



تلخيص Physiology

Module 4

Alexmed 2012-2019

Fekra Team

Physiology of Muscle

general

→ Muscles machine chemical E convert → mechanical
 → Muscles 50% of body weight
 Function → Mainly contraction.

* Muscle Fibers (cells)

→ building blocks of muscular system
 → Parallel to each other.

* Skeletal muscles → 640 muscle.
 → end by a tendon.

Function

- ① Movement of the body. حركة الجسم كله أو جزئ واحد
- ② Maintain body posture. تثبيت الجسم
- ③ generate heat during contraction توليد الحرارة أثناء انقباض العضلات
- ④ Stabilize joints تثبيت المفاصل
- ⑤ act as sphincter عضلات مثل عضلة على جانبي فتحة الشرج

Types of Skeletal Muscle Fibers

Red Muscle Fiber slow	pale muscle fiber Fast
① Thin Fibers	① Thick Fibers
② numerous Blood capillaries	② Few blood capillaries
③ numerous mitochondria	③ Few mitochondria
④ long latent period يعمل ببطء وقتاً طويلاً قبل انقباض	④ short latent period. يعمل بسرعة
⑤ Contract slowly يتعب ببطء	⑤ Contract rapidly يتعب بسهولة
⑥ large amount of myoglobin to store O_2 .	⑥ extensive sarcoplasmic reticulum → to pump Ca^{++} rapidly
* Back muscles	* Hand muscles

needs of each muscle

Red

athletes and bicycle

نظام الهوائية دور عايز به مجهود
لفترة طويلة

(N.B) aerobic system

pale

sprinter

يوصل لأقصى سرعة في وقت
قصير فعايز

quickly generated force

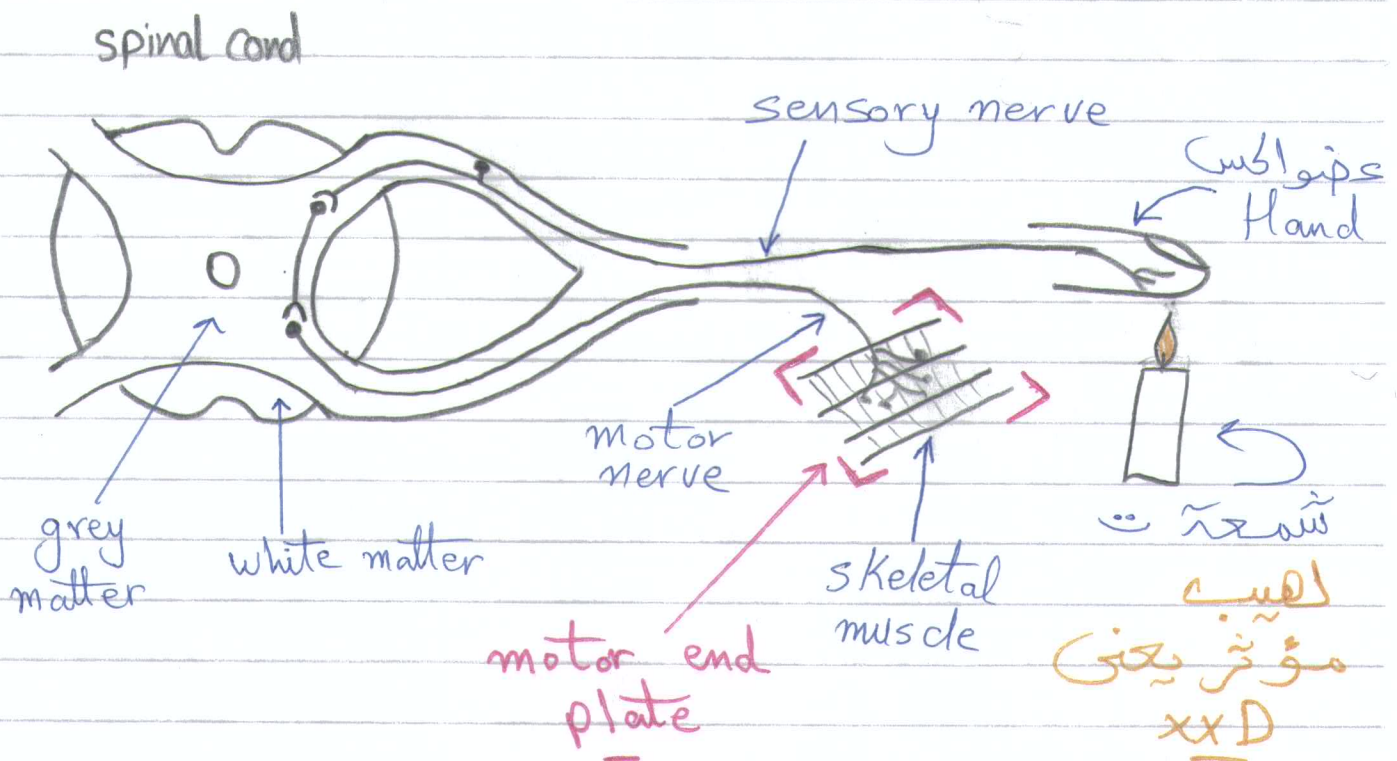
(N.B) anaerobic system

(N.B) Third Type → mixture of Fast, slow muscles.

Fast → have high ATPase Activity.

slow → High oxidative capacity.

nerve supply of skeletal muscle



Motor unit

*Skeletal muscle

→ nerve operated & can't work without motor supply
 يعني العضلة دي لا تعمل إلا أما يوصلها stimulation من ال nerve
 (so) it's under control of CNS.

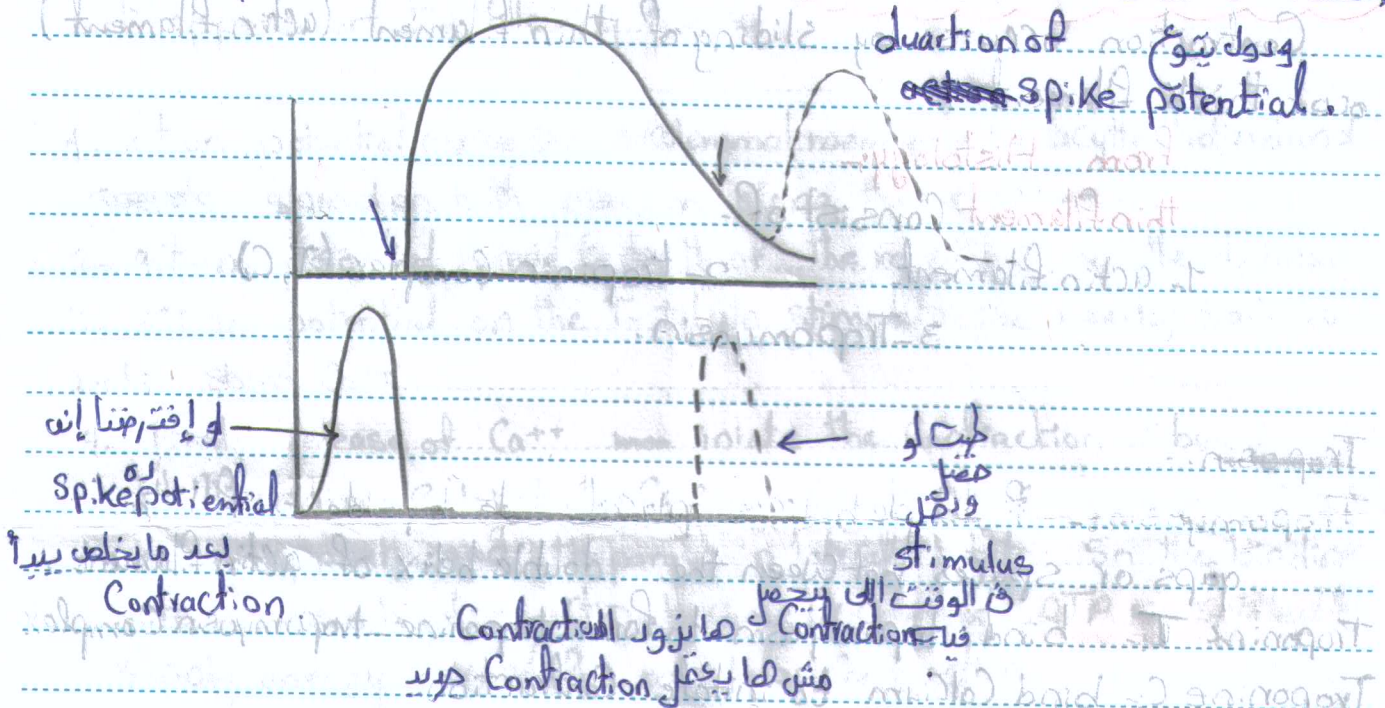
nerve cut * cause paralysis of muscle
 * complete loss of its function.

Motor unit → each one supply 30-150 muscle fiber
 → Follow Rule all or non rule
 ← قانونه الكل أو لا شيء

II. Excitability changes Refractory period

Excitability change in skeletal muscle fiber is the same in nerve fiber.

Refractory period in skeletal muscle is too short about 2 msec,



Refractory period end at the beginning of muscle contraction

(mechanical response)

skeletal muscle recover its excitability completely by the end of refractory period

action potential Contraction muscle
refractory period action potential muscle
other muscle 2 msec

So muscle can respond to other stimulus while its in the phase of contraction.



III. Mechanical Change in skeletal muscle:-

The electrical change is followed by mechanical response (muscle contraction).

* How Contraction occurs:-

Contraction occurs by sliding of thin filament (actin filament) over thick filament.

From Histology:-

thin filament consist of:-

1. actin filament
2. troponin Complex (T, C)
3. Tropomyosin.

Tropomyosin:-

Tropomyosin:- 2 double helices placed side by side to fill the gaps or spaces between the double helix of actin filament.

Troponin T:- bind tropomyosin to form troponin-tropomyosin complex.

Troponin C:- bind Calcium to initiate contraction.

during rest:-

Troponin T bind to tropomyosin forming troponin-tropomyosin complex.

These complex cover the binding site of head of myosin on actin filament so inhibit contraction.

during contraction:-

once Troponin C bind to Ca^{++} ions these complex (troponin-tropomyosin complex) is disappeared and tropomyosin is moved ~~laterally~~ laterally so the binding site become uncovered and these initiate the contraction.

How contraction occurs:-

by swinging of the myosin head followed by detaching and reattachment to the next linking site.

From Histo:- Head of myosin has ATPase activity and from



V.I.P A.T.P is used in muscular contraction and relaxation.

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Date:

these energy required for contraction is driven.

Excitation - Contraction Coupling.

it is the process by which action potential initiate muscle contraction.

it happens on the following steps:-

1. action potential arrive the sarcolemmal membrane by (action potential) and spread on both direction along the membrane.
2. action potential spread to depth of the myofibril via the T-tubule.
3. action potential on the T-tubule stimulate the nearby SAC to release stored Ca^{++} .
4. ~~Real~~ release of Ca^{++} initiate the contraction by:
 1. Troponin C bind to Calcium so troponin-tropomyosin complex is disappear and tropomyosin laterally rotate so the binding site of myosin head on actin become uncovered. ATP is splitted to supply energy needed for muscular contraction.

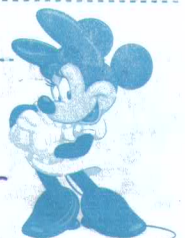
5. Sliding of the thin filament over thick filament due to formation of cross linkage between actin filament and head of myosin and this make muscle contract. more and more contraction is obtained by disconnection and swiveling and reconnection of myosin head to the binding site on actin filament.

* muscle relaxation occurs How?

When Calcium disappear from sarcoplasm. The troponin-tropomyosin is reformed and thus inhibit contraction.

How can Calcium disappear?:-

by active reuptake of calcium to sarcoplasmic reticulum to be stored again. active reuptake needs energy obtained from breakdown of A.T.P.



Types of muscular contraction

Isotonic Contraction

Tension

The same tension

length

short muscle

load

Carry moderate load

work

25% → benefit work
75% → heat

Isometric Contraction

- Increase tension.

- The same length.

- no load

100% → heat

Heat production

Initial heat - before shortening

Activation

Shortening

relaxation

maintenance

Conduction of the spike

Change in the structure of muscle

- breakdown of ATP
- uptake of Ca^{+2}

- maintenance of contracted state

Recovery heat

stoppage of contraction result from chemical process

pre-contraction state

result from oxidation of free f.A

supply energy for resynthesis of ATP

$$\text{The ratio} = \frac{\text{Recovery}}{\text{Initial}}$$

$$= 1$$

Find Yourself to Be What you want



Find Yourself to Be What you want



N.B: → hypertrophy → increase in muscle size.
- hyperplasia → increase the number of muscle cells.

Muscle hypertrophy

Muscle atrophy

Thick of muscle fiber

- muscle is not used
- decrease myosin and actin
- limbs are casts or brace

as → increased synthesis of myosin and actin filament

disuse atrophy

increase contractile strength

في حالة عدم الاستخدام
تقليل الألياف العضلية

increase the power of contraction

muscle denervation
"atrophy"

N.B weak muscular activity doesn't lead to muscle

re-innervation "3-4" months

electrical stimulation can protect the muscle from atrophy.

A. f. ...

... of the ...

Research ...

muscle fatigue

Temporary decrease in
the work of skeletal muscle

↓
defense mechanism
protect muscle from reaching
apoint → not produce ATP.

Causes:

- ↑ ADP and inorganic phosphate
 - accumulation of lactic acid
 - Depletion of energy
 - interruption of blood flow
- "Complete muscle fatigue"
as lossing of O_2 and
nutrients.

muscle Contrature

muscle contraction that
not initiate with
action potential.

Causes:

- depletion of ATP
- ↓ Ca^{+2} reuptake by
sarcoplasmic reticulum
- fail of relaxation



Muscle contracture (cramps) الشد العضلي

→ Sustained muscle contraction, not initiated by action potential in conditions
 * over worked * Fatigued

هذه العضلة فيه يتعبن ومابتعاش relax وفيه احساس فظيع بالألم

(cause)

* depletion نفاذ ATP

لذلك الطاقة اللازمة للاستعادة cations بواسطة sarcoplasmic R

(So) → Muscle Fail to relax

→ combination of myosin & actin.

* electromyography

تسجيل ضربات القلب آه

→ recording of electrical activity in skeletal muscle.

Muscle denervation

Skeletal muscle nerve dependant cases:

① Failure of Transmission to motor end plate.

② Cutting motor nerve

③ lesion anterior horn cells

Motor neurons



poliomyelitis

← فيروس نشل الأطفال

Denervation Lead to:

① Atrophy of muscle

انحسار العضلات

→ decrease in size



muscle replaced

Fibrous Tissue

	② Muscle Fasciculation	③ Muscle Fibrillations
cause	Pathological discharge From spinal cord	Hyper sensitivity of denervated muscle
naked eye	can be seen	can't be seen

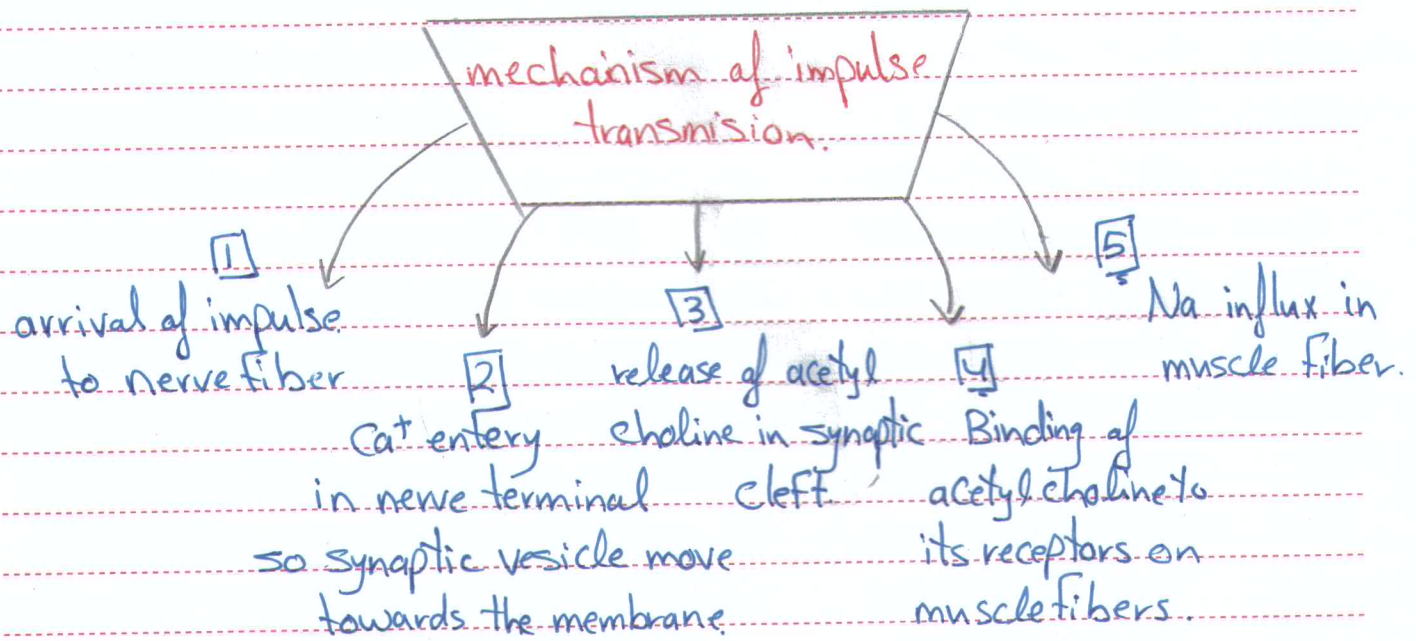


Motor end plate

Nerve ending by which motor neurons ends in skeletal muscle fiber

→ Site of neuromuscular Junction:-

mid-point (middle) of muscle fiber to enable action potential to spread in both directions.



Notes.

- * - synaptic cleft : space between nerve terminal and muscle fiber.
- * - Na influx inside muscle create a local action potential as it decrease membrane potential.

End plate potential :-

Na influx → decrease membrane potential → local action potential → action potential reach firing level → propagated action potential spread along muscle fiber.

↓

muscle contraction

Fate of acetylcholine :-

- * destroyed after one millisecond from its release in synaptic cleft.
- * hydrolysis of acetylcholine before this duration. prevents re-excitation of the muscle fiber after recovery from previous action potential.

Properties of neuromuscular transmission

<p>unidirectional</p> <p>from the nerve to muscle and not in opposite direction</p>	<p>Delay</p> <p>is 0.5 msec</p> <p>used for release of acetylcholine, its binding to receptors, depolarization and end plate potential till firing level.</p>	<p>Fatigue</p> <p>Motor end plate is first site suffering from fatigue.</p>
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