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RADIOLOGICAL ASSESSMENT OF MUSCLE MASS AND NUTRITION COACHING TO IMPROVE OUTCOMES IN CANCER PATIENTS UNDERGOING CHEMOTHERAPY: A SYSTEMATIC REVIEW

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Abstract

Background: Sarcopenia and cancer-associated cachexia are common in oncology, characterized by progressive muscle wasting, metabolic dysregulation, and impaired treatment tolerance. Radiological modalities such as computed tomography (CT), dual-energy X-ray absorptiometry (DEXA), ultrasound (US), and magnetic resonance imaging (MRI) are increasingly utilized to quantify skeletal muscle mass and guide nutritional interventions. **Objectives:** This systematic review aimed to synthesize evidence on radiological assessment of muscle mass and nutrition-related interventions in cancer and chronic disease patients, evaluating prognostic value, clinical outcomes, and therapeutic implications. **Methods:** Following PRISMA guidelines, a comprehensive search of PubMed, Embase, Scopus, and Web of Science identified studies published between 2009 and 2022. Eligible studies included randomized controlled trials, observational designs, and systematic reviews assessing radiological techniques for muscle mass evaluation or nutritional interventions in oncology and chronic disease populations. Primary outcomes included prevalence and detection of low skeletal muscle mass (LSMM), while secondary outcomes assessed survival, postoperative complications, treatment-related toxicity, quality of life, and functional performance. **Results:** Eight studies met inclusion criteria, encompassing populations with gastric, esophageal, colorectal, cervical, pancreatic, and advanced solid tumors, as well as end-stage renal disease and chronic kidney disease. Radiological assessments, particularly CT, consistently demonstrated superior accuracy compared to anthropometry or bioelectrical impedance analysis for detecting LSMM. Nutritional interventions—including whey protein, omega-3 fatty acids, artificial intelligence–assisted support, and smartphone app–based programs—improved nutritional markers, reduced treatment-related toxicity, preserved muscle quality, and enhanced quality of life. However, one randomized trial in elderly men found no added benefit of peri-exercise protein supplementation when baseline dietary protein intake was adequate. **Conclusions:** Radiological evaluation of muscle mass provides reliable and reproducible

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assessment of sarcopenia and cachexia, with prognostic and therapeutic relevance in cancer care. CT remains the gold standard, though ultrasound shows promise as a bedside alternative. Nutritional interventions tailored by imaging findings may mitigate toxicity and improve patient outcomes. Standardization of diagnostic thresholds and integration of artificial intelligence are critical for future clinical translation.

Keywords: Sarcopenia; Cachexia; Computed Tomography; Nutritional Intervention; Cancer; Radiology; Muscle Mass.

INTRODUCTION

Sarcopenia and cancer-associated cachexia are increasingly recognized as major determinants of outcomes in oncology and surgical populations. Both conditions are characterized by progressive skeletal muscle wasting, functional impairment, and metabolic dysregulation, which negatively influence survival, treatment tolerance, and postoperative recovery (Mortellaro et al. 2024). Cachexia, in particular, occurs in up to 80% of patients with advanced cancers and is associated with systemic inflammation, weight loss, and poor prognosis, while sarcopenia may also develop independently of body weight changes (Mortellaro et al. 2024).

The prognostic significance of low skeletal muscle mass (LSMM) has been extensively demonstrated across malignancies. In prostate cancer, CT-defined LSMM was found in 61% of patients and was significantly associated with overall survival, confirming its role as a prognostic biomarker that should be integrated into routine assessment (Meyer et al. 2022). Similarly, in gastric cancer, LSMM assessed by CT strongly predicted postoperative complications, severe morbidity, and both overall and disease-specific mortality, emphasizing the clinical importance of standardized radiological evaluation (Borggreve et al. 2020).

Head and neck oncology provides additional evidence: patients undergoing free flap reconstructive surgery with preoperative LSMM had more than double the odds of developing postoperative complications compared with those without sarcopenia, supporting the need for preoperative screening and targeted interventions (Ansari et al. 2023). These findings collectively underline that sarcopenia not only compromises long-term survival but also increases immediate surgical risks.

Advancements in imaging modalities have facilitated more precise assessment of body composition. While traditional anthropometric indices such as body mass index (BMI) are insufficient to capture muscle depletion, radiological methods such as CT, MRI, and dual-energy X-ray absorptiometry (DEXA) provide quantitative and qualitative insights (Shah et al. 2023). CT is widely regarded as the gold standard for evaluating skeletal muscle area and density, with emerging applications in the assessment of myosteatosis. DEXA, although widely available and less resource-intensive, still lacks standardized reporting parameters, limiting its broader clinical utility (Chaves et al. 2022).

Taken together, current evidence highlights that radiological assessment of muscle mass offers a reliable and reproducible means of identifying sarcopenia and cachexia in cancer patients, thereby informing prognosis and guiding perioperative and therapeutic

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strategies. However, heterogeneity in imaging protocols, cut-off definitions, and lack of universal implementation remain significant challenges (Mortellaro et al. 2024). This systematic review therefore aims to synthesize current evidence on radiological techniques for nutritional and muscle mass assessment, evaluating their prognostic value and clinical implications across diverse oncological and surgical settings.

METHODOLOGY

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol was developed to explore the role of radiological assessment of muscle mass and nutrition-related interventions in oncology and chronic disease patients.

Eligible studies were those that included adult patients diagnosed with cancer or chronic conditions in which sarcopenia, cachexia, or malnutrition were evaluated. We considered studies that employed radiological techniques such as computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), or dual-energy X-ray absorptiometry (DEXA) for muscle mass or body composition assessment. Nutritional interventions, including protein supplementation, omega-3 fatty acid supplementation, artificial intelligence (AI)–assisted nutritional support, and mobile application–based programs, were also within the scope. Comparators included standard care, placebo, or non-imaging-based assessment methods such as anthropometry and bioelectrical impedance analysis. The primary outcomes of interest were the detection and prevalence of low skeletal muscle mass (LSMM), sarcopenia, or cachexia, while secondary outcomes included treatment-related toxicity, postoperative complications, functional capacity, survival, and quality of life. Eligible designs comprised randomized controlled trials, observational studies, and systematic reviews with meta-analyses, published in English between 2009 and 2022.

The literature search was performed across multiple electronic databases, including PubMed, Embase, Scopus, and Web of Science. The search strategy combined Medical Subject Headings (MeSH) and free-text terms such as “sarcopenia,” “cachexia,” “muscle mass,” “malnutrition,” “computed tomography,” “magnetic resonance imaging,” “ultrasound,” “dual-energy X-ray absorptiometry,” “nutrition intervention,” “protein supplementation,” and “omega-3.” Reference lists of the included studies and relevant reviews were also screened manually to identify additional eligible publications.

Two reviewers independently screened the titles and abstracts of retrieved records, followed by full-text assessment for final eligibility. Disagreements at any stage were resolved by discussion and, where necessary, consultation with a third reviewer. The study selection process was summarized in a PRISMA flow diagram, documenting the number of records identified, screened, excluded, and included, along with the reasons for exclusion at the full-text stage.

Data extraction was performed independently by two reviewers using a predesigned template. Extracted variables included study characteristics (author, year, country,

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design, and sample size), patient demographics and disease characteristics, imaging modality used, diagnostic criteria for sarcopenia or cachexia, details of nutritional interventions and comparators, and outcomes assessed.

Quality appraisal was undertaken using validated tools appropriate to study design. Randomized controlled trials were assessed using the Cochrane Risk of Bias 2.0 tool, observational studies were evaluated with the Newcastle–Ottawa Scale (NOS), and systematic reviews were appraised using the AMSTAR-2 tool. Any discrepancies in assessment were resolved through consensus.

Given the clinical and methodological heterogeneity across studies, including variation in populations, interventions, and outcome definitions, we adopted a narrative synthesis approach. Findings were synthesized thematically, grouped by imaging modality and nutritional intervention, and compared against conventional assessment methods such as anthropometry and bioelectrical impedance analysis.

RESULTS

A total of eight studies met the eligibility criteria and included in this review. The studies published between 2009 and 2022 and include different patient populations, including those with gastric and esophageal cancer, colorectal cancer, cervical cancer, pancreatic cancer, advanced solid tumors, end-stage renal disease (ESRD), chronic kidney disease (CKD), and elderly men undergoing resistance training. The study designs comprised five randomized controlled trials (RCTs), two observational studies, and one retrospective analysis. Sample sizes ranged from 26 to 120 participants.

Characteristics of Included Studies

Miola et al. (2018) conducted a retrospective analysis of 70 patients with gastric and esophageal cancer and found that 54.3% had low lean body mass as assessed by CT, with mid-arm muscle circumference showing the best agreement with imaging-based findings. Verdijk et al. (2009) performed a 12-week randomized controlled trial in 26 elderly men and reported that protein supplementation before and after exercise did not further augment hypertrophy or strength gains compared to placebo.

Mazzuca et al. (2019) carried out a placebo-controlled RCT in 47 colorectal cancer patients and showed that whey protein supplementation improved nutritional status and significantly reduced chemotherapy-related toxicity. Aredes et al. (2019) reported results from a randomized, triple-blind clinical trial involving 40 cervical cancer patients undergoing chemoradiotherapy. Supplementation with omega-3 fatty acids preserved skeletal muscle quality and reduced treatment-related toxicity compared to placebo.

Casirati et al. (2021) conducted a prospective observational study on 67 patients with newly diagnosed advanced solid tumors. They found that 73% had sarcopenia as assessed by CT, compared with only 15% when using bioelectrical impedance analysis (BIA), suggesting that CT provided a more accurate assessment of body composition. Cheema et al. (2010) analyzed 49 patients with ESRD using baseline data from a

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randomized trial. The study reported that reduced muscle cross-sectional area and increased intramuscular lipid accumulation were associated with poor physical performance, reduced strength, and impaired gait function.

Chen et al. (2022) examined 120 patients with CKD stages 3–5 in a randomized trial comparing standard care with an AI-assisted hospital-to-home nutritional nursing model. The intervention group showed significant improvements in anthropometric indicators, serum albumin, hemoglobin, quality of life scores, and patient satisfaction. Keum et al. (2021) performed a 12-week randomized controlled trial in 40 pancreatic cancer patients using a mobile app–based nutritional program (Noom). The intervention group reported better quality of life scores and less decline in skeletal muscle index compared to controls. The use of advanced imaging techniques (CT) consistently demonstrated a higher sensitivity in detecting low lean body mass and sarcopenia compared with anthropometry or bioelectrical impedance. Nutritional interventions such as whey protein, omega-3 fatty acids, AI-assisted models, and app-based programs generally improved nutritional status, muscle quality, treatment tolerance, and quality of life. However, results were heterogeneous, with one trial (Verdijk et al. 2009) showing no added benefit of protein supplementation in adequately nourished elderly men.

Table 1: Summary Table of Studies

Citation	Study Design	Sample Size	Main Findings	Outcomes
Miola et al. 2018	Retrospective analysis	70 patients with gastric/esophageal cancer	54.3% had low lean body mass by CT; anthropometric methods less accurate; mid-arm muscle circumference best agreement.	CT assessment more reliable than anthropometry for detecting low lean body mass.
Verdijk et al. 2009	Randomized controlled trial (12 weeks)	26 elderly men	Protein supplementation before/after exercise did not further improve hypertrophy or strength gains compared to placebo.	Resistance training alone sufficient; timing of protein had no additional benefit in well-nourished elderly.
Mazzuca et al. 2019	Randomized placebo-controlled trial	47 colorectal cancer patients	Whey protein improved nutritional status and reduced chemotherapy toxicity compared to placebo.	Lower toxicity rates; whey protein may support muscle mass and reduce sarcopenia.
Aredes et al. 2019	Randomized triple-blind placebo-controlled trial	40 women with cervical cancer	ω-3 supplementation preserved skeletal muscle quality and reduced chemoradiotherapy toxicity.	Better nutritional status maintenance; less intramuscular fat infiltration; reduced treatment toxicity.
Casirati et al. 2021	Prospective observational study	67 patients with advanced solid tumors	73% had sarcopenia by CT, 15% by BIA; CT aligned better with malnutrition prevalence than BIA.	CT more accurate than BIA for body composition assessment in cancer patients.

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Cheema et al. 2010	Cross-sectional analysis (baseline data of RCT)	49 ESRD patients on hemodialysis	Low muscle CSA and higher intramuscular lipid associated with poor strength and walking ability.	Muscle wasting and fat infiltration linked to impaired functional capacity in ESRD.
Chen et al. 2022	Randomized controlled trial	120 CKD patients	Hospital-to-home AI-assisted nutrition improved anthropometry, serum proteins, and quality of life compared to standard care.	Better nutritional markers, higher patient satisfaction, improved renal perfusion and prognosis.
Keum et al. 2021	Randomized controlled trial (12 weeks)	40 pancreatic cancer patients	Mobile app–based nutrition program improved quality of life and reduced muscle loss compared to control.	Improved QoL scores; attenuated skeletal muscle index decline.

DISCUSSION

This systematic review synthesizes evidence from eight studies examining radiological assessment of muscle mass, sarcopenia, and cachexia, as well as their implications for nutritional interventions in oncology and chronic disease. The findings highlight the strengths of imaging modalities such as computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI), while also underscoring the variability in diagnostic criteria and prognostic applications.

Radiological Assessment of Muscle Mass

CT imaging has consistently emerged as the most validated tool for quantifying skeletal muscle mass. Amini et al. (2019) reviewed 388 studies and demonstrated wide heterogeneity in CT protocols, including landmarks, segmentation, and cut-off definitions, which complicates comparisons and clinical translation. Vogele et al. (2023) further emphasized that CT and MRI not only allow accurate detection of sarcopenia but can also be opportunistically applied in tumor patients where routine imaging is already performed, with artificial intelligence holding potential to enhance diagnostic reproducibility. Mortellaro et al. (2024) also supported CT as the gold standard, while acknowledging limitations such as radiation exposure and limited clinical uptake.

Ultrasound is increasingly recognized as a promising bedside tool. Casey et al. (2022) systematically reviewed 37 studies and confirmed strong associations between skeletal muscle ultrasound parameters (cross-sectional area, echogenicity) and outcomes including length of stay, survival, and treatment complications. Similarly, Wojda et al. (2015) highlighted that US, in combination with CT, offers practical applications for assessing lean body mass and nutritional risk in surgical and critical care settings.

Clinical Impact of Sarcopenia and Cachexia

The adverse clinical implications of sarcopenia and cachexia were evident across multiple studies. Bossi et al. (2021) highlighted the heterogeneity of malnutrition and sarcopenia

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across cancer types, with pancreatic, esophageal, and head and neck tumors carrying the highest prevalence. They also emphasized that malnutrition negatively affects treatment intensity, toxicity, quality of life, and survival. Mortellaro et al. (2024) described the interplay between sarcopenia and cancer cachexia, noting their combined impact on chemotherapy toxicity and functional decline.

The prognostic role of imaging-derived muscle measures is further underscored by Casey et al. (2022), who linked ultrasound-based findings to survival and hospital outcomes, and by Bettenworth et al. (2019), who demonstrated that cross-sectional imaging could effectively differentiate fibrosis from inflammation in Crohn's disease, underscoring its broader value in systemic wasting syndromes.

Advances and Limitations in Imaging Approaches

Despite the growing body of evidence, challenges remain. The lack of standardized diagnostic cut-offs for sarcopenia, as noted by Amini et al. (2019), limits comparability across studies and weakens the integration of findings into clinical guidelines. While CT remains the reference standard, concerns about radiation exposure persist (Mortellaro et al. 2024). Ultrasound, though non-ionizing and repeatable, is hindered by operator dependence and variability in measurement techniques (Casey et al. 2022; Wojda et al. 2015). MRI, while highly accurate, is costly and less accessible (Vogele et al. 2023). Bettenworth et al. (2019) also pointed out that cross-sectional imaging definitions remain inconsistent, reducing comparability between centers.

Implications for Clinical Practice and Future Research

Overall, the reviewed evidence suggests that radiological assessment of muscle mass is not only diagnostic but also prognostic. Opportunistic CT assessments in oncology can enable early detection of sarcopenia and cachexia (Vogele et al. 2023; Mortellaro et al. 2024), while ultrasound shows potential as a bedside monitoring tool in nutritionally vulnerable populations (Casey et al. 2022; Wojda et al. 2015). Importantly, early detection of muscle loss, as highlighted by Bossi et al. (2021), enables timely nutritional and rehabilitative interventions that may mitigate treatment toxicity and improve quality of life.

Future research should prioritize the development of standardized CT and US protocols, consensus cut-off definitions, and multicenter validation studies. Integrating artificial intelligence into imaging workflows may further enhance accuracy and reproducibility (Vogele et al. 2023). Interventional trials are warranted to test whether radiology-guided nutritional strategies can translate into improved survival and reduced treatment-related complications in oncology and chronic disease patients.

CONCLUSION

This systematic review highlights the central role of radiological assessment in detecting and monitoring sarcopenia and cancer-associated cachexia. Computed tomography consistently emerges as the gold standard for evaluating skeletal muscle mass and quality, while modalities such as ultrasound and DEXA provide valuable complementary

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tools with potential for broader clinical application. Evidence demonstrates that low skeletal muscle mass is strongly associated with increased treatment-related toxicity, postoperative complications, reduced functional capacity, and poorer survival across diverse cancer populations.

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