The Crossroads of Aging: An Intersection of Malnutrition, Frailty and Sarcopenia

Abstract:

The intersectional relationship between malnutrition, frailty and sarcopenia in older adults presents unique challenges for healthcare providers. Malnutrition, specifically, is a leading risk factors for disability, morbidity, and mortality in older adults. Despite improvements in screening procedures many older adults at risk for malnutrition are not identified which prevents effective management. Utilizing interdisciplinary approaches towards malnutrition screening is both effective and feasible. Physical therapists can play an important role in both the identification and management of malnutrition in older adults by remaining of common nutritional concerns in older adults and performing routine malnutrition screening.

Introduction:

In the United States (U.S.) where the population is becoming both older and more medically complex, the management of factors relating to disability, morbidity, and mortality in older adults is of increasing concern[1]. Of the many factors associated with disability, morbidity, and mortality risk in older adults, malnutrition is potentially one of the most concerning. Malnutrition is a condition defined as a deficiency or excess of energy, protein and micronutrients resulting in measurable adverse effects on tissue, function, and clinical outcome[2]. In older adults, the prevalence of malnutrition and those at risk of developing malnutrition is reported to be approximately 23%[3] with increased prevalence rates in older adults aged 75–80 years[3,4]. Several risk factors for developing malnutrition in older adults have been identified, including chronic illness, medications, economic hardship, social isolation, lower education level, impaired functional status, and symptoms of depression[5]. Older adults often possess at least one and possibly multiple of these risk factors for malnutrition; which may explain why the prevalence is so high in this population. Many of the risk factors for malnutrition are also interrelated and overlap with other clinical syndromes. For example, frailty which is defined as the presence of at least 3 out of 5 clinical criteria: low grip strength, exhaustion, slowed gait speed, low physical activity, and/or unintentional weight

loss[6] is closely related to malnutrition in older adults[1] and may be present in approximately 25% of individuals over the age of 65 and over 50% of those over the age of 85[7–10]. Both conditions are associated with functional decline, poor quality of life, cognitive impairment, increased healthcare costs, and increased mortality[11]. While malnutrition and frailty are interrelated, and may often be concurrently present in older adults[11,12], they are distinctly different syndromes. This relationship between frailty and malnutrition may explain why strategies to address either condition can be difficult to implement effectively in older adults.

As described previously, the potential adverse consequences of malnutrition in older adults are numerous. However, the effects of malnutrition on sarcopenia, defined as the loss of skeletal muscle mass and strength[13], are of particular concern in the elderly. Beginning in the 4th decade of life, skeletal muscle size, number, and strength decline with increased age alone in a linear fashion[14]; approximately 50% of muscle mass is lost by the 8th decade of life[15]. Additionally, the number of skeletal muscle satellite cells which mediate skeletal muscle repair in response to stress are also reduced; specifically in type-2 skeletal muscle fibers[16]. The presence of malnutrition can potentially exacerbate this age-related decline leading to impaired functional status, frailty and sarcopenia (the loss of skeletal muscle)[1,15,17]. Sarcopenia may also have additional ramifications throughout the body[18,19]. Skeletal muscle is highly metabolically active[15] and is the primary source of post-prandial insulin-stimulated glucose disposal[20] and exercise induced glucose uptake[21]. Loss of skeletal muscle mass may predispose older individuals to certain metabolic disorders such as insulin resistance and diabetes[15,21]. The key regulators of muscle protein synthesis are physical activity[22] and post-prandial plasma essential amino acid availability[22–24]. The skeletal muscles of older adults may demonstrate less sensitivity to these anabolic signaling pathways which is often referred to as “anabolic resistance” [24], especially in the presence of insulin resistance[25] and obesity[26,27]. Therefore, skeletal muscle mass and function, physical activity and nutritional intake form a complex and interdependent relationship influencing the health and functional status of older adults.

This intersectional relationship between frailty, sarcopenia, and malnutrition in older adults presents unique challenges for healthcare providers **(Figure 1.)**. Interdisciplinary collaboration between members of the healthcare professions is necessary to address the multiple interdependent factors associated with the factors of frailty; malnutrition. A landmark paper by Butterworth[28] identified that malnutrition was not only frequently encounter in many patients, but that was also negatively affecting patient outcomes, contributing to delayed healing, increased lengths of stay and elevated hospital costs. Despite decades of effort involving modifications to malnutrition screening procedures, new nutritional supplements, staff and patient education, and a dedication to clinical research, malnutrition in the older adult remains a prevalent issue. Recently, a collaborative effort to address this major issue resulted in the development of the Malnutrition Quality Improvement Initiative, which among many directives, places focus on interprofessional collaboration to address older adult malnutrition. Physical therapists have a unique opportunity to screen and identify patients at risk for malnutrition due to the increased face-time and frequent encounters with patients. Utilizing collaborative strategies which improve awareness and routine screening by all members of the healthcare team has been previously demonstrated to be an effective strategy for identifying patients at risk for malnutrition[29]. Recent research also indicates that utilizing collaborative strategies to malnutrition screening is both feasible and results in improved quality of care provided to older adults with malnutrition or at risk for malnutrition[30]. This review will highlight key principles and strategies to address malnutrition in older adults from the physical therapist perspective.

Nutritional Concerns of Older Adults

Presently, older adults are living longer more independent lives, and therefore clinicians must consider the nutritional concerns of older adults with long-term health in mind. Of relevance to physical therapists is the maintenance of mobility, muscle function, and muscle mass. Skeletal muscles are fundamental to the locomotion and strength required for completing activities of daily living in older adults[31]. The skeletal muscles also play significant roles in various physiological processes throughout the

body[18,19,21]. Sarcopenia and the loss of skeletal muscle mass and function has profound clinical significance, as reduced muscle mass and strength predicts immobility[32] and mortality[33]. Although physical therapy interventions are effective at combating loss of skeletal muscle mass and strength[34], the pathogenesis of sarcopenia is multifactorial. This includes age-related changes in hormones or inflammation which may require pharmaceutical intervention, but also includes modifiable lifestyle factors like physical activity and diet[35]. Therefore, the combination of physical therapy and nutritional interventions may optimize care in older adults[36]. Thus, healthcare professionals like physical therapists, should understand the primary nutritional components regulating skeletal muscle mass and function in older adults to optimize patient care and achieve desired outcomes, which has proven to be effective at combating malnutrition in other allied health professions[37].

Protein

Skeletal muscle is the primary protein reservoir in the body, accounting for >33% total body mass[38] and containing >40% of total body protein[39]. Unlike carbohydrates or fats, which have non-tissue storage forms (glycogen and triglycerides, respectively) and are catabolized when exogenous nutrients are not provided, protein must be catabolized from tissue; primarily skeletal muscle tissue. Thus, protein is required for the maintenance of skeletal muscle mass, and insufficient protein intake is associated with loss of muscle mass and function, a condition exacerbated with the anabolic resistance of aging. The current dietary guidelines recommend adults consume 0.8g of protein per kilogram bodyweight. However, due to a variety of physical, mental, social or economic barriers (Figure 1.), older adults often ingest below the recommended protein intake. Although a major concern is encouraging older adults to consume the recommended protein intake, just as important is whether the current recommendations for adults are appropriate for the *older* adult.

Recent work has demonstrated that the current recommended dietary allowance (RDA; 0.8g protein/kg/bodyweight) for protein may be inadequate to promote optimal health and muscle function in older adults[40–42]. Although long-term intervention trials are lacking, observational studies report improved muscle mass and function with higher protein intake in older adults[43], while short-term experimental trials provide strong evidence of that increased protein intake results in improved stimulation of skeletal muscle protein synthesis (MPS; a primary regulator of skeletal muscle mass)[44]. The current state of the literature suggests an increase of 50% beyond the RDA (1.2g protein/kg/bodyweight) may be required to promote skeletal muscle health in aging.[40–42]

Recent proceedings from the Protein Summit 2, indicate a need to consider meal by meal considerations for protein consumption, beyond just daily requirements, citing 20-30g threshold of leucine-rich protein for optimal signaling of MPS in healthy individuals[45]. However, this 'meal threshold' of protein and leucine for optimal MPS is reduced with advancing age and defines the anabolic resistance of aging. Current evidence suggests older adults may require ~40g of leucine-rich protein per meal to reach this MPS stimulatory threshold[46]. Given that insufficient protein and leucine intake is well documented, even in homebound older adults[47], ensuring older adults receive proper nutrition counseling is of particular importance. However, protein intake alone is not sufficient to ensure long-term maintenance of skeletal muscle mass.

Energy

Just as important as the single macronutrient, protein, is the consumption of enough total energy, or kilocalories each day. The maintenance of bodyweight balances on the ability to maintain energy intake; an energy deficit promotes bodyweight loss and an energy surplus promotes bodyweight gain. This relationship manifests on the tissue level as well. Therefore, if the goal of a physical therapy intervention is to regain or retain skeletal muscle mass and function, appropriate energy intake is required to optimize

the physiologic response to physical therapy interventions. Previous studies have demonstrated that lack of appropriate energy intake results in increased risk of frailty, hospital admissions, and length of stays[48].

Practical Implication: Awareness of the Nutritional Prescription

In older adults, physical, mental, or social barriers may exist that limit consumption or access to optimal nutrition including: poor dentition, loss of taste or smell, depression, medication interactions, or influences of other chronic diseases. Further, patients recommended for physical therapy services are often at increased risk of malnutrition[49] and may experience lapses of inactivity due to bedrest, exacerbating muscle and mobility loss[50]. Nutritional care for these individuals involves consumption of nutrient-dense and high-calorie foods (such as peanut butter or whole milk), along with recommended nutritional supplements to meet the energy needs of older adults with malnutrition or at risk of malnutrition. Awareness of these nutritional guidelines by physical therapists is important to ensure that consistent messages are provided by all members of the care team.

Sugar and Animal Protein

With older adults, addressing recently maligned nutritional concepts is of particular importance. For the general population, recommendations of reducing sugar and animal protein intake is associated with improved health outcomes[51,52]. However, in older adults maintaining mobility and muscle mass is of primary concern. Sugar provides a source of palatable calories that may also improve intake of important vitamins, minerals, and protein (an example, is a high-calorie milkshake). In this situation, sugar acts as a vehicle for providing optimal nutrition by improving the likelihood of consumption. Similarly, animal protein is high in protein, leucine, and calories per volume of food. In older adults as previously stated, the volume of food intake can be a limiting factor[53] and animal protein provides a nutrient-dense food source, allowing a relatively small meal to breach the 'meal threshold' for MPS and support skeletal muscle health

and positive energy balance. Physical therapists should communicate these concepts to older adults when discussing nutrition. Maintaining optimal nutritional intake is vital to successful aging.

Food- Drug Interactions

Older adults may also experience pharmacological interactions creating additional barriers to meeting recommendations. An older adult's nutritional status may be impacted by food-drug interactions. The interplay of foods and medications may impact both the efficacy of drug therapy and a person's nutritional status, while others have suggested polypharmacy contributes to both frailty and malnutrition[54]. Therefore, physical therapists need to understand common food-drug interactions so referrals may be directed to the registered dietitian for further nutritional evaluation.

The clinical effectiveness of drugs are influenced by absorption, distribution, metabolism, and excretion[55]. Absorption is the process of how drugs get into the circulatory system from through the gastrointestinal tract. Certain foods may increase the bioavailability of a drug while others, may interfere with absorption of a medication through the pharmacokinetic actions on the drug[56]. When medications have known interactions with drugs, dosing instructions will be provided with regards to when and how to take the medication. The presence of food may change pH, gastric emptying, or alter hepatic blood flow which may increase or decrease the bioavailability of medications[57,58]. The bioavailability of certain antibiotics such as penicillin and ciprofloxacin, are reduced when taken with foods, yet, other antibiotics such as clarithromycin have increased bioavailability when taken with food[57].

Many anticoagulant medications also have significant food-drug interactions requiring particular consideration[59]. Warfarin, which inhibits vitamin K-dependent coagulation factors, has 120 known drug-drug and food-drug interactions requiring monitoring for variable anticoagulation control[59]. Garlic, ginger, caffeine, clove, fish oil, onion, and cranberry may increase the risk of bleeding in patients taking warfarin.

Ginseng and green tea have the potential to reduce anticoagulation effects of warfarin[60]. Novel anticoagulants such as dabigatran, an oral direct thrombin inhibitor, and oral anti-Factor Xa inhibitors, rivaroxaban, apixaban, and edoxaban, have been developed to address food-drug interaction issues with warfarin treatment. These novel anticoagulants may be taken with or without food as the bioavailability has not been found to fluctuate based on the presence of food in the gastrointestinal tract[59].

Grapefruit and grapefruit juice has been studied extensively for food-drug interactions due to its inactivation of the CYP3A4 intestinal enzyme and potential prolonged inhibitory effect on intestinal clearance[61]. Additionally, grapefruit has an inhibitory effect on cellular transporters such as the efflux transporter P-glycoprotein and organic anion-transporting polypeptides mediating influx transport. Many grapefruit-drug interactions are fairly innocuous; however, some are more significant. For example, patients receiving statin therapy should avoid grapefruit juice due to the increased risk of developing rhabdomyolysis and myalgia[61]. Grapefruit may also increase the plasma concentration of calcium channel blockers[62].

Although this list of food-drug interactions is not exhaustive, the need for physical therapists to be aware of potential food-drug interactions in older patients is clearly demonstrated. These interactions also demonstrate the importance of open communications with other members of the healthcare team including registered dietitians, pharmacists, and physicians.

Drug-Appetite Interaction

Appetite is defined as a sensation of hunger that promotes food consumption, and satiation is the feeling of fullness that leads to meal termination and satiety between meals[63,64]. Appetite is controlled by short and long-term mechanisms that influence feeding behavior. Short term mechanisms include sensors in the GI tract that sense the presence or absence of food and food composition, such as fat or protein stimulating or inhibiting appetite[63,64]. Long-term mechanisms rely on the release of various hormones such as Ghrelin secreted from the stomach in response to the fasting state which serves to increase appetite.

Other long-term mechanisms include the release of peptide- yy from the ileum and colon resulting in suppression of appetite in response to food intake[63,64]. Cholecystokinin is released from the small intestine in response to the presence of protein and fat to suppress appetite. Insulin is secreted by the pancreas in response to high blood glucose to reduce blood glucose by increasing uptake into the skeletal muscles and suppressing appetite[63,64].

Poor appetite contributes to unintentional weight loss, malnutrition, and poor health outcomes; including mortality[63]. In the older adult, appetite decline may be attributed to several factors including physiological effects of aging, psychological functioning, social circumstances, acute illness, chronic disease, or medications[63]. As for medications, over 200 medications have been identified as altering both the taste and smell of food or causing nausea, which may reduce appetite. Over eighteen drug classes have been identified as impairing appetite including the following drug classes: antibiotics, cardiac medications, psychotropic medications, statins, and non-steroidal anti-inflammatory drugs[63]. Impaired appetite may have potential ramifications on mobility and the rehabilitation processes[65]. Therefore, physical therapists need to understand that older adults may have reduced appetite due to the normal physiological effects of aging and/or potential effects of certain medications. Physical therapists should collaborate with members of the allied healthcare team such as registered dietitians, pharmacists, and physicians to appropriately manage impaired appetite in older patients.

Effects on Rehabilitation Due to Poor Nutritional Intake

Nutritional intake affects all metabolic processes of the human body and may also influence rehabilitation outcomes. Impaired nutritional intake or malnutrition has found to negatively impact functional abilities and quality of life[65]. Therefore, the impact of nutritional intake is of particular concern in older patients due to the increased prevalence of malnutrition and sarcopenia in this population which are estimated to be upwards of 50.5% and 40%, respectively[36].

Poor nutrition is detrimental to older adults through loss of muscle mass and strength. However, optimizing nutrition may play a synergistic role in improving rehabilitation. Nutritional intervention in older adults improves recovery during post-hospitalization[40], benefiting outcomes relevant to physical therapy like handgrip strength[66] and fall risk[67]. Supporting data specific to combining nutrient intake and rehabilitation in older adults is feasible[68] and promising, but limited[36]. Until additional research is available to validate the combination of nutrient intake and rehabilitation therapy, implications can be drawn from studies surrounding nutrient intake and exercise training in older adults, as this mimics the functional mobility and muscle performance outcome goals of physical therapy interventions in this population. For example, the combination of nutritional supplementation with aerobic exercise[69]or resistance exercise[70] in older adults promotes greater improvements in muscle mass and strength than aerobic or resistance exercise alone. [71,72].

Practical Implications: Nutritional Screening and Referral

Adequate nutrition promotes beneficial adaptations in older adults while malnutrition exacerbates functional decline. For other innovative approaches to address the intersection of nutrition, frailty, and sarcopenia, the readers are directed to a recent review[73]. It is the role of the registered dietitian to identify a patient's nutritional needs, plan and implement nutritional interventions, and monitor the special needs of older adults. However, individuals with malnutrition or risk for malnutrition are too often missed and not appropriately referred to registered dietitians for medical nutrition therapy. Some studies suggest <10% of malnourished patients are appropriately identified in the hospital setting[74] and may be even less identified in other populations, such as community-dwelling older adults[74]. This lack of identification prevents timely and effective nutritional care.

Therefore, how do other health care professionals, like physical therapists, determine if a nutritional problem exists or if nutritional intervention is needed by a registered dietitian? Identifying older patients at risk for malnutrition can be accomplished by the addition of a simple screening process, performed by any member of the healthcare team, through the utilization of a standardized nutritional screening tool. It is important to note that nutritional screening by physical therapists is supported by the American Physical Therapy Association's House of Delegate position statement, P06-15-22-17, The Role of the Physical Therapist in Diet and Nutrition, which states "it is the role of the physical therapist to screen for and provide information on diet and nutritional issues to patients, clients, and the community within the scope of physical therapist practice."[75] Although, it is now suggested that identification of malnutrition requires a collaborative approach, physical therapists can play a pivotal role in identifying patients at risk for malnutrition. However, if a patient screens positive for malnutrition or malnutrition risk, a referral to a registered dietitian further nutritional assessment should be made. In such case, the patient may require medical nutrition therapy, which cannot be performed by the physical therapist. Importantly, malnutrition screening should not only aid in the identification of older adult patients at risk for malnutrition but should also create an open a line of communication between all members of the healthcare team and develop a streamlined referral process.

Since there is no gold standard for screening malnutrition, the use of a standardized tool may be the best option for screening purposes. Some commonly used tools include the Malnutrition Screening Tool (MST)[76] , the Malnutrition Universal Screening Tool (MUST)[77] , and the Mini Nutrition Assessment – Short Form (MNA-SF)[78]. Each of the tools can be administered in a timely manner and provide greater insight into a patient's risk for malnutrition, detailed in **Table 1**. Either of these tools can be easily implemented by a physical therapist, to assess the patient's risk of malnutrition. Of note, these screening tools do not assess the overall quality of nutritional intake, as a registered dietitian is required for that purpose.

Table 1 Standardized Nutrition Screen Tools

Screening Tool	Included Parameters	Length of Time to Administer	Sensitivity	Specificity	Validated Population
MST	Unintentional weight loss and appetite	1 minute	97.9%	100%	Acute Hospital
MUST	Unintentional weight loss, BMI, and disease severity	2-5 minutes	61%	76%	Acute Hospital
MNA-SF	Unintentional weight loss, change in food intake, mobility, disease severity, depression/dementia, and BMI,	3 minutes	93%	93%	Acute Hospital and Community-dwelling

Aside from the use of standardized tools, the Academy of Nutrition and Dietetics (AND) and the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) have identified six characteristics that associate with increased risk of malnutrition[79]. These characteristics include insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation, and diminished functional status as measured by hand-grip strength[79]. When two or more are of these characteristics are present a diagnosis of malnutrition is recommended. Five out of these six characteristics are easily identifiable by a physical therapist since they are strongly correlated to functional mobility and some of these assessments are components of a routine physical therapy examination. Therefore, the implementation of routine malnutrition screening appears to be feasible for physical therapists.

Within the screening process the clinician must also identify if the need for referral to a registered dietitian is warranted, based on the patient's current presentation, medical history, and the screening

clinician's scope of practice. An example of this scenario would be, a patient who possesses a medical condition, which has shown to strongly correlate with nutritional intake or the presence of complex medication interactions. If referral were to occur, a nutritional assessment would be completed by the registered dietitian to further identify risk and needs for appropriate intervention. In some cases, an immediate referral may not be warranted or available, and in that case the treating clinician would offer basic nutritional education, as is appropriate per the scope of practice of the physical therapist (which may vary by US state). Nutrition education involves sharing basic nutrition knowledge on healthy eating for older adults , which should be obtained from validated resources. These educational resources should be obtained from validated resources, such as the US Department of Health and Human Services' and the US Department of Agriculture's Dietary Guidelines for Americans[80] or the Academy of Nutrition and Dietetics' Dietary Guidelines and MyPlate for Seniors[81].

Nutritional Education versus Medical Nutrition Therapy

Medical nutrition therapy is nutrition diagnosis, intervention, and counseling implemented by the registered dietitian and is beyond the scope of the physical therapist[82]. Nutritional education is the reinforcement of basic or essential nutritional information and may be provided by a physical therapist or physical therapist assistant. Each clinician must distinguish these concepts and most importantly they must stay within the scope of their practice. However, nutritional education is within the physical therapist's scope and can be implemented by providing generalized nutritional information and helpful tips for healthier food and fluid intake, or directing patients to available and validated resources such as those mentioned previously[80,81]. Outside of direct patient interaction, the clinician can also advocate for federal, state, and local food and nutrition programs and services, especially within the home and community setting[83].

Summary

Malnutrition has significant consequences on patient outcomes, especially in older adults. Unfortunately, many older adults who are malnourished go untreated due to gaps in screening for malnutrition and malnutrition risk. Physical therapists can play an important role in the identification and management of malnutrition and malnutrition risk by remaining aware of common concerns in older adults and by performing routine malnutrition screening. Although medical nutrition therapy is performed by registered dietitians, physical therapists can provide basic nutritional education and should do so while acknowledging their scope of practice and their patient's medical and nutritional needs. Additionally, the combination physical therapy and nutritional interventions may provide optimal patient outcomes. Despite variations in scope of practice, all members of the healthcare team must strive to improve patient care through inter-professional communication and collaboration.

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