Muscle fatigue is an exercise-induced reduction of the maximal force generation capacity of a muscle. Fatigue is the result of many physiological adaptations to sustained contraction, including altered central drive, afferent-mediated inhibition/disfacilitation of motor neurons, and changes in the contractile apparatus. Neural and muscular adaptations to sustained contraction may be non-uniform over the population of motor units within a muscle. High-density (> 50 electrodes) surface EMG recordings provide a two-dimensional representation (topographical map) of EMG activity over the skin overlying the muscle. During static shoulder abduction of the upper trapezius muscle, surface EMG amplitude increases relatively more toward the cranial than the caudal portion of the upper trapezius. This results in a change in the EMG topographical map of activity, whose centroid (mean point of the amplitude distribution) shifts in the cranial direction. In addition, the EMG amplitude distribution over the muscle becomes less uniform as the contraction progresses. The shift in the distribution of surface EMG amplitude is positively correlated to the time to task failure, thus subjects who can hold the static contraction longer show a larger change in the spatial distribution of EMG amplitude over time. When a static task of shoulder elevation is compared to the same task with periodic, short increases in force, the variable-force task is less fatiguing than the static task even if the total work load is higher. Moreover, the shift of EMG activity toward the cranial direction is more pronounced in the variable-force task than in the static task, indicating less uniform muscle activation at the end of the task for the variable-force, compared to the static contraction. The modifications in EMG amplitude maps may be due to both neural and muscular changes with a non-uniform effect on the motor unit population. Non-uniform changes in muscle fiber membrane properties may occur due to the distribution of motor unit types within the muscle, intramuscular pressure, or degree of capillarisation. In addition, motor unit discharge rate and additional recruitment during a sustained contraction may depend on location. There is evidence that motor unit discharge rate may be reduced by afferent feedback in a non-uniform way. For example, elicitation of small diameter afferents by nociceptive stimulation of a part of the upper trapezius muscle, without changes in the fiber membrane properties, results in a local decrease in EMG amplitude in the painful location only, while the other muscle parts maintain the same or higher levels of activity. Moreover, the rate of motor unit recruitment, motor unit discharge rate and its rate of change over time during sustained contraction are different in the cranial and caudal parts of the upper trapezius muscle, as assessed by single motor unit recordings with wire electrodes in three muscle locations. The results suggest that during sustained contraction, the motor neuron output changes differently for motor units in different regions within a muscle and that motor unit recruitment with fatigue occur non-uniformly in the muscle. These mechanisms determine modifications in the distribution of EMG amplitude and have a role in the development of fatigue.

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