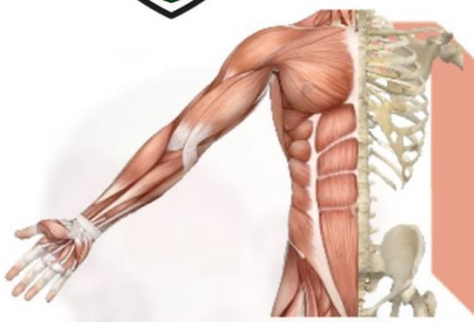

MSS

Musculoskeletal System

Doctor 2019 | Medicine | JU

3 Physiology

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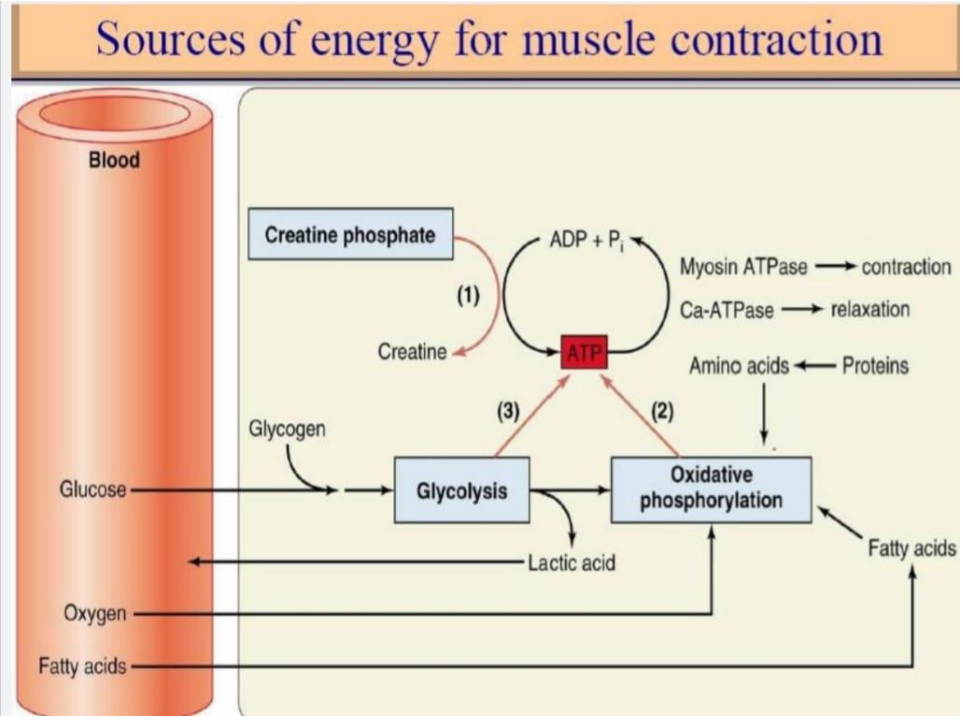
بسم الله الرحمن الرحيم

Muscle energy

(00:00-10:00)



We need a huge amount of ATPs to get the contractile process which are consumed for phosphorylation of heads, we also have myosin ATPase that split ATP to phosphorylate their heads, the out come of this reaction is ADP molecule that remains attached to that head , then this ADP is replaced with a new ATP to get the attachment for both heads of actin filaments but the amount of ATPs that are found in the muscle are sufficient for only (10-20) sec then all ATPs are consumed , what we have to do ?

We have micro energetic molecule called creatine phosphate, it can rephosphorylate ADP into ATP, this is sufficient only for few minutes.

Creatine phosphate + ADP + pı---> creatine + ATP

The muscles have another way to get ATP:

1. **Anaerobic**: like glycolysis to generate low amount of ATPs.
2. **Aerobic:** like oxidative phosphorylation, more ATPs are produced.

*Glycolysis is faster and gives small amount of ATP immediately, but oxidative phosphorylation taking place at the level of mitochondria and needs oxygen so it takes extra time.

• Classification of muscles :

1) **Depending upon striations**:
Striated muscle & Non striated muscle
2) **Depending upon the control** :

Voluntary and involuntary muscles.

3) **Depending upon Function**:

Skeletal, cardiac , and smooth muscles

● **skeletal muscle fibers** :

■ Red (slow) muscles

■ white (fast) muscles

The **fast** muscles depend more on **glycolysis** to get energy, while the **slow** muscles depend more on **oxidative phosphorylation.**

▪The **red** muscles are the **slow muscles**, their color is due to the myoglobins which **stores oxygen that is used for oxidative phosphorylation.**

In addition, red muscles have more **mitochondria** to produce more ATPs, and these muscles have **higher vascularization** which is different than white muscles.

♤ Some sports depend on white (fast) muscles like people who running for 100m (they have more fast muscle fibers) while running in marathon for long distance depends on red(slow) muscles (they have more slow muscle fibers) .

(10:00-20:00)

Muscle mechanics

Can we have contractions without shortening of the sarcomer?

We knew that shortening of sarcomeres makes contraction, but we can have contraction without shortening ! 👀

Imagine that you fixed the head of the muscles and stimulated it, you will not get shorting, you will have an interaction between thin and thick filaments will take place where thick filaments try to pull thin filaments towards the center of sarcomere.

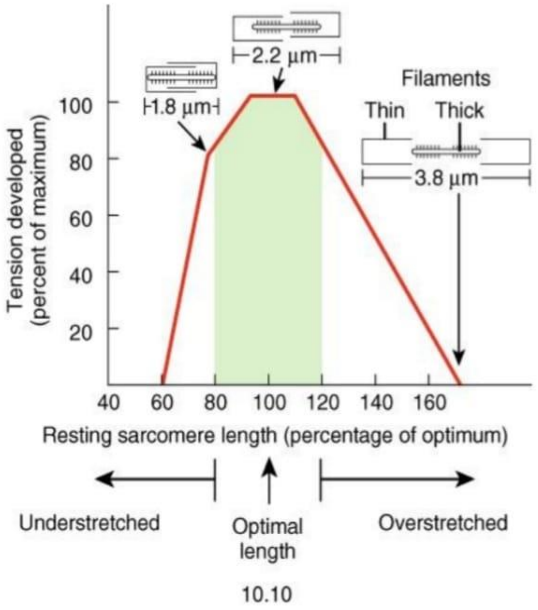
By that interaction We can get another parameter changes, not only the length which is called tension due to interaction of thin and thick filaments.

Figure 10.10

y axis: for tension can be developed due to the interaction between and thick filaments

X axis: for percentile of the length of sarcomere.

• The regular length of sarcomeres is 2.2 µm at rest, if you stretch the muscles fibers to have length of 3.8 µm, at this length no overlap between thin and thick filaments will occur, the tension at this point is **ZERO**.



• At 100% (at resting) :

1. optimal overlap between thin and thick filaments.

2.highest tension by stimulating the muscles fibers

• more than 100% for e.g: At 170%: no overlap, no tension

* more than 100% and less than170%, you can record some tension .

• less than 100% for e.g : At 80%, will record reduced tension.

Don't forget that the heads are fixed immediately and then stimulated.

*IN OUR BODY we will not have overstretched muscle unless we fix one head and try to stretch this muscle much longer, so the previous experiment was in a lab.

● **isotonic contraction**: when shortening the muscle take place with contraction without affecting the tension.

● **Isometric contraction**: no change at length and the heads are fixed, stimulating that muscle will cause contraction between thin and thick filaments , what will change is increasing of

tension in some muscles so we have specific transducer that is placed in the muscle to major the tension that can develop.

• Both types of contraction existing in our bodies because there is a lot of muscle, at any time you stimulate one.

(20:00-30:00)

NOW, we take the whole muscle - out of the body- and fixing the heads at resting length(notcontracted , not stretched), at this point we will have the highest interaction between thin and thick filaments and record the highest tension in that muscle.

If you start stretching the muscle then stimulating it, you will record the total tension, which include two tension:

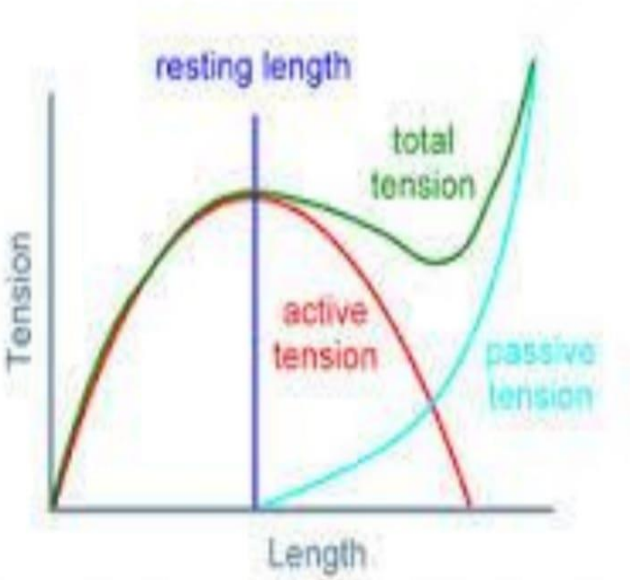
1. Active tension: tension that result by stimulation .
2. Passive tension: increase the tension by stretching.

Going to longer length will **increase** passive tension and **decrease** active tension.

Stretch the muscle--> increase length --> decrease the overlap between the thin and thick filaments --> decrease the **active tension**.

Shortening the muscle-->fixing the head--> recording the tension --> start getting lower tension .

● This theory is in accordance with the sliding theory with overlap. The tension that can be developed or recorded is depending on the overlap between thick and thin filaments that we are having. If you have more overlap - some shortening of the muscle – then fixing the heads , then recording the tension, you will get lower tension why ?



Length-Tension Curve of a Muscle

If we have thin filament overlap with the other half of thick filament, now we have two forces pulling against each other over the same thin filament ,this will reduce the tension . By Stretch will increase passive tension while decreasing the active tension.

SO any stretching on the muscle will create a tension.

You know muscle is elastic tissue which is like a rubber, so when stretching rubber and measuring the tension of the rubber you are getting increase in which we call it **passive tension.**

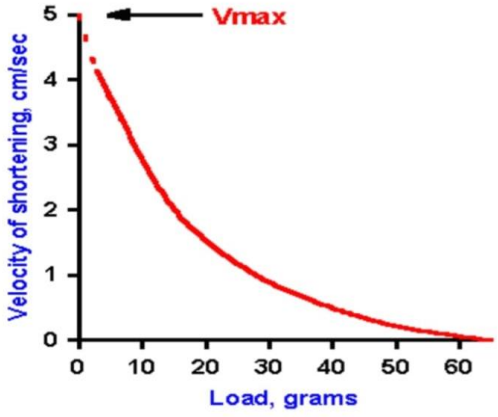
*The last two pictures are same about active tension , but the last one is taken as whole muscle.

**the higher active tension at resting length, while total tension can be increased depending on increasing the passive tension

**passive tension occurs due to stretching ,active tension occurs due to stimulating.

(30:0-43:47)

The relation between the velocity of contraction and the load we are having muscle



Once you have a load of zero, you will have maximum velocity of shortening ,at this point you reached ISOTONIC CONTRACTION increasing the load will reduce shortening velocity of that muscle because load makes some resistance that used by interaction between thin and thick filaments to overcome that load.

Once you have a big load ex. 60kg for one muscle, no contraction will take place, at this point you reached ISOMETRIC CONTRACTION

Fig. 10.15

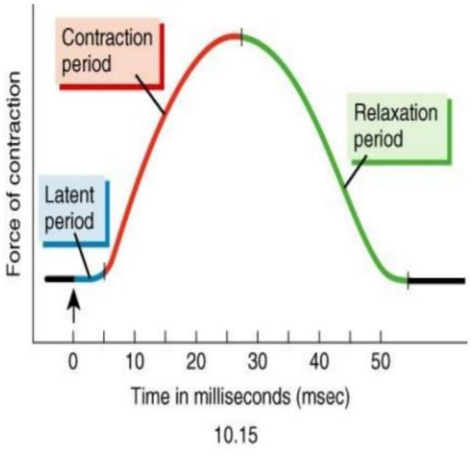
Picture 10.15

x axis : is related to time

y axis : is related to length of muscle

After stimulation ,the muscle will be shortening, and can be recorded like this curve (in blue color)

The maximum shortening is reached at the tip Of contraction period.After it, you will get relaxation



10.15

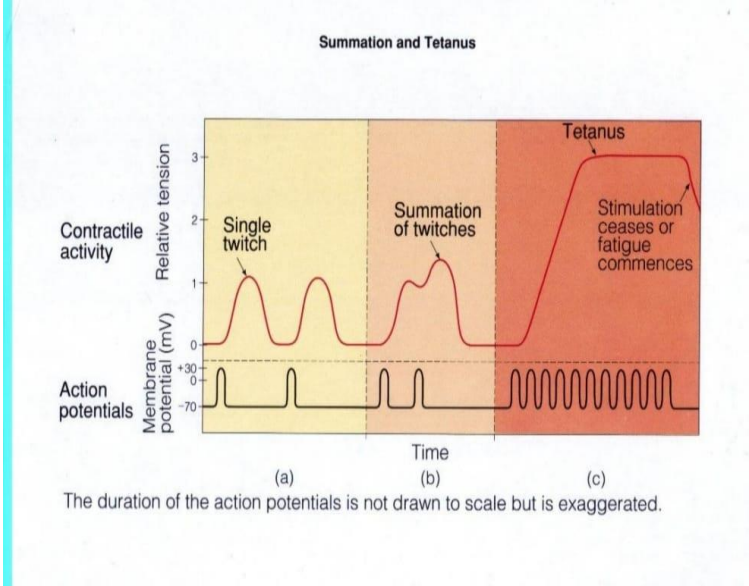
and the muscle will go back to original state. In this curve you can record 3 period :

1. Latent period **:we are not getting the start of contraction at this point**
2. **Contraction period**
3. Relaxation period **: with contraction period are called simple muscle twitch**

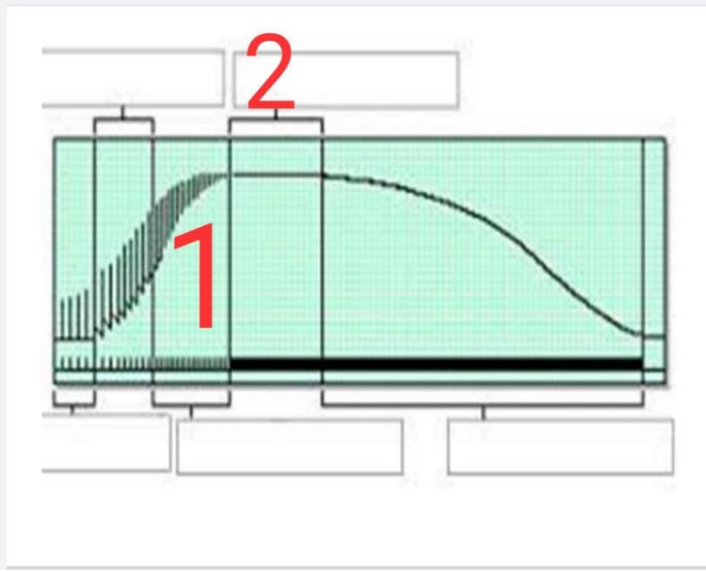
In this picture:

(a) down is the stimulation twitch then after latent period another twitch.

(b) if you have two stimuli come one after the other and you are starting the relaxation period, the second one lately can cause another twitch, this is called summation of twitches or frequency summation, because we get the two waves summation for contractile.



(c) if we have higher frequency of stimuli you are still in the contraction period and another stimuli are coming ,by high frequency of stimuli you get a point where you have contrition without any relaxation ,this is called tetanization



*This is a real recording, many stimuli are coming, if you have increased the frequency of stimuli, and the time between the two stimuli is shorter than the contraction period, you will get contraction without any relaxation, **tetanus.**

1.incomplete tetanization

2.complete tetanization

What happen if you continuing with high frequency of stimulation?

This will not last forever, after a period of time the length of the muscle started to be reduce until reach the original baseline of recording, so even though you increase the frequency very high, you will not get any contraction in this muscle which is called muscle fatigue.

" البِرُ لا يَبلى، والذَّنبُ لا يُنسى، والدّيّانُ لا يموت، فاعمَلْ ما شئْت "