Electromyography (EMG)

Muscle contraction

Measuring motor unit recruitment and muscle fatigue
Organization of human skeletal muscle
Innervation of skeletal muscle
Structure of the neuromuscular junction

(a) Neuromuscular junction

1. Acetylcholine (ACh) is released from synaptic vesicles.
2. ACh binds to ACh receptors.
3. Muscle action potential is produced.
4. ACh is broken down.

(b) Enlarged view of the neuromuscular junction

(c) Binding of acetylcholine to ACh receptors in the motor end plate
Synaptic transmission – contraction and relaxation in skeletal muscle

the extent of contraction depends on the level of intracellular Ca^{2+} increase
Muscle contraction: a single twitch

1 AP on the motor neuron leads to a twitch on all skeletal muscle fibers innervated by the same motor neuron.
**Motor unit**

**motor unit**: a single somatic motor neuron + all innervated skeletal muscle fibers

- precise movements (larynx, oculomotor neurons): small motor unit size (2 – 20 muscle fibers / motor neuron)
- large-scale, powerful movements (arm, leg): large motor unit size (2000 – 3000 muscle fibers / motor neuron)
Control of muscle tension / force

the extent and length of contraction can be regulated by

- **motor unit recruitment**
  - number of active motor neurons is increased
  - smallest / weakest motor units are activated first, followed by larger motor units
Control of muscle tension / force

the extent and length of contraction can be regulated by

- frequency of stimulation
  - wave summation: when the 2nd stimulus arrives before the complete relaxation of the previous twitch: increased Ca^{2+} level -> larger contraction
  - incomplete (unfused) and complete (fused) tetanus

![Graph showing muscle tension control](image-url)
Production of ATP for muscle contraction

From creatine phosphate: up to 15 sec only

From anaerobic glycolysis: in the lack of $O_2$, lactate is produced; up to 30-40 sec

From aerobic cellular respiration: requires $O_2$; for prolonged muscle activity
Muscle fatigue

inability of muscle to maintain force of contraction

- central fatigue: subject feels tiredness and ceases activity - CNS-mediated affects

- depletion of creatinin phosphate and glycogen, lack of $O_2$

- build-up of lactate and ADP

- inadequate release of $Ca^{2+}$ in the cytoplasm
Electromyography

measurement of the sum of electrical impulses provided by the activated muscle fibers during muscle contraction

- changes in skin voltage: EMG (electromyography)

- integrated EMG: a „moving average“ of EMG data; indicates total EMG output level

Dynamometry

measurement of the power of muscle contraction (clench force)
Measuring motor unit recruitment and muscle fatigue