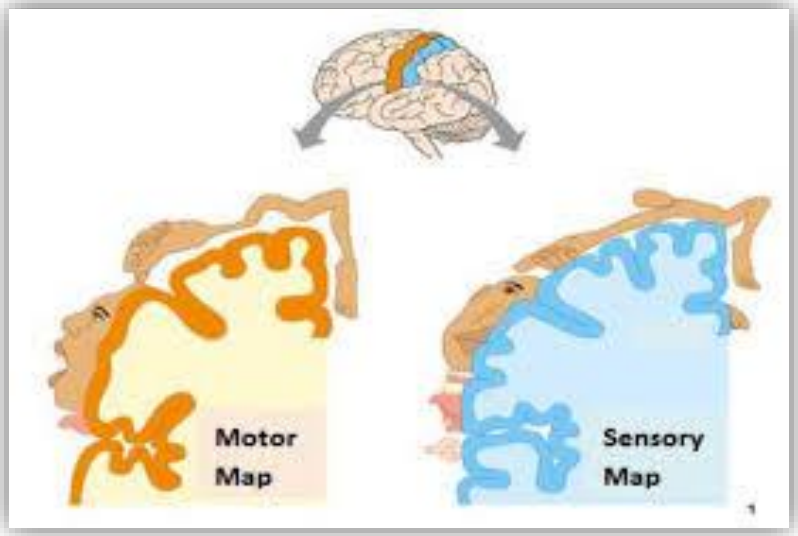
University of Diyala/ College of Medicine
Department of Physiology
Physiology Lab

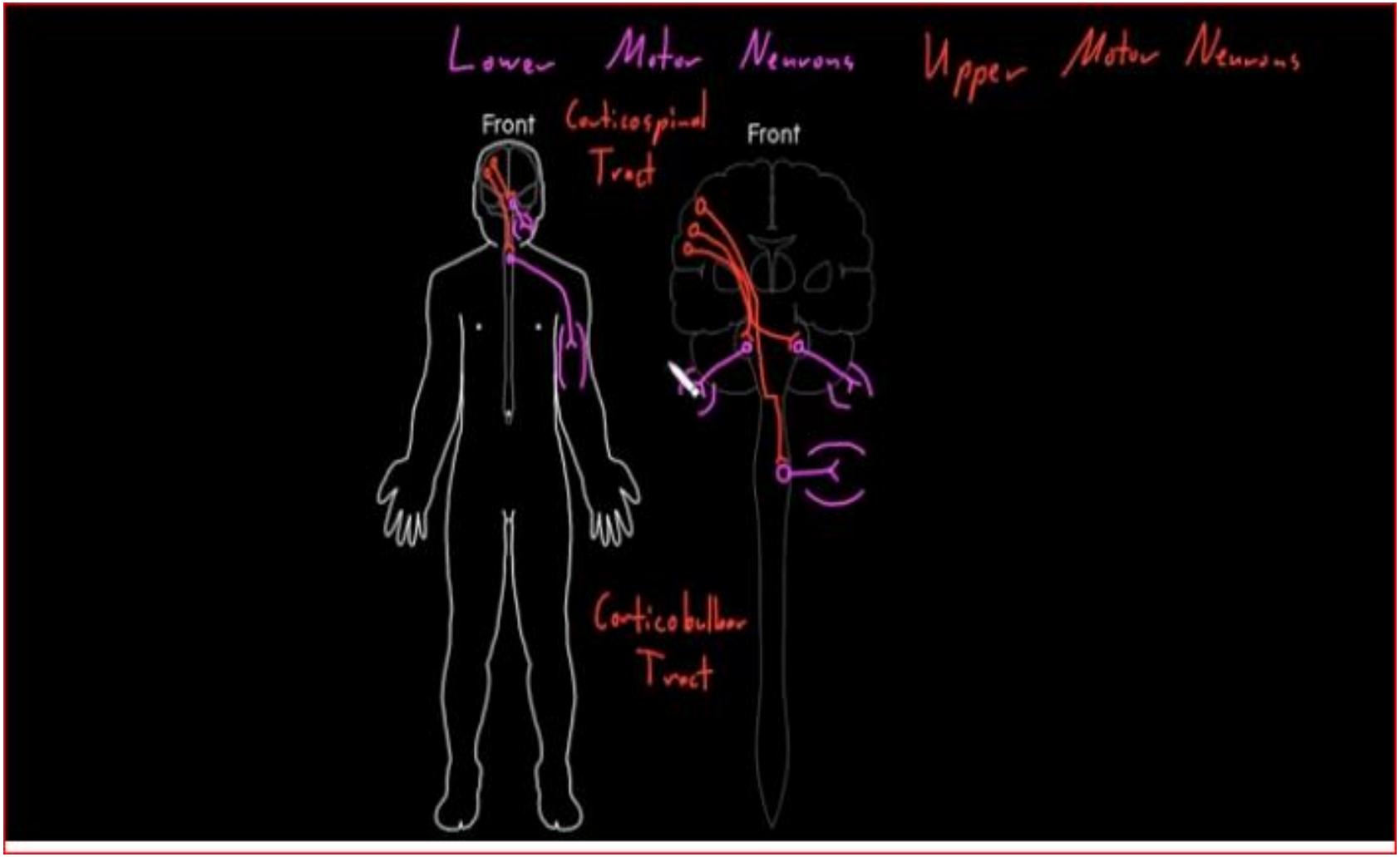
Examination of the Motor and Sensory Systems

Dr. Asmaa Abbas Ajwad



March 28th 2022

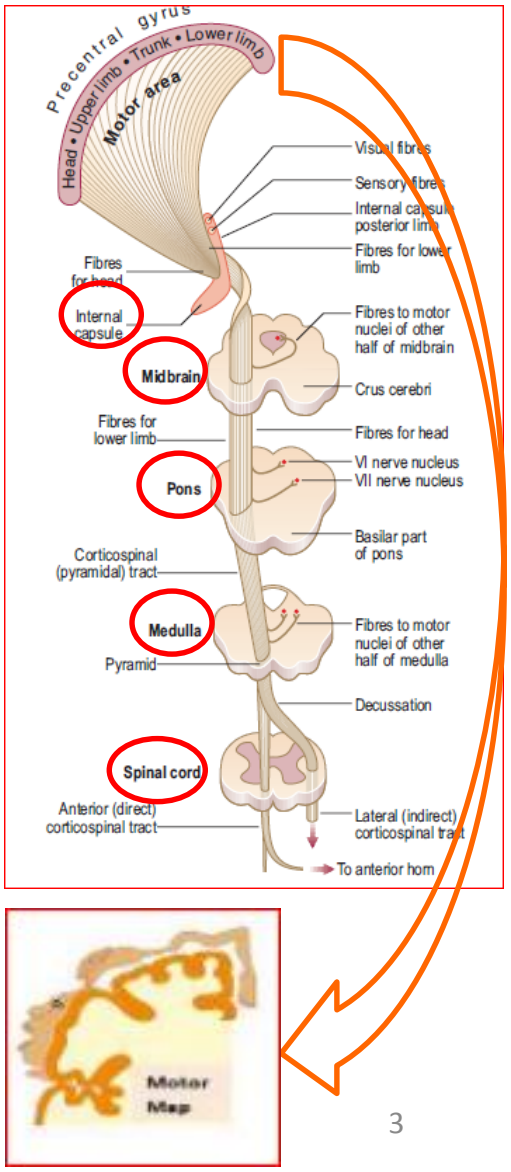
Introduction to the Motor System



Examination of the Motor System

➢ ***Anatomy:***

- Cross section of the brain shows you the landmarks of motor system pathway(see figure). Those landmarks include: ***cerebral cortex*** where the motor fibers originate, ***internal capsule*** deep within the brain, ***midbrain, pons, medulla, corticospinal tract with the spinal cord.***



- Fibers of the corticospinal tract arise from precentral gyrus (2/3 of it) and postcentral gyrus (1/3 of it). The descending fibers then pass through the internal capsule, midbrain, and pons. At the junction of the medulla oblongata and spinal cord , most of the fibers cross the midline at the decussation of the pyramid to form **lateral corticospinal tract** (80%). The remaining fibers do not cross but descend as **anterior corticospinal tract** (20%),these fibers eventually cross the midline and terminate in the anterior gray column of the spinal cord segment in the cervical and upper thoracic regions.

Examination of the Motor System

- In addition to the motor fibers, input from other systems involved in the control of movement, including extrapyramidal, cerebellar, vestibular and proprioceptive afferents, all converge on the cell bodies of lower motor neurons in the anterior horn of the gray matter in the spinal cord.

➢ **Neurological Examination of the Motor System Consists of:**

✓ *Inspection and palpation of muscles.*
✓ *Assessment of muscle tone.*
✓ *Testing movement and power.*
✓ *Examination of reflexes (superficial and tendon reflexes).*
✓ *Testing of coordination.*

➢ Examining the above parameters can tell us whether the disease is affecting the upper/lower motor neurons. ***Upper motor neuron lesion → corticospinal tract*** , ***Lower motor neuron lesion → peripheral spinal nerve and anterior horn cell.***

Inspection and Palpation of Muscles

➢ Inspection and palpation of muscles

- Proper inspection of the muscles requires full exposure of the patient with keeping him/her comfortable.
- Look for asymmetry, inspecting both proximally and distally.
- Note deformities, e.g. ***claw of the hands*** (ulnar nerve damage).

- Examine for wasting or hypertrophy, fasciculation and involuntary movement.
- Palpate muscles to assess their bulk and confirm wasting if present. Wasted muscles feel flabby. Inflammation of muscles (myositis) may associate with a tenderness and some forms of acute muscle necrosis that produces a firm woody feel.

➢ Common abnormalities:

- **Muscle bulk**

- Lower motor neuron (LMN) lesions may cause muscle wasting. Long standing upper motor neuron (UMN) lesions can result in a disuse atrophy of the muscle groups but wasting is not seen in acute lesion.
- Muscle disorders usually result in proximal wasting (the notable exception is myotonic dystrophy (distal), often with associated temporalis wasting).
- Certain occupations, e.g. professional sports players, may lead to physiological muscle hypertrophy.

Inspection and Palpation of Muscles

- **Fasciculation:** irregular twitches under the skin overlying resting muscles caused by individual motor units firing spontaneously. It occurs in LMN disease, usually in wasted muscles. ***Fasciculation is seen, not felt, so you may need to observe carefully for several minutes to be sure that this is not present.*** ***Physiological fasciculation*** is common, especially in the calves, but is not associated with weakness or wasting. ***Myokymia*** is rapid bursts of repetitive motor unit activity often occurring in an eyelid, and is rarely pathological.

- **Tremor:** an oscillatory movement about a joint or a group of joints resulting from alternating contraction and relaxation of muscles.

- ***Physiological tremor*** is a fine , fast tremor seen with **anxiety**. A similar tremor occurs in **hyperthyroidism** and those who drink too much of **alcohol** or **caffeine**.
- The slow and coarse asymmetrical ***tremor of Parkinson disease*** is worst at rest but reduced with voluntary movement. "***Pill rolling***" tremor (movement of the thumb across the finger tips). [Resting Termer].
- ***Intention tremor (action):*** tremor that is absent at rest but maximal on movement, and is usually due to cerebellar damage. It is assessed with the finger-to-nose test.

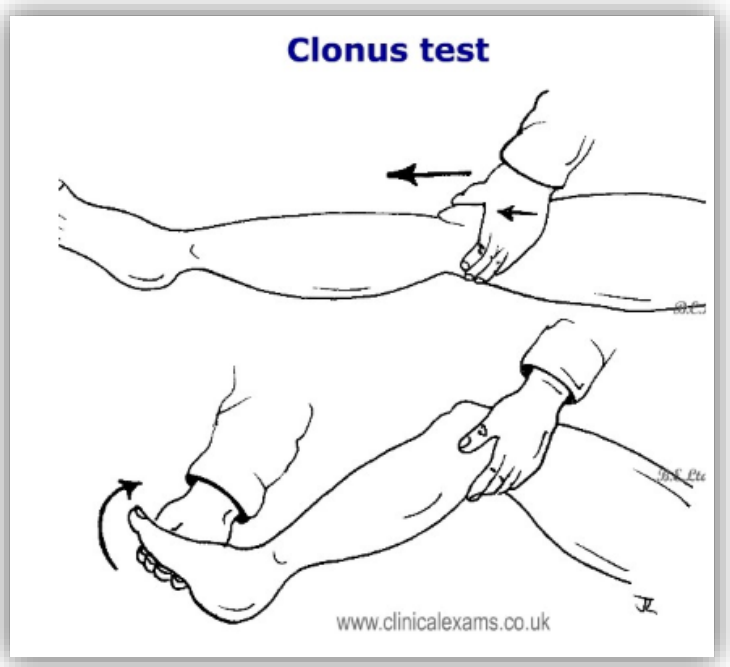
Assessment of Muscle Tone

- **Tone:**

- Resistance felt by the examiner when moving a joint passively through its range of movement (resistance of muscle to stretch). In normal people who are relaxed, there is an elastic type of resistance felt when a joint is moved. The tone could be normal, increased (hypertonia), or decreased (hypotonia).
- **Hypertonia** could be either spasticity or rigidity . Spasticity is a rapid built up of resistance during the first few degree of the passive movement and then as the movement continues there is lessening in the resistance. Rigidity on the other side is a sustained resistance to the passive movement .
- **Hyptonia** is a term used for the muscle that shows a very little resistance. This happens if the motor neuron to the muscle is cut, i.e. **(LMN) lesion** and usually associated with muscle wasting, weakness and hyporeflexia. It may be a feature of cerebellar disease. **Hypertonia** is a feature of **UMN lesion**.
- **Clonus** is a rhythmic series of involuntary muscle contractions evoked by a sudden stretch of the muscle. Clonus can occur in healthy individuals when they are tired. Sustained clonus is an indicative of UMN lesion (we have knee clonus and ankle clonus).

Examination of Muscle Tone

- ***Knee clonus*** is done by sharply pushing the patella toward the foot with the knee extended., sustain the pressure for few seconds.
- ***Ankle clonus*** is done by supporting the flexed knee with one hand in the popliteal fossa, then using the other hand to briskly dorsiflex the foot and sustain the pressure. (if knee clonus is present the patella will jerk up and down, if ankle clonus is present there will be a rhythmic beating of the foot).
- The presence of ***clonus*** is a sign of an ***upper motor neuron lesion***, and can also appear after ingesting potent serotogenic drugs.



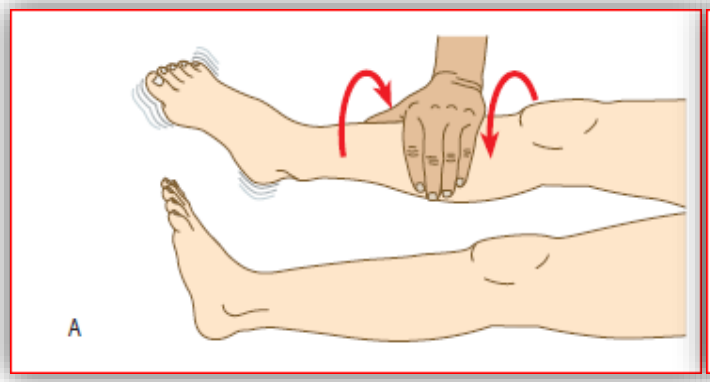
Examination of Muscle Tone

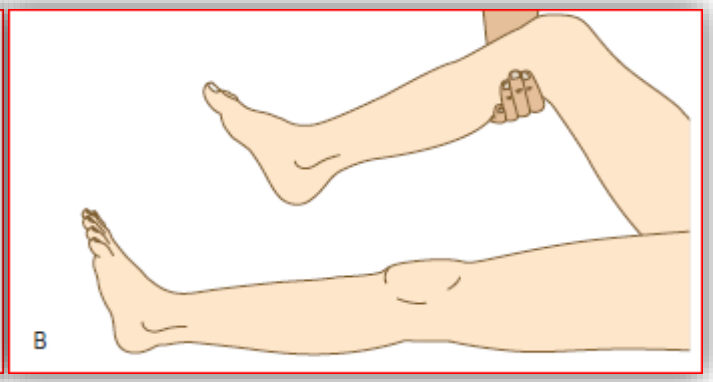
- Passive movement of the joint should be through as full a range as possible. , both slowly and quickly.

- ***Upper limb:*** hold the patient's hand as if shaking hands, using your other hand to support his/her elbow. Then rotate the forearm, flex and extend the wrist, elbow, and shoulder with varying the speed and direction of the movement.

If the tone is normal, there will be no resistance to these movement

- ***Lower limb:*** Begin with rolling or rotating the leg from side to side , then briskly lift the knee into a flexed position, observing the movement of the foot.

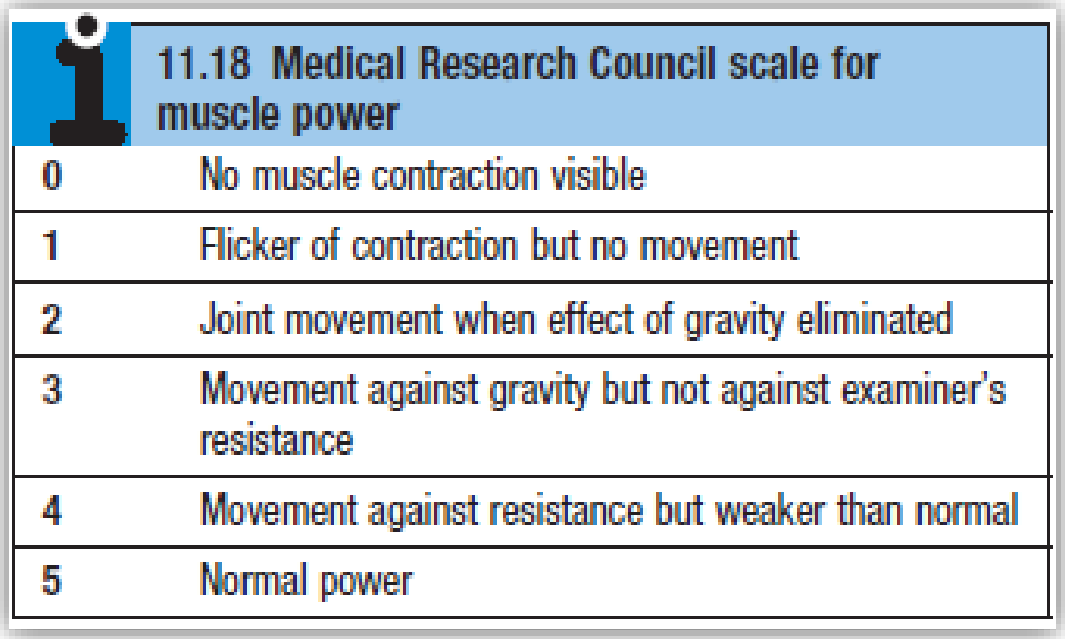




Testing for tone. (A) Rock the leg to and fro. (B) Quickly lift the leg at the knee and observe the movement of the heel.

Testing Movement and Power

- Strength varies with age, occupation and fitness. ***Muscle power*** is generally recorded based on the grading system which divides the power in to 6 grades (see table on the right).

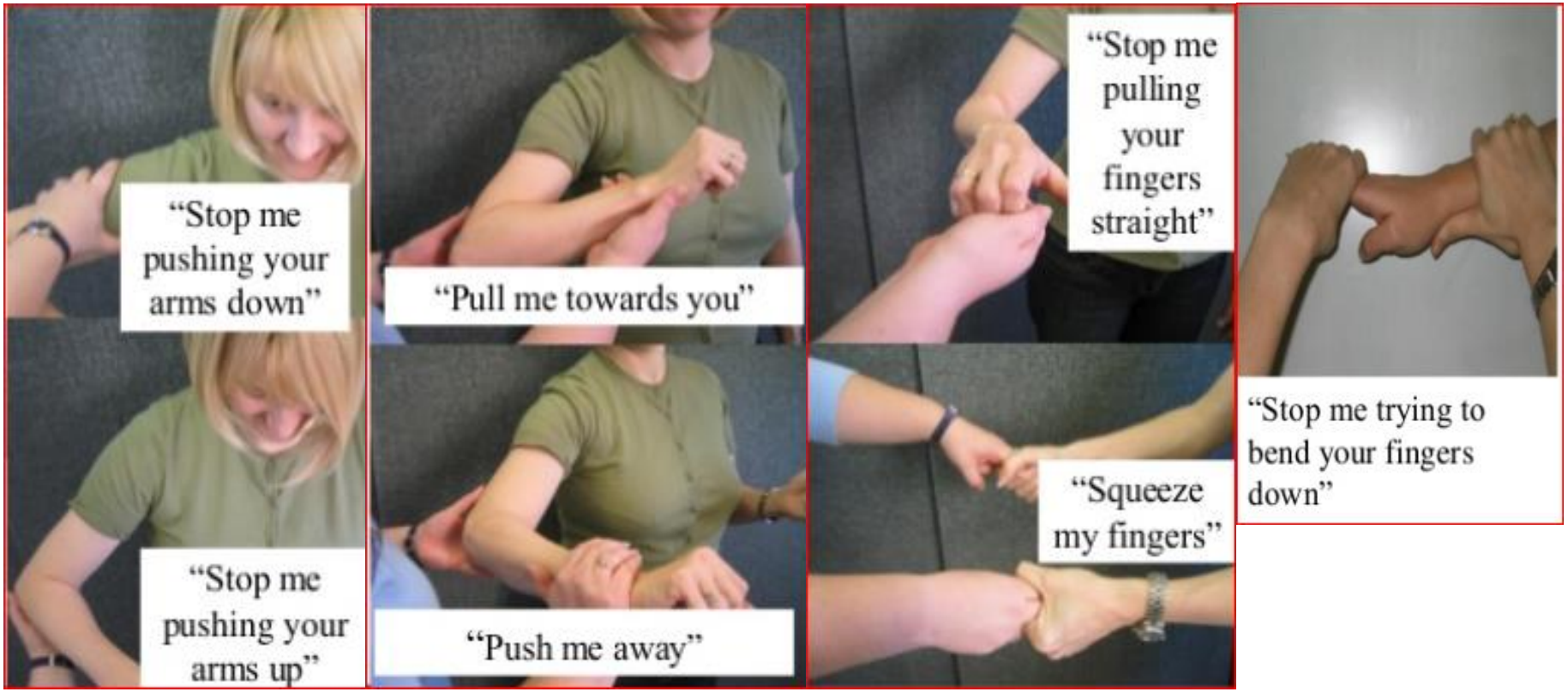


11.18 Medical Research Council scale for muscle power	
0	No muscle contraction visible
1	Flicker of contraction but no movement
2	Joint movement when effect of gravity eliminated
3	Movement against gravity but not against examiner's resistance
4	Movement against resistance but weaker than normal
5	Normal power

- Use the following list of joint movements to test the muscular power:

Upper limbs:	***Lower limbs:***
- ***Shoulder:*** abduction and adduction. - ***Elbow:*** flexion and extension. - ***Wrist:*** flexion and extension. - ***Finger:*** : flexion and extension. - ***Thumb:*** adduction.	- ***Hip:*** flexion, and extension. - ***Knee:*** flexion and extension. - ***Big toe:*** extension (dorsiflexion).

Testing Movement and Power



Upper limb test, from left to right:

Shoulder abduction and adduction

Elbow flexion and extension

Finger flexion

Finger extension

Testing Movement and Power

"Stop me pushing your foot down"

'Stop me trying to bend your knee"

"Stop me trying to straighten your

Lower limb test, from left to right:

Hip flexion and extension

Foot dorsiflexion and planter flexion

Knee extension and flexion

Testing Movement and Power

➢ Examination consequence:

- Test upper limb power with the patient sitting on the edge of the couch. Test lower limb power with the patient reclining.
- We have to examine individual muscle group in both limbs alternately or simultaneously so that the strength of the left and right can be directly **compared** when we give a grade for each group of muscles on each side.

➢ ***Common abnormalities:***

- ***UMN lesions*** result in ***weakness of a relatively large group of muscles*** (e.g. limb or more than one limb).
- ***LMN damage*** can cause ***paresis of specific muscle***.

Testing Movement and Power

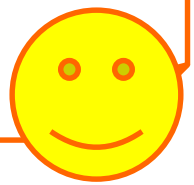
11.19 Causes of muscle weakness

Anatomical aetiology	Associated features	Common causes
Lower motor neurone	Wasting	Peripheral neuropathies or mononeuropathies
	Fasciculation	Radiculopathies
	Hypotonia	Anterior horn cell damage, e.g. poliomyelitis or motor neurone disease
	Reflexes absent or diminished	
Upper motor neurone	'Patterned' weakness (flexed arm, extended leg)	Stroke
	No muscle wasting	Spinal cord pathology
	Hyperreflexia	Multiple sclerosis
	Hypertonia	Brain tumour
Myopathies	Usually proximal weakness	Muscular dystrophies
		Inflammatory myopathies
		Corticosteroids
		Alcohol

11.20 Definitions of paralysis

Term	Definition
Paresis	Partial paralysis
Plegia	Complete paralysis
Monoplegia	Involvement of a single limb
Hemiplegia	Involvement of one-half of the body
Paraplegia/diplegia	Paralysis of the legs
Tetraplegia	Paralysis of all four limbs

- ***For table 11.19*** , associated features for UMN and LMN are required . No need to memorize the " common causes" here, just take a look.
- ***Table 11.20*** , all definition are required.



Examination of Reflexes

- **Reflexes are classified into :** *Deep tendon reflexes, superficial reflexes, and eye reflexes.*

Deep tendon reflexes

- ***A tendon reflex*** is the involuntary contraction of a muscle in response to stretch.
- It is mediated by a reflex arc consisting of an afferent (sensory) and an efferent (motor) neuron with one synapse between (a monosynaptic reflex).
- Muscle stretch activates the muscle spindles leading to contraction of the stretched muscle.
- The five most common reflexes are : biceps, triceps, supinator, knee, and ankle reflexes. Each reflex has a spinal segment level for integration.
  - *Biceps jerk → C5.*
  - *Triceps jerk →C7.*
  - *Supinator jerk → C6.*
  - *Knee jerk → L3,L4.*
  - *Ankle Jerk → S1.*

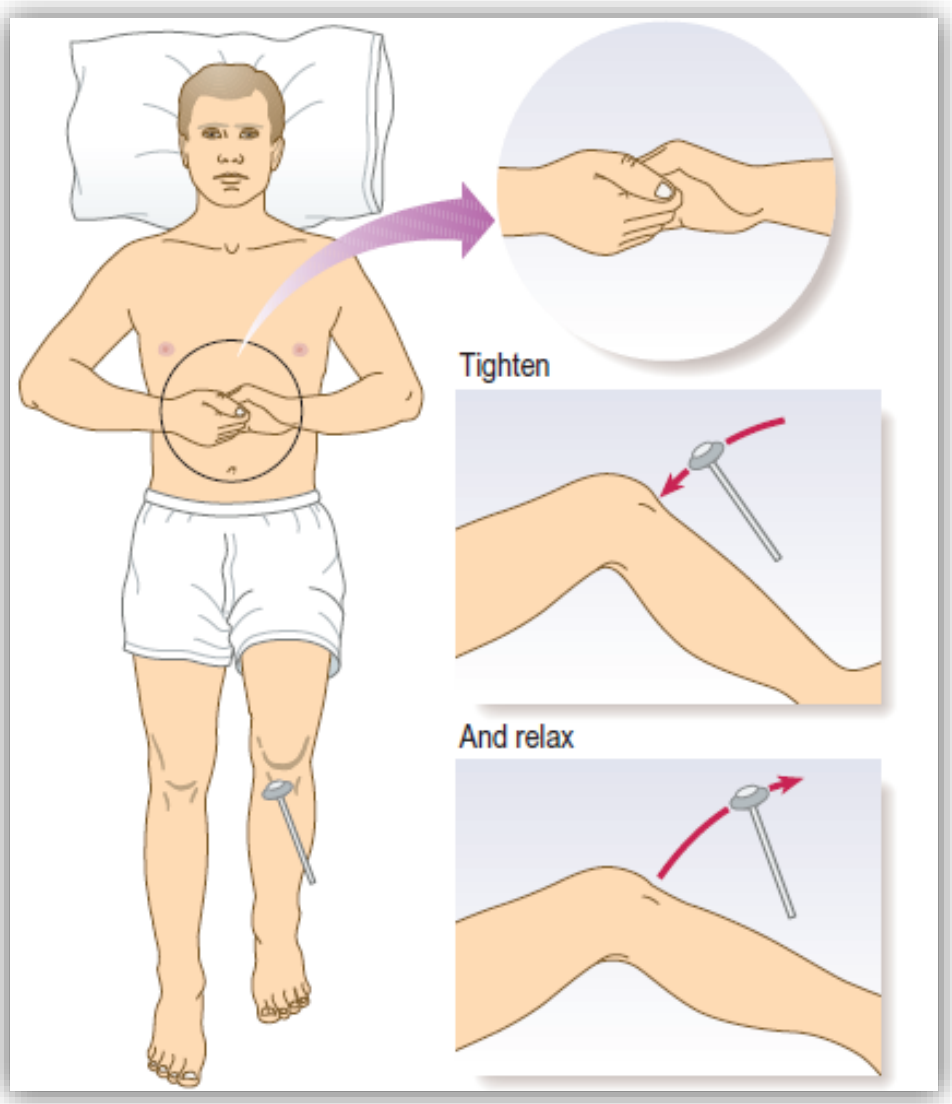
Examination of Tendon Reflexes

- Ask patient to relax and ensure that the muscle being tested is visible
- Strick the tendon with a sharp tap from a tendon hammer
- Observe the reflex muscle contraction of the stretched tendon
- Test the symmetry of the reflex for both sides
- If the reflex is still difficult to elicit or appears to be absent, use the **reinforcement** technique. For lower limb reflexes, ask the patient to interlock the flexed fingers and try to pull them apart at the time the tendon is being struck. For upper limb reflexes, ask the patient to clench the teeth. This is done in order to increase gamma efferent discharge that results in an increase in the excitability of ant. horn cells.
- Diminished or absent reflexes is a feature of LMN lesion . Increased reflexes (hyperreflexia) is a feature of UMN lesion.

❖ ***Deep reflexes are classified as :***

- Hyperactive → +++
- Normal → ++
- Sluggish → +
- Appear after reinforcement → -+
- Absent → -

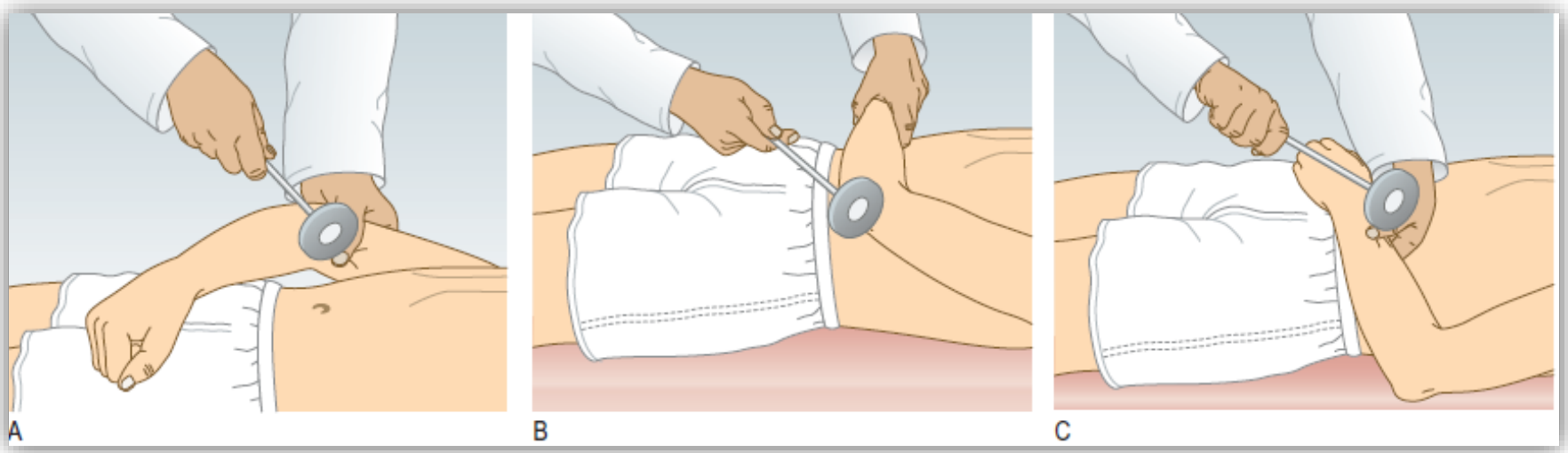
Reinforcement Technique



Reinforcement while eliciting the knee jerk

Examination of Tendon Reflexes/Upper Limbs

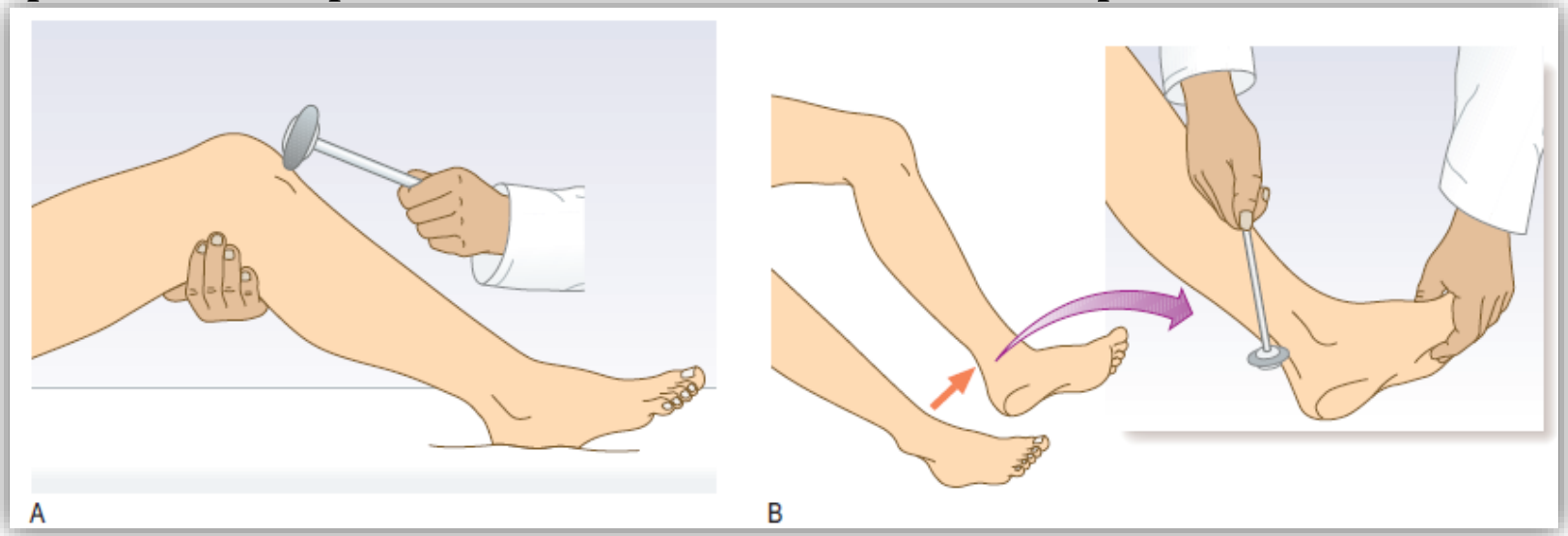
- ***Biceps Jerk:*** Flex the elbow of your subject to a right angle and the forearm placed in a semi pronated position. Put your left thumb or index finger firmly over the bicep tendon and strike it with a neurological hammer. The elbow will flex and at the same time slightly supinates due to biceps contraction.
- ***Triceps Jerk :*** Flex the elbow and support the forearm of your subject on your own left forearm. Tap the triceps tendon just proximal to the olecranon . The response is an extension of the elbow and a contraction of triceps muscle.
- ***Supinator Jerk:*** Hold the wrist of your subject with your left hand and tap the styloid process of the radius. This produces a supination of the forearm.



Testing the deep tendon reflexes of the upper limb. **(A)** Eliciting the biceps jerk, C5. **(B)** Triceps jerk, C7. **(C)** Supinator jerk, C6.

Examination of Tendon Reflexes/Lower Limb

- ***Knee Jerk:*** The patellar tendon is tapped; the reflex response is a contraction of quadriceps muscles. The subject should let his legs hang down loosely over the side of the bed. Place one hand gently on the quadriceps mass and tap the patellar tendon with a neurological hammer held in the other hand. The tendon should be hit midway between the low edge of the patella and the insertion of the tendon in the tibia. The contraction of the muscles can be felt.
- ***Ankle Jerk:*** Place the lower limb on the bed so that it lies everted and slightly flexed. Now, dorsiflex the foot slightly to stretch the Achilles tendon and with a hammer held in your right hand, strike the tendon on its post. surface. The response is a sharp contraction of the calf muscles and planter flexion of the foot.



Testing the deep tendon reflexes of the lower limb**. (A)** Eliciting the knee jerk (note that the legs should not be in contact with each other), L3, L4. **(B)** Ankle jerk of recumbent patient, S1.

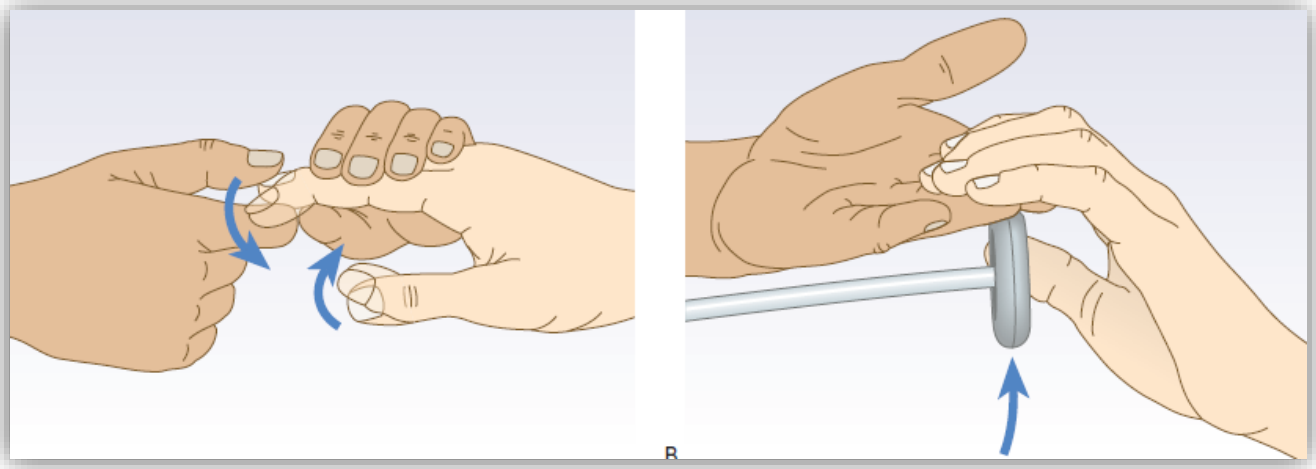
Examination of Tendon Reflexes/ Hand

➢ ***Hoffman's Reflex***

- Place your right index finger under the distal interphalangeal joint of the patient's middle finger.
- Use your right thumb to flick the patient's finger downwards.
- Look for any reflex flexion of the patient's thumb
- *+ve Hoffmann's reflex (excess thumb flexion) and finger jerks suggest hypertonia.*

➢ ***Finger Jerk***

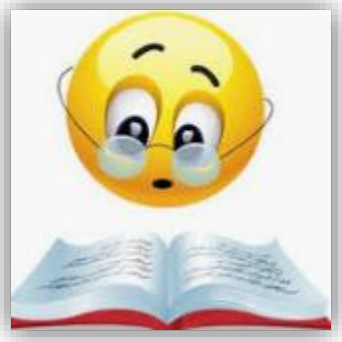
- Place your middle and index fingers across the palmar surface of the patient's proximal phalanges.
- Tap your own fingers with the hammer.
- Watch for flexion of the patient's fingers



Testing the deep tendon reflexes of the hand. (A) Hoffmann's sign. (B) Eliciting a finger jerk

Examination of Tendon Reflexes

- Have you heard about the ***inverted reflexes***? Read, think, and write about them in the empty box here :-)

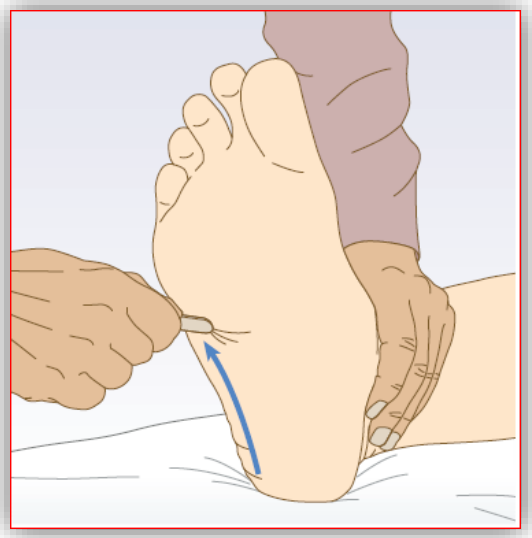


Examination of Superficial Reflexes

Superficial reflexes

- They are polysynaptic and evoked by cutaneous stimulation.
- Include: planter, abdominal, and cremasteric reflexes.

➢ ***Planter Reflex (S1-S2):*** The patient lies down with the soles of both feet opposed; the feet must be warm and relaxed. The sole of the foot is now scratched firmly but gently along the length of the outer border. Normal response should be a flexion of the big toe and adduction of other toes. In UMN lesion, there will be extension of the big toe with abduction of other toes (the same response is seen in infants and children below 1 year age because of incomplete development of nervous system (corticospinal tract) at that age). The normal response is called a ***negative Babinski's sign*** while abnormal one is called a ***positive Babinski's sign***.

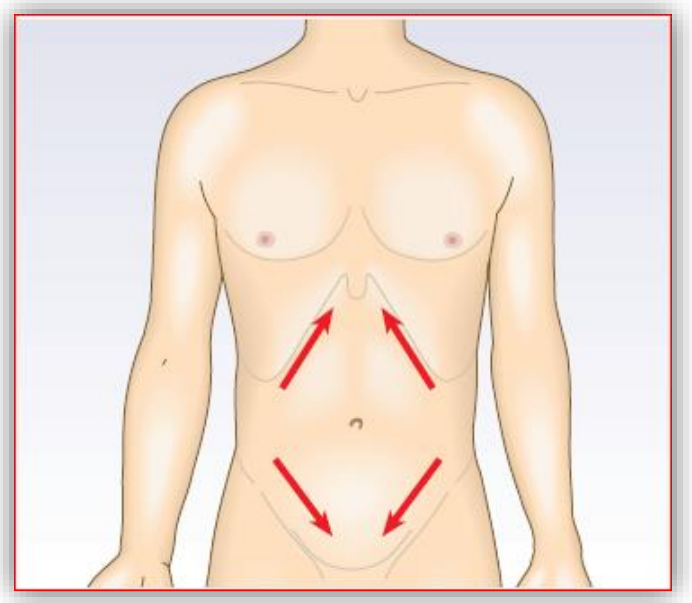


Eliciting the plantar reflex

Examination of Superficial Reflexes

➢ ***Abdominal Reflex (T8-T12):***

- This reflex is elicited with patient lying relaxed and in supine position obtained by stroking lightly with a key or thin wooden stick the abdominal skin in the from the outer aspect toward the midline . The response is a contraction of the underlying muscles with the umbilicus moving laterally/up/and down depending upon the quadrant being tested.
- Test this reflex on 4-quadrants of the ant. abdominal wall. It is difficult in elderly or obese and in multiparous woman.



Eliciting the abdominal reflex

Examination of Superficial Reflexes

- ***Cremasteric Reflex (L1-2):***

- Abduct and externally rotate the patient's thigh.
- Use an stick to stroke the upper medial aspect of the thigh.
- Normally the testis on the side stimulated will rise briskly.

Eye Reflexes

- **Corneal reflex**
- **Pupillary reaction to light**
- **Pupillary reaction to accommodation**

We have a separate lab to talk about these reflexes, so leave them for now.

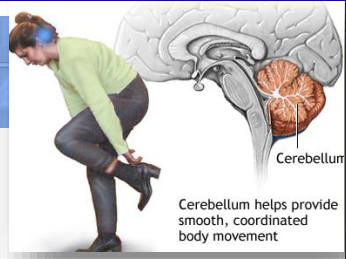
Primitive Reflexes

- Include (snout, grasp, palmomental, and glabellar tap) reflexes.
- When present singly, they are of a limited significance BUT if found in numbers they suggest diffuse or frontal cerebral damage.
- They are present in neonates and young infants. Their absence in 4 months after birth may indicate pathology.
- In adults, they are often present in severe acquired brain damage due to trauma, anoxia, diffuse vascular or malignant disease, encephalopathy, and dementia.

11.25 Primitive reflexes

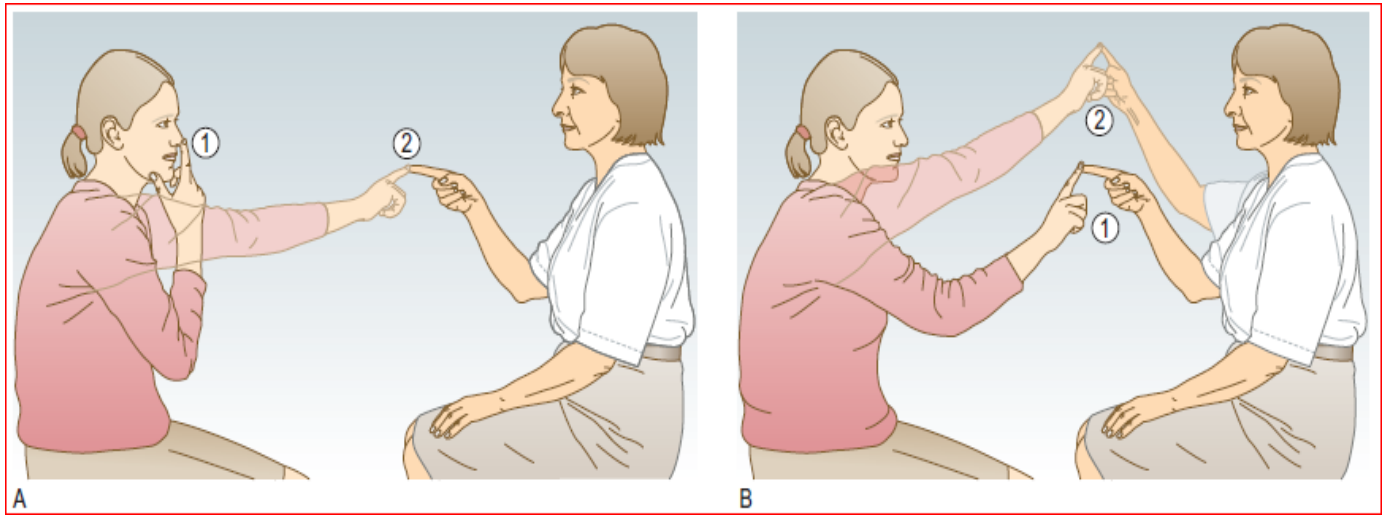
Snout reflex
• Lightly tap the lips. An abnormal response is lip pouting
Grasp reflex
• Firmly stroke the palm from the radial side. In an abnormal response, your finger is gripped by the patient's hand
Palmomental reflex
• Apply firm pressure to the palm next to the thenar eminence with a tongue depressor. An abnormal response is ipsilateral puckering of the chin
Glabellar tap
• Stand behind the patient and tap repeatedly between his eyebrows with the tip of your index finger. Normally the blink response stops after three or four taps

Coordination



- The cerebellum plays an important role in the coordination.
- Cerebellar function is tested by the following:

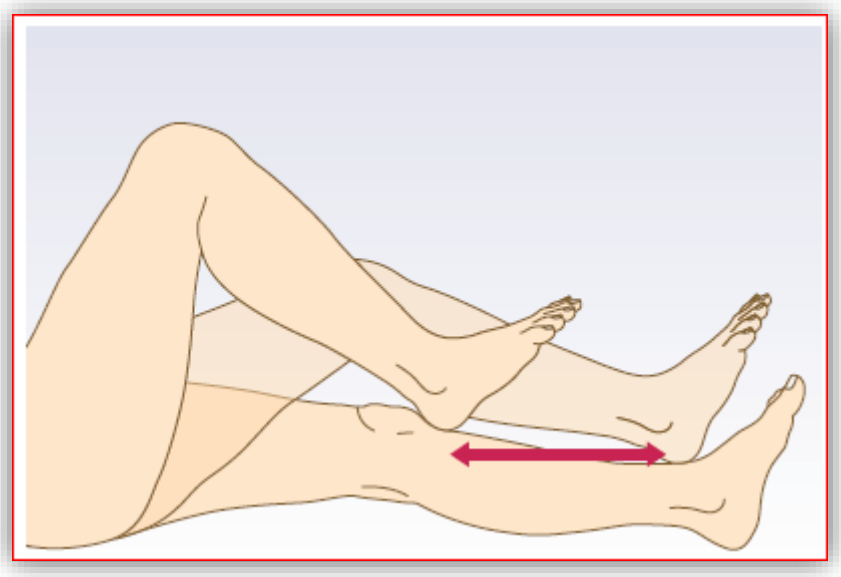
1. ***Finger-to-nose test*** performed by asking the patient to touch his/her own nose and the examiner's finger alternatively as quickly , accurately, and smoothly as possible. The examiner holds a finger at arm length from the patient. The patient is instructed to touch the finger and then the nose. This is repeated several times. Patients with cerebellar disease persistently overshoot the target. The patient may also has a tremor as the finger approaches the target. To make the test more sensitive, change the position of your target finger.



Finger-to-nose test. (A) Ask the patient to touch the tip of her nose and then your finger. (B) Move your finger from one position to another, towards and away from the patient, as well as from side to side.

Coordination

2. ***Heel-to-shin test*** which is performed by having the patient lies on his/her back. Ask the patient to slide the heel of one lower extremity down the shin of the other starting at the knee. A smooth movement should be seen with heel staying on the shin. In patients with cerebellar disease, the heel wobbles from side to another.



Performing the heel-to-shin test with the right leg.

Coordination

3. Rapid alternating movement

a. Ask the patient to pronate and supinate one hand on the other one rapidly.

b. Ask the patient to touch thumb to each finger as quickly as possible.

c. Ask patient to slap the thigh, raise the hand, turn it over and slap the thigh again rapidly. This pattern should be repeated as quickly as possible.

d. Remember that we have ***Romberg sign for vestibular function test***. ***Romberg test*** is performed by asking the patient to stand unaided with their eyes closed. If the patient sways or loses balance then this test is positive. Stand near the patients in case they fall. Whilst Romberg's test does not directly test for ***cerebellar ataxia***, it helps to differentiate ***cerebellar ataxia from sensory ataxia***. In cerebellar ataxia the patient is likely to be unsteady on their feet even with the eyes open.

Coordination

4. Rebound phenomena (rarely useful)

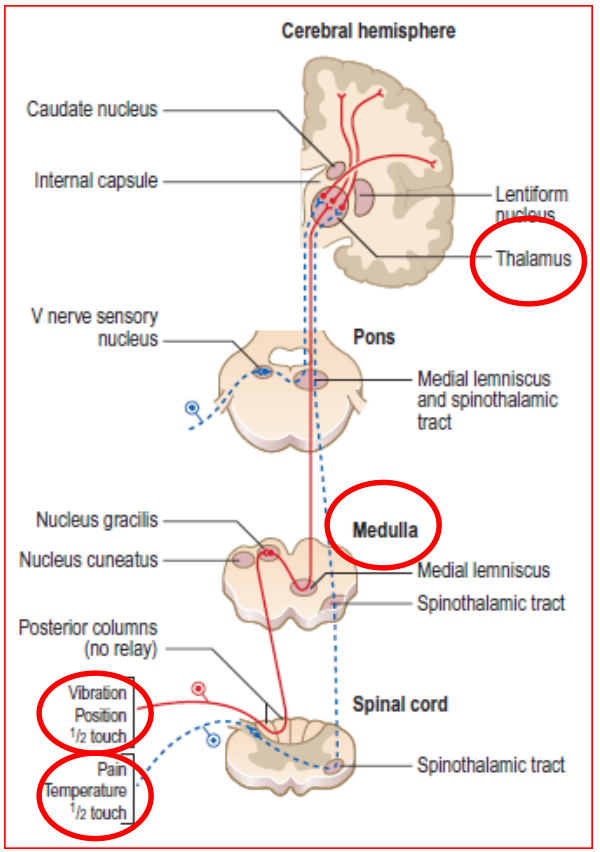
- Ask the patient to stretch his arms out and maintain this position.
- Push the patient's wrist quickly downward and observe the returning movement.

5.Gait: watch the subject when walking. Some neurological diseases can cause characteristic gaits.

a. Drunken gait → in cerebellar ataxia
b. Stamping gait → in tabes dorsalis
c. Spastic gait → in hemiplegia
d. Shuffling gait → in Parkinson's disease
e. High stepping gait → in peripheral neuropathy

Examination of the Sensory System

- ***Anatomy:*** conscious proprioception (joint position sense) and vibration are conveyed in large, fast conducting fibers in the post. (dorsal) columns. Pain and temperature sensation are carried by small, slow-conducting fibers of spinothalamic tract. The post. column remains ipsilateral from the point of entry up to the medulla but most pain & temperature fibers cross within one or two segments of entry to the contralateral spinothalamic tract. All sensory fibers rely in the thalamus before sending information to The sensory cortex.



- Sensory system examination is unnecessary unless the patient complains sensory symptoms or you suspect a specific pathology such as spinal cord compression. Sensory symptoms include pain, spontaneous abnormal sensation usually of “tingling” or “pins & needles”, and loss of sensation or numbness.

- All tests here are performed while the subject’s eyes are closed.

Examination of Sensory System

- **The Sensory Modalities:** In addition to the modalities conveyed in the principal ascending pathways (***touch, pain, temperature, vibration and joint position sense***), sensory examination includes ***tests of discriminative aspects of sensation*** which may be impaired by lesions of the sensory cortex.
- **Examination sequence:**

✓ ***Light touch***

- Light touch is evaluated by lightly touching the patient with a small piece of gauze/cotton. Ask patient to close his/her eyes and to say "yes" when the touch is felt. Try touching the patient on fingers and toes. If the sensation is felt (normal), continue with the next step. If the sensation is abnormal, work proximally till a sensory level can be determined.
- Pressure sensation is tested with a blunt object (tip of finger) pressed on different areas of the skin. The pressure should not be strong to avoid pain sensation.

✓ ***Pain***

- For **superficial pain**, prick the skin lightly with a sharp pin. Compare the degree of pricking required to elicit pain sensation at different parts of the body. For **deep pain** squeeze muscles or Achilles tendon. Do not apply pressure with an instrument like a pen.

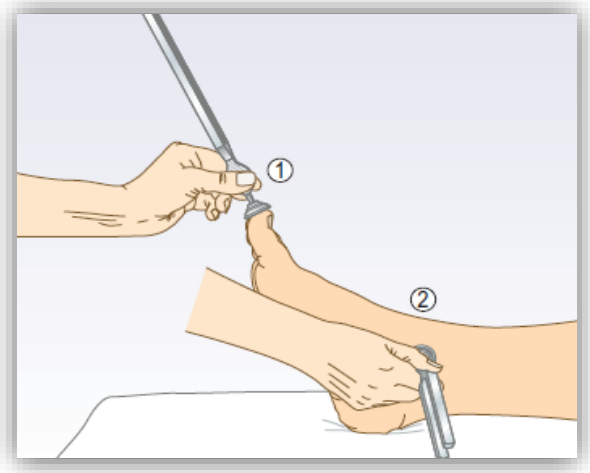
Examination of Sensory System

✓ ***Temperature***

- Touch the patient with a cold metallic object, e.g. tuning fork, and ask if it feels cold. More sensitive assessment requires tubes of hot (40°C) and cold water (15°C) but is seldom performed.

✓ ***Vibration***

- Place a vibrating 128-Hz tuning fork over the sternum. Ask the patient, 'Do you feel it buzzing?'
- Place it on the tip of the big toe . If sensation is impaired, place the fork on the interphalangeal joint and progress proximally, to the medial malleolus, tibial tuberosity and anterior iliac spine, depending upon the response.
- Repeat the process in the upper limb. Start at the distal interphalangeal joint of the forefinger, and if sensation is impaired, proceed proximally.



Testing vibration sensation. At the big toe (1) and the ankle (2)

Examination of Sensory System

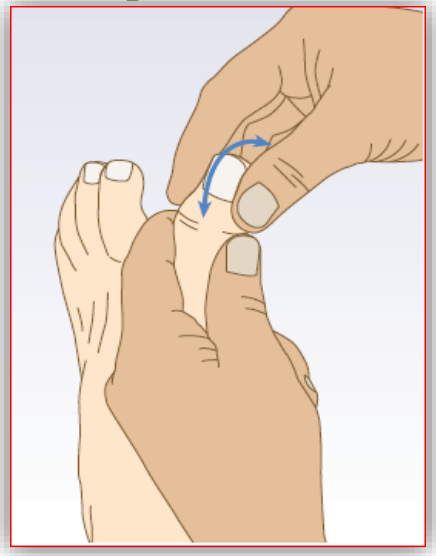
✓ ***Joint position sense***

- Change the position of different joints and move the finger of your patient passively up, down, right, and left whilst his/her eyes are closed. Ask him/her to describe the passive movement induced and the final position at which his/her joint was put. Big toe is used in lower limb test.

✓ ***Two point discrimination (TPD)***

- Gently hold two pins (or tipped school compasses) 2 to 3 mm apart and touch the patient finger tip. Ask the patient to state the number of pins felt. Because different areas of the body have different sensitivities, you must know these differences. At the finger tip TPD is 2 mm apart, tongue: 1mm, toes 3-8 mm, palm 8-12 m, and back 40-60 mm. Parietal lobe lesion impairs TPD.

TPD test



Testing for position sense in the big toe

Examination of Sensory System

✓ ***Stereognosis and Graphaesthesia***

- Ask the patient to close his eyes.
- Place a familiar object, e.g. coin or key, in his hand and ask him to identify it (stereognosis).
- Use the blunt end of a pencil or stick and trace letters or digits on the patient's palm. Ask the patient to identify the figure (graphaesthesia).

Some Terms in Sensation

- ***Hypoesthesia***(decreased sensation): the sensation of temperature, pain, or light touch diminished when compared with a normal limb.
- ***Paresthesia:*** Tingling, or pins and needles , spontaneous or provoked. Not unduly unpleasant or painful.
- ***Dysesthesia:*** an unpleasant, abnormal sense of touch. It often presents as pain but may also present as an inappropriate, but not discomforting sensation.
- ***Hyperesthesia:*** an increase in sensitivity (patient feels a touch as a pricking or burning sensation).
- ***Analgesia:*** absence of the sense of pain without losing the consciousness.
- ***Anesthesia:*** local or general insensibility to pain with or without loss of consciousness induced by an anesthetic.

Fun Facts About the Brain

- These facts will teach you interesting bits of information about the physical make-up of the human brain.
- **Weight**. The weight of the human brain is about 3 lbs.
- **Cerebrum**. The cerebrum is the largest part of the brain and makes up 85% of the brain's weight.
- **Skin**. Your skin weighs twice as much as your brain.
- **Gray matter**. The brain's gray matter is made up of neurons, which gather and transmit signals.
- **White matter**. The white matter is made up of dendrites and axons, which create the network by which neurons send their signals.
- **Gray and white**. Your brain is 60% white matter and 40% gray matter.
- **Water**. The brain is made up of about 75% water.