GAIT PERTURBATION RESPONSE IN PRE AND POST-SURGICAL ANTERIOR CRUCIATE LIGAMENT DEFICIENT SUBJECTS AND HEALTHY CONTROLS

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Introduction
It has been suggested that chronic anterior cruciate ligament deficient (ACLD) subjects develop a “quadriceps avoidance gait” (QA) pattern (sustained internal knee flexor moment throughout stance) to reduce anterior tibial shear during gait (Berchuck et al., 1990). However, other investigators have refuted the development of the QA phenomenon (Roberts et al., 1999). Reconstructive surgery is sometimes used to re-establish mechanical stability in the ACLD knee. Investigations involving ACL reconstructed (ACLR) subjects suggest pre-injury gait characteristics can be re-established over time (Devita et al., 1998). Additional studies are needed to support or refute the development of a QA gait pattern in chronic ACLD subjects and few studies have been conducted on ACLD subjects prior to and following surgical repair. This was the first study to determine the joint moments associated with a forward perturbation paradigm and no studies have been conducted regarding the effects of an unexpected perturbation on ACLD or ACLR individuals. Therefore, the purpose of this study was 1) to determine how normal gait patterns may change as a result of chronic ACLD and surgical repair and 2) to determine the effect of an unexpected forward gait perturbation on ACLD subjects prior to and following surgical repair compared to healthy controls.

Methods
Ten chronic ACLD who had sustained an isolated unilateral ACL injury greater than 2 years prior to testing (range 2.2 yr.–16.1 yr.; mean 5.7 yr.) and 10 age and gender-matched uninjured controls (CON) participated in this study. The ACLD subjects had a normal contralateral knee and were tested prior to and 3-months following bone-patellar tendon-bone autograft ACL surgical repair. Subjects walked across a 5m long walkway with a hydraulically driven moveable force plate imbedded within. The force plate moved 10cm at 40cm/s and was triggered immediately upon heel contact. Video and kinetic data were collected and inverse dynamics calculations made to estimate the ankle, knee, and hip joint angles and internal joint moments during the stance phase of gait. Data were recorded from 48 trials. The first 12 trials consisted of “true control” non-perturbation (NP) trials to establish normal gait patterns. Following the true control NP trials, 36 additional trials were performed consisting of 12 forward perturbations (FP), 12 backward perturbations (BP) and 12 “catch” NP trials randomly ordered to prevent anticipation of the FP. It was hypothesized that significant differences between the true control and catch NP trials would indicate anticipation. Data were analyzed according to 5 phases of stance based on kinetic data. Repeated measure ANOVAs were performed to indicate differences (α=0.05), if any, between the ACLD, surgically repaired ACLR, and uninjured CON limbs within the NP and FP conditions.

Results & Discussion
Non-Perturbed Gait Patterns
No significant differences were observed between the true control and catch NP trials for any variable. In the present investigation, evidence of a QA gait pattern was not observed for any ACLD subject (Fig 1). These results suggest that development of a QA gait pattern may be less common than previously reported. Following ACL surgery, the ACLR subjects exhibited a significantly greater knee extensor moment during early NP stance and a reduced knee flexor moment for the remainder of stance compared to ACLD and CON (Fig 1). The ACLR knee moment pattern was similar to previous investigations involving acutely injured and repaired ACLD subjects (Devita et al., 1997) and suggests that ACL surgery significantly alters knee moment patterns.
The hamstring muscles, as a component of the hip extensor moment, are believed to be effective synergists to the ACL in reducing anterior tibial shear (Pandy et al., 1997). In the present investigation the ACLD and ACLR subjects demonstrated an increase in hip extensor moment following heel strike and the ACLD group exhibited a prolonged hip extensor moment possibly to reduce anterior tibial shear during mid-stance (Fig 2).

Response to Unexpected Forward Perturbations during Gait
Examination of group differences within the FP condition reveals no significant between-group differences in hip moments (Fig 4) but the ACLD group demonstrated a significantly greater knee extensor moment near midstance compared to CON (Fig 3). The ACLR group demonstrated a significantly greater and sustained knee extensor moment compared to CON and pre-surgical ACLD values during FP (Fig 3). These data suggest the ACLD and ACLR group demonstrated increased knee extensor muscle activity possibly in an effort to prevent vertical collapse in response to the unexpected FP.

![Figure 1. Knee moments for ACLD, ACLR, and CON (solid thick and thin lines = mean ± 1SD) subjects during NP gait. Positive values indicate extensor moment, negative values indicate flexor moment.](image1)

![Figure 2. Knee moments for ACLD, ACLR, and CON (solid thick and thin lines = mean ± 1SD) subjects during FP gait. Positive values indicate extensor moment, negative values indicate flexor moment.](image2)

![Figure 3. Hip moments for ACLD, ACLR, and CON (solid thick and thin lines = mean ± 1SD) subjects during NP gait. Positive values indicate extensor moment, negative values indicate flexor moment.](image3)

![Figure 4. Hip moments for ACLD, ACLR, and CON (solid thick and thin lines = mean ± 1SD) subjects during FP gait. Positive values indicate extensor moment, negative values indicate flexor moment.](image4)

References

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