Muscle Tone & Posture

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Muscle Tone

- Even when a skeletal muscle is relaxed, a certain amount of contraction usually remains;
- The resting level tension of a muscle is called «muscle tone»,
- Muscle tone is assessed by examining its response to a stretch.
  - Because of the muscle tone, there is a slight and uniform resistance when the muscle is stretched by an external force

Muscle Tone

- Muscle tone prepares body for movements.
  - Maintaining an appropriate level of muscle tone allows muscle to make an optimal response to a movement.
- Important for posture
  - Muscle tone in the extensor muscles, helps maintain posture while standing.

Muscle Tone

- In smooth muscle; muscle tone is due to a baseline Ca^{++} level of cytosol.
  - Calcium causes low-level tension which generated by cross-bridges.
- In skeletal muscle; muscle tone is due to two mechanisms:
  - Passive elastic properties of the muscles and joints
  - Sustained (tonic) low rate of nerve impulses coming from spinal cord.

Muscle Tone

- Skeletal muscle tone depends on alpha motor neuron activity controlled by brain and muscle spindle
- Muscle spindle activity regulates muscle tone.
  - 1a sensory axons from muscle spindle make synapse alpha motor neuron and it is a major contributor to this tonic firing.
- Tone is modified by altering sensitivity of the muscle spindles
  - Gamma motor neuron regulates the muscle spindle
  - Establish a baseline level of alpha motor neuron acitivity and muscle tone.

Abnormal Muscle Tone

Hypotonia

- Abnormally low muscle tone
- Hypotonia is accompanied by weakness of muscles and decreased reflex response
- It could cause atrophy in the muscle
- Hypotonia is frequently caused by disorders of alpha motor neuron which is classified as **«lower motor neuron syndrome»**

Abnormal Muscle Tone

Hypertonia

- Abnormally high muscle tone
- Increased resistance is due to an increased level of alpha motor neuron activity
- There are different forms of hypertonia such as spasticity, rigidity etc.
- Hypertonia is frequently caused by disorders of the descending pathways that change responsiveness of alpha motor neurons.
- **«Upper motor neuron syndrome»**

Lower Motor Neuron Syndrome

- Damage to lower motor neuron cause;

- Hypotonia
- paralysis
- paresis
- areflexia
- Muscles may exhibit fibrilations or fasciculations which are spontanteous twitches of denervated muscle
- Fibrilations= caused by changes in excitability of muscle fibers
- Fasciculations= caused by abnormal activity of injured alpha motor neuron

Upper Motor Neuron Syndrome

- Damage to the descending motor pathways first cause;
- Immediate weakness of related muscle on contralateral side (most severe in arms and legs).
- This initial period of hypotonia after upper neuron injury is called «**spinal shock**»
  - Spinal shock reflects the decreased activity of spinal circuits after sudden deprivation of inputs from the brain
  - After several days, spinal cord circuits regain much of their functions (thanks to plasticity)
  - After the spinal shock is over, some symptoms emerge (such as spasticity, rigidity, babinski sign)

Upper Motor Neuron Syndrome

Spasticity

- Form of hypertonia; increased resistance to passive movement due to loss of inhibitory signals from cortex
- Characteristic sign; Clasp-knife phenomenon

➢ First, muscle provides high resistance to stretch and then suddenly yields (like a blade of pocket knife)

➢ Hyperactivity of stretch reflex cause resistance;

➢ When the force is increased, golgi tendon reflex is involved and inhibits the muscle tone

Upper Motor Neuron Syndrome

Babinski sign

- Normal response of an adult to stroking the sole of feet is flexion of toes
- Following the upper motor neuron damage, this stimulus cause extension of big toe (babinski sign)
- This sign is normal in healthy infants because of the incomplete upper motor neuron control

Upper Motor Neuron Syndrome

Decerebration Rigidity

- Extensive upper motor neuron lesions above the brain stem results rigid extension of the limbs
- It is explained by remaining activity of intact descending pathways from vestibular nuclei and reticular formation whihc have a excitatory influence on extensors

Posture

- Muscle activity support body weight against gravity and maintains upright posture.
- Maintaining posture requires maintaining balance.
  - Center of gravity must be kept within the base of support.
  - If the gravity center has moved, body will Wall
  - Yet people have balance in unstable equilibrium because of the postural reflexes

Posture

- Sensory information of postural reflexes come from three sources:
  - Eyes; the vestibular apparatus; receptors that involved in proprioception
  - (Loss of vision or vestibular inputs alone does not cause the person lose balance; but loss of proprioceptive inputs cause loss of posture and bakance)
- Efferent pathways are the alpha motor neurons to skeletal muscles

Posture

- Crossed-extensor reflex is one of the example that maintain upright posture

  - One leg is flexed and lifted off the ground; other leg extended more strongly to support the body weight.
  - Also various muscle contracts and shift the center of gravity.

Posture

- Vestibular nuclei and reticular formation send signals to the spinal cord for maintain posture
  - Projection from vestibular nuclei ensure a rapid response to any postural instability that detected by inner ear
  - Reticular formation regulates motor program and does adjustments that stabilize the posture during ongoing movements

Posture

- Even a simple move is accompanied by the activation of muscle which seems unrelated.
- Reticular formation is responsible for this adjustments
- Subjects uses his arm to pull a handle
  - ➢ Biceps contracts at 200 ms
  - ➢ Gastrocnemius also contracts even before than biceps
  - ➢ Feedforward mechanism

Posture

- Effect of upcoming movement to the posture evaluated and different muscles are involved in motor plan to protect posture = feedforward mechanism
- Sensory inputs from ongoing movements regulates posture = feedback mechanism

Walking

- Crossed-extensor reflex: One limb extends while other limb flexes.

  → Basic mehanism for walking

- Just like this reflex, walking is under spinal control.
- The circuit for the coordinated control of walking within the spinal cord.
- The circuit for the coordinate rhythmic motor activity are called central pattern generators.

Walking

- Pattern generators are usually neurons which has pacemaker properties
- NMDA glutamate receptors are mainly responsible for pattern generation.
- NMDA receptors open when membrane is depolarized and allow Ca^{+2} and Na^{+} current inside to the cell.
- Interneurons also have calcium-activated potassium channels.
- All these channels give cells pacemaker properties

Walking

- Glutamate causes the NMDA receptors to open
- Membrane depolarizes; Na^{+} and Ca^{+2} flow into the cell.
- Ca causes the K^{+}-channels to open
- K^{+} leaves the neuron,
  membrane hyperpolarizes
- Ca^{+2} flow to the cell stops.
- K^{+}-channels close
- Membrane depolarize
- Activation cycle repeats

Walking

- In vertebrates, pacemaker neurons are not solely responsible for generating rhythyms.
- There is also **interconnected circuits**
- Pacemaker activities are embedded within interconnected circuits.
- The combination of pacemaker properties and synaptic interconnections that produces rhythmic activities like walking.

Walking

- Similar to the crossed-extensor reflex, flexion on one leg is accompanied by extension of other leg.
- There are also interconnected circuits between lumbar and cervical segments which responsible for swinging arms by walking.
- Adjustment while walking are controlled by upper motor neurons (brain's control on movement)

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