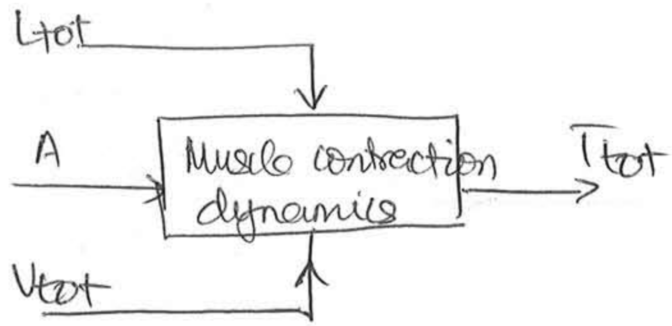
Lecture 10

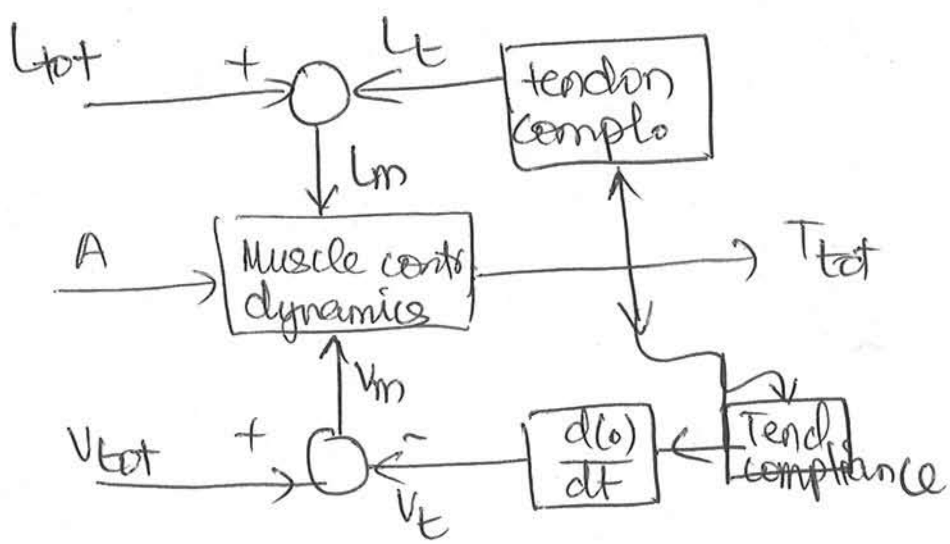
Last time : inclusion of tendons

- Will inclusion of tendons in the model change the total dynamics

Till now assumed



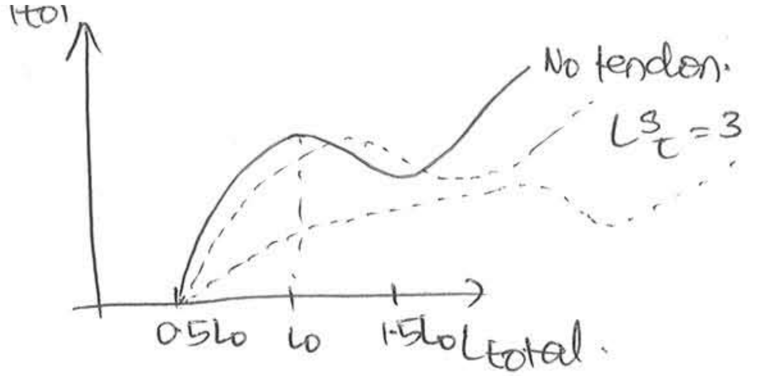
But last lecture, we showed



Defined slack length $L_{\tau}^{s} = \dfrac{L_{tendon}}{L_{m0}}$

Also $\dfrac{L_{tot}}{L_{m_0}} = 0.5 + 0.033\, L_{\tau}^{s}$

so if L_{τ}^{s} is large, can change things quite a bit. say (10)



Having tendons does not incr. total tension.

What happens if a musculotendon sys. w/ high L^s_τ is used to estimate the activated tension?

Take home message of tendons:

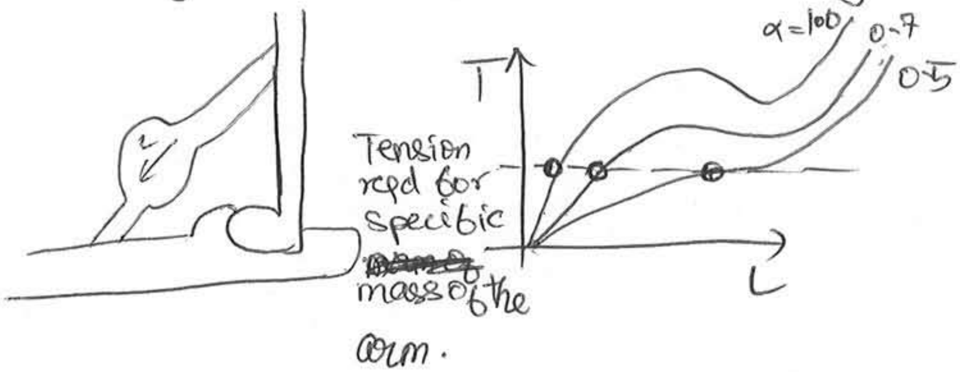
- It's a spring w/ almost const. k w/ no damping.
- It does not affect total tension ≡ exerted force.
- It affects the muscle dynamics
- Longer tendons shift the tension-length curve to the right
- Calculated active tension is not correct w/ long tendons
- Long tendons exist more distal
  - ↳ space limitation
  - ↳ absorbs shocks

Single Joint Dynamics

How do multiple muscles work together to move one joint?

If only one muscle is attached to a joint,

the joint $\tau \overset{\text{roughly}}{\propto}$ neural activity α



To move it both directions, need an antagonist.

Joints typically have many muscles for control + stability

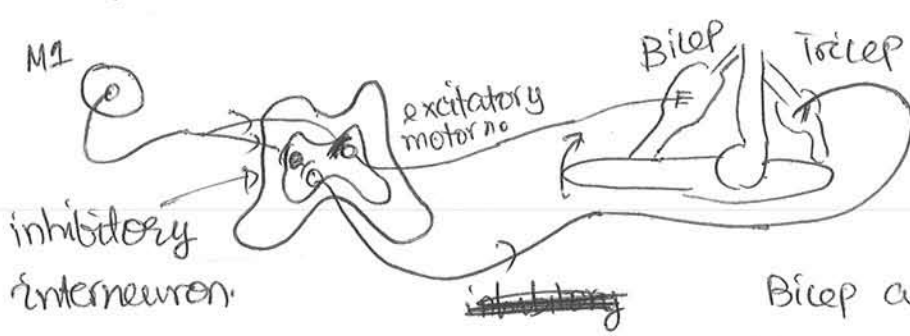
when there are many muscles, how are they controlled?

ON OFF
OFF ON

well, that's one way.

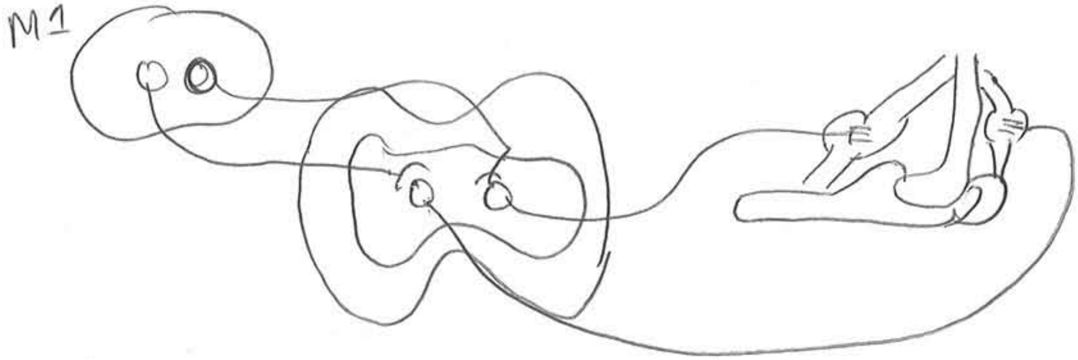
Two-ways to change the joint angle.

Reciprocal innervation



Bicep activity ↑
Tricep " ↓

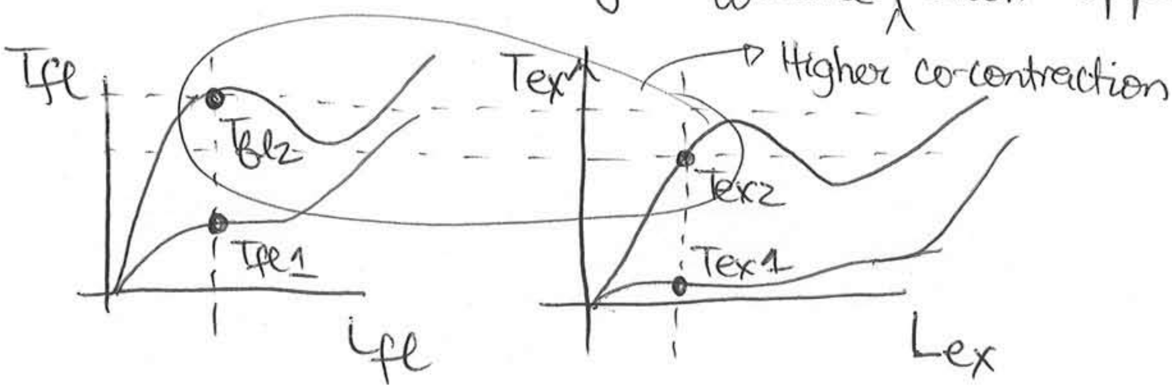
Co-contraction



~~Lots of~~ Lot of activity in bicep.

Some " " tricep

Joint mvt. caused by difference in activity btw opposing muscles



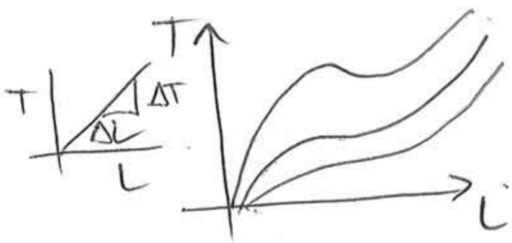
If $T_{fl1} - T_{ex1} = T_{fl2} - T_{ex2}$, (ignore gravity external loads)

it produces the same mvts.

But! the joint stiffness (spring-like properties, rejects external perturbation)

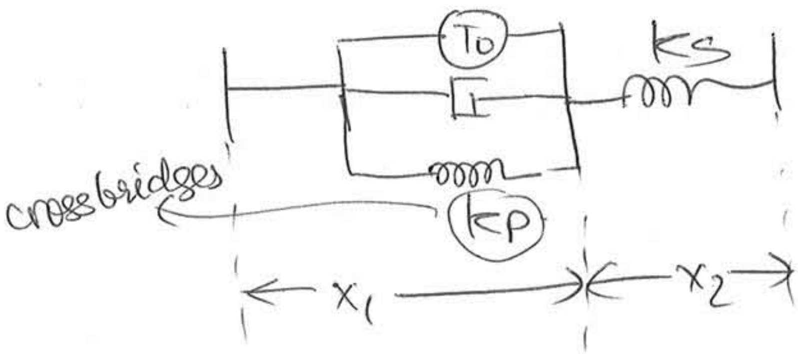
is all in the overlap (co-activation) of the opposing muscle activity level.

Remember stiffness → slope of tension-length curve.



more α, stiffer muscle is.

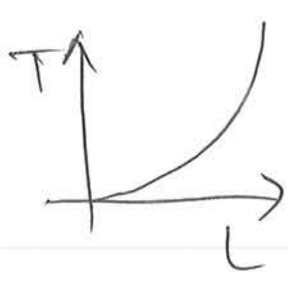
Physical explanation



For x_1, the higher α is, the shorter it gets.

For x_2, the slack is removed as α increases

Remember Ks is a combo of muscle connective tissue



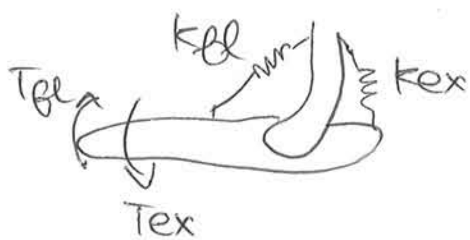
as α ↑

T_{tot} ↑

T_{ks} ↑

K ↑

For a joint, consider a static case.



When K_{ex} & K_{fl} are low $\Rightarrow$ total K is low.

- susceptible to external perturbation

When the activity level is higher, K_{ex} & K_{fl} are high

$\Rightarrow$ rejects external noise

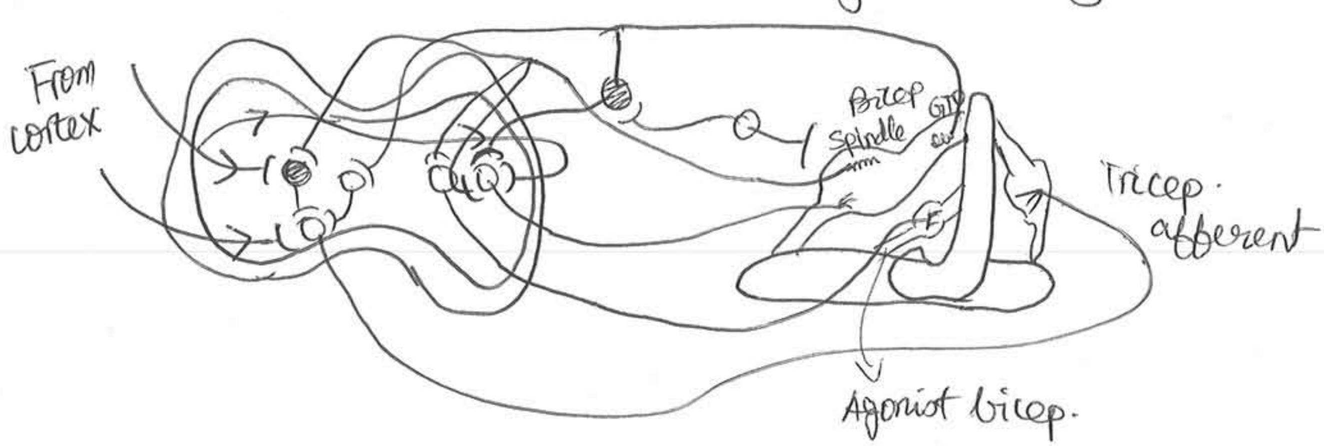
Try it w/ your elbow!!

When the task (i.e. reqd load) is unknown, it's best to co-contract to reject unknown/unpredictable noise

- we co-contract muscle when learning a task & slowly switch to reciprocal innervation w/ learning.

↳ more later

Reflex system coords w/ antagonist + agonist muscles



w/ passive stretch → monosynaptic feedback
also to agonist muscles
inhibit antagonist (to relax)

From cortex: can change from reciprocal to co-contraction

GTO excites the antagonist (inhibits agonist)

Skin pinch (cutaneous stimulation) has an inhibitory effect

Interneurons are connected to many other muscles, that are not even related to the same joint

e.g. Balancing after an acute cutaneous stimulation