Proceedings of

The International Meat Secretariat's Symposium on Protein Requirements

for optimal health throughout all life stages

September 16, 2013 • Granada, Spain

"As the world's population increases rapidly and against the constraints of limiting land, water and food resources, it is more important than ever to be able to define accurately the amount and quality of protein required to meet human nutritional needs and describe appropriately the protein supplied."

(Dietary protein quality evaluation in human nutrition: Report of an FAO Expert Consultation 2013)

Given protein's critical role in current and future dietary requirements for an increasing world population and the emerging science suggesting the potential inadequacies of the current protein recommendations, the International Meat Secretariat (IMS) hosted a symposium on protein requirements for optimal health throughout the lifecycle during the International Union of Nutritional Sciences (IUNS) International Congress of Nutrition in Granada, Spain, September 2013. The agenda included four renowned protein scientists who provided evidence-based information about the nutritional qualities of meat and its role in a healthful, sustainable diet. The session was coordinated by the chair of the International Meat Secretariat's Human Nutrition and Health Committee.

Symposium Summary

Leading protein scientists presented strong evidence supporting a beneficial effect to increasing high-quality protein intake during all life stages. The International Meat Secretariat Human Nutrition and Health Committee hosted this important global event during the IUNS International Congress of Nutrition in Granada Spain, September 16, 2013. Two speakers, Professors Paul Moughan and Rajavel Elango, explained why the method for establishing the Recommended Dietary Allowance (RDA) for all life stages may not be taking into consideration all relevant factors and offered new solutions for determining a more precise RDA. Professors Nancy Rodriguez and Caryl Nowson addressed the need to consider functional outcomes when evaluating protein needs throughout the lifecycle.

Professor Moughan reported on the United Nations Food & Agriculture Organization (FAO) Expert Consultation to review recommendations on the characterization of dietary protein quality in humans. A significant finding of the Expert Consultation was the need to assess each individual dietary indispensable amino acid as a nutrient in its own right, since a large body of research shows that the various amino acids have differing physiological and regulatory roles. To more accurately reflect protein digestion in humans, the recommendation is that true ileal amino-acid digestibility be assessed for each dietary indispensable amino acid, rather than a value for a single, faecal, crude-protein digestibility. Additional research is needed to fully implement the digestible indispensable amino acid score (DIAAS).

Professor Elango also addressed a new method for calculating protein requirements for adults and children. Several drawbacks are associated with the calculation of RDAs from nitrogen (N) balance studies. The indicator amino acid oxidation (IAAO) technique has emerged as a viable alternative to determine essential amino acid requirements in adults. IAAO is based on the concept that all amino acids in the body are in excess and therefore oxidized when one essential amino acid is deficient for protein synthesis. Professor Elango explained how to determine protein requirements in adults and children using the IAAO system. The data derived from using the IAAO method of calculation suggests the RDA for adults and children may be underestimated by at least 50 percent.

Professor Rodriguez focused on the importance of adequate protein intake complemented with an active lifestyle to promote healthy aging, bone health, and the prevention of sarcopenia. Recent research shows that consumption of approximately 25-30 g of high-quality protein maximally stimulates muscle protein synthesis in old, as well as young, persons. An extension of these findings suggests that a protein intake of 25-30 g at three intervals throughout the day may provide older adults with the greatest opportunity to sustain muscle mass. This translates to a daily intake of 1.1-1.5 g protein/kg/d. An increase in protein intake also has shown benefits to bone health by increasing calcium absorption, negating previous evidence to the contrary. In addition, high-quality proteins are a nutrient-dense source of many essential micronutrients which contribute to the nutritional status of older adults.

Professor Nowson's presentation focused on the protein needs of older people. An early study found that older people who consumed the U.S. RDA for 10 days were in negative N- balance. It appears the body will lose lean mass when necessary to maintain N-balance. Additionally, older people tend to have lower rates of protein synthesis and whole-body protein breakdown in response to an anabolic stimulus. Evidence is emerging from randomized controlled trials that a diet including at least 1.3 g/kg/d combined with twice-weekly progressive resistance exercise clearly benefits older adults by enhancing lean muscle mass and leg strength. For this reason, food- and meal-based strategies rather than supplemental drinks are likely to be more sustainable and are recommended as the initial approach to optimising protein intake in older people.

Experts estimate that higher protein intakes in the approximate range of 1.1 to 1.5 g/kg/d may contribute to better muscle and bone maintenance and improve quality of life. Children have even higher protein needs for growth; for example, school age children (6-10 y) may require protein intakes of at least 1.55 g/kg/d. Researchers recommend that at least two meals (ideally three) a day should contain 25 to 30 grams of high-quality protein from naturally nutrient-rich foods for optimal health.

In closing the symposium, Mary Ann Binnie, the chair of the International Meat Secretariat's Human Nutrition and Health Committee, reiterated that increasing dietary protein intake throughout the lifecycle may be beneficial. She supported the new FAO-proposed methodology for determining protein quality as it will allow a more precise characterization of the true quality of protein. Ms. Binnie thanked the symposium speakers on behalf of the International Meat Secretariat for sharing recent research which marks a significant step forward in understanding what foods might best provide protein needs for optimal health throughout all life stages.

Dietary Protein Quality: *New Perspectives*

Summary of the proposed recommended approach to scoring the quality of proteins

- Considering amino acids as individual nutrients (digestible/bioavailable) gives maximum information
- Digestible indispensable amino acid score (DIAAS) incorporates recent scientific advances, and is an improvement over the protein digestibility-corrected amino acid score (PDCAAS)
- Before DIAAS can be fully implemented, more comprehensive data on the true ileal-amino-acid digestibility of foods is needed
- Establishment of such a world food dataset is urgent
- This is an important step in the fight against malnutrition

Paul J. Moughan BAgrSc (Hons), PhD, DSc, FRSNZ, FRSC

Professor Paul J Moughan holds the position of Distinguished Professor, Massey University, New Zealand and is Director of the Riddet Institute. His research has encompassed the fields of human and animal nutrition, food chemistry, functional foods, mammalian growth biology and digestive physiology. He has published in excess of 350 scientific works. In 1995 he was awarded Doctor of Science and in 1997 was awarded a Personal Chair at Massey University and was elected a Fellow of the Royal Society of New Zealand. He is a Fellow of the Royal Society of Chemistry, Cambridge, England. In 2011 he was appointed Chair of the FAO Expert Consultation to review recommendations on the characterisation of dietary protein quality in humans.

Background

Foods are digested in the alimentary canal and their constituent proteins are broken down to amino acids and small peptides. During absorption by the enterocyte, the peptides are themselves hydrolysed mainly to free amino acids. Most of the absorbed amino acids are either used by body cells for protein synthesis or they are oxidised. The amounts of dietary indispensable amino acids present in a protein and the extent to which they may be used for protein synthesis is referred to loosely, as "protein quality." Protein quality evaluation aims to determine the capacity of a food protein or diet to meet the protein and indispensable amino acid requirements of an individual. The protein and amino acid requirement values reflect the amounts of absorbed amino acids and nitrogen required to support particular metabolic states (e.g. maintenance of body protein in adults, growth in children, lactation) or to underpin optimal function. Adequate dietary protein and amino acid intakes are needed for supporting optimal growth in children and for various health outcomes such as body weight management in adults or muscle mass retention in the elderly.

Food proteins are derived from a wide variety of sources and are not of equal quality. It is important, therefore, to be able to describe dietary protein quality accurately. An accurate description of dietary protein quality is of fundamental importance for dietary assessment and nutritional planning, for ensuring food security, for the food regulatory environment, and for trade purposes. Many methods for assessing dietary protein quality have different relevance for different applications and objectives, but a commonly applied method has been the protein digestibility-corrected amino acid score, PDCAAS.

FAO Expert Consultation Recommendations

Several perceived shortcomings of the PDCAAS method, however, have led to its revision. The findings of a recently held FAO Expert Consultation have been published (FAO 2013) and herald significant changes in the proposed recommended approach to scoring the "quality" of proteins. Firstly, it is recommended that each individual dietary indispensable amino acid be considered as a nutrient in its own right. This recognises a large body of research, demonstrating specific physiological and regulatory roles for individual amino acids (Jonker et al. 2012). The amino acid contents of foods in tables and databases should be given as true ileal-digestible amino acids. For foods whereby the protein may have been damaged during processing, true ileal-digestible reactive lysine (Moughan and Rutherfurd 1996) contents should also be given. Where an overall score for a protein source, whole food, or diet is required, calculation of digestible indispensable amino acid score (DIAAS) is recommended. DIAAS is a ratio:

DIAAS = [(mg of digestible dietary indispensable amino acid in 1 g of the dietary protein) / (mg of the same dietary indispensable amino acid in 1 g of the reference protein)].

The ratio is calculated for each dietary indispensable amino acid and the lowest value is designated as the score, DIAAS. DIAAS can be less than or more than 1.0. Values above 1.0 are not to be truncated, as was done for PDCAAS, except when calculating DIAAS to determine protein or amino acid intakes for mixed diets or sole source foods, where truncated values must be used. The non-truncation of DIAAS for protein sources used as food ingredients, means that the score provides information about the protein's potency as a complementary protein source. The recommended (FAO 2013) amino acid scoring patterns (i.e. amino acid pattern of the reference protein) to be used for calculating DIAAS are:

- infants (birth to 6 months), the amino acid pattern of breast milk;
- young children (6 months to 3 years), the pattern for the 6-month-old infant;
- older children, adolescents and adults, the pattern for the 3 to 10 year old.

For regulatory purposes, two scoring patterns are given (FAO 2013): the amino acid composition of human milk for infant formulas; and for all other foods and population groups the pattern for young children (6 months to 3 years old).

The key differences between DIAAS and the former PDCAAS are the amended rules around truncation of the score and that true ileal amino-acid digestibility is used for each dietary indispensable amino acid, rather than a single, faecal, crude-protein-digestibility value. The latter change is a significant step forward in accurately describing the absorbed amount of each of the dietary indispensable amino acids. The true ileal amino-acid digestibility (the disappearance of dietary amino acids by the end of the small intestine) would preferably be determined in humans but, when not possible, a workable solution would be in the growing pig (the preferred model) or the growing rat. For proteins whereby lysine may have undergone structural changes (e.g. processed foods, or foods that have been stored for prolonged periods of time), the true ileal digestibility of reactive lysine should be determined in addition to the true ileal digestibility of the other dietary indispensable amino acids. There is an important distinction between amino-acid digestibility and availability. Digestibility refers to the disappearance of the amino acid during transit through the gut (assumed to be absorption), while availability refers to the uptake of an amino acid in a structural form that can be used for body protein synthesis (Fuller 2012). The amino acid lysine is particularly susceptible to undergoing chemical reactions with other food constituents during processing, some types of cooking, and storage. As a result lysine molecules may be altered structurally and thus rendered "unavailable." These altered molecules may be absorbed but cannot be used for protein synthesis and are excreted from the body. Thus, for some foods, determination of the digestibility of reactive (i.e. structurally unaltered or available) lysine is very important. The term "reactive" means that the lysine is in an unaltered form, whereby it can react with certain reagents.

How should ileal amino-acid digestibility be determined?

Ideally, amino-acid digestibility would be determined in human subjects, but this is not practical for routine food evaluation purposes. Ileal amino-acid digestibility can be determined in adult humans, either with the cooperation of ileostomates or by using the naso-ileal intubation method. Both approaches have shortcomings and limitations, and are really restricted to experimental situations and to validating the application to humans of digestibility data obtained using animal models. The growing pig is considered to be a satisfactory animal model for protein digestion in humans, and ileal digesta can be sampled routinely (Deglaire and Moughan 2012). Correction of the ileal-digesta amino-acid flows for endogenous amino acids must be made (Moughan and Rutherfurd 2012) to obtain "true" as opposed to "apparent" digestibility coefficients.

One of the conclusions of the FAO Expert Consultation was that before true ileal amino-acid-digestibility data can be applied in practice for the determination of DIAAS, more work needs to be undertaken to develop a robust inter-species regression relationship to allow the prediction of ileal amino-acid digestibility in humans based on data from the growing pig. Also, although published data on the true ileal amino-acid digestibility of human foods and protein sources exists, the Consultation concluded that research needs to be conducted to provide a more complete data set. Research is now needed urgently to generate the inter-species prediction equations and to provide a contemporary digestibility data set for human foods. Once such information is available, the new DIAAS system can become fully operational. Currently, available data for the true ileal-digestible amino-acid contents of selected protein sources is shown in Table 1, and some DIAAS and PDCAAS values are given in Table 2.

Table 1. True ileal-digestible amino acids (g/kg dry matter) in several protein sources

	WPI[2]	MPC[3]	SPI[4]	Meat	Myofibrillar protein
Lysine	147[1]	89[1]	54[1]	82	99
Threonine	58	43	33	41	49
Tryptophan	30	16	14	12	12
Isoleucine	73	51	42	42	51
Total branched chain	301	212	159	163	193
Glutamic acid	231	227	201	142	172
Methionine	26	22	13	24	31

[1] Available lysine based on reactive lysine determined using o-methylisourea; [2] Whey Protein Isolate; [3] Milk Protein Concentrate; [4] Soya Protein Isolate

Data courtesy of Fonterra and Riddet Institute and from Cui et al. 2013.

Table 2. DIAAS and PDCAAS for selected protein sources

	WPI[1]	MPC[2]	WPC[3]	SPI[4]	Pearl Barley	Meat	Muscle hydrolysate
DIAAS[5]	1.25	1.31	1.10	1.00	0.58	1.1	0.93
PDCAAS[5]	1.00	1.00	1.00	1.00	0.52[6]		

[1] Whey Protein Isolate; [2] Milk Protein Concentrate; [3] Whey Protein Concentrate; [4] Soya Protein Isolate;
[5] Reference amino acid pattern for young child, 6 months to 3 years (FAO 2013); [6] NB a more poorly digested protein

Data courtesy of Fonterra and Riddet Institute.

Conclusions

In 2013, the FAO Expert Consultation published its review of recommendations on the characterisation of dietary protein quality in humans. Recommendations included the urgent need to consider amino acids as individual nutrients and to adopt DIAAS to score protein quality. Before DIASS can be fully implemented, more comprehensive data on the true ileal amino-acid digestibility of foods must be developed.

REFERENCES

Cui J, Chong B, Moughan PJ, Rutherfurd SM, Singh H, Wilkinson B. Gross and true ileal digestible amino acid contents of several animal body proteins and their hydrolysates. Meat Science 2013; 94, 349-354.

Deglaire A, Moughan PJ. Animal models for determining amino acid digestibility in humans – a review. British Journal of Nutrition 2012; 108, S273-S281.

FAO 2013. Dietary protein quality evaluation in human nutrition. Report of an FAO Expert Consultation.

Fuller M. Determination of protein and amino acid digestibility in foods including implications of gut microbial amino acid synthesis. British Journal of Nutrition 2012; 108, S238-S246.

Jonker R, Deutz N.E.P, Engelen M.P.K.J. Role of specific dietary amino acids in clinical conditions. British Journal of Nutrition 2012; 108, S139-S148.

Moughan PJ, Rutherfurd SM. A new method for determining digestible reactive lysine in foods. Journal of Agricultural and Food Chemistry 1996; 44, 2202-2209.

Moughan PJ, Rutherfurd SM. Gut luminal endogenous protein: Implications for the determination of ileal amino acid digestibility in humans. British Journal of Nutrition 2012; 108, S258-S263.

Protein Needs of Children: *Are Current Dietary Recommendations Appropriate?*

Rajavel Elango, PhD
Dr. Rajavel Elango is an Assistant Professor of Pediatrics at the Faculty of Medicine, School of Population and Public Health, University of British Columbia. He is also a Scientist Level 1 at the Child & Family Research Institute, BC Children's Hospital, and an associate member in the Human Nutrition Program at the Faculty of Land and Food Systems, University of British Columbia. Dr. Elango's current research program at the University of British Columbia is focused on the identification of the dietary requirements for protein and amino acids during critical life stages including pregnancy and childhood malnutrition.

Summary of need for new protein intake recommendations

- Current protein intake recommendations for children are inadequate
- 'Optimal' protein and amino acid intakes could have health benefits
- Protein requirements must be considered in the context of:
  - o Amino acid composition
  - o Dietary energy
  - o Parasite infestation
  - o Global implications

Background

The current recommendations for protein requirements in children (6-10 y) are based on the recent Dietary Reference Intakes (DRI 2005) and WHO/FAO/UNU Expert Consultation Report (2007). The mean (estimated average requirement, EAR) and population-safe (recommended dietary allowance, RDA) recommendation for good quality protein were set at 0.76 and 0.95 g/kg/day, respectively. These recommendations were derived using a factorial calculation where the mean requirement is the maintenance needs plus an additional component for growth, which was estimated from the rate of protein deposition and the efficiency of protein utilization. The maintenance needs were based on adult protein requirements derived from nitrogen (N) balance studies. N balance has various methodological drawbacks, including overestimation of nitrogen intakes, underestimation of nitrogen excretion and hence an overall underestimation of N balance. Furthermore, N balance studies require a minimum 7-day test diet adaptation for the dietary change to be reflected in urinary nitrogen excretion (DRI 2005). Due to ethical reasons, such prolonged periods of adaptation to deficient protein intakes is not possible in young children. Hence, the development of valid and minimally invasive techniques to directly determine protein requirements in children is needed.

Recent Advances in Methods to Determine Protein and Amino Acid Requirements

Using stable isotope tracers, the Indicator Amino Acid Oxidation (IAAO) technique has emerged as a viable alternative to determine essential amino acid requirements in human adults (DRI 2005; Elango et al. 2008).

Indicator Amino Acid Oxidation

The IAAO technique is based on the concept that when one essential amino acid is deficient for protein synthesis, then all other amino acids, including the indicator amino acid (another essential amino acid, usually L-[1-13C]phenylalanine), are in excess and therefore will be oxidized. This is primarily because excess amino acids cannot be stored and therefore must be partitioned between incorporation into protein or oxidation. With increasing intake of the limiting amino acid, oxidation of the indicator amino acid will decrease, reflecting increasing incorporation into protein (Elango et al. 2012). Once the requirement is met for the limiting amino acid, there will be no further change in the oxidation of the indicator amino acid with increasing intake of the test amino acid (Figure 1). The inflection point where the oxidation of the indicator amino acid stops decreasing and reaches a plateau is referred to as the 'breakpoint.' The breakpoint, identified with the use of two-phase linear regression analysis, indicates the EAR of the limiting (test) amino acid. The 95% confidence interval (CI) represents the RDA, which is the safe amount of protein or amino acid consumption by populations. This minimally invasive IAAO method has been systematically applied to determine most essential amino acid requirements in adult humans, healthy children, and in patients with disease. The requirement values obtained using the IAAO method were used to derive amino acid intake recommendations in the DRI (2005) and FAO (2007) reports.

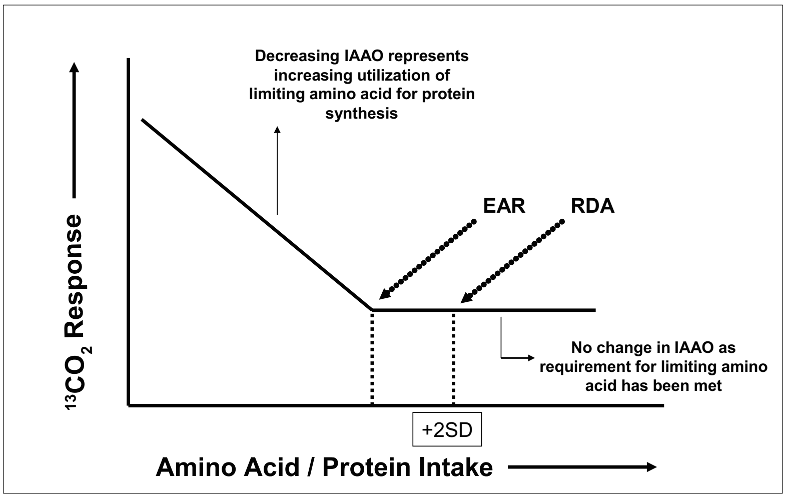


Figure 1. Concept of the indicator amino acid oxidation technique (adapted from Elango et al. 2012)

Application of IAAO to Determine Protein Requirements in Adult Humans

Due to the minimally invasive procedures involved (single study day, oral stable isotope dose and sampling of breath), the IAAO method was applied to determine the total protein requirement in adult humans (Humayun et al. 2007). Eight young adult subjects participated in seven studies each, in which they received graded intakes of protein ranging from 0.1 to 1.8 g/kg/day, and indicator amino acid (L-[1-13C]phenylalanine) oxidation was measured on each day. The diets provided energy at 1.5 × resting energy expenditure, with 33% of energy from fat, and variable energy from carbohydrate (48-66%) and protein (1-19%), based on the amino acid composition of egg protein. The intake of phenylalanine (indicator amino acid) was maintained at a constant level, with excess tyrosine, to ensure that with increasing intakes of total protein nitrogen the indicator amino acid was partitioned between oxidation and protein synthesis. With increasing protein intakes, oxidation of phenylalanine decreased until a breakpoint was reached (between an intake of 0.9 and 1.2 g/kg/day). There was no further decrease in phenylalanine oxidation with increasing protein intake, suggesting no further incorporation of the indicator amino acid into protein. Application of the two-phase linear regression analysis to the data identified a breakpoint (mean requirement) and the upper 95% CI, population-safe requirement. The mean and population-safe requirements were determined to be 0.93 and 1.2 g/kg/day and are 41% and 50%, respectively higher than the current DRI recommendations (Table 1). To confirm the validity of the results, a re-analysis of pre-existing nitrogen balance studies (with intakes above Zero-N balance) was conducted using two-phase linear regression analysis. The EAR and RDA were estimated to be 0.91 and 0.99 g/kg/day, respectively, and the results support each other (Humayun et al. 2007).

Table 1. Protein requirements in humans

	DRI 2005/FAO 2007 Adults/Children g/kg/d	N Balance (re-analyzed)‡ g/kg/d	IAAO§ Adults/Children g/kg/d
Estimated Average Requirement (EAR)	0.66/0.76	0.91	0.93/1.3
Recommended Dietary Allowance (RDA)	0.80/0.95	0.99	1.2/1.55

‡Reanalysis of existing nitrogen balance studies using two-phase linear regression analysis
§IAAO, indicator amino acid oxidation

Application of IAAO to Determine Protein Requirements in Children

Most recently, the IAAO method has been used to determine protein requirements in 6- to 10-year-old children and the mean and safe protein requirements were determined to be 1.3 and 1.55 g/kg/day, respectively (Elango et al. 2011). The current DRI and FAO recommendations are set at 0.76 and 0.95 g/kg/day. The new values are significantly higher than current recommendations (Table 1).

Gattas et al. (1990) conducted the only other direct study to estimate protein requirements in children of similar age (8-10 y), using N balance. Eight healthy children in Chile each received 0.6, 0.8, 1.0 and 1.2 g/kg/day as a mixed diet for 10 days. A mean intake of 0.94 g/kg/day for satisfactory nitrogen retention using single linear regression analysis, and a population-safe intake of 1.2 g/kg/day, was determined. These N balance estimates are 38% and 29% lower than the mean and population-safe IAAO requirements of 1.3 and 1.55 g/kg/day, respectively. However we believe that some of the differences can be explained by the choice of test protein intakes, as well as the method of data analysis. The highest intake tested was 1.2 g protein/kg/day, thus making it impossible to test for a response to greater protein intake. Also, the choice of fitting a linear regression analysis model to determine zero N balance is not appropriate because the physiologic response relationship between N intake and balance is not linear; a decreased efficiency of protein utilization occurs as zero balance approaches (DRI 2005). A two-phase linear regression analysis is more appropriate, as shown earlier in our re-analysis of existing adult N balance data (Humayun et al. 2007). N balance data analyzed using linear regression results in an overestimate of Zero-N balance by at least 10%, which leads to a 20% underestimation of protein requirements. Applying a 20% increase to the N balance based requirement estimates derived by Gattas et al. (1990) in school-age children yields a mean and population-safe protein requirement of 1.13 and 1.44 g/kg/day, which, although are 15% and 8% lower than the results from the current study (Table 1), are nonetheless much greater than the current DRI (2005) and FAO recommendations (2007).

Conclusions

Newer stable isotope-based techniques to determine protein requirements need to be developed and applied in vulnerable populations such as children, pregnant women, elderly etc. Based on the minimally invasive IAAO method to determine protein requirements in adult humans and children, current recommendations appear significantly underestimated. A re-assessment of recommendations for protein intake in children is an urgent need.

REFERENCES

DRI 2005. Institute of Medicine, Food and Nutrition Board, Dietary Reference Intakes: Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington DC: The National Academy Press 2005.

Elango R, Ball RO, Humayun MA, Pencharz PB. Protein requirement of healthy school-age children determined by the indicator amino acid oxidation method. Am J Clin Nutr 2011; 94:1545-1552.

Elango R, Ball RO, Pencharz PB. Indicator amino acid oxidation: concept and application. J Nutr 2008;138:243-246.

Elango R, Ball RO, Pencharz PB. Recent advances in determining protein and amino acid requirements in humans. Br J Nutr 2012;108 Suppl 2:S22-30.

FAO 2007. Protein and amino acid requirements in human nutrition. Report of a joint WHO/FAO/UNU expert consultation. Geneva, Switzerland. 2007 (WHO Technical Report Series, No. 935).

Gattas V, Barrera GA, Riumallo JS, Uauy R. Protein-energy requirements of prepubertal school-age boys determined by using the nitrogen-balance response to a mixed-protein diet. Am J Clin Nutr 1990; 52:1037-42.

Humayun MA, Ball RO, Elango R, Pencharz PB. Reevaluation of the protein requirement in young men with the indicator amino acid oxidation technique. Am J Clin Nutr 2007; 86:995-1002.

Getting older, getting better!
Eating and exercising for healthy aging

Summary of eating and exercising for healthy aging

- Protein intake ranging from 1.1 to 1.3 g/kg/d distributed in meals throughout the day will maximize muscle protein synthesis and contribute to better bone health when consumed with adequate calcium
- The type, content and timing of protein meals can be used along with regular exercise to optimize dietary protein efficiency in healthy older adults
- Routine consumption of good quality protein throughout the day can assist in optimizing nutritional status in older men and women

Nancy Rodriguez
PhD, RD, CSSD, FGACSM
Nancy Rodriguez is a Professor of Nutritional Sciences in the College of Agriculture and Natural Resources (CANR) with joint appointments in Departments of Kinesiology and Allied Health Sciences at the University of Connecticut. She directs the Sports Nutrition program at the University and for the Department of Sports Medicine in the Division of Athletics. Dr. Rodriguez is an Associate Editor for Medicine and Science in Sports and Exercise and she serves on Editorial Boards for ACSM's Health & Fitness Journal, the Journal of Nutrition, the Journal of Applied Physiology, and the International Journal of Nutrition and Exercise Metabolism. She shares her expertise in the courses she teaches at UConn where she is a University of Connecticut Teaching Fellow.

Background

Aging well is an eminent challenge. As men and women live longer, they are engaged in a lifestyle that includes sustained employment and substantial opportunities for varied recreation and retreat. Aging does not discriminate and regardless of cultural preferences and socioeconomic status, today's baby boomer generation is health conscious and motivated to embrace recommendations aimed at vibrant longevity. A contemporary approach to diet design for healthy aging is consuming protein in amounts that exceed the Recommended Dietary Allowance (0.8 g/kg) but rest well within the Acceptable Macronutrient Distribution Range (10-35% of energy intake). When combined with an active lifestyle, this level of protein intake may thwart muscle loss, improve bone health, and enhance nutritional status in individuals as they grow older.

Protein Recommendations and Aging

Sarcopenia

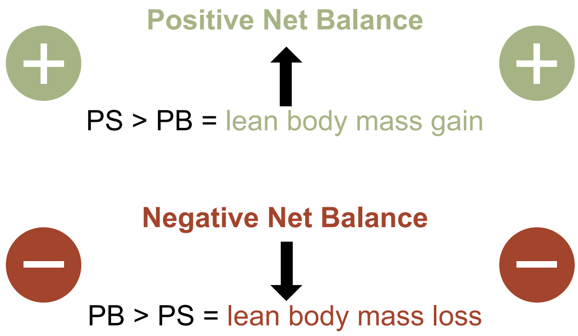
The loss of muscle tissue as a natural part of the aging process defines sarcopenia. As a term, sarcopenia is not common to most people's vocabulary although the muscle wasting that occurs as men and women progress into later life is readily acknowledged. Noted changes in body composition that occur with age are the reduction in lean body mass with a simultaneous increase in fat mass that becomes apparent in early middle-age at approximately 40-50 years. The loss of lean body mass is paralleled by reductions in muscle strength. This specific outcome is cause for most concern because loss of muscle strength is a prequel to loss of muscle function which predisposes older men and women to falls and fractures that can significantly affect quality of life and be potentially fatal.

The mechanisms of sarcopenia are progressive and evolve from the cellular level and eventually translate into behaviors characterized by inactivity. Changes at the cellular level include a reduction in the number of neurons, satellite cell activation and proliferation, contractile protein gene expression and muscle-specific mRNA translation. Modifications in muscle metabolism follow and changes in the endocrine environment coupled with reduced tissue responsiveness to hormones and nutrients may eventually lead to various degrees of malnutrition. Ultimately, a range of physical inactivity ensues and the loss of muscle mass is perpetuated.

Whether this process is an absolute in the physiology of aging has been challenged in recent years as researchers have focused efforts on the relationship between level of dietary protein and routine exercise (Dickinson et al. 2013; Volpi et al. 2012). With specific regard to dietary protein consumption, studies have documented that the acute mixed muscle protein synthetic response to protein consumption is actually similar between young and old individuals (Paddon-Jones and Rasmussen 2009). While the combined effects of exercise and protein consumption on protein utilization by older individuals have not been clearly delineated, there does appear to be a combined synergistic benefit (Dickinson et al. 2013). Further studies to identify specific mechanisms that mediate these responses are needed since aging remains linked to a blunted muscle-protein synthetic response to feeding, insulin, and exercise.

In an effort to overcome these physiological factors, recent research has evaluated whether a practical and balanced approach to higher protein intakes may be beneficial to protein utilization in older men and women and delay the onset of, or slow, muscle loss with aging (Paddon-Jones and Rasmussen 2009). This approach takes advantage of the fact that consumption of approximately 25-30 g of high quality protein maximally stimulates muscle protein synthesis in old, as well as young, persons. The proposed relationship between protein intake and muscle protein synthetic response is shown in figure 1. An extended application of these scientific findings is to distribute daily protein intake throughout the day in amounts that approximate 25-30 g per meal to optimize muscle protein utilization in a manner that might contribute to sustenance of muscle mass in older men and women. Because high quality protein sources such as beef, chicken, eggs, and fish are nutrient dense, routine incorporation of these whole foods in the diet can assist older adults in meeting recommended protein intake while simultaneously keeping calorie intake sensible.

Figure 1: Proposed Relationship Between Protein Intake and Muscle Protein Synthetic Response



Protein Synthesis (PS) – Protein Breakdown (PB) = Protein Balance

Bone Health

The relationship between dietary protein consumption and bone health has changed over the last decade as evidence showing a favorable effect of protein on bone has mounted (Gaffney-Stromberg et al. 2009). The common misconception that increased protein intake causes calcium losses from the body that can ultimately weaken bone has been disproven. Like muscle protein, the skeleton and its constituent proteins are dynamic – constantly being broken down and synthesized. For bone mass and quality to be sustained, calcium intake must be adequate. As methods for assessing calcium absorption and bone turnover became more sophisticated, investigations focused on the possible mechanism by which higher protein intakes might affect calcium utilization. This work demonstrated that higher protein intakes combined with recommended calcium consumption actually enhanced calcium absorption that contributed to the noted increase in urinary calcium excretion with increased dietary protein. Therefore, dietary protein was not 'pulling' calcium from the bone for eventual excretion by the kidney but improving calcium uptake by the body (Gaffney-Stromberg et al. 2009).

Contrary to popular belief, lower protein diets (< 0.8 g/kg/day) actually compromise bone's ability to repair and recover from fractures, whereas diets moderate in protein (1-1.5 g/kg/d) are associated with normal calcium metabolism, greater bone mass, and fewer fractures when calcium intakes are adequate (Gaffney-Stromberg et al. 2009). This relationship is significant in the context of the musculoskeletal system and reinforces the integration of muscle and bone for healthy aging. An appreciation for the parallel that exists between osteoporosis and sarcopenia is important when considering lifestyle interventions such as protein intake and routine physical activity for healthy aging.

Nutritional Status

In the context of longevity, living well, and staying healthy, the role of high-quality protein foods as nutrient-dense sources of essential micronutrients cannot be overstated (Asp et al. 2012; Meydani 2001). Iron, calcium, zinc, the B-complex vitamins, and antioxidants such as Vitamin E are found in animal products like meat, dairy, poultry, and seafood which are both protein and nutrient dense. That is, the calories provided by a standard serving of these whole foods in a meal, are packed with essential amino acids along with these micronutrients making their incorporation into daily menus a wise choice given their contribution to improved nutritional status in older adults (Asp et al. 2012).

Conclusion

In conclusion, it is important to note that the RDA sets the minimal amount of dietary protein for most adults, and is based on nitrogen balance, not functional outcomes. This is particularly relevant to dietary directives for healthy aging. Current evidence suggests that most healthy people require dietary protein intake ≥1.0 g/kg/d to prevent muscle loss. Given that maximal stimulation of muscle protein synthesis is achieved with an approximate 30-gram protein meal, consuming 3 meals daily, a typical 70-80 kg person would consume 1.1-1.5 g protein/kg/d. Protein intake at this level will contribute to better bone health when consumed with a calcium-adequate diet. The type, content and timing of protein-centric meals can be used, along with exercise, to optimize dietary protein efficiency in healthy older adults. Finally, routine consumption of good quality protein throughout the day can assist in optimizing nutritional status in older men and women. From a practical perspective, innovative diet design based on whole foods, complemented with an active lifestyle respective to the individual, provides a feasible and reasonable approach to aging well.

REFERENCES

Asp, ML, Belury MA, Collene AL, Droll KR, Richardson JR. Dietary protein and beef consumption predict for markers of muscle mass and nutrition status in older adults. J Nutr Health Aging 2012; 16(9): 784-790.

Dickinson JM, Volpi E., Rasmussen BB. Exercise and nutrition to target protein synthesis impairments in aging skeletal muscle. Exerc Sport Sci Rev 2013; 41(4): 216-223.

Gaffney-Stromberg E, Insogna K, Kerstetter J, Rodriguez N. Increasing dietary protein requirements in the elderly for optimal muscle and bone health. J Am Geriatr Soc 2009; 57(6): 1073-1079.

Meydani, M. Nutrition interventions in aging and age-associated disease. Ann N Y Acad Sci 2001; 928: 226-235.

Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia. Curr Opin Clin Nutr Metab Care 2009; 12(1): 86-90.

Volpi, E, Campbell WW, Dwyer JT, Jensen GL, Johnson MA, Morley JE, Wolfe, RR. Is the optimal level of protein intake for older adults greater than the recommended dietary allowances? J Gerontol A Biol Sci Med Sci 2012; 68(6): 677-681.

Protein for long life: *Do Older Adults Need More Protein to Live Longer?*

Summary of protein recommendations for optimal health and function

- A protein intake of at least 1.3 g/kg/day, utilising high-quality protein sources, is beneficial
- Consume at least 3 meals per day with a significant amount of protein (25-30 g) consumed in at least two meals per day
- Perform progressive resistance exercise at least twice per week

Caryl Nowson
PhD, BSc, Dip.Nut.Diet
Professor Caryl Nowson holds the chair of Professor of Nutrition and Ageing, School of Exercise and Nutrition Sciences, Deakin University, Burwood, Melbourne Australia, and is team leader of Food, Lifestyle and Health group within the Centre for Physical Activity and Nutrition Research. She has a research program spanning 30 years that has focused on two major diseases of ageing: nutrition related to hypertension, and nutrition related to bone health. She has a particular interest in the relationship of dietary factors to health outcomes for the elderly, particularly falls and fractures.

Background

Recently, debate among nutrition experts regarding the recommended dietary protein intake for older people has increased. It has been proposed that dietary protein intakes for optimal health should be considerably higher than the current minimum protein requirements. A leading cause of disability and reduced quality of life in older people is osteoporosis with one in three women and one in six men experiencing an osteoporotic fracture in their life time. In Australia, the incidence of osteoporotic fractures is also predicted to increase, from one every 8.1 minutes in 2001 to one every 3.7 minutes in 2021 (Sambrook et al. 2002). Fracture risk is increased when bone density is low, and loss of muscle mass is associated with loss of bone mass. Muscle weakness predicts falls and subsequent fractures. Muscle weakness is associated with age-related muscle loss which in turn is related to osteoporosis and leads to a life of restricted mobility, loss of independence, and reduced life expectancy (Cederholm et al. 2013). Frailty and accelerated age-related muscle loss (sarcopenia) are closely related, and frail older people are by definition sarcopenic (Morley et al. 2011). Sarcopenia is a complex process involving a range of age-related physiological changes combined with the adoption of a sedentary lifestyle and a sub-optimal dietary pattern (Paddon-Jones et al. 2008). Frailty significantly increases the risk of adverse health outcomes, such as falls, hospitalization, disability, loss of independent living and death (Fried et al. 2001). Frailty is difficult to define but a common definition, the Fried Frailty Index (FFI), requires the presence of three or more of five components: weight loss, exhaustion, weakness, slowness and low physical activity (Fried et al. 2001). Between 6% and 25% of free-living individuals aged 65 years and older may be considered frail and this percentage increases to between 25% and 40% in those aged 80 years and above (Strandberg et al. 2007). Two key effective interventions to reduce sacropenia include a dietary strategy to address nutrient deficiencies, specifically protein, and an exercise regime, particular resistance exercise (Gillespie et al. 2009).

Recommended Dietary Intakes for Protein for Older People

Traditionally, protein requirements have been derived on the basis of sufficient dietary protein to ensure nitrogen balance. The most recent meta-analysis included studies which assessed a total of 235 individuals, though only 16 individuals were older (68-84 y) (Rand et al. 2003). An early study found that older healthy subjects were in negative nitrogen balance after consuming the U.S. protein recommended dietary allowance (RDA) for 10 days (Campbell et al. 1994). It appears that the body adapts to a lower protein intake to maintain nitrogen balance by breaking down lean mass, which will ultimately result in rapid progression to sarcopenia, frailty and reduced quality of life in older people. Older people appear to have lower rates of protein synthesis and lower rates of whole-body proteolysis in response to an anabolic stimulus (consuming food or performing resistance exercise), which is consistent with overall slower tissue remodelling (Kumar et al. 2009).

Evidence is emerging that this "anabolic resistance" in older people can be overcome by ingesting protein supplements or foods that are rich in the essential amino acid leucine (Bell et al. 2005; Symons et al. 2009). This increase in protein synthesis appears to be further enhanced by resistance exercise (Drummond et al. 2009). Recent evidence suggests that optimal health for older people, particularly optimal muscle retention, may require dietary protein intakes greater than the RDA. The need to assess dietary protein requirements in terms of functional outcomes associated with morbidity and predictive of mortality is increasingly recognized. These predictive functional outcomes are related to the ability to perform simple physical tasks, such as the ability to get up out of a chair and walk a short distance at a reasonable speed. Optimal levels of dietary protein need to be assessed in the context of the range of physical activity levels present in the older population, from those who are relatively inactive to those who are performing the recommended regular weight-bearing activities. Consistent with approaches to reduce chronic disease in younger people, dietary recommendations to reduce health risk and optimise quality of life in the later years must be combined with recommendations for physical activity.

Evidence of Higher Protein Requirements for Older People

Evidence is accumulating to suggest older people intake an optimal protein level of approximately 1.3 g/kg/d which would support increased muscle mass with emerging evidence for a benefit on function/physical performance. Evidence from randomised controlled trials shows a higher-protein diet of at least 1.3 g/kg/d combined with twice-weekly progressive resistance provides a clear benefit by enhancing lean muscle mass gain and leg strength in older people (Tieland, Borgonjen-Van den Berg et al. 2012; Tieland, Dirks et al. 2012). These studies were conducted in frail, older community-dwelling participants of average body weight who ingested twice-daily protein supplements consisting of two 15 g milk-based protein drinks (250 ml each) which raised total daily protein intake from 1.0 to 1.3-1.4 g/kg/d.

A dietary plan that includes 25-30 g of high-quality protein per meal (60 g/day) has been proposed to maximize muscle protein synthesis. It has been shown that ingestion of approximately 25-30 g of protein per meal maximally stimulates muscle protein synthesis in both young and older individuals (Paddon-Jones et al. 2004; Cuthbertson et al. 2005; Katsanos et al. 2005). Many older people may be consuming only minimal amounts of protein at each meal throughout the day and may not reach the threshold intake of 25-30 g protein to stimulate protein synthesis. Two recent protein-supplement studies have demonstrated an improvement in physical performance with a protein supplement. One study showed an increase in lean mass with a protein supplement combined with resistance exercise (Tieland, Borgonjen-Van den Berg et al. 2012). The second study demonstrated that a modest 30-40% increase in total dietary protein has some clear benefits on muscle mass (Tieland, Dirks et al. 2012). A recent study found that a protein-enriched diet equivalent to ~1.3 g/kg/d achieved through twice daily consumption of 80 g of cooked beef, veal, or lamb on most days during a period of 14 weeks was safe and effective for enhancing the effects of progressive resistant training on lean mass in elderly women (Daly et al. 2013, submitted). On the basis of this accumulating evidence, older people would be advised to consume protein intakes up to 1.3 g/kg/d.

Conclusions

Any intervention or strategy to assist in maintaining muscle strength needs to be readily achievable and acceptable to older people in the long-term. A strategy is more likely to be sustainable if it can be incorporated into a food-based dietary approach meeting all their dietary requirements while enhancing their enjoyment in life. For this reason, food- and meal-based strategies rather than supplemental drinks are likely to be more sustainable and are recommended as the initial approach to optimising protein intake in older people.

REFERENCES

Bell JA, Cadenas JG, Fujita S, Rasmussen BB, Volpi E. Short-term insulin and nutritional energy provision do not stimulate muscle protein synthesis if blood amino acid availability decreases. American Journal of Physiology, Endocrinology and Metabolism 2005; 289:E999-1006.

Campbell WW, Crim MC, Dallal GE, Evans WJ, Young VR. Increased protein requirements in elderly people: New data and retrospective reassessments. The American Journal of Clinical Nutrition 1994; 60:501-509.

Cederholm T, Cruz-Jentoft AJ, Maggi S. Sarcopenia and fragility fractures. European Journal of Physical and Rehabilitation Medicine 2013; 49:111-117.

Cuthbertson D, Atherton P, Babraj J, Leese G, Rennie MJ, Smith K, Taylor PM, Wackerhage H, Waddell T. Anabolic signaling deficits underlie amino acid resistance of wasting, aging muscle. FASEB Journal : Official Publication of the Federation of American Societies for Experimental Biology 2005; 19:422-424.

Drummond MJ, Dhanani S, Dreyer HC, Fry CS, Glynn EL, Rasmussen BB, Timmerman KL, Volpi E. Rapamycin administration in humans blocks the contraction-induced increase in skeletal muscle protein synthesis. The Journal of Physiology 2009; 587:1535-1546.

Fried LP, Burke G, Gottdiener J, Hirsch C, Kop WJ, McBurnie MA, Newman AB, Seeman T, Tangen CM, Tracy R, Walston J; Cardiovascular Health Study Collaborative Research G. Frailty in older adults: Evidence for a phenotype. The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences 2001; 56:M146-156.

Gillespie LD, Cumming RG, Gates S, Gillespie WJ, Lamb SE, Robertson MC, Rowe BH. Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Reviews 2009; 9:CD007146.

Katsanos CS, Aarsland A, Kobayashi H, Sheffield-Moore M, Wolfe RR. Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids. The American Journal of Clinical Nutrition 2005; 82:1065-1073.

Kumar V, Atherton P, Hildebrandt W, Hiscock N, Patel R, Rankin D, Rennie MJ, Selby A, Seynnes O, Smith K, Williams J. Age-related differences in the dose-response relationship of muscle protein synthesis to resistance exercise in young and old men. The Journal of Physiology 2009; 587:211-217.

Morley JE. Frailty: Diagnosis and management. The Journal of Nutrition, Health & Aging 2011; 15:667-670.

Paddon-Jones D, Aarsland A, Ferrando AA, Sheffield-Moore M, Volpi E, Wolfe RR, Wolf SE, Zhang XJ. Amino acid ingestion improves muscle protein synthesis in the young and elderly. American Journal of Physiology, Endocrinology and Metabolism 2004; 286:E321-328.

Paddon-Jones D, Campbell WW, Short KR, Volpi E, Wolfe RR. Role of dietary protein in the sarcopenia of aging. The American Journal of Clinical Nutrition 2008; 87:1562S-1566S.

Rand WM, Pellett PL, Young VR. Meta-analysis of nitrogen balance studies for estimating protein requirements in healthy adults. The American Journal of Clinical Nutrition 2003; 77:109-127.

Sambrook PN, Ebeling PR, Phillips SR, Seeman E; National Prescribing S, Osteoporosis A. Preventing Osteoporosis: Outcomes of the australian fracture prevention summit. The Medical Journal of Australia 2002; 176 Suppl:S1-16.

Strandberg TE, Pitkala KH. Frailty in elderly people. Lancet 2007; 369:1328-1329.

Symons TB, Paddon-Jones D, Sheffield-Moore M, Wolfe RR. A moderate serving of high-quality protein maximally stimulates skeletal muscle protein synthesis in young and elderly subjects. Journal of the American Dietetic Association 2009; 109:1582-1586.

Tieland M, Borgonjen-Van den Berg KJ, de Groot LCPGM, van Loon LJC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: Scope for improvement. European Journal of Nutrition 2012; 51:173-179.

Tieland M, Dirks ML, de Groot LC, van de Rest O, van der Zwaluw N, van Loon LJ, Verdijk LB. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: A randomized, double-blind, placebo-controlled trial. Journal of the American Medical Directors Association 2012; 13:713-719.

INTERNATIONAL
MEAT
SECRETARIAT

Oficina Permanente Internacional de la Carne

Office International de la Viande

www.meat-ims.org

The Symposium was hosted and sponsored by the International Meat Secretariat.

Landbrug & Fødevarer

Axelborg, Axeltorv 3
1609 København V.
Tlf. 3339 4000
E-mail: info@lf.dk
W. www.lf.dk

Find flere oplysninger på www.diaetistforum.dk