CURVE INFLECTION AND MODIFICATION OF THE ANTERIOR KNEE LAXITY COMPLIANCE INDEX: SPECIFIC VARIABLES TO ASSESS ANTERIOR CRUCIATE LIGAMENT INTEGRITY

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INTRODUCTION

Knee arthrometry is a common, reliable method to assess ACL integrity [1]. Current clinical techniques assess asymmetries in displacement at set arbitrary anterior forces as shown in Figure 1. The purpose of this study was to identify measures with greater sensitivity that could be used to assess ACL integrity in healthy (CTRL), ACL deficient (ACLD) and ACL reconstructed (ACLR) athletes.

METHODS

Anterior knee laxity curves were obtained using a CompuKT Knee Ligament Arthrometer from 230 limbs in 115 subjects (ACLD=15, ACLR=60, CTRL=50) by a single, highly reliable clinician (MVP; ICC=0.92). Displacements at 0, 67, 89 and 134 N of anterior force were identified using MATLAB. Linear portions of each curve were identified and the line of best fit was calculated.

Variables assessed included (1) inflection point, (2) compliance index (CI), and (3) modified compliance index (MCI). These variables are illustrated in Figure 2. Inflection point was defined as the point of intersection of the linear portions. CI was defined as the difference in displacements at 67 and 89 N of anterior force [2]. MCI was defined as the compliance of post-inflection stiffness over 22 N. If no inflection point was identified, MCI was defined as the compliance over 22 N. Statistical interactions were evaluated using 3x2 repeated measures ANOVA. A least significant difference test was used for multiple comparisons.

RESULTS AND DISCUSSION

Significant group-side interactions (p<0.001) were identified for displacement at inflection, CI, and...
MCI. Figure 3 shows boxplots of distributions by limb for all three subject groups for CI and MCI. Inflection points were identified in all ACLR and CTRL limbs. 40% of ACLD subjects exhibited no inflection on the deficient limb. CI demonstrated significant differences between CTRL and ACLR/ACLD groups (p<0.0001), however no differences were found between ACLR and ACLD (p=0.135). Post-hoc analyses of MCI demonstrated differences between all groups (p<0.0001). MCI > 1mm predicted ACL deficiency with 100% sensitivity (Sn) and 94.3% specificity (Sp) compared to 100% Sn and 58.8% Sp for CI>1. Asymmetry in AP laxity greater than 3mm at 134 N was 60% Sn and 100% Sp. 36.6% of reconstructed limbs had MCI greater than 1mm while 83.3% had CI greater than 1mm and 48.3% had asymmetry greater than 3mm.

The results from this study demonstrate the utility of analyzing arthrometric curve-shapes to better determine the status of the anterior cruciate ligament compared to currently applied criteria. Few studies to date have examined stiffness characteristics in arthrometric curves as a means of cruciate ligament assessment. Our results illustrate the need to take into account a commonly encountered range in arthrometric curves where the tangent stiffness is increasing. In doing so, the discrepancy in distributions between the healthy limbs of each group was vastly decreased. Liu et al conducted a modeling study in which a simulated KT arthrometric curve was obtained [3]. Their results indicated that in the event of a partial ACL tear, analysis of stiffness and rate of change of stiffness may be more sensitive to the condition of the ACL than displacement asymmetries [3]. The current study has adopted this methodology and applied it in a clinical setting while accounting for curve-shape variability from subject to subject, demonstrating the clinical validity of this approach.

CONCLUSIONS

Inflection point and modified compliance index scores of anterior knee laxity curves may serve as simple and accurate clinical diagnostic and outcome variables to assess ACL or graft integrity. The modified compliance index is useful for single leg data and may be more useful than displacement asymmetries in assessment of graft failure.

REFERENCES


ACKNOWLEDGEMENTS

The authors would like to acknowledge funding from NFL Charities, NIH/NIAMS Grants R01-AR049735, R01-AR055563 and R01-AR056259, F32 AR 055844 and Dr. Marepalli B. Rao for his assistance.

Figure 3: A) The distributions between groups and limbs of shows high variability even within healthy limbs. No significant difference was found between the ACL reconstructed and deficient groups. B) The modified compliance index vastly reduces the variability between the healthy limbs of each population and demonstrated significant differences between reconstructed and deficient limbs.