Effective translation of current dietary guidance: understanding and communicating the concepts of minimal and optimal levels of dietary protein

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ABSTRACT
Dietitians and health care providers have critical roles in the translation of the dietary guidance to practice. The protein content of diets for adults can be based on the Recommended Dietary Allowance (RDA) of 0.80 g/kg per day. Alternatively, the most recent Dietary Reference Intakes (DRIs) for macronutrients reflect expanded guidance for assessing protein needs and consider the relative relation of absolute amounts of protein, carbohydrate, and fat to total energy intake in the context of chronic disease prevention. The Acceptable Macronutrient Distribution Range (AMDR) reflects the interrelation between the macronutrients and affords dietitians and clinicians additional flexibility in diet planning. Accounting for the caloric value of RDAs for carbohydrate and fat, “flexible calories” emerge as an opportunity to create varied eating plans that provide for protein intakes in excess of the RDA but within the AMDR. Protein Summit 2.0 highlighted the growing body of scientific evidence documenting the benefits of higher protein intakes at amounts approximating twice the RDA, which include promotion of healthy body weight and preservation of lean body mass and functional ability with age. The essential amino acid (EAA) density of a food also emerged as a novel concept analogous to “nutrient density,” which can enable the practitioner to calculate the caloric cost associated with a specific protein source to attain the daily requirement of EAs to accomplish various health outcomes because these indispensable nutrients have a significant role in protein utilization and metabolic regulation. Tailoring recommendations unique to an individual’s varying goals and needs remains a challenge. However, flexibility within the application of DRIs to include consideration of the AMDR provides a sound framework to guide practitioners in effective translation of current dietary guidance with a specific regard for the documented benefits of higher protein intakes.

Keywords: dietary guidance, protein, essential amino acids, recommendations, optimal intake, diet prescription

INTRODUCTION
The Dietary Reference Intakes (DRIs) were initiated in 1997 and reassessed the Recommended Dietary Allowances (RDAs) for essential nutrients utilizing the full scope of past and recent scientific evidence with provisions to revisit each recommendation when new data warranted such action. The effort was a significant advancement toward evidence-based guideline development and recognized the usefulness of DRIs, in addition to the Estimated Average Requirement (EAR) and RDA, to include Adequate Intake (AI) and Tolerable Upper Intake Level (UL). Acceptable Macronutrient Distribution Ranges (AMDRs), which aim to minimize chronic disease risk while maintaining adequate macronutrient intakes against the back drop of adequate energy intake and physical activity, were also introduced. This article considers DRIs in the context of translating the science specific to current and recommended protein intakes for improved health outcomes, including weight management, preservation of lean body mass, and maintenance of functional abilities with age, in populations targeted by Protein Summit 2.0. Considerations for the role that protein quality has in diet design, specifically acknowledging that providing essential amino acids (EAs) is central to the protein requirement, are presented along with suggested approaches for accomplishing better health and well-being by focusing on dietary protein. Dietitians and health care providers play an important role in the interpretation, application, and dissemination of evidence-based recommendations and the translation of dietary guidance into practical tactics for eating to improve health and wellness outcomes. Of particular significance is the greater range of flexibility in designing dietary approaches for individuals and the

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6 Abbreviations used: AI, Adequate Intake; AMDR, Acceptable Macronutrient Distribution Range; EAA, essential amino acid; EAR, Estimated Average Requirement; DIAAS, Digestible Indispensable Amino Acid Score; DRI, Dietary Reference Intake; FSR, fractional synthetic rate; RCT, randomized controlled trial; RDA, Recommended Dietary Allowance; UL, Tolerable Upper Intake Level.

public with specific regard to protein intake provided by the protein DRIs and AMDRs (2).

**HISTORY**

A historical perspective of the protein RDA is helpful in understanding the purpose and intent of the original protein requirements and the evolution of current recommendations for the macronutrients. The requirement for protein was addressed in 1941 in the environment of the war effort and amid goals to define minimum intake requirements in the face of rationing and limited provision of foods for troops overseas. The importance of these values being “modifiable” to accommodate different circumstances was clearly noted (3). By the 1980s there was an abundance of published data from nitrogen balance studies, which became the foundation for the use of this method by national and international organizations to define protein requirements. Rand et al. (4) re-examined the data in a meta-analysis that yielded values similar to the FAO/WHO/UNU estimates, as well as the DRI EAR (0.66 g/kg per day), which serves as the basis for the statistically derived RDA of 0.80 g/kg per day.

**AMDR**

The macronutrient DRIs (2) represent the first effort to numerically define requirements for carbohydrate and fat. The AMDRs delineate upper and lower bounds for the percentage of calories provided from protein, carbohydrate, and fat in a dietary pattern. In addition, they recognize the interrelation between macronutrients and the concept that adjusting the intake of one macronutrient influences the amount of the other macronutrients consumed. The AMDRs introduce tremendous flexibility in designing diets customized to individual needs. AMDRs of 45–65% and 20–35% of calories for carbohydrate and fat, respectively, were based on reviews of the scientific literature that focused on the relation between carbohydrate and fat intake and the incidence, progression, and management of chronic diseases including cardiovascular disease, cancer, obesity, and metabolic syndrome (2; chapter 11). Because the RDA for carbohydrate and the AI for fat were determined to be nominal amounts to cover glucose needs for central nervous system functions and essential fatty acids needed from the diet (2; pp. 280–93, pp. 440–81), the flexible amounts of these macronutrient calories in a diet are substantial, more than half of the daily energy requirement. The AMDR for protein is 10–35% of calories, which allows for a greater contribution of dietary protein to remaining macronutrient influences the amount of the other macronutrients consumed. The AMDRs introduce tremendous flexibility in designing diets customized to individual needs. AMDRs of 45–65% and 20–35% of calories for carbohydrate and fat, respectively, were based on reviews of the scientific literature that focused on the relation between carbohydrate and fat intake and the incidence, progression, and management of chronic diseases including cardiovascular disease, cancer, obesity, and metabolic syndrome (2; chapter 11). Because the RDA for carbohydrate and the AI for fat were determined to be nominal amounts to cover glucose needs for central nervous system functions and essential fatty acids needed from the diet (2; pp. 280–93, pp. 440–81), the flexible amounts of these macronutrient calories in a diet are substantial, more than half of the daily energy requirement. The AMDR for protein is 10–35% of calories, which allows for a greater contribution of dietary protein to remaining macronutrient distribution ranges of the AMDRs but provides only one target amount of protein intake in grams based on the RDA as opposed to a range of potential intakes (5). In other words, taking advantage of a range of protein intakes within flexible calories may help improve health and compliance outcomes vs. relying on the RDA alone to estimate protein needs.

**PROTEIN CONSUMPTION IN THE UNITED STATES**

The average daily protein intake for Americans is 1.2–1.5 g/kg per day or ~16% of calories of protein based on NHANES 2003–2004 data (6). These values exceed the RDA but are within the AMDR and well below the upper range of 35% of energy as protein. Government-based nutrition tools such as MyPlate (7) also promote a number of protein servings that provide more than the protein RDA for the average (70-kg) adult. A 7-d 2000-kcal/d sample menu plan averages 19% of protein energy, providing ~1.4 g/kg protein per day without specific regard for protein source.

Given the theme of Protein Summit 2.0 and the considerable evidence that habitual protein intakes approximately twice the RDA impart a variety of health benefits, dietitians, as well as clinicians and other nutrition educators, are challenged to appropriately use available protein intake recommendations to optimize diet design. The use of the terms “recommended” and “allowance” could be misconstrued to mean that 0.80 g protein/kg per day is the appropriate amount of protein to consume and is not to be exceeded. For example, the use of an RDA as an upper boundary for nutrient intake or as a justification to reduce a particular nutrient in the diet is inappropriate (8). In fact, no UL for protein has been established.

An analysis of studies by the Institute of Medicine examining adverse consequences of high-protein diets failed to identify a level of protein intake that increased the risk of health problems including osteoporosis, cancer, obesity, kidney stones, or renal disease (2; p. 692–5, p. 841–5). The Institute of Medicine’s DRI committee did not define a UL for dietary protein given the lack of sufficient evidence documenting that increased protein intake is associated with increased risk or negative outcomes. The committee acknowledged that at the highest reported US protein intake of 2.7 g/kg per day or the highest reported percentage of total energy from protein of 23.7% there is a low risk of adverse effects. The accompanying articles in this supplement issue provide a convincing argument that consuming protein at amounts well within recommended values imparts a variety of health benefits and may be an important public health approach to managing chronic diseases.

As outlined in the following discussion, recent studies and reviews of the literature support the position that protein should comprise a significant portion of flexible calories. Epidemiologic studies, randomized controlled trials (RCTs), and meta-analyses of relevant studies among other research strategies showed beneficial outcomes of protein intakes ~2 times greater than the RDA. Improvements related to muscle anabolism, body composition, weight management, metabolic function, and healthy aging have been shown across a spectrum of populations. These benefits have application across the life cycle and may ultimately contribute to an improved quality of life, a concept avoided in scientific studies because of the difficulty in defining and standardizing the term as well as in assessment.

In practice, this concept is a reality and the practitioner understands the importance of quality of life to individuals seeking to improve their health through diet with various goals in mind. These include, but are not limited to, positive self-esteem and a healthy body image, the ability to engage in recreational activity, and the capacity to complete household chores and hobbies, as well as to remain ambulatory and independent with...
advancing age (9). These seemingly diverse, and often elusive, endpoints can be viewed as being commonly mediated by some aspect of muscle synthesis [fractional synthetic rate (FSR)], body composition, and muscle function (strength, balance, metabolic capacity) (10).

OBESITY

Designing diet interventions for weight management is one potential platform for increasing protein intake in at-risk populations. The current Dietary Guidelines for Americans (11) delivers the message that adults should strive to be highly active and adhere to healthy eating patterns. Unfortunately, obesity has increased substantially over the past 2 decades and a good proportion of the population is restricting calories or attempting some dietary strategy to lose weight. A nationwide survey revealed that overweight women constituted a strong following belief in the ability of protein-centric diets to prevent weight gain and to enhance weight-loss efforts (12). There is substantial evidence that suggests that meal plans providing protein intakes that approximate twice the RDA influence appetite and satiety, spare muscle mass, and favor thermogenesis, thereby enhancing efforts to manage weight and improve body composition. Several recent reviews (13–15) addressed the impact of high-protein diets on energy expenditure and satiety as well as their effect on weight loss, body composition, cardiovascular disease markers, and glycemic control. A meta-analysis (16) showed that energy-restricted, high-protein diets (1.25 ± 0.17 g/kg per day) vs. a standard-protein diet (0.72 ± 0.09 g/kg per day) produced more favorable changes for reductions in body weight, fat mass, and triglycerides and protected against reductions in lean body mass and resting energy expenditure in weight loss. Numerous other studies (17–22) supported the benefits of protein in terms of greater fat loss, less lean body mass loss, and specific effects of protein on obesity comorbidities including type 2 diabetes and hypertension. In total, a solid body of literature validates the importance of protein in the diet for individuals struggling to achieve and maintain a healthy body weight.

EXERCISE AND PHYSICAL ACTIVITY

Adults boasting a healthy body weight, very active individuals and elite athletes, have long understood and appreciated the importance of diets that emphasize high-quality protein (23, 24). For example, athletes and healthy, active individuals who routinely exercise have an accelerated need to promote muscle growth, repair damaged cells and tissue, and synthesize hormones and immune factors. On the basis of a myriad of outcomes including nitrogen balance and whole-body protein turnover, protein intakes ranging from 1.2 to 2.0 g/kg per day are recommended for physically active people (23–27). These recommendations also acknowledge that different types and quality of protein can affect amino acid availability, EAAs in particular, and that appropriately timed protein intake is an important component of an overall training program.

The adaptive advantages experienced by athletes who consume protein at amounts higher than the RDA include faster recovery, increased muscle mass and strength, and improved mental and physical performance. Recent studies ranging from 1 to 3 wk of protein supplementation of ≥2.3 g/kg body weight (range: 2.3–3.0 g/kg) reported results for the Daily Analysis of Life Demands for Athletes (DALDA) questionnaire, which measures 9 stress sources and related symptoms on a scale of “normal” or “worse than” or “better than” normal. Resistance-trained and endurance athletes who consume at least 2.8 g/kg protein daily reported reduced stress, fatigue, and diet dissatisfaction (i.e., “better than normal” DALDA scores) (28, 29), whereas those consuming lower amounts (≥2.3 g/kg) complained of “worse than normal” fatigue scores during weight loss (29, 30) and after high-intensity training (28). The maintenance of lean body mass during short-term caloric restriction aimed at obtaining a particular body mass category or a better force-to-mass ratio during competition is also supported by higher protein intakes (≥1.6 kg/g body weight) (29, 30). Finally, both acute and long-term benefits of increased dietary protein are noted in measures of muscle and whole-body protein remodeling. Witard et al. (31) reported acute increases of 49–56% in myofibrillar muscle protein synthesis among resistance-trained athletes supplemented with incremental amounts of whey protein immediately after a bout of unilateral exercise. A longer-term study by Gaine et al. (32) found that chronic elevations in dietary protein (i.e., 1.8 g/kg for 4 wk) similarly enhanced whole-body protein remodeling after acute endurance exercise.

Data such as these suggest that the RDA of 0.80 g/kg per day is insufficient to sustain synthesis of new muscle proteins, maintain lean body mass, and repair muscle damage while maintaining energy balance after strenuous exercise training and athletic competition (33). The important point for dietitians and other allied health professionals is that the current recommended protein intakes for athletes, at least twice the RDA, are well within the AMDR of the DRIs. Of more significance to this discussion is the widely accepted practice of recommending protein intakes that are greater than the RDA for athletes, as well as healthy active men and women, without the skepticism that accompanies this practice on a broader population level.

MIDLIFE CONSIDERATIONS

The scientific literature is limited with specific regard to optimal protein needs of adults aged 30–50 y. Maintaining a healthy body weight during midlife is challenging because metabolic and physiologic shifts occur (34) alongside lifestyle factors that may decrease physical activity (35) or promote increased food consumption or unhealthy food choices (36). Maintaining adequate protein intake in adulthood for the preservation of lean body mass can potentially sustain muscle reserves during middle age that could potentially dictate an individual’s success in overcoming health challenges that coincide with the onset of aging. A meta-analysis of studies linking physical capability with mortality identified 5 studies (the average age of subjects was <60 y) in which grip strength correlated with mortality. Cooper et al. (37) systematically reviewed 24 studies and showed that poorer physical function (weaker grip strength, slower walking speed and chair rising, and shorter standing balance time) in older adults was associated with higher subsequent risk of fracture, cognitive outcomes, cardiovascular disease, hospitalization, and institutionalization. Acute metabolic studies showed that the catabolic response to 10 d of bed rest
in volunteers ~50 y of age more closely resembled that of ~70 y olds than that of healthy middle-aged adults (38, 39).

Although few studies have looked at dietary patterns and strength/health outcomes over time, limited data suggest a benefit to higher protein consumption as a countermeasure to losses in muscle mass during middle age. Energy and macronutrient intakes were assessed in a British population at ages 36 and 43 y and correlated with 3 measures of physical ability (grip strength, standing balance time, and chair rises) at age 53 y. Energy intake was positively associated with grip strength, and there was some indication of relations of protein intake with grip strength and standing balance time (40). Data from RCTs also suggest that consuming higher amounts of protein (>1.2 g/kg per day) during middle age may be advantageous for promoting muscle mass. In a meta-analysis, Cermak et al. (41) compared RCTs (n = 9) that investigated higher-protein diets and resistance-type exercise training of at least 6 wk in duration among healthy older (≥50 y) vs. younger (<49 y) subjects. Compared with placebo, protein supplementation significantly augmented exercise-induced gains in types I and II muscle fiber cross-sectional area in younger subjects (+45% and +54%, respectively) but not in older subjects (+22% and −19%, respectively). In total, these data suggest that middle age represents a unique opportunity to enhance muscle gains achieved by resistance training through dietary modification that includes higher protein intake.

Summit participants considered that sarcopenia, the loss of muscle with aging, could be approached in the context of the osteoporosis model. That is, neither osteoporosis nor sarcopenia are conditions that develop acutely but rather are insidious processes that are precipitated by suboptimal lifestyle factors throughout life. The concept of laying down peak bone mass during childhood and adolescence via diet and exercise strategies to prevent osteoporosis later in life may also apply to muscle mass accretion and maintenance throughout adulthood to avoid sarcopenia. Adults in this midlife category may prove to be the most important demographic to benefit from increased dietary protein in terms of optimizing muscle and bone mass before the onset of anabolic resistance.

### AGING

Muscle accretion is compromised in older and elderly adults despite the ingestion of protein at the level of the RDA. Epidemiologic and longitudinal studies (42, 43) found that healthy elderly individuals who consumed the highest amounts of protein or were provided with protein supplements lost less lean body mass over time than did cohorts with lower protein intakes. The loss of lean body mass despite relatively high protein consumption reflects the age-related anabolic resistance observed in acute metabolic studies.

Two companion articles in this supplement issue (44, 45) detail the concepts outlined below. Briefly, subjects aged ≥65 y showed a blunted muscle FSR response to amino acid stimulation compared with younger individuals (46). Comparable responses can be achieved with higher doses of amino acids, particularly when the EAA leucine comprises a significant percentage of the formulation (47). Although supplements can be useful, healthy older adults also benefit from habitual ingestion of higher dietary protein in terms of muscle strength and function and overall morbidity and mortality (48). Furthermore, there is evidence to suggest that eating patterns can be manipulated to enhance responsiveness to dietary protein. The equal distribution of a threshold amount of protein in 3 meals throughout the day may yield a greater cumulative response in muscle FSR than a single large dose given daily in this population (49). Mamerow et al. (50) reported higher mixed-muscle protein FSR with an even distribution of protein intake in a 7-d crossover study in adults aged 25–37 y, which may be relevant to older adults as well. A position paper (51) from a European research group cited specific reasons for higher protein needs in healthy older adults. These include age-related changes in protein metabolism, such as high splanchnic extraction and anabolic resistance to ingested proteins, as well as greater utilization of protein to offset inflammatory and catabolic conditions that occur with diseases of aging. They specifically recommended for individuals >65 y a daily protein intake of 1.0–1.2 g protein/kg and even more for active and exercising individuals. Finally, the role of incorporating more protein into the diet as a preventative strategy against the development of frailty and advanced states of disability is proposed (44). Although an age-specific RDA >0.80 g/kg per day for protein for adults aged >65 y has not been established, the AMDRs easily accommodate an increase in protein consumption for this age group.

### PROTEIN QUALITY AND EAA DENSITY

In all circumstances, particularly those most directly linked with muscle protein synthesis, the quality of protein is as important as protein quantity. The dietary guidelines emphasize “high quality protein” as the preferred source (11) but provide little in the way of specific criteria to categorize protein quality. Protein quality is determined by its EAA content, unique amino acid profile, and the digestibility of each EAA in the protein (51). The current protein DRI includes specific recommendations for each of the EAA's (2). Practitioners are encouraged to contemplate meeting EAA needs while simultaneously fulfilling protein prescriptions in various meal plans.

Beyond the vital, and widely accepted, role in stimulating muscle protein synthesis, individual EAAs function in many metabolic pathways. For example, phenylalanine and tryptophan serve as key precursors for selected neurotransmitters, arginine is an important regulator of nitric oxide production, and glutamine is central to many aspects of gut function (52). The Digestible Indispensable Amino Acid Score (DIAAS) is the most current and advanced scoring system and considers the digestibility of each EAA in the protein food source and the amount and profile of EAA's in the protein (53). The DIAAS value per se is meaningful to diet design because it provides a ranking system to compare individual protein sources on the basis of their ability to meet the EAA requirements. Animal protein sources are ranked high for quality because a smaller quantity can be consumed to meet EAA RDAs compared with wheat and plant sources.

The EAA density of a food is a novel concept analogous to “nutrient density,” which can enable the practitioner to calculate the caloric cost associated with a specific protein source’s contribution to the daily requirement of EAAs. This concept evolved from thoughtful consideration of potential methods to advance approaches to diet design that exploit a protein source’s ability to provide EAAs in an efficient manner specific to its energy content. This approach supplements the RDA and maximizes the flexibility.
provided by the AMDRs to achieve recommended protein intakes in an efficient calorie package to prevent, slow the progression of, or manage chronic diseases. This concept underscores the critical role that dietary protein has in supplying EAAs for human health and nutrition. Diets can be customized to efficiently meet nutrient needs that target the individual. This approach could advance practical efforts to ensure that protein needs are met in individuals with compromised energy intake (e.g., cancer patients, the elderly, athletes in weight-sensitive sports). As the food database expands (limited currently by the difficulty of the assessment method), the DIAAS should prove valuable in tailoring menus for all chosen diets.

Implementing EAA density simultaneously with nutrient density in configuring menus that provide appropriate calories for weight management and optimal health across the life span is a logical tactic to support public health initiatives specific to nutrition. For example, lactoovovegetarians could rely on high-quality milk and egg proteins to efficiently meet EAA needs, whereas vegans would be advised to include soy and soy protein isolates to attain requirements within a reasonable caloric allowance. As individuals age and their energy needs are reduced, consuming essential nutrients from whole foods that are nutrient dense (i.e., providing EAAs and micronutrients) can assist with maintaining weight as well as muscle and bone mass. The concept of protein quality should not be overlooked in dietary guidance.

SUMMARY AND CONCLUSIONS

The current and most comprehensive nutrition standards, the DRIs, present an opportunity to expand the range of diet recommendations, customized to the individual and with particular regard for dietary protein. The RDA of 0.80 g/kg per day is derived from the EAR (0.66 g/kg per day), a level sufficient to avoid deficiency in half the population. This article notes the fact that there is no intent for the RDA to maximize protein utilization given various physiologic or pathophysiologic states and highlights that the AMDRs provide a framework to optimize protein intakes for individuals at various stages of life and health. The influence of each macronutrient on the other is relevant and important as we discuss meal patterns and advise people to focus on a whole and simple foods approach to healthy, balanced eating. This overarching goal, along with the ever-increasing body of scientific evidence, supports protein intake above the RDA. Dietitians are encouraged to promote protein as the first choice in meeting maintenance and flexible energy requirements.

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