Protein Needs of Older Adults Engaged in Resistance Training: A Review

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Protein recommendations by some professional organizations for young adults engaged in resistance training (RT) are higher than the recommended dietary allowance (RDA), but recommendations for resistance-training older adults (>50 years old) are not well characterized. Some argue that the current RDA is adequate, but others indicate increased protein needs. Although concerns have been raised about the consequences of high protein intake, protein intake above the RDA in older adults is associated with increased bone-mineral density when calcium intake is adequate and does not appear to compromise renal health in older individuals with normal renal function. Individual protein needs for older adults in RT are likely highly variable according to health and training regimen, but an intake of 1.0–1.3 g · kg\(^{-1}\) · day\(^{-1}\) should adequately and safely meet the needs of older adults engaged in RT, provided that their energy needs are met.

Key Words: strength, muscle mass, aging

Older adults make up a significant and increasing segment of the U.S. population; in 2002 there were approximately 60 million American men and women over 55 years of age (U.S. Department of Commerce, 2003). A number of physiological changes accompany the normal aging process, including a decline in muscle mass and strength (sarcopenia) and concomitant decline in physical functioning. Because muscle serves as a protein reservoir in times of physiological stress in addition to its role in movement, strategies to maintain muscle mass in aging adults are of utmost importance. Increasing evidence indicates that resistance training (RT), defined as strength or weight training including free weights, isokinetic training, variable resistance, and static (isometric) training (Graves, Pollock, & Bryant, 2001), can enhance muscle-protein synthesis, as well as muscle mass and strength, in older individuals (Ades, Ballor, Ashikaga, Utton, & Sreekumaran, 1996; Hagerman et al., 2000; Schulte & Yarasheski, 2001; Yarasheski, 2003). In order to benefit maximally from RT, it is vital that dietary protein needs be met. At this point in time, there is disagreement on the protein needs of adults engaged in RT; specific recommendations for older individuals engaged in RT are even less certain.

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Results of recent studies suggest that the current recommended dietary allowance (RDA) for protein might not be adequate for older people to maintain skeletal muscle (Campbell et al., 2002; Campbell, Trappe, Wolfe, & Evans, 2001). For mature adults (defined as over age 50) engaging in RT, the amount of protein needed to provide for muscle repair and growth might be higher than for those not strength training. According to a position statement by the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine, protein recommendations for resistance-training adults might be as high as 1.7 g · kg\(^{-1}\) · day\(^{-1}\) for the first few months of intensive training (American Dietetic Association, 2000). Although ages were not specified in the recommendation, older individuals do not typically engage in such high-intensity RT. In contrast, the Food and Nutrition Board of the Institute of Medicine (FNB/IOM) concluded that individuals young and old engaged in RT do not need dietary protein in amounts greater than the current RDA of 0.8 g · kg\(^{-1}\) · day\(^{-1}\) (FNB/IOM, 2002). Because protein-intake recommendations for older adults engaged in RT are not well defined, the purpose of this review was to evaluate the existing literature on protein needs for mature adults engaged in RT.

### Changes in Body Composition Associated With Aging

Age-related changes in body composition include a reduction in lean body mass accompanied by an increase in body fat (Guo, Zeller, Chumlea, & Siervogel, 1999). The decrease in muscle is greater in the lower body than in the upper body in both sexes (Janssen, Heymsfield, Wang, & Ross, 2000). Although the average skeletal-muscle mass in men is 36% greater than in women (Janssen et al.), women begin to lose strength at a later age than men (Lindle et al., 1997), and the overall decrease in skeletal-muscle mass is greater in men than in women (Gallagher et al., 1997).

Loss of muscle mass is particularly prevalent after the 5th decade of life (Janssen et al., 2000). The exact cause of this age-associated sarcopenia is unclear, but hormonal changes and protein metabolism, inflammation, undernutrition, and inactivity have been identified as contributing factors (Bortz, 1982; Fiatarone et al., 1990; Morais et al., 1997; Short & Nair, 2001; Yarasheski, 2003). An irreversible degeneration of muscle fibers (specifically, Type II fibers) takes place, which suggests that loss of muscle mass is related to not only reduction in fiber size but also a loss of fiber units (Doherty, Vandervoort, Taylor, & Brown, 1993).

### Resistance Training and Older Adults

According to the Surgeon General, RT can decrease the risk of accidents resulting from muscle weakness, fatigue, and poor balance (U.S. Department of Health and Human Services, 1996). RT can be performed by almost anyone, and many cardiac-rehabilitation programs include weight lifting to increase strength and endurance (Evans & Cyr-Campbell, 1997). Even with RT’s numerous benefits, however,
current data suggest that less than 10% of older adults participate in some form of strength training (U.S. Department of Health and Human Services, 2000).

In physically frail men and women, participation in a RT program for as little as 8 weeks resulted in a 48% improvement in gait speed, as well as increased muscle-protein synthesis (Fiatarone et al., 1990; Yarasheski et al., 1999). In two separate studies both 12 weeks in length, 22 women (mean age 70 years) and 14 men (mean age 63 years) showed strength gains resulting in part from an increase in Type II muscle-fiber area (Brown, McCartney, & Sale, 1990; Charette et al., 1991). Increases in muscle strength are not always accompanied by an increase in fat-free mass (FFM; Campbell, Crim, Young, Joseph, & Evans, 1995; Meredith, Frontera, O’Reilly, & Evans, 1992), and in some instances there is a decrease in FFM, which could be caused by inadequate protein consumption (Campbell et al., 2002).

RT can prevent the increase in percentage body fat, which is a recognized adverse consequence of aging (Campbell, Crim, Young, & Evans, 1994; Hunter, Wetzstein, Fields, Brown, & Bamman, 2000; Pratley et al., 1994; Sipila & Suominen, 1995). Of 17 studies on strength-training adults age 50 and older included in a recent review, all but two reported increased strength. The two that did not report strength improvement were home-based programs, and participants in those studies might not have adhered to the exercise protocol (Seguin & Nelson, 2003).

RT can also have a protective effect on bone-mineral density (BMD). In a 1-year randomized controlled trial involving 39 postmenopausal women, femoral-neck and lumbar-spine BMD increased in women engaged in RT, whereas the control group exhibited a corresponding decrease in BMD (Nelson et al., 1994). Although most studies report no change in total body mass with RT, there is typically an increase in FFM (Campbell et al., 1994; Hunter et al., 2000; Pratley et al., 1994). This increase in FFM has significant implications for older adults because it results in increased resting energy expenditure and fat oxidation (Treuth, Hunter, Weinsier, & Kell, 1995), which would have favorable effects on body composition and energy balance.

Lack of exercise is considered the most important predictor of disability in the elderly (Bunout et al., 2001). Studies have shown that muscle responds to RT with noticeable and rapid improvement into the 9th decade of life (Fiatarone et al., 1990). Older adults can benefit from RT by increasing strength, resulting in an ability to live independently as they age with decreased health risks (Westerterp & Meijer, 2001). For optimal well-being, RT should be incorporated into the fitness programs of both men and women by no later than the 5th decade as a means to preserve muscle mass (Janssen et al., 2000).

**Protein Recommendations and Intake**

**by Older Adults (General)**

In 2002, the FNB/IOM established the dietary reference intakes for protein at 0.8 g · kg⁻¹ · day⁻¹ for all men and women age 19 years and older, independent of body composition and physical activity, which is the same as the previous RDA for protein.
issued by the FNB of the National Research Council in 1989. Because protein need is based on body weight and lean body mass decreases with age, the FNB determined that the dietary reference intake for the general adult population is sufficient for older or mature adults (FNB/IOM, 2002). The appropriateness of extrapolating the RDA for younger individuals to older adults warrants further investigation, because protein absorption and metabolism are affected by age (Schlenker, 1998), and the frequent use of medications might also influence requirements.

Most researchers agree that currently there are no data on which to base a recommendation for an adequate dietary protein intake for mature adults (FNB/IOM, 2002). There is a general consensus, however, that a protein intake slightly over the RDA is better than an intake lower than the RDA for older adults (Campbell et al., 2001). A 10-year longitudinal study among independently living elderly adults indicated that women with protein intakes greater than the current RDA had fewer health problems (Vellas et al., 1996). In addition, skeletal muscle serves as a reservoir for protein, and this reservoir is important during periods of stress or decreased energy intake, which often occur in the elderly (Schlenker, 1998).

Because of the physiological stress and various metabolic changes that occur with aging, dietary nitrogen utilization is less efficient and associated with increased nitrogen excretion in older individuals (Mahan & Escott-Stump, 2004). Because of decreased energy needs with age, it might be advisable for mature adults to increase the proportion of total energy from protein to maintain nitrogen status without creating energy excess (Prothro, 1989). Although there is currently no established tolerable upper intake level for protein, the International Dietary Energy Consultative Group has recommended that protein intake not exceed 2.0 g · kg\(^{-1}\) · day\(^{-1}\), the upper limit currently safely consumed by well-nourished populations (Durnin et al., 1999).

Some researchers suggest that the aging body is accommodating inadequate protein intake with losses in physiological function (Campbell et al., 1994, 2001; Castaneda, Chamley, Evans, & Crim, 1995; Chevalier, Gougeon, Nayar, & Morais, 2003; Gersovitz, Motil, Munro, Scrimshaw, & Young, 1982). Loss of skeletal muscle with aging might be a reflection of long-term marginally inadequate protein intake (Campbell et al., 2001). A 30-day nitrogen-balance study including 7 men (mean age of 75) and 8 women (mean age of 78) concluded that a protein level of 0.8 g · kg\(^{-1}\) · day\(^{-1}\) was not adequate to achieve nitrogen balance in most of the participants. It is important to note that the experiment was divided into three periods of 10 days each, which might not have been long enough to reach a steady state of nitrogen excretion (Morse, Haub, Evans, & Campbell, 2001). In addition, when nitrogen-balance studies are conducted with participants receiving less than adequate energy intake, protein requirements can be overestimated (Millward, Fereday, Gibson, & Pacy, 1997), and because participants in this study lost a small amount of weight, inadequate energy intake might have confounded the results.

Changing the feeding pattern rather than increasing dietary protein in the elderly might be a viable option for minimizing or preventing age-related sarcopenia. Arnal et al. (1999) found that consuming 80% of one’s daily protein at
noon (pulse pattern) was more efficient in improving nitrogen retention than was spreading protein intake over four meals (spread pattern). After an adaptive period, 15 women (mean age of 68) were given 1.7 g · kg\(^{-1}\) · day\(^{-1}\) protein either in a pulse pattern or in a spread pattern for 14 days. The pulse pattern resulted in a significant increase in nitrogen balance, as well as whole-body protein turnover and synthesis. The pulse pattern resulted in greater nitrogen retention. A subsequent study in old rats found that a pulse pattern of protein intake increased muscle-protein synthesis (Arnal et al., 2002). Because high-protein diets could be a problem for the elderly because of decreased renal function (discussed later), pulsing protein intake might be a good alternative to help prevent age-related loss of muscle mass. Because the level of protein intake in the human study was over double the RDA, however, similar studies at lower protein levels need to be conducted before pulsing is recommended.

Protein intake by mature adults generally meets the RDA based on the last Continuing Survey of Food Intakes by Individuals (U.S. Environmental Protection Agency, 2003). The mean intake of protein for the general population was found to be 1.5 g · kg\(^{-1}\) · day\(^{-1}\), compared with 0.97 g · kg\(^{-1}\) · day\(^{-1}\) for men and women 51 years and older. At the 99th percentile, protein intake for mature adults was 1.7 g · kg\(^{-1}\) · day\(^{-1}\). Not all older individuals consume adequate protein, however, as illustrated by a study of older individuals in New England in which a significant proportion of elderly participants did not consume adequate protein, with approximately 15% of those age 65–70 having inadequate intake (Cid-Ruzafa, Caulfield, Barron, & West, 1999).

**Protein Needs of Older Adults Engaged in Resistance Training**

Protein recommendations for RT are controversial. The American Dietetic Association (2000) recommends a protein intake higher than the RDA to meet increased demands for repair and growth of muscle during RT, whereas other professionals disagree with a recommendation higher than the RDA. Many factors influence the protein need during RT, including intensity, duration, and frequency of training, as well as type of training, conditioning, and adaptation. Many of the experiments examining protein needs were of short duration and included small sample sizes. In addition, true nitrogen balance, which is commonly used to assess protein requirements, is very difficult to determine, and some estimation of nitrogen intake and output is necessary. Therefore, many studies examining protein requirements during RT have limited generalizability. In addition, many studies do not include gradations of protein intake, which makes it difficult to pinpoint the actual protein requirement.

Nonetheless, there is some evidence for increased protein need during RT, particularly for the young. In a randomized double-blind cross-over study involving young novice strength athletes (mean age 22 years), protein needs were 100% greater than the RDA, with recommendations as high as 1.7 g · kg\(^{-1}\) · day\(^{-1}\) (Lemon,
Tarnopolsky, MacDougall, & Atkinson, 1992). During the intensive RT program (6 days/week) a protein intake of 1.43 g · kg\(^{-1}\) · day\(^{-1}\) was needed to achieve nitrogen balance. Timing of protein intake was not mentioned, but as suggested by other studies (Esmarck et al., 2001), this could have influenced observable gains in lean body mass, which did not occur. A similar 8-week study involving young male strength athletes concluded that a protein intake of 1.76 g · kg\(^{-1}\) · day\(^{-1}\) could satisfy dietary protein needs (Tarnopolsky et al., 1992). Additional studies report that protein in excess of 1.35 g · kg\(^{-1}\) · day\(^{-1}\) (Lemon et al.) and 2.4 g · kg\(^{-1}\) · day\(^{-1}\) (Tarnopolsky et al.) do not increase muscle mass or strength gains.

The protein recommendations for RT are based primarily on studies involving young participants and might not be applicable to mature adults engaged in RT. Metabolism of protein changes with aging in general (e.g., decreased turnover rate), and some aspects of muscle response to RT change with aging (Pehme, Alev, Kaasik, & Seene, 2004), so extrapolating the recommendation for protein intake to older individuals might not be appropriate. Studies on the protein needs of mature adults engaged in RT are contradictory and limited at best, generally concluding that the current RDA is adequate (Campbell et al., 1995) or too low (Campbell et al., 2002).

A 14-week controlled diet-and-exercise study involving older adults (12 men, 17 women; mean age 66) led the investigators to question the adequacy of the protein RDA for older individuals (Campbell et al., 2002). The participants were divided into three groups (sedentary, lower body RT, and whole-body RT), and all consumed 0.8 g protein · kg\(^{-1}\) · day\(^{-1}\). Although strength and muscle-mass gains were observed in the RT groups, all three groups exhibited a loss of FFM. In another 14-week study of older adults engaged in RT (8 men, 4 women; mean age 66), two levels of protein were consumed (0.8 g · kg\(^{-1}\) · day\(^{-1}\) and 1.6 g · kg\(^{-1}\) · day\(^{-1}\)) to determine the effect of protein intake on protein metabolism (Campbell et al., 1995). There was no difference in the change in body composition with RT between the two groups, and efficiency of nitrogen retention with RT was increased with the lower protein intake in an attempt to meet the body’s needs for protein. These results indicate that the body might be able to adapt to lower protein intakes and that the current RDA might be adequate.

Rosenbloom (2000) states that it is reasonable to assume that the protein needs of mature adults in RT are similar to those of younger individuals. On the other hand, protein needs for mature adults in RT might be lower than for younger individuals because of the decrease in whole-body protein turnover and protein synthesis with aging (Morais et al., 1997; Nair, 1995) and because older individuals do not train with the same intensity or duration as younger people (Kavanagh & Shephard, 1990; Walter, Hart, Sutton, McIntosh, & Gauld, 1988). For those reasons, Sacheck and Roubenoff (1999) recommend 0.8–1.0 g · kg\(^{-1}\) · day\(^{-1}\) for older individuals in RT, and Evans (1995) suggests 1.0–1.25 g · kg\(^{-1}\) · day\(^{-1}\).

It is important to note, however, that among mature adults, individual needs might vary according to the intensity of training, as well as other physiological, environmental, and dietary variables in this heterogeneous population. Another
consideration is that experienced strength athletes might actually have lower protein needs than do those new to RT, because more protein is required to build than to maintain muscle, and with training, protein metabolism might become more efficient (Lemon, 1998; Lemon et al., 1992). Therefore, protein needs of mature adults in RT might change with conditioning.

In addition to the amount of protein, the type and timing of protein consumption during RT are also being questioned. In a 13-week study, a group of sedentary men (mean age 59 years) consumed either a lacto-ovovegetarian diet or a mixed diet (omnivorous) and then participated in two RT sessions per week for 12 weeks (Campbell et al., 1999). Mean percentage body fat decreased and FFM increased in the omnivorous group, whereas mean percentage body fat increased and FFM decreased in the lacto-ovovegetarian group, suggesting that a diet higher in meat protein is beneficial for RT. The change in muscle mass as assessed by urinary creatinine excretion, however, tended to overestimate muscle mass with increased meat consumption (Campbell et al., 1999).

Muscle hypertrophy from RT is enhanced when the ingestion of protein occurs immediately after the exercise session compared with several hours later (Esmarck et al., 2001). In a 12-week RT program, 13 men (mean age 74) were given an oral protein-gel supplement (10 g protein, 7 g carbohydrate, 3.3 g lipid) either at time zero or 2 hr after a 30-min RT session. Total dietary protein intake averaged 14–15% of energy, or 1.02 g · kg\(^{-1}\) · day\(^{-1}\). Lean body mass increased 1.8% in the group that received the supplement immediately after RT and decreased 1.5% in the group that received the supplement 2 hr after RT. The absence of an increase in muscle mass when protein was ingested 2 hr later emphasizes the importance of protein intake immediately after a RT session (Esmarck et al.).

**Possible Adverse Consequences of Increased Protein Intake**

Concern has been expressed about the potential negative consequences of a high-protein diet. Although there is no official definition of *high-protein diet*, a number of negative consequences have been associated with increased protein intake, most notably bone loss and renal impairment.

**BONE-MINERAL DENSITY**

The aging kidney appears to have a reduced capacity to excrete acid, so the possible adverse consequences of the acid load from dietary protein is of particular concern in terms of bone health in older individuals, because bone acts as a buffer via bone resorption (Barzel & Massey, 1998). It appears, however, that moderately high protein intake, 1.0–1.3 g · kg\(^{-1}\) · day\(^{-1}\), not only does not have harmful effects on bone health but also might actually be beneficial to bone health. An 8-week study of 15 postmenopausal women found that calcium retention was not affected by an increase in meat in the diet and was actually slightly improved compared with a low-meat diet (Roughead, Johnson, Lykken, & Hunt, 2003). The results
suggest that if early hypercalciuria occurs in response to a high-meat diet, adaptation occurs within 3 weeks. Another study found that protein exerts a positive effect on BMD when calcium intake is adequate (Whiting, Boyle, Thompson, Mirwald, & Faulkner, 2002). It is important to note the protein level in studies examining calcium balance in high- versus low-protein diets. A short-term “low-protein” diet resulted in a positive calcium balance, compared with a negative calcium balance with a “high-protein” diet in elderly participants, but the low-protein diet consisted of 0.8 g · kg\(^{-1}\) · day\(^{-1}\), compared with 2 g · kg\(^{-1}\) · day\(^{-1}\) for the high-protein group (Licata, Bou, Bartter, & West, 1981). When Draper, Piche, and Gibson (1991) examined the protein intake from commonly consumed foods in a more moderate range of intakes (58 vs. 92 g/day), the high-protein diet did not adversely affect calcium balance.

Recent studies have examined the association between dietary protein and the skeletal health of elderly men and women. Some studies have found a positive correlation between protein and BMD (Dawson-Hughes & Harris, 2002; Hannan et al., 2000; Munger, Cerhan, & Chiu, 1999; Promislow, Goodman-Gruen, Slymen, & Barrett-Connor, 2002; Rapuri, Gallagher, & Haynatzka, 2003), whereas others found that higher protein intake was associated with increased fracture rates in the elderly (Feskanich, Willett, Stampfer, & Colditz, 1996; Sellmeyer, Stone, Sebastian, & Cummings, 2001).

Protein interacts with other nutrients to influence bone health. Adequate calcium is necessary to promote bone health with increased protein (Hannan et al., 2000; Rapuri et al., 2003; Whiting et al., 2002). When phosphorus intake increases with protein intake, calcium balance is preserved (Teegarden et al., 1998), and phosphorus intake generally increases with protein intake because many high-protein foods are also good sources of phosphorus. In addition, increased calcium excretion that might occur with high protein intakes might be attenuated with the consumption of alkali buffers such as fruits and vegetables (Barzel & Massey, 1998). It appears that, when taken in the context of a healthy diet (i.e., adequate in calcium and rich in fruits and vegetables), moderately high protein intake from commonly consumed foods is not harmful.

**RENA L FUNCTION**

Because excess amino acids are deaminated and excreted by the kidney as urea, some view high-protein diets as “stressful” to the kidneys. Although restricting dietary protein has been a common treatment in attempting to slow the decline in the glomerular filtration rate in those with renal disease, few studies have examined the effect of differing levels of dietary protein on renal function in healthy individuals. The lack of a standard definition for *high-protein diet* and a shortage of long-term studies make it difficult to make an evidence-based conclusion on the influence of protein intake on renal health.

With regard to athletes, protein intakes as high as 2.8 g · kg\(^{-1}\) · day\(^{-1}\), when consumed by healthy, young athletes, have not resulted in harmful effects on kidney
function (Poortmans & Dellalieux, 2000). Likewise, no significant association was found between total protein intake and change in estimated glomerular filtration rate in a group of 1,135 participants (mean age 65 years) with normal renal function from the Nurses Health Study (Knight, Stampfer, Hankinson, Spiegelman, & Curhan, 2003). In the same study, participants with mild renal insufficiency (mean age 67 years) in the highest quintile of protein intake (93 g/day) had lower estimated glomerular filtration rates than those of participants with lower protein intakes, indicating better renal function with higher protein intake. In a recent review, Friedman (2004) concluded that there are no clear renal-related contraindications to high-protein diets in those with healthy renal function, but high-protein diets are contraindicated in those with renal impairment. It might be prudent to screen for proteinuria to rule out renal impairment in older individuals before they embark on diets more than double the RDA.

**Conclusions and Recommendations for Future Research**

Certain physiological changes associated with aging, including reduced lean body mass and loss of strength, can diminish physical functioning and quality of life, and RT might help prevent or slow the progression of this age-related phenomenon. Adequate dietary protein is also important for maintaining muscle mass, but protein requirements for older adults in RT are not well defined, and the data on which to base a recommendation are limited.

The heterogeneity of this population, in addition to variable training regimens, makes setting a specific protein recommendation problematic. It appears that mature adults engaged in RT might benefit from a protein intake greater than the current RDA of 0.8 g · kg\(^{-1}\) · day\(^{-1}\) because (a) the RDA might not maintain muscle mass of the elderly in general, (b) RT might increase protein needs in older individuals, and (c) there is little compelling evidence that protein intake above the RDA will induce renal problems. A moderate protein intake of 1.0–1.3 g · kg\(^{-1}\) · day\(^{-1}\), which translates to 60–78 g/day for a 60-kg person, appears safe and adequate for building muscle mass and strength for most mature adults engaged in RT, provided that kilocalorie needs are met. More studies with larger sample sizes, a wider range of protein intakes, and different intensities of training would help refine the protein needs of mature adults engaged in RT.

**References**


