Technical and measurement report
Clinical measurement of mechanical ankle instability

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ABSTRACT
Clinicians commonly use the anterior draw test (ligament laxity) and distal fibular position (lateral malleolus displacement), to measure ankle instability. The purpose of this study was to establish intra-rater and inter-rater reliability for the anterior draw test and distal fibular position in a clinical setting.

The anterior draw test (AD) was measured with a plastic Goniometer, and was defined as the linear displacement of the foot as it is drawn anteriorly with the ankle held in 20 degrees of plantar-flexion. Distal fibular position (DFP) was measured in standing using a digital vernier caliper and was the relative linear distance between the lateral and the medial malleoli.

20 participants aged 21–28 volunteered for the study and were measured on both ankles. It was found that Intra-tester reliability (ICC) ranged from 0.88 to 0.97 for AD and DFP; while inter-tester reliability (ICC) was 0.6 for AD and 0.77 for DFP. In addition for measures across trials, the standard error of the measurement (SEM) was, on average 0.66 mm for AD and 1.7 mm for DFP. While the limits of agreement (LOA) was ±0.17 mm for AD and ±4.03 mm for DFP. However, the SEM and LOA between testers was 2.27 mm and 10.4 mm respectively for AD; and for 3.1 mm and 10.4 mm for DFP. Overall the results suggest that both measures, as defined in this study exhibit moderate to good reliability and low standard error of measurement, suggesting a high degree of repeatability across trials.

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1. Introduction
Lateral ankle sprains as a result of unexpected, forceful inward torsional movements constitute a large percentage of all reported injuries managed in busy out-patient clinics. These injuries most often result in deficits that lead to the mechanical instability of the ankle. It has been proposed that this instability is as a result of damage to the lateral ligaments supporting the joint (Hertel, 2002) and/or the displacement of the lateral malleolus (Kavanagh, 1999; Hubbard et al., 2004, 2006; Hubbard et al., 2007).

In measuring instability at the ankle joint secondary to ligamentous laxity/damage of the anterior talofibular ligament (ATFL), the anterior draw test is commonly used (Magee, 2008). Several cadaveric studies have demonstrated an increase in the anterior translation of the talus when the ATFL is cut (Kerkhoffs et al., 2001, 2002; Phisitkul et al., 2009). Similarly, radiographic evidence has shown increased anterior displacement of the talus with the application of an anterior force using a mechanical stress device (Hubbard et al., 2004).

A second variable that aims to measure mechanical integrity of the talocrural joint which has recently been reported in the literature is the distal position of the lateral malleolus, commonly referred to in the literature as “positional fault” (O’Brien and Vicenzino, 1998; Kavanagh, 1999; Mulligan, 2004; Hubbard and Hertel, 2008). Cadaveric studies have reported mal-alignment of the lateral malleolus with sectioning of the anterior tibiofibular ligament (Beumer et al., 2006). Mulligan (2004) has suggested that with ankle sprains the distal end of the fibula is displaced relative to the tibia causing articular instability. Several studies have reported a displacement of the fibula in patients with ankle instability (O’Brien and Vicenzino, 1998; Kavanagh, 1999; Berkowitz and Kim, 2004; Mulligan, 2004; Hubbard and Hertel, 2008). In contrast to technically more sophisticated methods of measuring distal fibular position (Kavanagh, 1999; Hubbard et al., 2006), in this study it was measured using a simple vernier caliper.

It is important to use reliable methods of measurement when assessing the ankle for instability. To the best of our knowledge the reliability the anterior draw (AD) as well as a measure of distal fibular position (DFP) as defined in this study has not been reported in the literature. Thus, the purpose of this study was to establish intra-rater and inter-rater reliability of these measurements.
2. Methods

2.1. Participants

20 young adults (15 females and 5 males) between the ages of 20–30 years were tested on both ankles. 12 participants had sustained ankle sprains in the past while eight (8) were healthy. Participants who had sustained fractures or had undergone surgical interventions were excluded from the study. The study was approved by the institutional review board of the university.

2.2. Tests

2.2.1. Anterior draw (AD)

A clear, plastic Goniometer with its movable arm fixed at 20 degrees of plantar-flexion and with linear markings in millimeters was used for measurement of the anterior draw. To standardize starting position the fixed arm of the goniometer is secured to the lateral aspect of the lower leg with its axis coinciding with the joint axis while the participant’s foot is held along the movable arm. Grasping the heel of the test ankle with one hand and stabilizing the lower leg with the other hand, the foot is drawn along the movable arm of goniometer until no more motion is experienced. The anterior linear displacement of the foot along the goniometer arm is the measure of AD and represents the degree of ligamentous laxity.

2.2.2. Distal fibular position (DFP)

A digital vernier caliper with a bubble level was used to measure DFP. The bubble level ensured leveling of the vernier caliper in both the frontal and sagittal planes. As seen in Fig. 2, the fixed jaw of the caliper was placed at the point of maximum malleolar convexity and the movable extension was extended toward the wall. The distance between the point of maximum convexity and the wall was read from a digital display. The relative linear difference between the perpendicular distance of the lateral and medial malleolus from the wall defined DFP.

2.3. Procedure

Participants were tested on both measures in a random order. Measurements were made on both the involved/left and the uninvolved/right ankles.

For measuring anterior draw (Fig. 1) participants were positioned supine lying with the leg well supported, knee flexed, resting on a firm bolster and foot positioned beyond the edge of the bed such that the test ankle was free to move. The lateral malleolus (ankle joint axis) and the lateral aspect of the fibula were palpated and routine markings with a washable marker were made so as to standardize the position of the goniometer. A marking was also made on the lateral border of the foot at the level of the crease at the head of the 5th metatarsal to make it easier to read displacement measurements. Next the fixed arm of the goniometer was attached to the lower leg along the fibula while the lateral border of the foot was aligned to the movable arm, which was fixed at 20 degrees of plantar-flexion and the axis was positioned over the joint axis. Maintaining the foot in this position, an initial reading was taken at the crease of the 5th metatarsal. With the tester grasping the heel with one hand and stabilizing the lower leg and goniometer just above the ankle with the other, the test foot was gently drawn anteriorly along the arm of the goniometer until it moved no more and a second reading was taken. To avoid error due to parallax and awkwardness, one tester performed the maneuver while the other did the reading. The difference between the two readings defined the anterior translation (displacement) or anterior draw (AD).

Next the lateral and medial malleoli were palpated and surface markings were made along their anterior margins. Participants were positioned with their backs toward the wall. Foot placements were marked on the floor to standardize starting position. As shown in Fig. 2, a digital vernier caliper (with a bubble level) calibrated in millimeters was used to measure the distance between the wall and the maximum curvature of the malleoli. The difference between the two measurements defined distal fibula position (DFP). Testers practiced performing the two measures as outlined above for five days prior to testing.

For intra-tester reliability each of the testers measured the participant three times on each of the measures. To evaluate inter-tester reliability two testers measured each ankle on each of the dependent variables. Testing was carried out in a random order according to a 2 (testers) × 2 (dependent measures) × 2 (ankles) × 3 (trials) matrix.

2.4. Data analysis

A reliability index was determined using the Intra-class Correlation Coefficient (ICC) using PASW statistical software v17.3 Intra-
variability from trial to trial. The ICC(2, 1) for anterior draw for tester 1 was 0.96, and was 0.97 respectively. It was found that both testers had low error and demonstrated low error both testers on the two measures. Both testers demonstrated a good association between scores and demonstrated low error both testers on the two measures. Both testers demonstrated a good degree of association between measures across trials for anterior draw and distal malleolar position.

3.1. Intra-tester reliability

Table 1 shows the means (SD), ICC, SEM and 95% LOA scores for both testers on the two measures. Both testers demonstrated a good association between scores and demonstrated low error variability from trial to trial. The ICC2, 1 for anterior draw for tester 1 and 2 was 0.96, and was 0.97 respectively. The ICC2, 1 for positional fault was 0.97 for tester 1 and 0.91 for tester 2. In addition, for AD, tester 1 had a SEM of 0.6 mm and 95% of the scores ranged between ±0.19 mm, while tester 2 had a SEM of 0.7 mm with scores between ±0.15 mm. While for PF, tester 1 and 2 had a SEM of 1.2 (LOA = ±3.16) and 2.1 mm (LOA = ±4.9) respectively.

3.2. Inter-tester reliability

Table 2 shows the means (SD), ICC, SEM and 95% LOA across testers for both measures. There is a moderate degree of association between the two testers when measuring anterior draw; ICC2, 1 = 0.7 and positional fault; ICC2, 1 = 0.6. In addition, it is observed that the SEM and LOA for both measures were relatively higher across testers than within a tester: AD = 2.27 mm (LOA = 0.54) and PF = 3.1 mm (LOA = 10.4).

4. Discussion

In this study we analyzed the reliability of two simple, clinically relevant measures that aim to evaluate the mechanical integrity of the ankle joint. Overall, the results of our study provide strong evidence that both the ankle anterior draw (AD) and the relative distal malleolar position (DFP) as measured in this study are highly repeatable.

The anterior draw maneuver, similar to the anterior draw test was used to measure the anterior displacement of the foot in this study. This test has been traditionally used by clinicians to assess the integrity of the anterior talofibular ligament. In this study when both testers measured AD (across trials) their scores were highly repeatable with a low standard error of measurement from trial to trial. In addition, 95% of the scores for both testers were approximately between ±0.2 mm, thus providing clinicians a reliable means to measure instability. Similarly, high reliability scores have been reported by others who measured ankle joint laxity using sophisticated, mechanical instruments (Hubbard et al., 2004; Kerkhoffs et al., 2005; Docherty and Rybak-Webb, 2009). De Vries et al. (2010) reported high intra-tester reliability using the manual anterior draw test in healthy ankles; however they categorized displacement on an ordinal scale (0–3) and were not clear as to how they measured it.

The DFP or the relative position of the lateral malleolus is a measure that purports to provide clinically relevant information regarding the mechanical integrity of the talofibular joint. Recently, this measure has gained greater importance due to its use in measuring the effects of therapeutic mobilization techniques (O’Brien and Vicenzino, 1998; Mulligan, 2004; Vicenzino et al., 2007). A fundamental premise of these techniques is to realign the lateral malleolus to its uninjured position. Accordingly, it is important that the relative alignment be measured objectively. It was found that both testers had low error and demonstrated a good degree of association between measures across the ankle joint.


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