Motor control and neuromuscular fatigue

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Ageing induces a marked decline in the performance of the motor system. In addition to the decrease in muscle mass, there is a loss of motor neurones and a reinnervation of denervated muscle fibres by surviving motor units, which increases the innervation ratio of these units (McNeil et al., 2005). This profound motor unit remodelling during ageing has functional implications on the neural control of muscle contraction. Although, the control of movement is a complex integration of sensory feedbacks, motor effector properties, and descending inputs from higher CNS centres, this presentation will mainly focus on the capacity for maximal voluntary activation in normal and fatiguing conditions, and on the adaptations of reflex activities.

Maximality of muscle activation
Impairment in voluntary muscle activation may contribute to the weakness commonly observed in older adults. Some studies reported age-related deficits in muscle activation (Stevens et al., 2003) but other did not (De Serres and Enoka, 1998). Although differences in methodologies and/or muscles tested may explain the discrepancy, they do not entirely account for the conflicting results. Interestingly, in a carefully conducted study using the twitch-interpolation method, Jakobi and Rice (2002) attested that older adults can achieve similar voluntary activation as young men, during isometric contractions, if sufficient attempts are provided. In recent experiments in ankle dorsiflexors, we confirmed this observation and extended the discussion for concentric (CON) and eccentric (ECC) contractions (Klass et al., 2005).

Reflex activities
The control of movement involves mechanisms that are induced by sensory feedback. Among them, the myotatic reflex plays an important role, for example in the control of sway during standing and balance during locomotion. Contradictory findings have been reported in the few studies that have recorded the adaptation of the tendon reflex with ageing. Investigators reported no change in reflex latency and amplitude, whereas others observed a prolonged reflex latency and declined amplitude. Recent studies, using the Hoffmann (H) reflex, documented a decrease in spinal reflex excitability in the ankle plantar flexors with ageing (Scaglioni et al., 2002). In the ankle dorsiflexors, we also observed a reduction in the amplitudes of the H reflex and the long-latency reflex (normalised to the background EMG activity), during a submaximal sustained contraction. These observations indicate that spinal and supraspinal reflexes excitability is altered with ageing.

Voluntary activation and muscle fatigue
The contribution of neural mechanisms to muscle fatigue is task-depend. Despite the great number of studies that have examined the mechanisms of fatigue, few works investigated the effect of ageing on the neuromuscular fatigability, specifically during maximal ECC and CON contractions. Although, a lesser fatigability has been reported during incremental isometric contractions in elderly compared with young adults (Ken-Braun et al., 2002), we observed a greater force decline in elderly subjects during both CON and ECC contractions. The absence of change in voluntary activation, tested by the twitch-interpolation method, suggests that central fatigue did not play a role in the force decrease during the two fatigue tasks, in elderly and young adults. In contrast, the data indicated that fatiguing CON and ECC contractions were mainly associated with alterations in intracellular processes. These changes, however, were associated with impaired neuromuscular transmission and/or conduction velocity in elderly adults.

In conclusion, our experimental observations show that motor unit remodelling during ageing (McNeil et al., 2005) is accompanied by changes in spinal and supraspinal reflexes excitability. However, the results clearly indicate that the capability of the central nervous system, to produce maximal activation in the dorsiflexor muscles, is preserved in healthy elderly subjects in both normal and fatiguing conditions.

References

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