Reflexes

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Learning objectives: reflexes

Students will be able to describe:

1. The clinical importance of testing reflexes.
2. The essential components of spinal reflexes.
3. The stretch reflex.
4. The flexion reflex.
5. The tonic neck reflexes.
6. The concept of descending control of reflexes.

- Decerebrate rigidity.
- Decorticate rigidity.
- Babinski sign.
- Treatments for cerebral palsy.
Definition of reflex: unlearned motor response to sensory stimulus. (NOT as used in common speech, synonymous with reaction time).

There are dozens of reflexes, different reflexes mediated by different levels of the motor system. We will only cover a very few.
Why study reflexes?

Reflexes have both clinical and scientific importance. Clinical: abnormal reflex is a reflection of dysfunction of some component of the motor system. WHY?

Circuitry for a reflex may be present in the spinal cord or brainstem BUT reflex strength or gain may be modulated by descending pathways-stronger, weaker, totally suppressed.

Scientific: understand how much motor behavior is programmed at different levels of the system, (clinical applications).
Spinal reflexes

How much motor behavior is mediated by the spinal cord alone?

The spinal cord does more than carry messages to and from the brain.

Circuitry for locomotion is in the spinal cord, even in mammals. It needs to be turned on or modulated by higher levels of the nervous system.

Look first at simpler circuits:
- stretch reflex
- flexion-crossed extension reflex
Stimulus- stretch of a muscle.
Response- contraction of the same muscle.
Tested by a tendon tap which stretches the muscle.
(clinical term: deep tendon reflex or DTR)
It is always part of physical exam because its strength reflects the function of higher levels of the motor system.
Stretch reflex circuit

The afferent: Ia fiber from spindle, synapses on mn. The efferent: axon of α mn to the same muscle.

The stretch reflex is a monosynaptic reflex, with a very short latency (delay stimulus to response).
The stretch reflex and coordination

As the agonist contracts, its antagonist relaxes—coordination. Circuit: the Ia afferent fiber also synapses on an inhibitory interneuron that in turn synapses on a motoneuron to the antagonist muscle. This pattern is called reciprocal innervation. Thus coordination wired in at the level of the spinal cord.

![Diagram of the stretch reflex and coordination](image)
Muscle tone is defined as resistance to passive stretch (again, not as used in common speech).
Flexion-crossed extension reflex

Stimulus: noxious (damaging, painful) stimulus to skin
Response: contraction of flexors and relaxation of extensors at every joint of the limb.
Much more complex circuitry than for the stretch reflex.

Spinal reflex-it occurs even with the spinal cord transected and no conscious sensation or awareness of pain.
“Crossed-extension”

This reflex disturbs posture, and there is a reflex adjustment to aid posture. The leg on opposite (contralateral) side extends to increase support. The pattern of connections referred to as “double reciprocal innervation.”

Flexion-crossed extension reflex: *schematic* of circuitry, input from small area of skin affects mn pools on both sides of spinal cord; extensive connections in spinal cord.
Spinal pattern generators and locomotion

Even more complex motor behavior is organized in spinal cord, the basic patterns of muscle contraction for locomotion. Circuits are called “spinal pattern generators,” for rhythmic behaviors. (alternate flexion and extension of each limb in sequence). Higher levels needed to turn on and modulate the circuitry, but do not need to program it. Modulation - e.g. changes in gait when walking on different surfaces. Raises clinical possibility of activating this circuitry in people with spinal transections.
Tonic neck reflexes (spinal cord+ brainstem)
The position of the limbs is determined by position of head.
Head tilted up: forelimbs extend, hindlimbs flex

Head tilted down: forelimbs flex, hindlimbs extend.

Head turned to side: ipsilateral limb extends, contralateral limb flexes.
These reflexes are present at birth, disappear as descending pathways are myelinated, can reemerge if higher levels are damaged.
ALL reflexes are under the control of higher levels of the motor system (descending axons from motor cortex and brainstem).

**EXAMPLES:**
a. flexion reflex modulation  
b. tonic neck reflex disappearance  
c. spinal shock  
d. Babinski sign  
e. effects on muscle tone (decerebrate and decorticate rigidity)
Spinal shock

Spinal shock is the complete absence of reflexes immediately following spinal transection. The spinal reflexes gradually return.

The period of time varies among species, the more complex the CNS the longer the period of recovery.

The endpoint may be hyperreflexia.

(The mechanisms for recovery not understood.)
Babinski sign: damage to motor cortex or PT

Normal plantar response

Down

Extensor plantar response
(Babinski sign)

Up

Fanning of toes

NORMAL in newborns
Abnormalities of muscle tone

The strength (gain) of stretch reflex is affected by the rest of the motor system. Abnormalities in muscle tone from disturbance of the control of the stretch reflex are characteristic of many diseases/disorders. Increased excitability- hypertonia, **rigidity**, most common with damage to motor system. Decreased excitability- hypotonia, flaccidity, seen in some developmental disorders (e.g. Down syndrome, Prader-Willi syndrome).
Understanding the physiological basis of rigidity and the role of the stretch reflex has led to effective treatments for clinically-occurring rigidity.

The stretch reflex circuit is in the spinal cord. BUT its strength is regulated by axons descending from motor cortex (pyramidal tract) and brainstem (vestibulospinal, reticulospinal, rubrospinal) tracts.

There are several descending pathways: some +, some - to stretch reflex circuit. The effects on extensor and flexor motoneuron pools are different.
Decerebrate rigidity

Seen experimentally after a midbrain transection at the intercollicular level. (clinically rare but seen e.g. hemorrhage at midbrain level)

Increased tone in extensors (antigravity muscles) of all 4 limbs.

This increased extensor tone is mediated by the stretch reflex: cut **dorsal roots**, rigidity goes away.
Clinically a much more common pattern is increased muscle tone in the flexors of the arms and the extensors of the legs called **decorticate rigidity**. (again different effects on flexors and extensors)

(e.g. stroke that damages motor cortex or the pyramidal tract, effects seen on contralateral side of the body)
Spasticity

Spasticity: clinical term that includes increased muscle tone (rigidity), hyperactive stretch reflexes, clonus, clasp knife reflex. Increased tone is velocity dependent (how rapidly is stretch applied).

Babinski sign.

Clonus- more than one contraction for a single stretch. Clasp knife reflex: arm is flexed, try to extend it (stretching the flexor)- resistance at first, then resistance “melts away” afferents now thought to be pain fibers in muscle that inhibit the stretch reflex.
Spasticity in cerebral palsy

CP- damage to motor system at or prior to birth. (any component or combination of components; cause may be infection in mother, not usually birth anoxia).

Many patients with CP have spasticity, affects appearance, posture, ability to move.

Danger of “contractures”, shortening of tendons so that limb becomes immobile. This can lead to joint problems like arthritis. Treatments for rigidity in CP: dorsal rhizotomy (cut afferents to stretch reflex), selected dorsal roots. Injections of baclofen into spinal cord, inhibit stretch reflex.
Spasticity may also be seen in other diseases that affect the motor system, e.g. multiple sclerosis.

Increased muscle tone (rigidity) is also seen in Parkinson’s Disease **BUT** affects both flexors and extensors, different pattern.
Disability language

in England “spastic” was acceptable term for CP until very recently

here it is playground insult

(why not “ataxic”???)

UK “fit” acceptable term for seizure, here not
UK “learning difficulties”
USA “intellectual disabilities” (replacing “MR”)