

MUSCLE ATROPHY AND SARCOPENIA

Narici M, Morse C, Reeves N, Thom J

Institute for Biophysical and Clinical Research into Human Movement, Manchester Metropolitan University, UK

Introduction

Muscle atrophy and weakness are commonly found in disuse and ageing. Typically, muscle mass decreases by about 30% between the ages of 20 and 80 years (2). Differently from disuse, which involves only a reduction of muscle fibre size but not in number, sarcopenia involves both phenomena. The etiology of sarcopenia, is far more complex than that of disuse-atrophy, since this age-related muscle loss is secondary to neuropathic processes and also involves metabolic, hormonal, nutritional and immunologic factors. One cause of sarcopenia that is often over-looked, is the reduction of physical activity with ageing. In fact, despite the well documented effects of inactivity on muscle mass (1), the role of disuse in sarcopenia is poorly documented. However, recent evidence shows that even non-sedentary elderly individuals are about 20% less physically active than younger adults (3). This suggests that the loss of muscle mass in sarcopenia is not simply due to the effect of aging *per se* but that disuse significantly contributes to muscle wasting in old age.

So far, sarcopenia and disuse have been described either as decrease in muscle cross-sectional area or volume. However, new findings show that these morphometric changes are accompanied by marked alterations in muscle architecture; these are likely to have important functional repercussions since the force-velocity and length-force relationships, are strongly-dependent on the number of sarcomeres placed in series as well as in parallel. The following data will highlight the alterations in muscle architecture associated with ageing and disuse (long-term bed rest) and the reversibility of such changes in response to increased loading.

Methods and Results

Ageing

We investigated *in vivo* using ultrasound and MRI, plantarflexor muscles' architecture in young (20-30 yr old, n=20) and older males (70+ yr old, n=21) and related these to the maximum isometric force of these muscles. After the comparative measurements with the young group, the elderly males underwent a 12-month training programme (Better-Ageing programme) including resistive, aerobic, stretching and postural exercises. Compared to the young group, the elderly males presented marked alterations in muscle architecture since plantarflexor muscle volume (VOL), fibre fascicle length (Lf) and pennation angle were reduced on average by 13%, 13-18 % and by 8-16%, respectively (P<0.001). From the values of VOL and Lf, the resulting muscle physiological CSA (PCSA=VOL/Lf) was 13% (P<0.01) smaller in the older males. Since maximum isometric plantarflexor force was 36% lower in the older males (P<0.001), changes in muscle architecture were estimated to account for about 1/3 of the loss in muscle strength. Following the 12-month training period, muscle strength increased by 21% and muscle volume by 18% (P<0.05). Interestingly, training resulted in an increase in pennation angle and in fascicle length.

Long-term bed rest (LTBR)

Ten males (age 32.7±3.6 years, means±SD) underwent a period of 90-day bed rest (ESA LTBR 2001-2). Six individuals acted as non-exercising (NEX) controls while four performed intensive resistive exercise (EX). Gastrocnemius medialis (GM) muscle CSA and architecture (at rest and during contraction) were assessed by MRI and ultrasound, respectively.

After LTBR, plantarflexors force decreased significantly (P<0.001) in both EX (pre 3131±510; post 1815±464 N) and NEX (pre 2896±918; post 1294±623 N) groups. GM CSA decreased by 32% in the NEX and by 16% in the EX groups (P<0.05). GM resting fascicle length decreased in both EX (pre 41.3±2.1; post 38.3±1.2 mm) and NEX (pre 39.9±3.8; post 36.2± 3.3mm) groups by -7 and -10%, respectively (P<0.001). Resting pennation angle decreased by -13% in both EX (pre 26.6±2.9; post 23.2±2.8 deg) and NEX (pre 29.8±3.7; post 25.7±3.5 deg) groups (P<0.002). GM muscle fascicle shortening during maximum plantarflexion was -17 and -35% smaller in E and NEX, respectively.



The Rehabilitation of Sport Muscle and Tendon Injuries

Conclusion

The present findings show that both sarcopenia and disuse involve marked alterations in muscle architecture. The fact that both muscle CSA and fascicle length are reduced, illustrates that a loss of sarcomeres both in parallel and in series occurs in both conditions. Such changes are expected to significantly contribute to the loss in muscle strength and shortening velocity following prolonged disuse and ageing in humans. These changes, however, may be partially reversed by training, and may contribute to prevent muscle weakness and atrophy in ageing and disuse.

Supported by European Commission Framework V funding (*'Better-Ageing'* Project, No. QLRT-2001-00323)

References

1. Di Prampero PE, Narici MV. *J Biomech* 36: 403–412, 2003.
2. Macaluso A et al.: *Muscle Nerve* 25: 858-863, 2002.
3. Morse C et al.: *Eur J Appl Physiol*; 2004 (in press).