Significance of Sarcopenia in the Elderly

Chhanda Dutta

Geriatrics Program, National Institute of Aging, Bethesda, MD 20893

ABSTRACT At the present time, there is only limited understanding of the public health significance of sarcopenia. The well-recognized functional consequences of sarcopenia include gait and balance problems and increased risk for fall. Ultimately, these impairments can lead to the loss of physical functional independence. However, sarcopenia may also contribute to an increased risk for chronic diseases such as diabetes and osteoporosis. Future studies of the pathophysiologic significance of sarcopenia need to consider the contribution(s) of muscle properties (e.g., muscle fiber composition, muscle blood flow, fatigue characteristics, innervation) to alterations in physical performance, metabolism and physiology, and skeletal health. More comprehensive studies on the sequelae of sarcopenia are critical to an accurate assessment of the public health burden that sarcopenia poses to the elderly population. J. Nutr. 127: 992S–993S, 1997.

KEY WORDS: • sarcopenia • aging • muscle mass

Sarcopenia is a generic term for the loss of skeletal muscle mass, strength and quality. Examples of muscle properties that contribute to muscle quality include fiber composition, innervation, contractility, fatigue characteristics, capillary density, and glucose metabolism and uptake. A considerable amount of clinical research conducted on the consequences of sarcopenia has focused on the role of decreased muscle mass and strength in the development of physical functional impairments in the elderly. In contrast, little attention has been given to other potential effects of sarcopenia on metabolic or physiological parameters and on skeletal health problems with climbing stairs. Consequently, our current perception of the public health effect of sarcopenia may be narrow. There are scattered reports in the literature that may provide some insight into novel avenues of future research in this area, and a brief discussion of these reports is provided in this article.

FUNCTIONAL CONSEQUENCES

Weakness of the lower extremities has been implicated with difficulties in rising from a chair and getting out of bed (Alexander et al. 1991 and 1995), in slow gait speed (Judge et al. 1992) and in balance and falls (Wolfson et al. 1995). Yet, little is known about changes in other muscle properties that could contribute to functional impairments. For instance, a person may have the strength to pick up a bag of groceries but not to carry the bag home. The inability to carry a bag of groceries home could be related to changes in the intrinsic contractile properties of muscle, in the fatigue characteristics of muscle and/or in muscle blood flow. Biomechanical studies of gait and balance have revealed that during an impending fall, the critical issue is not only the maximum joint torque developed but also the rate of joint torque development (Chen et al. 1994). Bassey et al. (1992) found that there was a significant relationship between leg extensor power and rising from a chair, climbing stairs and walking speed. These findings underscore the need for future studies examining the contribution of muscle properties to an individual’s capacity to perform tasks encountered in everyday life.

METABOLIC AND PHYSIOLOGICAL CONSEQUENCES

The elucidation of the metabolic and physiological consequences of sarcopenia represents a particularly challenging area of research. Heat and cold intolerance (Kenney and Buskirk 1995), decreased metabolic rate (Poehlman et al. 1995) and obesity (Calles-Escandon et al. 1995) are examples of putative metabolic consequences of sarcopenia. The pivotal issue in the determination of the metabolic and physiologic sequelae of sarcopenia is the extent to which loss of muscle mass or quality plays a role in the development of metabolic and physiologic impairments versus complex, age-associated changes in body composition (e.g., increases in fat mass). This particular issue is illustrated by an area of continued controversy that centers on the mechanism(s) of insulin resistance in old age. Findings from several studies indicate that increased central adiposity is a major contributor to glucose intolerance and insulin resistance in old age (Boden et al. 1993, Cefalu et al. 1995, Colman et al. 1995). However, Houmard et al. (1995) demonstrated age-related decreases in the levels of the insulin-sensitive glucose transport protein, GLUT4, in skeletal muscle. Hence, insulin insensitivity and glucose intolerance in the elderly probably result from increased abdominal fat, as well as from alterations in glucose uptake by muscle. An evaluation of the independent role of adiposity should be considered in the design of future studies, in order to accurately establish the metabolic and physiologic consequences of sarcopenia.

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MUSCLE QUALITY AND SKELETAL HEALTH

Efforts in this research field have been confined to the factors influencing muscle weakness as it relates to the occurrence of falls and fractures. However, muscle weakness may have other detrimental effects on skeletal health, and these possibilities have remained virtually unexplored. Studies conducted in the 1960s identified mechanically generated electrical forces, known as piezoelectricity (Bassett 1968), which could influence the quality of bone (i.e., density, strength and architecture). Subsequent investigations revealed that piezoelectric forces generated by muscular activity could mediate the response of bone to its mechanical environment (McDonald and Houston 1990), primarily through the stimulation of bone formation (Brighton et al. 1988 and 1991). Therefore, forces generated by muscle contractions could be an important determinant of bone quality. For example, weakness of the back extensor muscles may play a role in the pathogenesis of vertebral compression fractures in postmenopausal women, due to inadequate support of the vertebral column by the surrounding musculature (Limburg et al. 1991, Sinaki et al. 1993). Presently, this relationship remains speculative because weakness of the back extensor muscles could also result from disuse due to back pain associated with vertebral fractures. Because vertebral fractures represent a substantial health burden to postmenopausal women, studies are needed to determine whether muscle weakness precedes and contributes to the development of vertebral deformities and compression fractures.

Another novel aspect of the potential interrelationship between muscle quality and skeletal health is whether muscle can modulate mechanical loads on bone, thereby altering the susceptibility of bone to fracture. For example, muscle may be able to attenuate the impact forces on bone after a fall and thereby serve as a protective barrier against an ensuing fracture. In a study by Nordsetten and Ekeland (1993a), in vivo biomechanical testing of rat tibia strength and induced muscle contraction of the lower leg muscles were combined to determine whether muscle strength could significantly affect the mechanical properties of bone. In this experimental model, it was demonstrated that an induced maximum voluntary contraction during biomechanical testing protected the rat tibia from fracture (Nordsetten and Ekeland 1993b), including osteopenic bone (Nordsetten et al. 1994).

Conversely, muscle quality could also play a direct role in increased fracture risk by augmenting the mechanical forces on bone. Yoshikawa et al. (1994) combined electromyography and surgically implanted strain gauges to monitor muscle fatigue (in quadriceps and hamstrings) and bone strain (distal tibia) in adult foxhounds. The results indicated that neuromuscular fatigue was associated with a 26–35% increase in the compressive and tensile forces on bone. This raises the possibility that age-related changes in muscle properties could be an etiologic factor in the occurrences of fractures, especially under circumstances of increased bone fragility (e.g., decreased bone density, substantial loss of trabecular connectivity and abnormal bone architecture). The provocative nature of the finding from this series of animal studies holds great promise in generating novel approaches for prevention or reduction of fracture risk in the elderly. Moreover, a concerted effort from researchers in the bone and muscle fields is needed to translate these animal data into the clinical realm.

LITERATURE CITED


