The physiological basis of neuromuscular fatigue during high intensity exercise

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Abstract

Introduction:

Neuromuscular fatigue refers to a reduction in maximal force generation capacity, and is categorized as central and peripheral. Central fatigue is defined as a reduction in the ability of the central nervous system to voluntarily activate muscles, and peripheral fatigue indicates a decrease in the contractile strength of muscle fibers. During high intensity exercise, motor neurons are involved in the recruitment of type IIB muscle fibers as they are fast-twitch, high glycolytic, and have low aerobic capacity. Furthermore, group III and IV muscle afferents detect the physiological circumstances in the body and convey signals to the brain that influence the onset of central and peripheral fatigue.

Methods:

A PRISMA flow diagram was created to record relevant studies found from scholarly databases. Inclusion criteria required studies from 2005 to 2017, and subject grouping headings required key terms indicating that the presence of central and peripheral fatigue was analyzed on healthy adult subjects performing exercise. To ensure that high quality studies were analyzed, each article was independently rated using the National Institute of Health Quality Assessment Tool criteria.

Discussion:

During low intensity exercise, asynchronous motor unit recruitment is involved in delaying the onset of muscle fatigue. However, this is not apparent in high intensity exercises, as maximal motor unit firing is required in order to sustain a maximal level of force output. Persistent firing of action potentials to maintain muscle contraction results in acetylcholine depletion at the motor end plate, initiating the process of central fatigue. Furthermore, due to prolonged metabolite accumulation in skeletal muscle fibers, group III and IV afferents convey signals to the motor cortex and cause a reduction in the action potential conduction velocities along the contracting muscle. This leads to the onset of peripheral fatigue. As high intensity exercise proceeds, electromyogram (EMG) measurements display this as an increase in amplitude to reflect heightened motor unit recruitment and a compressed power density spectrum alongside a decreased centre frequency. This is determined by the innervated muscle fiber's conduction velocity and subsequent variations in the action potential waveform shape.

Conclusion:

A record of current studies systematically display the overview of muscle fatigue and its underlying mechanisms during exercise. However, further research is yet to be conducted for a more comprehensive understanding regarding the onset and recovery of neuromuscular fatigue in varied population demographics and physiological circumstances. Likewise, the distinctive roles of group III and IV muscle afferents in supraspinal stimulation require further investigation in order to gain a holistic understanding of their involvement in central fatigue and resistance training. Additional research in this subject matter is currently being explored through technology involving imaging studies, as they have potential to elucidate motor cortex activity alongside other regions of the brain and portray neuromuscular muscle fatigue eminently.

Keywords

neuromuscular fatigue, central fatigue, peripheral fatigue, maximal voluntary contraction, EMG, motor unit, group III/IV muscle afferents, lactate, acetylcholine, high intensity exercise, skeletal muscle

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