Review article

# Morphological changes caused by aging on skeletal muscles and effects of exercise: a literature review

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## Abstract

The main components of the skeletal muscle are myocytes, capillaries and interstitial tissue. Aging affects these components differently with loss of muscle fibers (sarcopenia) as the most important change since it is the primary responsible for muscle function decrease with aging. Among non-pharmacological factors that may have a beneficial influence on the effects of aging on the muscle, exercises are the most appropriate. Both resistance and aerobic exercises have proven to curtail the effects of muscle aging. The aim of this paper is to present a review of the main morphological changes that aging brings about in muscles and show the importance of exercising to minimize these changes.

**Keywords:** skeletal muscle, aging, exercise.

## 1 Introduction

Increasingly, the census points to aging of the population. In 2005 there were worldwide, approximately 3.5 million people over 85 years of age. By projection, in 50 years there will be about 22 million people in this age bracket (SPIRDUSO, 1995). In Brazil, according to IBGE (Brazilian Institute of Geography and Statistics) between 1998 and 2008 the population over 60 years increased from 9 to 11% (INSTITUTO..., 2009).With aging, functional limitations arise leading to functional disability (RICE and LAPLANTE, 1992). Such inability is directly related to the progressive decline of muscle mass and strength or sarcopenia (VOLTARELLI, MELLO and DUARTE, 2007). Sarcopenia is characterized by a series of biochemical and morphological changes that impair muscle function (ROUBENOFF and HUNGHES, 2000; FIGUEIREDO, MOTA, APPELL et al., 2006). Of the several factors are involved in the genesis of sarcopenia, sedentarism and nutrition (DE ARAUJO SILVA, FRISOLI JUNIOR, PINHEIRO et al., 2006) are the most important. Several studies in literature show the importance of an active lifestyle to minimize effects of aging on tissues (WISLØFF, HELGERUD, KEMI et al., 2001; MATSUDO, MATSUDO and BARROS NETO, 2001; JONES, BAAR, OJUKA et al., 2003; JACOB FILHO, 1995).

New concepts about the benefits of physical activity for health improvement recommend that the relation between exercise, health, quality of life and aging be increasingly discussed and analyzed scientifically (PATE, PRATT, BLAIR et al., 1995; DAVINI and NUNES, 2003).

Studies have attempted to establish a standard level of physical activity in different populations of elderly individuals. (CASPERSEN, KRISKA and DEARWATER, 1994) analyzed five major surveys on types of physical activity in the male population over 65 years of age in England, the USA and Holland. According to these studies, walking was one of the most often performed activities in this group, encompassing from 38 to 72%, followed by gardening which was prevalent among 37 to 67% of the aged. Activities such as running, jogging, playing tennis and golf were carried out by at least one in every ten individuals.

It is recommended that the elderly should perform moderate-intensity physical activity for at least 30 minutes on most days of the week, preferably daily in a continuous or accumulated way. Awareness of use of this types of exercises for health improvement has shown different findings according to the gender and location analyzed (ANDRADE, MATSUDO, MATSUDO et al. 1999). The study was conducted by preparing a questionnaire and applying it in different cities of the state of São Paulo. In small cities the pattern of awareness about benefits of physical activity for 30 minutes per day was positive in 32% of women and 35% of men. Similarly, 36% of women and 31% of men thought that physical activity should be practiced three to four times a week and for more than 30 minutes per session. In the metropolitan area and large cities of the state, the pattern was different, almost 40% of women and 51% of men answered the questions.

Furthermore, studies indicate that physical inactivity is related to depletion of reserves and functional deficits in muscle strength and neuromuscular activation leading to an increase of functional problems, structural weakness and falls (DREWNOWSKI and EVANS, 2001; MAZZEO and TANAKA, 2001; THOMPSON, 2002; GUIMARÃES, GALDINO, MARTINS et al., 2004). Physical activity plays an essential role in reducing causes of incapacity with a protective effect for tissues, especially the muscles in natural aging, promoting an improved quality of life. Aerobic

exercise is known to induce a number of favorable responses that contribute to healthy aging (AMERICAN..., 1998).

In literature, effects and benefits of strength training exercises to preserve muscle of elderly people are well known (KLITGAARD, 1990; CHARRETTE, McEVOY, PYKA et al., 1991; MATSUDO, MATSUDO and BARROS NETO, 2000; DAVINI and NUNES, 2003; VALE, NOVAES and DANTAS, 2005; NASCIMENTO DA SILVA, 2007). However, the influence of aerobic training (especially walking) on muscles of the elderly has been neglected and there are few studies on the subject.

This study aims to present a review on the effects of aging of the skeletal muscles and show the influence of performing exercises on these effects.

## 2 Material and methods

The PubMed (www.pubmed.nl) and MEDLINE databases were used to conduct the literature search using keywords without restrictions. In this systematization, papers were searched using the following keywords: aging, skeletal muscle, exercise.

## 3 Results

Aging can be defined as a progressive and irreversible decline of body functions resulting from biochemical and morphological changes (FIGUEIREDO, MOTA, APPELL et al., 2008). Several longitudinal and stratified studies have shown that quality of life is clearly associated to regular physical activity, which is also important to delay the effects of aging and incidence of degenerative diseases (FIATARONE, O'NEILL, RYAN et al., 1994; KEYSOR, 2003; MANINI and PAHOR, 2009). One of the regular physical activity's benefits is maintenance of muscle mass in aging. As muscle strength is related to the muscle cross sectional area, fiber loss and decreased muscle cross sectional area alter muscle ability to generate force.

With aging the most obvious morphological changes in muscles include: decrease in number of muscle fibers with concurrent decrease of their cross-sectional area, fewer capillaries and increased connective tissue and of interstitial space (CACCIA, HARRIS and JOHNSON, 1979; PAYNE, DODD and LEEUWENBURGH, 2003; CHUNG and NG, 2006).

## 4 Effects of aging

### *4.1 Muscle fibers*

Aging causes loss of muscle mass, (ROUBENOFF and HUNGHES, 2000; NARICI, REEVES, MORSE et al., 2004) reported that between 20 to 80 years of age a person loses about 40% of muscle mass. However Volpi, Reza and Satochi (2004), states that an individual loses 3 to 8% of muscle mass per year. Muscle mass reduction with consequent loss of muscle strength may progress until an elderly person is unable to perform common daily activities. These changes imply structural changes in skeletal muscle and the nervous system related to muscles such as decreased protein synthesis, gradual degeneration of the nervous system, reduced transmission speed of nerve stimulation and in some muscle fibers, motor endplates can also deteriorate. The aging process causes a decrease in the cross sectional area of both fast and slow contraction, where muscle fibers are replaced by connective tissue. The change of cross sectional area of muscle is more related to muscle fiber loss than to decrease of their cross sectional area.

### *4.2 Number of capillaries*

Several factors may affect the number of capillaries in muscle: with the development, with the degree of activity and aging (KANO, SHIMEGI, FURUKAWA et al., 2002). As for the effects of aging on muscle capillaries, some authors do not agree. Various studies show a decrease of muscle capillaries (DEGENS, RINGNALDA and HOOFD, 1994) while others show no changes with aging (MITCHELL, BYRNES and MAZZEO, 1991; CARTEE, 1994a, b). Finally, there are studies that show the same increase of muscle capillary density with aging (DAVIDSON, CLAUGUE, HORAN et al., 1999). Nevertheless reduction in the number of muscle capillaries is a factor that can alter muscle strength. This reduction has functional implications since it reduces blood flow to active muscles and consequently decreases oxygen and nutrients supply and removal capacity for metabolites and heat (SOARES and CARVALHO, 1999).

Kutsuzawa, Shioya, Kurita et al. (2001) found that the muscle oxygenation process is slower in elderly than in young and concluded that this is due to poor blood circulation in the muscle caused by the aging process.

### *4.3 Interstitium*

Reduction in the cross sectional area of muscle with aging is accompanied by an increase of the interstitial space. Rice, Cunningham, Paterson et al. (1989) and Overand, Cunningham, Kramer et al. (1992) reported a 27% increase in interstitial space of the flexor muscles of the arm, 45% of arm extensors and 81% in the plantar flexors of the foot. Overand, Cunningham, Kramer et al. (1992) found a 59% increase in interstitial tissue of the quadriceps and of 127% for the hamstrings.

Maintaining muscle mass is important to maintain muscle strength with aging, as it is essential for functional capacity and independent living (FLECK and KRAEMER, 1999). This goal can be achieved by exercises.

## 5 Effects of exercise

It is known that even in the elderly, regular physical exercise is crucial to sustain the mass and hence muscle strength (KLITGAARD, 1990; CHARRETTE, McEVOY, PYKA et al., 1991; MATSUDO, MATSUDO and BARROS NETO, 2000; WILLARDSON, 2002; DAVINI and NUNES, 2003; VALE, NOVAES and DANTAS 2005; NASCIMENTO DA SILVA, 2007). Elderly that are physically less active have a lower muscle mass. Thus, a vicious circle is established, further increasing their lack of physical and functional activity (ROUBENOFF and HUNGHES, 2000; VANDERVOOT, 2002; CARVALHO, 2002; CARVALHO, OLIVEIRA, MAGALHÃES et al., 2003).

It is well known that performance of strength training exercises enhances protein synthesis and hypertrophy of muscle fibers minimizing loss of muscle mass and change of function (PORTER, 2001; NARICI, REEVES, MORSE et al., 2004, TAAFFE, 2006). However, knowledge

about the effects of other types of exercises on muscle mass remains scarce.

Angiogenesis as response to training, i.e. development of new capillaries occurs in the elderly as well as in the young (ROGERS and EVANS, 1993; SPIRDUSO, 1995) state that aerobic training in elderly stimulates growth of capillaries and improves the activity of oxidative enzymes. With aging, especially in sedentary people, capillarity decreased.

In 1998, Rantanen and Heinekken found that elderly of both genders with a high level of physical activity in their daily routine kept muscle strength at a level higher than that of the sedentary. Since then regular physical activity has become one of the best ways to maintain healthy muscles.

It is well known, for example, that after immobilization due to being bedridden, a cast or a wheelchair, situations that are more or less common in the elderly (CARVALHO, 2002), there is a muscle mass loss. According to Bloomfield (1997), after 4 to 6 weeks in bed, changes take place and muscle mass decreases from 6 to 40%. Daley and Spinks (2000) reported that the musculoskeletal system probably has the greatest adaptation capacity to different usage patterns. Namely, when lack of use is the pattern, muscle mass decreases, morphological changes in muscle and functional dependence appear. Muscle atrophy was also seen in older athletes who have trained throughout life, but who fail to practice physical activity (WISWELL, HAWKINS, JAQUE et al., 2001).

Reduced physical activity in older adults not only has adverse effects on muscle mass, but also on other organs: reduced cardiorespiratory fitness, osteoporosis, poor circulation in the lower limbs, lower self-esteem, greater dependence in daily life and decreased social interaction skills (DURSTINE, PAINTER, FRANKLIN et al., 2000).

## 6 Conclusion

Results of the works reviewed disclose that regular performance of exercises has a beneficial influence on the effects of aging of the diverse components of the muscle: capillaries, connective tissue and especially muscle fibers.

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