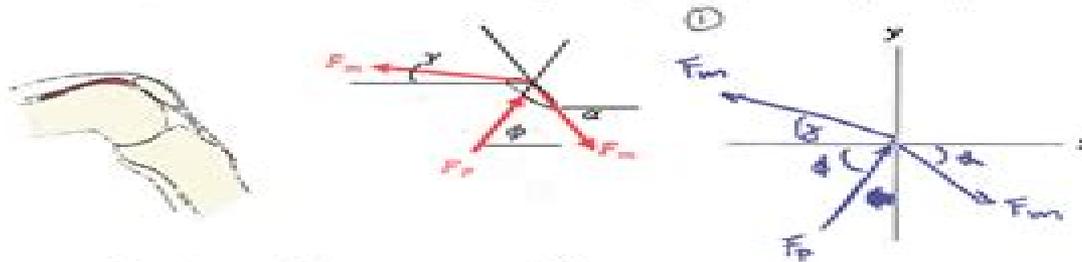


Problem 1:

As discussed in class, the patella helps to provide an additional moment arm to the quadriceps muscle to reduce the force necessary to extend the knee. Noting that the patella acts like a pulley, we can see that the muscle tension helps push the patella against the distal condyle of the femur. Using the knee diagrams below, complete the following:

1. Draw a FBD on the xy -axes assuming that the patellar compressive and muscle forces all intersect at the origin.
2. Write a set of force and moment balance equations describing the joint
3. Find expressions for the patellar contact angle, ϕ , and the patellar force F_p , as functions of muscle force magnitude and direction (F_m, γ, α).
4. How do you expect the patellar force to be different during a deep squat (high knee flexion angle) compared to standing? Justify your answer using the equations developed in (3).



$$\textcircled{2} \sum F_x = 0: -F_m \cos \gamma + F_p \cos \phi + F_m \cos \alpha = 0$$

$$F_p = \frac{F_m (\cos \gamma - \cos \alpha)}{\cos \phi}$$

$$\uparrow \sum F_y = 0: F_m \sin \gamma + F_p \sin \phi - F_m \sin \alpha = 0$$

$$\sum M = 0$$

$$\textcircled{3} \text{ FROM } \sum F_y \rightarrow \sin \phi = \frac{F_m (\sin \alpha - \sin \gamma)}{F_p} = \frac{\cos \phi (\sin \alpha - \sin \gamma)}{\cos \gamma - \cos \alpha}$$

$$\text{TAN } \phi = \frac{\sin \alpha - \sin \gamma}{\cos \gamma - \cos \alpha}$$

$$\phi = \text{TAN}^{-1} \left[\frac{\sin \alpha - \sin \gamma}{\cos \gamma - \cos \alpha} \right]$$

$\textcircled{4}$ AT HIGH FLEXION: α INCREASES } $F_p \approx \frac{1 - \cos \alpha}{\cos \phi} \rightarrow F_p \dots$
 $\gamma \approx \text{CONST, SMALL}$ } $F_m \cos \phi$ } INCREASES
 $\rightarrow \alpha \rightarrow 90^\circ \dots \rightarrow 45^\circ$ } $F_m \sin \alpha$ } DECREASES

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