Deceleration of Skeletal Muscle Atrophy and Disability in Aging Population: Effect of Exercise

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Abstract

Exercise is an effective measure for the prevention and management of different muscle injuries, diseases and atrophy in elderly. Endurance exercise increase skeletal muscle oxidative capacity, resistance exercise cause hypertrophy of fast-twitch muscle fibers. Exercise improved muscle plasticity in the elderly, and makes skeletal muscle possible to modify age-associated decline in physical performance and enhancing life quality in the elderly. Resistance exercise increase the turnover rate of contractile proteins, and following adaptational changes first appeared in newly formed or regenerating fibers and these changes lead to the remodeling of contractile apparatus and increase in strength generating capacity of skeletal muscle. Dependence of turnover rate of contractile proteins from oxidative capacity of muscle show that turnover of contractile proteins provides a mechanism by which the effect of exercise causes changes in muscle metabolism in accordance with the needs of the myofibrillar apparatus. Both endurance and resistance exercise have a preventive role in the development of muscle atrophy, but a combination of both with different frequency, intensity and duration has been shown to be more effective among aging population. Aim of this paper is discuss about possibilities of using exercise in prevention of muscle atrophy in elderly and describe how exercise improve muscle plasticity, make skeletal muscle possible to modify age-associated decline in physical performance and enhancing life quality in aging population.

Keywords: Aging; Skeletal muscle; Atrophy; Preventive role of exercise

Introduction

Aging is a multifactorial process associated with changes in muscle mass, strength, endurance and the inability to maintain balance [1,2]. Risk factors for falling lead to severe injury [3], changes in skeletal muscle quantity and quality lead to disability in the aging population [4]. The rate of muscle loss is 1% to 2% per year past the age of 50, as a result 25% under age of 70 and 40% over of 80 are sarcopenic [5,6]. In both young and aged skeletal muscle unloading and hormonal myopathies [7], including glucocorticoid myopathy have an important role in development of muscle atrophy when atrophic muscle becomes active [4,8,9], muscle mass increases, but the recovery of muscle strength takes much longer time [4,10,11]. For prevention or management of many different injuries and diseases, a specific exercise tailored for rehabilitation needs, including assisted exercise are widely used in recent years. In this short review we discuss about possibilities of using exercise in prevention of muscle atrophy in elderly and describe how appropriate exercise improve muscle plasticity, make skeletal muscle possible to modify age-associated decline in physical performance and enhancing life quality in aging population.

Aging Muscle

The decline of muscle mass in elderly is caused by type II fiber atrophy and loss in the number of Fast-Twitch (FT) muscle fibers. Increased variability in fiber size, accumulation of non grouping, scattered and angulated fibers, atrophy [12,13]. Loss of fiber number, decreased production of anabolic hormones testosterone, growth hormone, Insulin-like Growth Factor-1 (IGF-1), and an increase in the release of catabolic agents are principal causes of sarcopenia. Interleukin-6 also amplify the rate of muscle wasting [14,15]. Aging skeletal muscle becomes less powerful, fat is redistributed from the depot to muscle [16], intensive collagen synthesis and post-translational changes in its structure reduce the elasticity of ligaments [17,18].

Effect of Exercise

Exercise is a effective measure for the prevention and management of different muscle injuries
and diseases. For example, in case of glucocorticoid caused myopathy, both endurance and resistance exercise have a preventive role in the development of muscle atrophy, but a combination of both with different frequency, intensity and duration has been shown to be more effective among aging population [4,8,19]. Intensive short-lasting resistance exercise have an anticitabolic effect on the contractile apparatus and the ECM of skeletal muscle [4,20]. Glucocorticoids increased myofibrillar protein degradation in FT muscles, while fibril-and network-forming collagen specific mRNA levels decreased in FT and Slow-Twitch (ST) muscles [21]. Both the myofibrillar apparatus and the Extracellular Matrix (ECM) play a crucial role in changes of muscle strength during glucocorticoid administration and following muscle loading [22]. Decrease in endurance capacity in elderly is related with decrease in oxidative capacity of muscle. Endurance exercise are effective in increasing of skeletal muscle oxidative capacity, metabolism and plasticity [23,24].

**Effect of Resistance Exercise**

Muscle atrophy contributes to but does not completely explain the decrease in strength in the elderly. The age-related decrease in muscle mass and strength is a consequence of the complete loss of fibers associated with the decrease in the number of motor units and fiber atrophy [25]. Resistance exercise is strong stimulus for growth of adult skeletal muscle due to fiber hypertrophy and improving athletic performance, enhancing general health and fitness. Resistance exercise used in rehabilitation after surgery or an injury, or just for the pleasure of exercise [26]. Resistance exercise is an effective measure in the elderly, improving glucose intolerance, including improvements in insulin signaling defects, reduction in tumor necrosis factor-α, increases in adiponectin and IGF-1 concentrations, and reductions in total and abdominal visceral fat [27]. Resistance exercise improves skeletal muscle metabolism and through it muscle function in the elderly and their life quality [4]. Resistance exercise enhances the synthesis rate of myofibrillar proteins but not that of sarcoplasmic proteins and this is related to mammalian target of rapamycin by activating proteins within the nitrogen-activated protein kinase [28,29]. A significant difference was observed between previously trained young and old participants in recovery from resistance exercise [30]. These results suggest a more rapid recovery in the young group. Recovery from damaging exercise is slower as a result of age, whereas there are no age related differences in recovery from less damaging metabolic fatigue [31]. Resistance exercise, during which the power of exercise increased less than 5% per session, caused hypertrophy of both FT and ST muscle fibers, an increase of myonuclear number via fusion of satellite cells with damaged fibers or formation of new muscle fibers as a result of myoblast fusion in order to maintain myonuclear domain size [10,32]. Resistance exercise increase the turnover rate of contractile proteins, and following adaptational changes first appeared in newly formed or regenerating fibers and these changes lead to the remodeling of contractile apparatus and increase in strength generating capacity of muscle [16].

**Effect of Endurance Exercise**

Endurance exercise increase skeletal muscle oxidative capacity, plasticity and enhancing life quality in the elderly. Improved muscle plasticity in the elderly makes skeletal muscle possible to modify the age-associated decline in physical performance [33]. Increased aerobic capacity in elderly people is related to an increase in the abilities of the cardiovascular system, and to the lesser extent to an increase in muscle mitochondrial concentration [34]. So, regular aerobic exercise provides a ground for an increase in muscle oxidative capacity in the elderly. Dependence of turnover rate of contractile proteins from oxidative capacity of muscle show that turnover of contractile proteins provides a mechanism by which the effect of exercise causes changes in muscle metabolism in accordance with the needs of the myofibrillar apparatus [35]. As the contractile proteins turnover decreases in the elderly, and endurance exercise stimulates an increase in the oxidative capacity of skeletal muscle by an increase in mitochondrial biogeneses and supports via faster protein turnover improvement of muscle function. Aging-associated reduction in AMP-Activated Protein Kinase (AMPK) activity is the main factor in reduced mitochondrial function [36]. Endurance exercise caused AMPK activation in aging FT muscles [37] and AMPK α1 isoform is related to the metabolic adaptation of skeletal muscle [38]. Myosin Heavy Chain (MyHC) and Myosin Light Chain (MyLC) isoforms play an important role in the process of modulation of contractile apparatus during endurance exercise [39], as well as C-protein binds myosin and actin and affects mechanical properties myosin cross bridges by linking the S2 segment of myosin to the backbone of thick filament is sensitive to the volume of endurance exercise [40].

**Effect of Concurrent Resistance and Endurance Exercise**

Concurrent resistance and endurance exercise decrease the gain in muscle mass in comparison with resistance exercise for alone in top athletes [41]. Described effect explained by AMPK blocking the activation of mammalian Target of Rapamycin Complex-1 (TORC 1) by phosphorylating and activating the Tuberous Sclerosis Complex-2 (TSC 2) [42]. Concurrent resistance and endurance exercise in elderly men has shown that strength gain was similar to that observed with resistance exercise alone, although resistance exercise volume was half of that resistance exercise alone [43]. Using lower exercise volumes in concurrent exercise in older men in comparison with endurance and resistance exercise alone leads to similar strength enhancement with no presence of interference in this population [44,45]. In the elderly population, improvement in both strength and cardiorespiratory fitness is important and concurrent exercise is the best strategy to enhance cardiorespiratory fitness as it has been shown in the literature [46]. It has shown that concurrent exercise improved performance in all occupational tasks and did not interfere with improvements in strength, power and endurance measures compared to endurance and resistance exercise alone in recreational athletes [47]. Theoretical complications in the full understanding of concurrent exercise effect on the skeletal muscle are:

1. It is not clear whether muscle fibers are capable to undergo hypertrophy and maintain endurance capacity at the same time.
2. Why the effect of concurrent exercise is different in top and recreational athletes.

**Conclusions**

Aging is associated with changes in muscle mass, strength, endurance and the inability to maintain balance. Risk factors for falling lead to severe injury, changes in skeletal muscle quantity and quality lead to disability in the aging population. Decrease in endurance capacity in elderly is related with decrease in oxidative capacity of muscle. Endurance exercise are effective in increasing of skeletal muscle oxidative capacity and metabolim. Resistance exercise is strong stimulus for growth of adult skeletal muscle due to fiber...
hypertrophy and improving athletic performance, enhancing general health and fitness. Resistance exercise is an effective measure in the elderly, improving glucose intolerance, including improvements in insulin signaling defects, reduction in tumor necrosis factor-a, increases in adiponectin and IGF-1 concentrations, and effective in reduction of total and visceral fat. Concurrent resistance and endurance exercise improve performance in all occupational tasks and did not interfere with improvements in strength, power and endurance measures compared to endurance and resistance exercise alone in aging population.

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References

35. Seene T, Kaasuk P, Seppet E. Crosstalk between mitochondria and


