DYNAMIC CHANGES IN ANTERIOR/POSTERIOR TRANSLATION AND INTERNAL/EXTERNAL ROTATION OF THE KNEE DURING CYCLING

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INTRODUCTION

Cycling is a very popular competitive sport, recreational activity, and rehabilitative therapy. For competitive athletes, the sport can be strenuous, and the intense training can lead to overuse injuries. For recreation and rehabilitation, on the other hand, the main benefits of cycling seem to be that it has minimal impact and can be well-controlled and gentle. However, overuse injuries at the knee have been reported during cycling (e.g. Ruby, 1992, Hannaford, 1986). In addition, cycling is used for rehabilitation following knee injury. Therefore, understanding the kinematics of the knee is particularly important since motions such as anterior/posterior (AP) translation and internal/external (IE) rotation can cause stress in soft tissue structures. While there are a number of important studies describing kinematic and kinetics during cycling (e.g. Ruby, 1992, Hannaford, 1986) due to technological limitations, very little work has been done to understand the relative motion of the femur and tibia. With the development of the point-cluster technique (PCT) (Andriacchi, 1998), it is now possible to collect highly accurate data which can shed light on the dynamic function of the soft-tissue structures of the knee during cycling. In particular, this study will focus on the dynamic envelope of knee motion.

Past studies have shown that dynamically, the knee operates in an envelope of motion between flexion and extension (Dyrby, 1999). For different activities, the same flexion angles produced an offset of secondary positions of the femur with respect to the tibia. These motions were dependent on the external forces and were shown to be different for dynamic activities such as walking and stair climbing as well as passive activities such as leg extension. Walking and stair climbing have complex loading patterns that include flexion/extension moments as well as IE rotational moments. This study used the PCT to determine secondary offsets during partial weight bearing seated cycling.

METHODOLOGY

An experienced cyclist with no history of musculoskeletal involvement was tested in the laboratory. Data was collected while pedaling on a professionally-fitted road cycle with clipless pedals (Look) using a stationary fixed-resistance trainer (Performance TravelTrac 2000). The subject’s right leg was tested at multiple gear ratios and cadences. Motion was tracked using a four-camera optoelectronic digitizer (Qualisys). The PCT was used to obtain the six degree-of-freedom motion of the knee. The PCT uses 21 retro-reflective markers placed on the lower limb segments to create two cluster groups: one on the thigh and one on the shank. Motion is described in a fixed tibial reference system. Several five-second trials were collected.

A two-tailed T-test with unequal variances ($\alpha = 0.05$) was used to compare the AP position of the femur with respect to the tibia during the push and pull phases at 78 degrees of knee flexion, the midpoint of knee motion for this subject.

RESULTS AND DISCUSSION

Ranges of motion were consistent throughout the trials. The results for one typical trial with a 42:15 gear ratio and a cadence of 62 rotations per minute are presented. Figure 1 shows the IE Rotation and AP Translation for 5 consecutive cycles. As shown in Figure 1, there is no hysteresis seen between the push and pull phases for IE rotation. There is, however, a significant offset shown for the AP translation ($p<0.001$). At 78° flexion the pull phase averaged 1.4 ± 0.06 cm., while the push phase averaged 0.9 ± 0.02 cm.

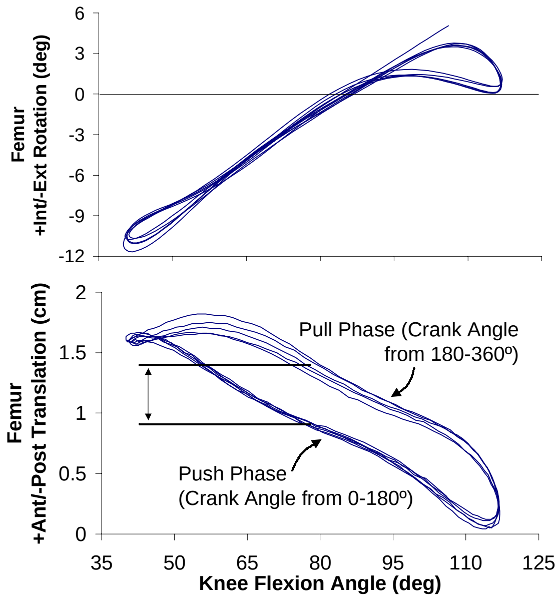

Figure 1. Motion of the femur relative to the tibia for 5 consecutive cycles. The significant offset in AP motion is noted by the arrows.

Using minimum knee flexion as a reference point, the knee internally rotated to a peak just after max knee flexion, then externally rotated as the knee continued to extend. Anterior translation was greatest at minimum knee flexion. The femur translated posteriorly with flexion, reaching greatest posterior translation when the knee was fully flexed.

CONCLUSION

This study demonstrated a dynamic offset in the AP motion of the knee between the push and pull phases of cycling. The femur is forward (tibia pulled back) during the pull phase (hamstrings contracting). During the push phase (quadriceps contracting) the tibia is forward relative to the pull phase. This is the first study to show a dynamic offset in the AP movement of the knee during cycling. This offset can influence soft tissue strains and should be considered for patients during rehabilitation.

This study presents new information to increase the understanding of knee kinematics during cycling. Using this method of analysis coupled with force data, researchers will be able to further determine the etiology of overuse injuries, develop more successful rehabilitation regimes, and improve coaching/training techniques.

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