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Original Article

Nutrition and Sarcopenia

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Abstract

From 50 yr, men and women are at an increased risk of developing sarcopenia, a disorder that increases the risk of falls and fractures. The development of sarcopenia may be attenuated through healthy lifestyle changes, which include adequate dietary protein and vitamin D intakes, and regular physical activity/exercise. Protein intake and physical activity are the main anabolic stimuli for muscle protein synthesis. Exercise training leads to increased muscle mass and strength, and the combination of optimal protein intake and exercise produces a greater degree of muscle protein accretion than either intervention alone. Recommendations for optimal dietary protein intake are 1.0–1.2 g/kg body weight/d with an optimal repartition over each daily meal, together with adequate vitamin D intake at 800 IU/d to maintain serum 25-hydroxyvitamin D levels >50 nmol/L (20 ng/mL), alongside regular physical activity/exercise 3–5 times/wk combined with protein intake in close proximity to exercise.

Key Words: Dietary intakes; falls; musculoskeletal health; physical exercise; vitamin D.

Introduction

Age-related alterations include a decline in muscle mass and strength, known as sarcopenia, which is responsible for a higher risk of falls and fractures, and resulting disability, loss of independence, decreased quality of life (QoL), and increased mortality *(1,2)*. The loss of muscle mass and strength with aging is associated with reduced dietary protein intake, resistance of muscle protein synthesis to anabolic stimuli, low vitamin D intake, reduced physical activity, and the menopause in women *(3)*. Sarcopenia is now recognized as a major clinical problem for older adults; prevalence estimates worldwide have varied from 3% to 30% according to the operational definition applied. A higher prevalence of sarcopenia approaching 30% can be found among those aged >80 yr. Men and women with sarcopenia have worse physical performance and poorer self-reported general health and physical functioning scores than those without. Direct health care costs caused by this syndrome were estimated at $18.5 billion for the US in 2000.

Between 2000 and 2050, the proportion of the world's population aged >60 yr is predicted to double from 11% to 22%. The absolute number of people aged ≥60 yr is expected to increase from 605 million to 2 billion by 2050, and the number of people aged ≥80 yr will quadruple to 395 million by 2050. Many of the very old lose their ability to live independently because of limited mobility. The prevalence of sarcopenia rises sharply with increasing age, thus preventive therapy beforehand is important.

Age-Associated Loss of Muscle Mass and Strength

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength, with associated increase risk of adverse outcomes such as physical disability, poor QoL, and death *(1,2)*. Muscle mass and to a greater extent muscle strength and power decline, together with an increase in fat mass in both sexes. After about 50 yr, muscle mass decreases at an annual rate of 1–2%. Muscle strength declines by 1.5% between 50 and 60 yr and by 3% thereafter. The risk of falls is elevated in individuals with reduced muscle strength.

A more accelerated loss of muscle mass and strength has been suggested to occur in various clinically compromised older populations, such as those who are obese, have type 2

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diabetes mellitus, or cardiovascular disease. Low fitness in old age was associated with greater weight loss and loss of lean mass than observed in those with high fitness. A correlation between muscle mass index and degree of disability has been shown. Leg muscle mass could be expected to correlate with muscle strength; however, the age-related decline in muscle strength is greater than the loss of muscle mass (4). In a meta-analysis, a poor correlation between muscle mass and strength has been found. Loss in muscle strength is reflected by tests of functionality such as gait speed, which decreases with age, and that correlates with the risk of institutionalization and survival. Sarcopenia may be defined using a combination of measures of muscle mass and physical performance (1).

Nutrition, Physical Activity and Muscle Protein Synthesis

Any loss of muscle protein results from an imbalance between muscle protein synthesis and muscle protein breakdown (3,5). Lean tissue mass and function depend on continuous rebuilding of proteins. Basal, fasting whole body and muscle protein synthesis rates are reduced in the older population; mixed muscle protein synthesis declines with age at a rate of 3.5% per decade from age 20 to 90 yr. However, differences in basal muscle protein turnover between old and young men do not appear to explain the muscle loss that occurs with age.

Exercise can enhance muscle protein synthesis irrespective of age. The ingestion of protein and amino acids stimulates muscle protein synthesis. A marked increase in whole-body protein synthesis is observed on feeding and is partly attributed to an increase in muscle protein accretion. However, the anabolic sensitivity of skeletal muscle tissue to protein feeding seems to become reduced with aging, which has led to the concept of anabolic resistance occurring with advanced age. Anabolic resistance may be affected by dietary protein digestion rate, amino acid absorption, plasma amino acid availability, hormonal response, and myofibrillar protein synthesis capacity.

Postprandial protein digestion impacts muscle synthesis (6). The more amino acids become available following meal ingestion, the greater postprandial muscle protein synthesis rates generally observed (7). Besides protein digestion and absorption kinetics, different protein sources may vary in their capacity to stimulate postprandial muscle protein synthesis rate, possibly in relation to differences in amino acid composition, that is, different amino acids elicit different anabolic responses. For example, whey protein ingestion stimulates postprandial muscle protein accretion more effectively than does ingestion of intact or hydrolyzed casein in older men. This effect probably results from both the more rapid digestion and absorption of whey protein and also the higher leucine content of whey compared with casein. Leucine is a key anabolic amino acid that exerts a dose response effect on muscle protein synthesis. Leucine co-ingestion with a bolus of dietary protein can further augment postprandial muscle protein synthesis rates in elderly men. Following the administration of mixed meals, the stimulation of muscle protein synthesis is reduced in elderly people, due to insulin resistance, and the anabolic effect of amino acids appears blunted. These age-related alterations in amino acid metabolism may be overcome by the provision of excess leucine, changes in the daily protein intake pattern, or increased exercise, which improve muscle protein synthesis.

Mechanisms for alterations of protein use in older persons are three-fold: inadequate intake of protein, reduced ability to use available protein (e.g., anabolic resistance, tissue redistribution of amino acids), and a greater need for protein (inflammatory diseases). Dietary proteins have a direct effect on key regulatory proteins and growth factors involved in muscle metabolism, such as mammalian target of rapamycin (mTOR) enzyme and insulin-like growth factor-I (IGF-I). Branched-chain amino acids lead to activation of mTOR, and aromatic amino acids (which are particularly prevalent in dairy protein) lead to increased IGF-I, resulting in greater muscle mass and strength. Guidelines for dietary protein intake advise similar intake for all adults, regardless of age, at around 0.8 g of protein per kilogram of body weight each day (g/kg BW/d). A low dietary intake of protein (0.45 g/kg BW) in elderly healthy women, a level quite common in those presenting with hip fracture, is associated with reduced plasma IGF-I levels and skeletal muscle fiber atrophy. Both high and moderate protein intake in older adults are associated with reduced mortality.

According to the National Health and Nutrition Examination Survey 2003−2004, dietary protein intake decreases with increasing age, with daily protein intake averaging 91 ± 22 g/d among adults aged 19−30 yr, decreasing to approximately 66 ± 17 g/d in the elderly. Among the elderly, protein intake is below the estimated average daily requirement in 35% of institutionalized individuals and in 10% of community-dwelling frail elderly people. A positive association of dairy protein intake with muscle mass has been found in elderly women (aged 80−92 yr). In addition to the total amount, the distribution of protein intake over the day may be important; it is proposed that 20−25 g of dietary protein per meal is required to allow an appropriate stimulation of postprandial muscle protein synthesis over a 24-h period. This appears to be more effective than skewing protein intake toward an evening meal. Institutionalized elderly people have especially low nutritional protein intake at breakfast. Therefore, meeting a protein threshold at each meal (of approx 30 g/meal) represents an efficient strategy for middle-aged and older adults concerned with maintaining muscle mass while controlling body fat.

Dietary protein intake correlates with appendicular lean mass; in community-dwelling adults, participants in the highest quintile of protein intake lost 40% less lean mass than did those in the lowest quintile over 3 yr. The least muscle loss was seen in the elderly (aged 70−79 yr) consuming protein at 1.1 g/kg/BW/d or 18% of total energy intake. Furthermore, increased protein intake in postmenopausal