Reliability of a New Device for Measuring Knee Laxity

Ramón A. Ruberte Thiele, Nkemakolam Egekeze, Brian K. Downie, Bruce S. Miller
University of Michigan, Ann Arbor, MI
rruberte@med.umich.edu

Introduction: The anterior cruciate ligament (ACL) provides up to 86% of the resistance for anterior/posterior (A/P) translation in the knee (1). ACL injuries lead to various functional deficits due to anterior and rotational instability (2). One way to examine the functional integrity of the ACL is by evaluating the passive A/P laxity of the knee (3). In this test, knee laxity is defined as anterior tibial translation (ATT) under a known applied load. There are many commercial devices that quantify laxity, although none are considered a clinical “gold standard” (3). We have developed a new device to evaluate knee laxity. The objective of this study was to evaluate the test/re-test reliability of our device.

Materials and Methods: Subjects: Ten normal individuals, 8 males and 2 females, were tested. All subjects had no history of knee injury. Activity levels ranged from sedentary to average-level, representing population that presents with ACL tears. Knee laxity device (KLD): The KLD was an upgraded version of a previously used device at our institution (4). It was developed to record ATT while simultaneously monitoring lower-extremity muscle response by means of surface electromyography (EMG). ATT was measured by calculating the difference between anterior displacements recorded by linear potentiometers placed on the patella and the tibial tuberosity. Lower-extremity muscle function was monitored with the MyoTrac II EMG system (Thought Technology Ltd) with sensors over the quadriceps and hamstrings. Volunteers were seated with the knee flexed 30-40° (verified with goniometer) and the foot fixed in 10-15° of ankle dorsiflexion (Figure 1). This flexion angle was used because it is generally thought of as the slack-taut transition position for the ACL (3). Medial, lateral and anterior pads were used to limit femoral motion during testing. The weight-bearing status of the tested limb was monitored by a scale under the foot to ensure the subject never applied a load greater than 20% of their weight. A constant test force, delivered by a pneumatic system, was then abruptly applied to the posterior aspect of the calf for one second or less. The load magnitude was 20% of the subject’s weight (verified with load cell). To prevent anticipation of force application, randomized time intervals were used. Recordings were sampled at 1kHz and data was captured using a DAQ card, LabVIEW (National Instruments Corp), and a PC. Testing protocol: After a brief orientation, each subject was weighed. Five maximal voluntary contraction (MVC) readings of the quadriceps and hamstring muscles of the subject's tested leg were then recorded. Ten percent of the mean MVC value was used as a threshold with the goal of ensuring muscle relaxation during testing. After a brief period of preconditioning during which the anteriorly directed test force was applied several times, the tests were run. During all tests, subjects were asked not to contract their muscles in response to the force (verified with EMG). Five normalized step-force trials were applied to each subject, and the results were averaged. The same set of tests was then repeated on the same leg 24-72hrs later. Statistics: An intraclass correlation coefficient (ICC2,1) was used to determine within tester reliability for ATT measurement. In addition the mean difference and standard deviation (SD) with 95% confidence intervals (CI) for the mean difference from trial one to trial two was calculated with SAS (SAS Institute Inc).

Results: The volunteers had a mean age of 29.4yrs (range: 24-41yrs) and a mean weight of 211.3lbs (range: 135.2-265.5lbs). No attention was paid to dominant leg effects, although 8 had their reported dominant leg tested. Moderate reliability was found in A/P knee laxity measurements between days. The (ICC2,1) value for test/re-test reliability was 0.66. ATT values ranged from 0.37±0.05mm to 2.96±0.53mm on day 1, and 0.44±0.04mm to 2.52±0.11mm on day 2. The mean±SD of the difference in means from trial 1 to trial 2 was -0.03±0.57mm (lower 95% CI: -0.44mm; upper 95% CI: 0.38mm).

Discussion: This study presents the KLD as a research tool for examining A/P knee laxity. Its test/re-test reliability was shown to be moderate. However, this compares very favorably with the ICC values reported for the KT-1000 arthrometer in measuring ATT (intraclass ICC: 0.59 for novice and ICC: 0.68 for experienced user; intertester ICC: 0.64) (3). The test/re-test reliability of the KLD had a lower 95% CI of -0.44mm and an upper 95% CI of 0.38mm. This is significantly better than that reported for the KT-1000 device in determining ATT (95% CI for novice user: ±3.99mm; 95% CI for experienced user: ±3.89mm; overall 95% CI: ±3.74mm). It is generally accepted that an interlimb difference of 3mm or more is an indication of knee laxity (3). Thus, poor reliability in the KT-1000 device may result in false negative tests (3). Furthermore, although our ATT values were on the lower end of that reported in the literature for normal subjects (typically 2-6mm), there is evidence to support that current devices typically overestimate the laxity of the knee (3, 4). We believe our device has features that allow it to better reflect knee joint laxity: 1. Applying an anterior force equivalent to 20% body weight likely reflects better the knee joint laxity in contrast to commercial devices that apply the same given load to all subjects; 2. Muscle activation has been shown to reduce ATT. Our device has the capability of monitoring EMG signals during testing, which current devices do not allow; and 3. The weight-bearing status of the tested limb has also been shown to significantly affect ATT values. This too can be monitored in our current testing setup, whereas commercial devices do not contemplate this possibility (3, 4).

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