Injuries to the anterior cruciate ligament (ACL) are among the most common pathologies of the knee. These injuries result in considerable discomfort and functional limitations. The ACL is essential for normal biomechanics of the knee. The ACL is important in controlling anterior tibial translation (ATT), and the hamstrings provide the dynamic stability.

The KT1000 arthrometer (Medmetric®, San Diego, Calif) is an instrument used to quantify tibial translation on the femur. It has been used in numerous studies to assess ACL laxity.1-6 Reports of reliability have been variable with two factors being the primary influence: experience of the examiner with the equipment and degree of patient relaxation. Malcolm et al.7 reported that, on average, 93% of the retest measurements were within 2 mm of agreement, whereas Forster et al.2 reported “substantial” inter- and intraexaminer variation and highlighted the importance of the “experience” of the examiner. In fact, if the data of the least experienced examiner were discounted, 91% of the remaining physicians were within 2 mm in test–retest measurements. Given the availability of a device such as the KT1000, there might be a clinical value in using the KT1000 to quantify ATT with a hamstring contraction (i.e., dynamic ATT). Currently, there is nothing in the literature on this application.

Hamstring strengthening after ACL injury is an important component of the rehabilitation protocol because of the hamstrings’ ability to mitigate ATT. It appears logical that by increasing hamstring strength, an individual should be able to decrease ATT. Static ATT assessment with a KT1000 stresses the ACL to end range, whereas a hamstring contraction before ATT can limit the ACL from being stressed to end range. This is a concept explained by the hysteresis curve.8-10 The viscoelastic behavior of a ligament has been demonstrated by the stress–strain interrelationship. When stress is initially applied to a ligament, the response is the uncrimping of the collagen fibers (toe zone). With increasing stress, the collagen fibers begin to be stretched (elastic zone) but will recoil to their original length when the force is removed. With further stress, the plastic zone is reached and deformation of the collagen fibers occurs. Finally, if stress continues to be applied or increased, ligamentous failure can occur.8-10 Thus, in theory, if the difference between static and dynamic ATT is large, the individual is functioning in the elastic zone of the hysteresis curve. In this example, the athlete is able to recruit the hamstrings to control excessive ATT. If the difference between static and dynamic displacement is small, however, it might be postulated that the individual is functioning near or at the plastic zone of the ACL. Functioning at or near the plastic zone might result in permanent deformation or failure. Comparison of static and dynamic ATT values could be useful to serve as a predictor of ACL sprain or disruption.

In an attempt to explore this concept, we undertook a preliminary examination of dynamic use of the KT1000. First, we assessed intrarater reliability of the KT1000 using Pearson product–moment correlation coefficients (r values) and found it to be .93 for static testing and .85 for dynamic testing. Next, 38 healthy individuals with no previous knee pathology were tested via both modes (Figure 1). Table 1 demonstrates the significant difference between static and dynamic ATT for both men and women. This substantiated the
reported variability in KT1000 values when hamstring relaxation cannot be achieved with static testing. As expected, when the hamstrings’ relaxation was confirmed via palpation of the tendons, there was little correlation (Table 2) between static ATT and hamstring strength (assessed with a MicroFET handheld dynamometer as shown in Figure 2). The previous literature11-13 has suggested, however, that even in the resting state, muscle contributes up to one third of the passive tension of resisting ATT, but Table 2 demonstrates that there was a higher correlation when a hamstring contraction was performed before ATT in both men and women. It appears logical that hamstring strength would play an increased role in mitigating ATT.

In summary, this exercise served as a preliminary investigation on the use of a well-recognized piece of examination equipment in an alternative mode. Granted, there are additional factors such as femoral-notch width, Q angle, excessive foot pronation, and genu recurvatum that might predispose an individual to an ACL injury.6,14 Of course the timing of muscle recruitment is also an issue. Likewise, hamstring strength, particularly eccentric strength and the ratio of quadriceps to hamstring strength, is important, but the concept of dynamic ATT might be a more functional application of this strength ratio.15-17 Thus, if a critical difference between static and dynamic ATT could be identified, this technique could be valuable as a predictor of potential ACL injury. This testing process could

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**TABLE 1. ANTERIOR TIBIAL TRANSLATION WITH AND WITHOUT HAMSTRING CONTRACTION**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Static KT1000, M ± SD</th>
<th>Dynamic KT1000, M ± SD</th>
<th>p Value (2-Tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6.2 ± 2.6 mm</td>
<td>1.3 ± 2.4 mm</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>7.2 ± 2.1 mm</td>
<td>1.7 ± 1.5 mm</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

**TABLE 2. PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS (r) BETWEEN HAMSTRING STRENGTH AND ANTERIOR TIBIAL TRANSLATION WITH AND WITHOUT HAMSTRING CONTRACTION**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Hamstring Strength to Static KT1000</th>
<th>Hamstring Strength to Dynamic KT1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>r = .13</td>
<td>r = .41</td>
</tr>
<tr>
<td>Female</td>
<td>r = .22</td>
<td>r = .35</td>
</tr>
</tbody>
</table>

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**Figure 1** KT1000 technique for assessing anterior tibial translation.

**Figure 2** Technique for assessing eccentric hamstring strength using a handheld dynamometer.
be a part of preseason screening or serve as a tool to determine readiness for return to play. Additional research is needed, however, to quantify the critical difference between static and dynamic ATT. Although this process is developing, we thought that describing this preliminary work was worthwhile to introduce our theory and begin to explore the clinical feasibility. We welcome any input that clinicians might have regarding the exploration of this assessment tool (Dawn. T.Gulick@Widener.edu).

References


Dawn Gulick is an associate professor at Widener University in the Institute for Physical Therapy in Chester, PA. She is also a partner in AquaSport Physical Therapy and the author of two books, a book chapter, and over 20 peer-reviewed manuscripts.

Brian LaRue and Brian Berge were students at Widener University at the time of this study.