflecting the need for a well-coordinated and adaptable treatment strategy. [25, 26, 27]

Nutritional management

Cancer treatments, including chemotherapy and surgery, profoundly affect nutritional status. Over 50% of patients undergoing chemotherapy experience side effects such as dysgeusia, nausea, vomiting, and mucositis, while radiotherapy also causes significant complications. Poor nutritional health is strongly linked to increased surgical risks and postoperative complications. Nutritional interventions aim to detect, prevent, and manage malnutrition through dietary counseling, the use of oral nutritional supplements (ONS), or, where appropriate, artificial nutrition methods, including enteral or parenteral feeding, to optimize patient outcomes and recovery.

Oral nutrition

In clinical practice, oral nutrition is prioritized because it helps maintain patient autonomy, fosters social interactions, and supports psychological well-being. Individualized dietary counseling, tailored to a patient's specific nutritional, clinical, and psychological needs, enhances quality of life and helps manage treatment-related challenges. Such counseling requires comprehensive assessments of nutritional status, dietary habits, symptoms, and the level of support needed for effective implementation.

Artificial nutrition

Enteral nutrition (EN) should be prioritized when intestinal function is preserved, as it helps maintain gut integrity and reduces the risk of bacterial translocation and infections. A standard polymeric feeding formula is recommended. EN is indicated for undernourished or at-risk patients during chemotherapy if undernutrition or inadequate food intake is present or expected. However, routine use of artificial nutrition during chemotherapy is not recommended. In cases of severe mucositis or obstructive tumors, percutaneous endoscopic gastrostomy (PEG) or nasogastric tubes are preferred. EN is contraindicated in conditions such as intestinal obstruction, severe shock, or ischemia. In these cases or when EN is insufficient, parenteral nutrition (PN) may be considered as an alternative or in combination with EN.

Surgery, radiotherapy, and chemotherapy

To minimize the metabolic stress and catabolism associated with surgery in undernourished cancer patients, the Enhanced Recovery After Surgery (ERAS) program is recommended. This protocol includes essential principles such as malnutrition screening, providing additional nutritional support when necessary, avoiding preoperative fasting, considering preoperative carbohydrate treatment, reintroducing oral feeding on the first postoperative day, and promoting early mobilization. For oncologic surgical patients at moderate to severe nutritional risk, nutritional support before and after surgery is crucial. In cases of severe malnutrition, surgery may need to be delayed, and routine nutritional support should be prioritized, especially for elderly sarcopenic patients.

For patients undergoing radiotherapy or chemotherapy, complications such as oral mucositis, dysphagia, and diarrhea can exacerbate nutritional challenges. Nutritional counseling is particularly important in patients with head and neck cancers, thoracic cancers, and gastrointestinal tract cancers. When needed, oral nutritional supplements (ONS) should be provided. These supplements, known for their convenience and ease of use, are commonly regarded as a preferred option for patients at risk of malnutrition. ONS, specifically formulated for medical purposes, help enhance nutrient and energy intake through the oral route, supplementing inadequate regular food consumption.In the presence of severe mucositis or obstructive tumors, artificial nutrition may be required. Parenteral nutrition is generally not recommended in patients undergoing radiotherapy or chemoradiotherapy unless oral or enteral nutrition cannot meet nutritional needs. [28, 29]

Integrated strategies for treating sarcopenia and cachexia

Treating sarcopenia and cachexia effectively requires a multidimensional approach that prioritizes improving muscle mass, function, and overall physical performance. While dietary interventions, such as protein supplementation and vitamin D optimization, are beneficial for age-related sarcopenia, they are often insufficient for reversing cachexia. Nutritional strategies must include adequate caloric intake, targeted nutrients, and sustained intervention. Physical exercise, particularly resistance and aerobic training, has proven more effective than pharmacological options for enhancing muscle strength and reducing inflammation. Exercise activates molecular pathways that support muscle growth and metabolic adaptations, though barriers like access and motivation often hinder implementation, especially in older cancer patients. Pharmacological treatments, such as appetite stimulants (e.g., megestrol, steroids, and cannabinoids), and anti-inflammatory agents, have shown limited and inconsistent benefits. Medications like corticosteroids may pose risks for older adults. Multimodal approaches, integrating exercise, nutrition, and anti-inflammatory therapies, represent the most promising strategy but require further research to optimize outcomes in oncology patients. [23]

Future directions

Establishing clear diagnostic criteria and implementing tailored management strategies are essential for effective interventions, particularly in older cancer patients. Advancing research

is crucial to better comprehend changes in body composition and their impact on nutritional status and treatment outcomes. Future efforts should focus on comprehensive, multilevel approaches, including mandatory nutritional screening, revisions to reimbursement policies, the development of educational initiatives, and the integration of telehealth solutions to enhance care delivery. [30]

Summary

The prevention and management of sarcopenia, particularly in elderly and oncology populations, must be recognized as a critical component of modern medical care. As this review has demonstrated, nutritional interventions including protein intake optimization, vitamin D supplementation, and anti-inflammatory support can significantly mitigate muscle loss and improve physical function.

In oncology patients, where sarcopenia and cachexia often coexist and negatively affect treatment outcomes, integrating nutrition into cancer therapy from the earliest stages is essential. Tailored, multidisciplinary strategies that combine dietary support with physical activity and regular assessment offer the most promising results in preserving muscle mass, improving resilience, and enhancing quality of life.

Future clinical practice should move toward proactive and individualized care models, where nutrition is not a secondary concern, but a central therapeutic pillar particularly for vulnerable populations at risk of sarcopenia-related complications.

Disclosure

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