Biomechanics of the knee-extension exercise. Effect of cutting the anterior cruciate ligament


Abstract: We conducted this study to determine the effective moment arm of the knee extensor mechanism and the conditions under which the anterior cruciate ligament is loaded during knee-extension exercises. The moment arm was calculated from measurement of the quadriceps force required to extend the knee with and without resistive weights placed at the foot, the leg weight, and the location of its center of gravity. Changes in three-dimensional joint motion after the anterior cruciate ligament was removed were considered to be an indication that the ligament was loaded. The quadriceps force rose during the initial phase of knee extension and remained nearly constant at an average value of 177 newtons between 50 and 15 degrees. With extension past 15 degrees it rose rapidly, reaching an average of 350 newtons at zero degrees of extension, and continued to increase with hyperextension. The addition of thirty-one newtons (seven pounds) at the foot approximately doubled the quadriceps force that was required to extend the knee. The effective moment arm of the extensor mechanism increased with knee extension, peaked at approximately 20 degrees, and rapidly decreased with further extension. No change was found in the quadriceps force or its effective moment arm when the anterior cruciate ligament was sectioned except in hyperextension, where the quadriceps force decreased in two of five specimens. There was, however, an increased anterior tibial displacement in the range of 30 degrees to full extension, suggesting that the anterior cruciate ligament is loaded in that flexion arc. Clinical Relevance: This study demonstrates that very large quadriceps forces are required to accomplish the last 15 degrees of extension during leg-raising exercises, typically twice those required to reach 30 degrees of flexion. The large forces that are required to obtain full extension explain why an extensor lag occurs with quadriceps weakness even though a full passive range of motion is possible. Since thirty-one newtons (seven pounds) of resistive weight added at the foot approximately doubles the quadriceps forces required to extend the leg alone, using such weights can produce very large quadriceps forces and concurrent patellofemoral and tibiofemoral contact forces. Because the quadriceps force increases little as the leg is extended from 50 to 15 degrees, in patients with patellofemoral chondroses for whom a full range of joint motion is not desired, quadriceps exercises can be limited to the amount of extension without decreasing quadriceps force.(ABSTRACT TRUNCATED AT 400 WORDS)