PHYSIOLOGY

Lec: 27

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General physiology
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lecture 26
Skeletal Muscle Mechanics

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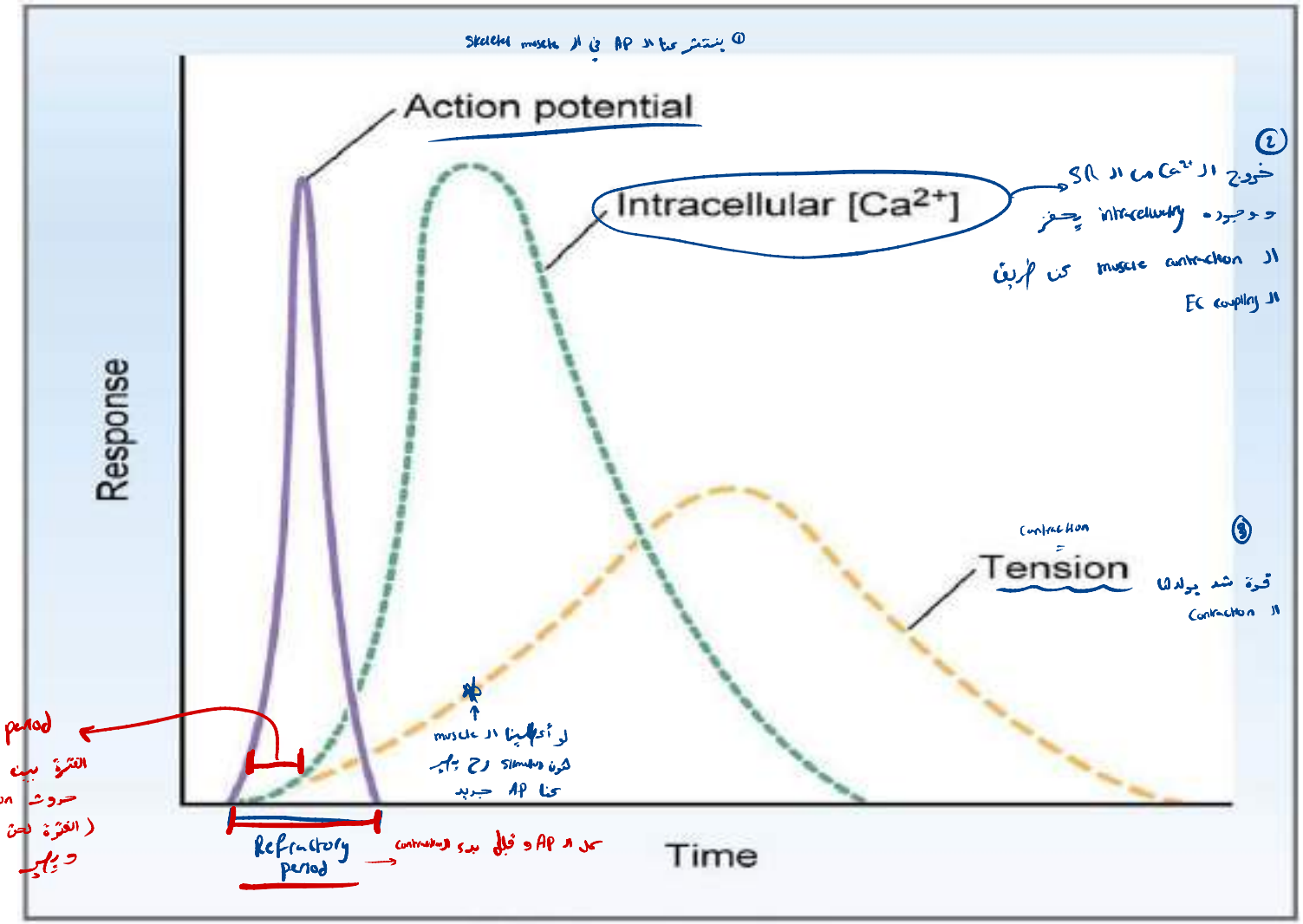
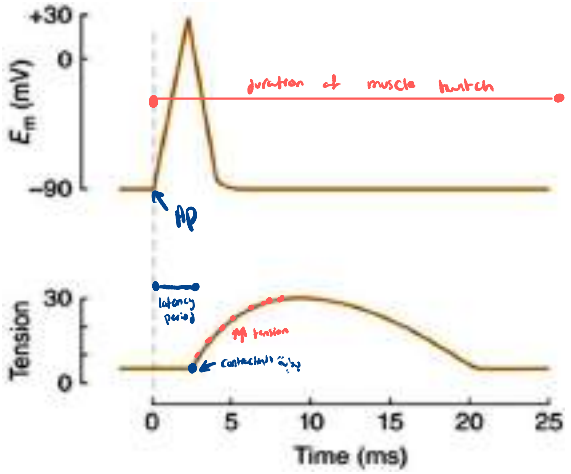
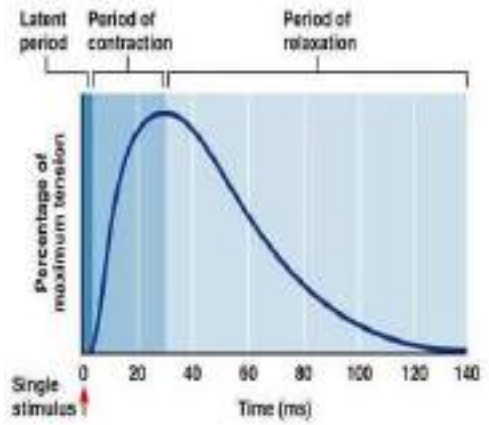
Temporal sequence of events in excitation-contraction coupling in skeletal



The electrical and mechanical responses of a mammalian skeletal muscle

- Muscle Twitch = muscle contraction
- A single action potential causes a brief contraction followed by relaxation.
- **Latency 2 msec**
- duration of the twitch varies with the type of muscle being tested.
- "Fast" muscle fibers, primarily those concerned with fine, rapid, precise movement, have twitch durations as short as 7.5 ms.
- "Slow" muscle fibers, principally those involved in strong, gross, sustained movements, have twitch durations up to 100 ms.





Mechanical properties of muscle contraction

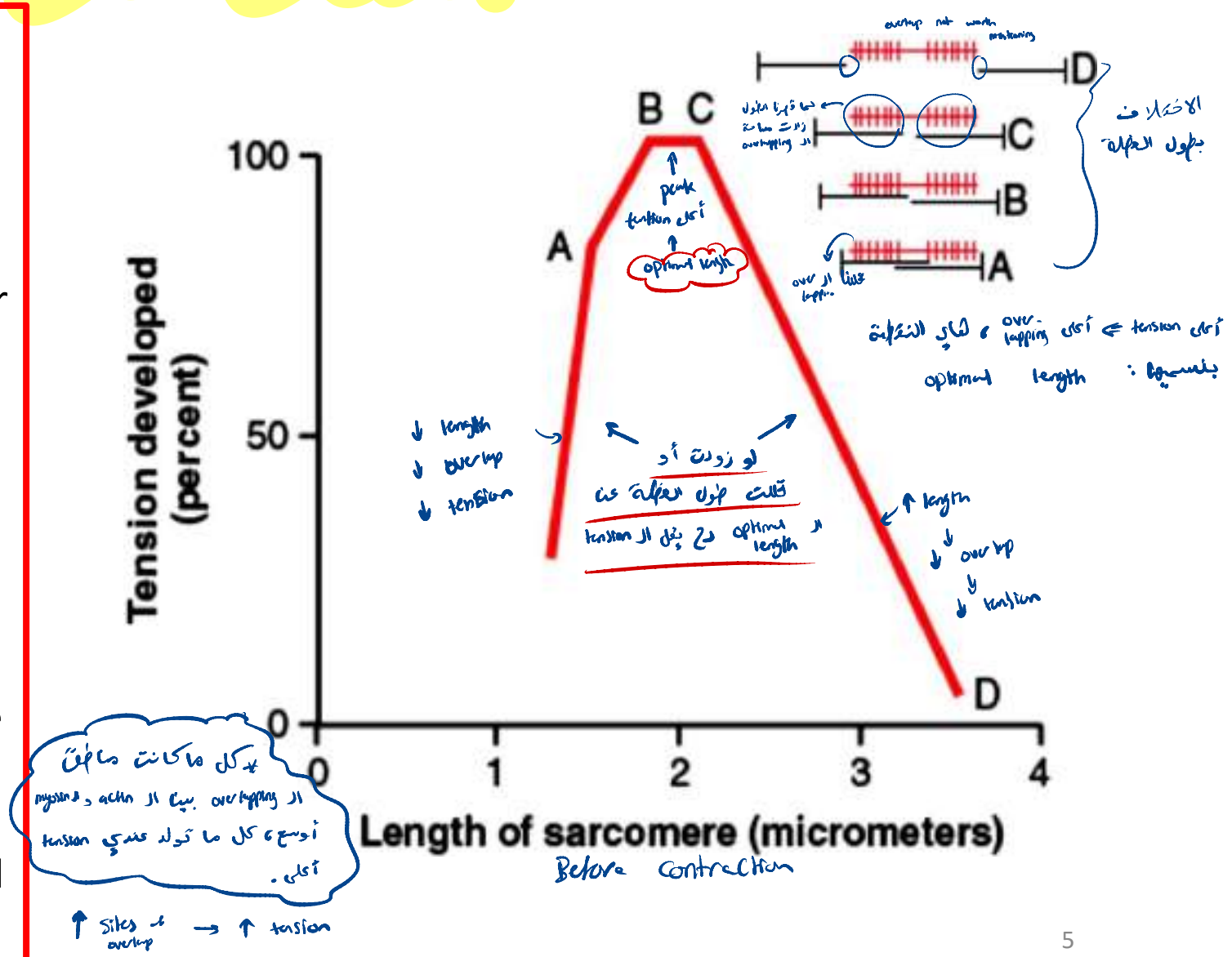
Length tension relationship

A length-tension diagram for a single fully contracted Sarcomere It shows the effect of sarcomere length and the amount of myosin- actin filament overlap on the active tension developed by a contracting muscle fiber

Maximum strength of contraction when the sarcomere is 2.0 to 2.2 micrometers in length.

At the upper right are the relative positions of the actin and myosin filaments at different sarcomere lengths from point *A* to point *D*.

Amount of Actin and Myosin Filament Overlap Determines Tension Developed by the Contracting Muscle



Effect of Muscle Length on Force of Contraction in the Whole Intact isolated Muscle
Relation of muscle length to tension in the isolated muscle both before and during muscle contraction

Active tension cannot be measured directly What can be measured?

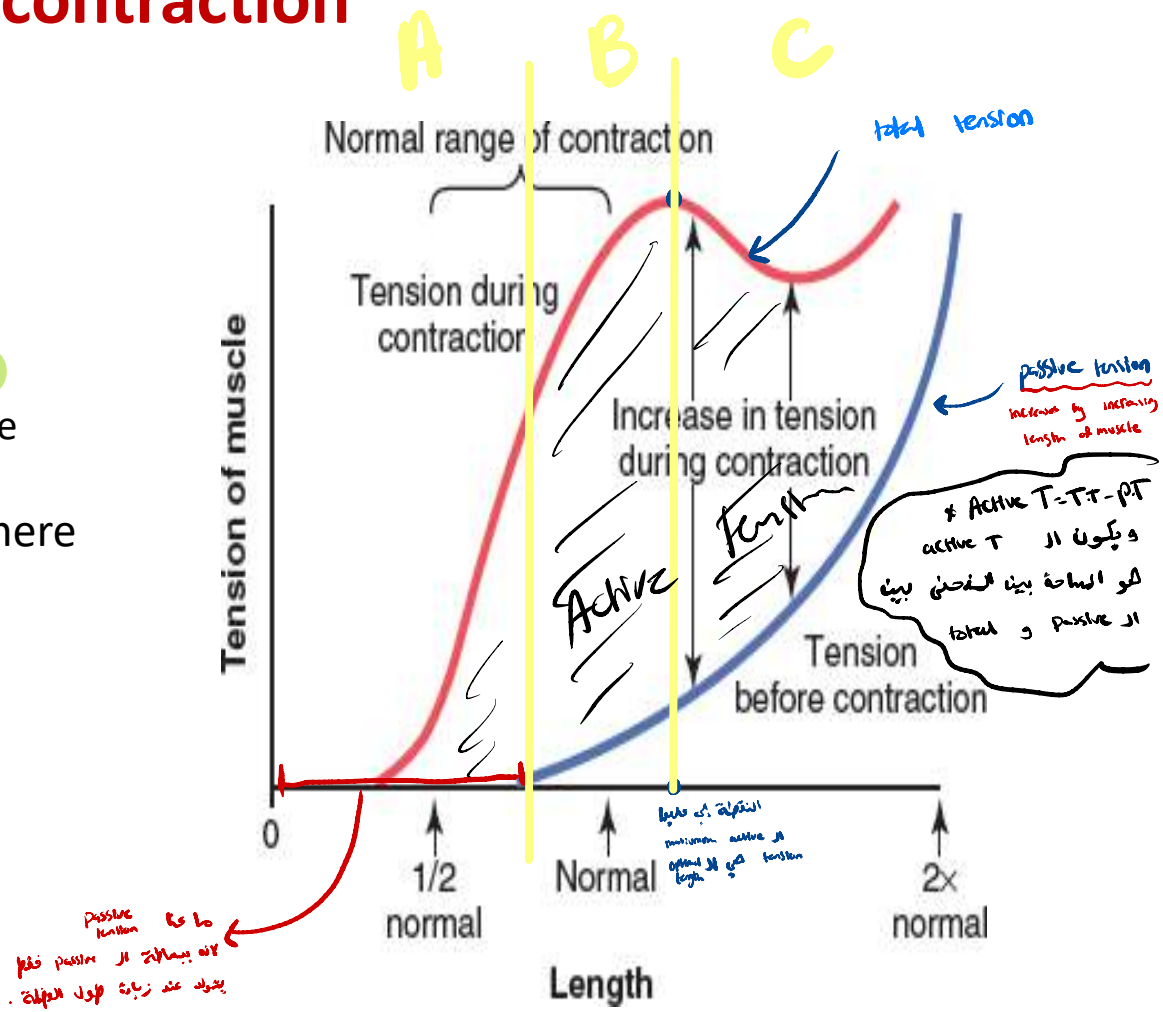
(1) passive tension - *tension required to extend a resting muscle*

(2) (2) total tension - *active tension and passive combined*

The active or developed tension is the difference between the total tension and the passive tension. It is the tension that the muscle produces during the contraction..

when the muscle is at its normal *resting* length, which is at a sarcomere length of about 2 micrometers, it contracts on activation with the approximate maximum force of contraction. However, the *increase* in tension that occurs during contraction, called *active tension*, decreases as the muscle is stretched beyond its normal length—that is, to a sarcomere length greater than about 2.2 micrometers.

Note that active tension falls away linearly with increasing resting length



Muscle length or preload

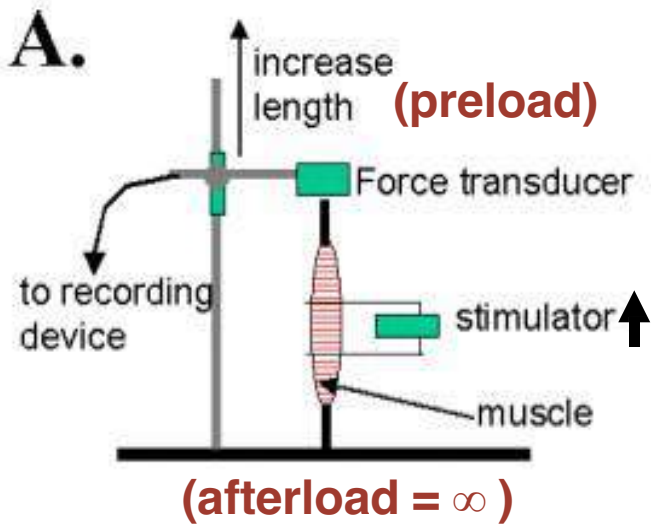
V. imp

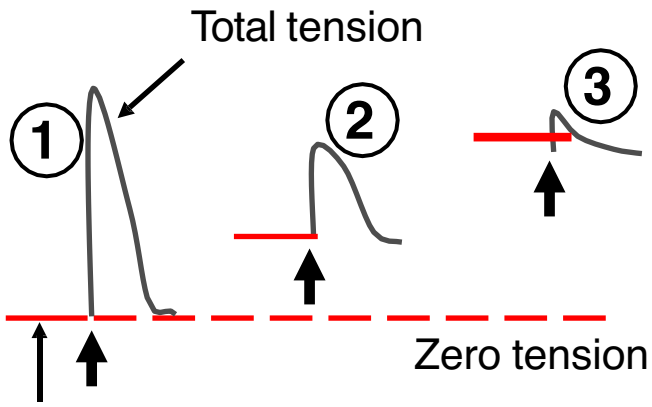
A: < optimal length → ↓ active tension // no passive tension // Total tension = Active tension

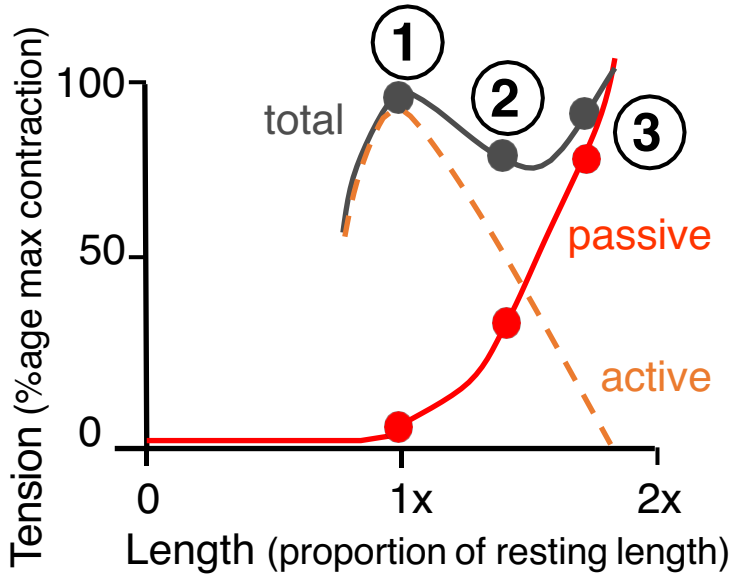
B: optimal length → Maximum active tension [no passive tension]

C: > optimal length → ↑ passive tension // ↓ active tension // ↓ total tension [total = active − passive // a/g]

Length-tension relation – the experiment



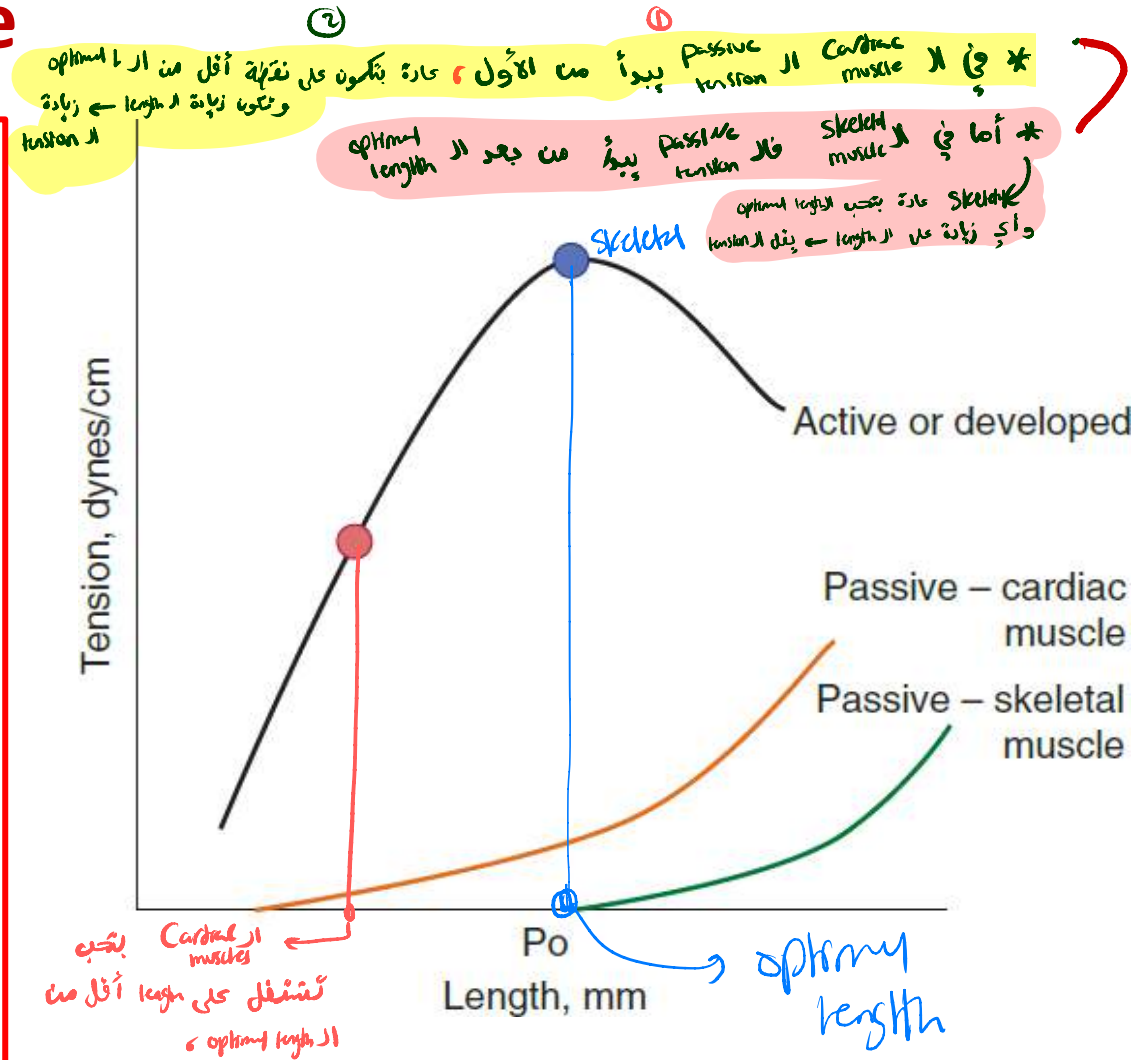




Comparison of the length tension relationship of skeletal and cardiac muscle

Note that in skeletal muscle, the fibers are usually operating at the blue point—resting length is optimum because most skeletal muscle
is held in place by the bones and resting length cannot vary greatly.

Cardiac muscle normally operates at lower (red point) than optimum length and therefore has reserve capacity to increase tension development, that is, have stronger contractions, when resting length is increased



The length tension relationship in cardiac muscle and skeletal muscle

- **Differences are primarily due to the presence of passive tension at shorter length in cardiac muscles due to**
  - Anatomic differences in structure of skeletal muscle (all of the fibers in parallel) and cardiac muscle (fibers exist in a basket weave-type pattern)
  - The properties of the noncontractile components in skeletal muscle versus cardiac muscle.
    - in skeletal muscle, the fibers are usually operating at an optimal resting length because most skeletal muscle is held in place by the bones and resting length cannot vary greatly.
  - Cardiac muscle normally operates at lower than optimum length and therefore has reserve capacity to increase tension development, that is, have stronger contractions, when resting length is increased.
  - In the intact heart, cardiac cell resting length is set by the volume in the ventricle(EDV) at the end of diastole (the relaxed state of cardiac muscle).