KIN 412/512 Biomechanics of the Skeletal System

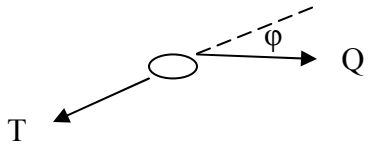
Problem Set 1 (One knee problem with many parts)

Due: Tuesday November 1, 2005 10:40 AM

Instructions: Show **all** your work including the equations used.

Complete problem 8.5 from Wiktorin and Nordin (1986) with the following additions and modifications:

1. Use the symbols Q for quadriceps muscle force, T for patellar tendon force, J_T for tibiofemoral joint force, and J_P for patellofemoral joint force.
2. Assume the weight being lifted has a mass of 12 kg rather than 10 kg.
3. Use g = 9.8 m/s^2 (rather than 10 m/s^2 as the book does) when converting mass in kg to weight in N.
4. Do not ignore the weight of the lower leg + foot (LLF). Instead assume the mass of the LLF is 3.5 kg and the center of mass of the LLF is 15 cm distal to the knee axis.
5. Assume the moment arm for the patellar tendon force T about the tibiofemoral joint is 4.2 cm when the knee is fully extended and 4.5 cm when the knee is flexed 60°.
6. Do not assume the patella acts like a frictionless pulley. Instead, select appropriate T/Q ratios from the literature and cite the appropriate source(s) of your data.
7. Assume the angle of pull between the patellar tendon force (T) and the long axis of the tibia is 20° when the knee is fully extended and 10° when the knee is flexed 60°.
8. Assume the angle φ between T and Q is 30° when the knee is fully extended and 70° when the knee is flexed 60°.



9. For all three parts of the problem, compute T, J_T (magnitude and direction), and J_P (magnitude only).
10. For J_T compute both the shear and compressive components. Using the shear component, state which ligament (ACL or PCL) is sustaining this force and explain your answer.
11. You do not need to answer any discussion question(s) since the solutions to these questions are presented in Wiktorin and Nordin.

and at 15° of knee flexion? At what joint angle will the exercise be most effective?

2. Will the patient be able to extend the knee joint the last 15° while wearing the weight boot? In discussing this question, make use of your experience with quadriceps muscle exercises.

8.5. Exercising the Knee Extensor Muscles in a Sitting Position on the Quadriceps Table

Torque

This example shows that if the magnitude and direction of a force are held constant, a change in the point of application affects the moment arm, and thus the torque.

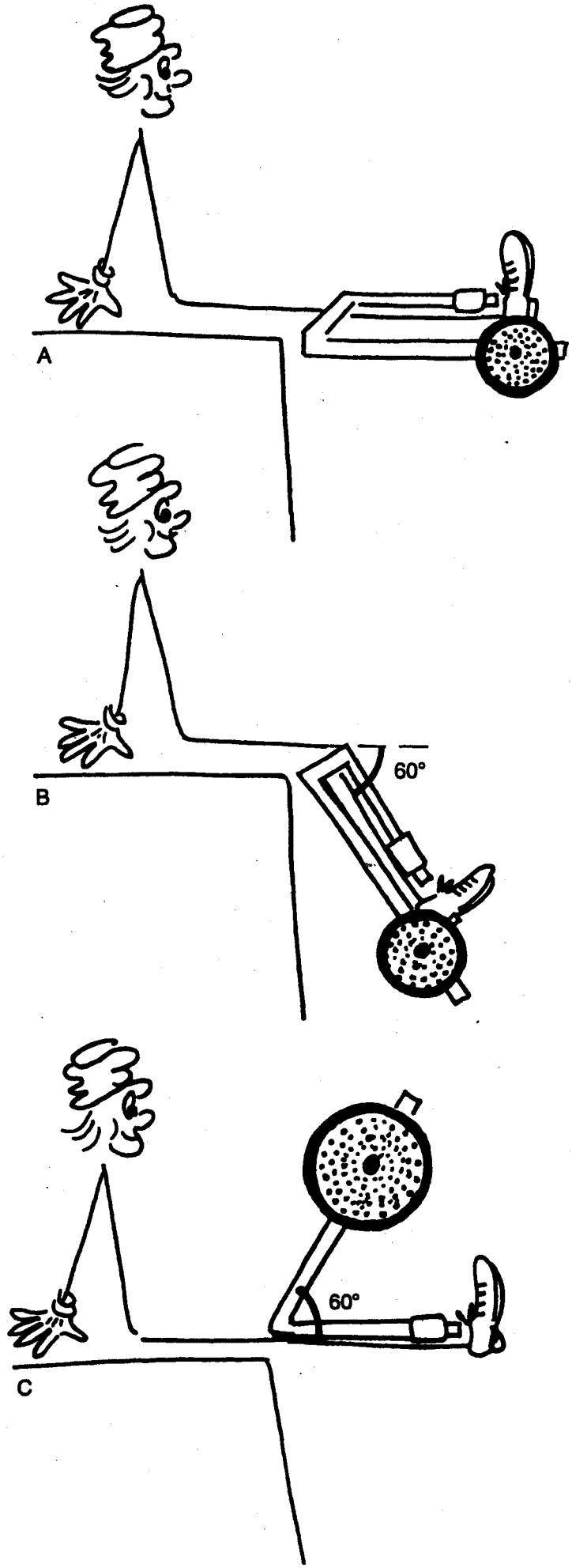
Problems

A patient is exercising the knee extensor muscles while sitting on the quadriceps table. A 10-kg weight is placed on the weight arm 0.35 m from the center of motion of the knee joint.

8.5A. How large a torque must the knee extensor muscles counteract at full extension (M_1) (Figure 8.5A) and at 60° of knee flexion (M_2) (Figure 8.5B) if the weight arm and the resistance arm are parallel? Disregard the weight of the lower leg and the weight of the weight arm and resistance arm.

8.5B. Because the knee extensor muscles can normally produce less torque at full extension than at 60° of knee flexion, the weight arm is moved upward at a 60° angle from the resistance arm. With this placement of the weight arm, the external torque reaches its maximum at 60° of knee flexion; the knee extensor muscle force is also usually the largest at this point in the range of motion. With the knee joint in full extension, how heavy a weight must be attached to the weight arm for the torque to equal that in problem 8.5A (Figure 8.5C)? The force produced by the attached weight is designated as T.

Figure 8.5. Knee extensor muscle exercises with the individual in a sitting position on the quadriceps table. With the weight arm and resistance arm parallel, the knee joint is fully extended (Figure A) and flexed 60° (Figure B). In Figure C, the weight arm is moved upward at a 60° angle to the resistance arm, and the knee joint is in full extension.


A
B
60°
C
60°