A METHOD FOR TESTING SHOE TORSIONAL AND TOE BREAK FLEXIBILITIES

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INTRODUCTION

Many groups have looked at the relationship between shoe structure and lower extremity function (Miller, 2000, Stacoff, 2001, Jarboe and Quesada, 2003). To evaluate this relationship it's essential to develop a consistent strategy for measuring structural shoe parameters. In the first test, the tendency to rotate about the long axis of the shoe (i.e. torsional flexibility) was measured. In the second test, the tendency to rotate about the shoe's toe-break (i.e. toe break flexibility) was measured similar to the qualitative method proposed by Rossi (Rossi, 1986). In this abstract, we focus on presenting the design and test methods with preliminary results to illustrate the consistency of both techniques.

METHODS

Experiments were performed using an Instron 4201 tensile tester connected via a cable to a pulley/forefoot plate assembly rotating at 10°/sec. Force and displacement, were converted to moment and angle after collection at 20 Hz with a National Instruments A/D board (AT-MIO-16F).

The test jig, illustrated in Figure 1, was modifiable to allow both torsional and toe break flexibility testing. Common to both setups, the rearfoot grounding device (1 in Figure 1) could translate to accommodate shoes of different lengths. The rear foot of the shoe was secured by rotating the knob (2) that was connected to a vertically translating screw. For the torsional testing (A), the moment was converted from the force through a pulley (3) and applied to the shoe through the forefoot plate (4). The front of the shoe was grounded to the forefoot plate by simultaneously tightening the two knobs (5) connected to a horizontal bar. For testing the toe break flexibility (B), the axis of rotation, and therefore the pulley assembly (6) was offset by 12° from perpendicular to the long axis of the shoe to approximate the orientation of an imaginary line connecting the 1^{st} and 5^{th} metatarsal heads (Parham, 1992). The front of the shoe was grounded to the forefoot plate (7) by applying a clamp (8) at the approximate position of the 3^{rd} metatarsal head.

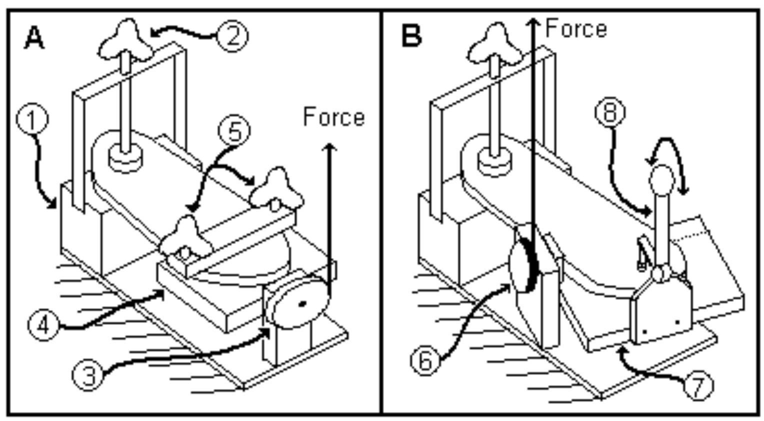

Figure 1: Experimental setup for testing torsional flexibility (A) and toe break flexibility (B).

For measuring torsional flexibility, the shoe was centered relative to the axis of rotation of the forefoot plate, as suggested in the standard developed by ASTM for running shoes (ASTM, 1994). Next the heel and forefoot areas of the shoe were grounded such that the front edge of the shoe was adjacent to the front of the forefoot plate and the back edge of the shoe was aligned with the backside of the rear foot-grounding device. Next, after applying a 0.10 Nm preload, the shoe was rotated 40° in a direction that would simulate forefoot inversion. For measuring toe break flexibility, the approximate position of the 1^{st} and 5^{th} metatarsal heads was marked on the medial and lateral shoe borders. The two marks on the lateral sides of the shoe were aligned relative to a line drawn on the forefoot plate identifying the axis of rotation of the test jig. The clamp was applied to ground the front end of the shoe to the forefoot plate. Finally, the heel area of the shoe was secured to the rear foot-grounding device. The test was initiated after applying a 0.25 Nm preload by invoking a slight rotation of the forefoot plate. The test was finished after the forefoot plate was rotated to approximately 55° from horizontal. The termination angle was selected to match the position of the foot at the toe-off stage of stance phase (Rossi, 1986).

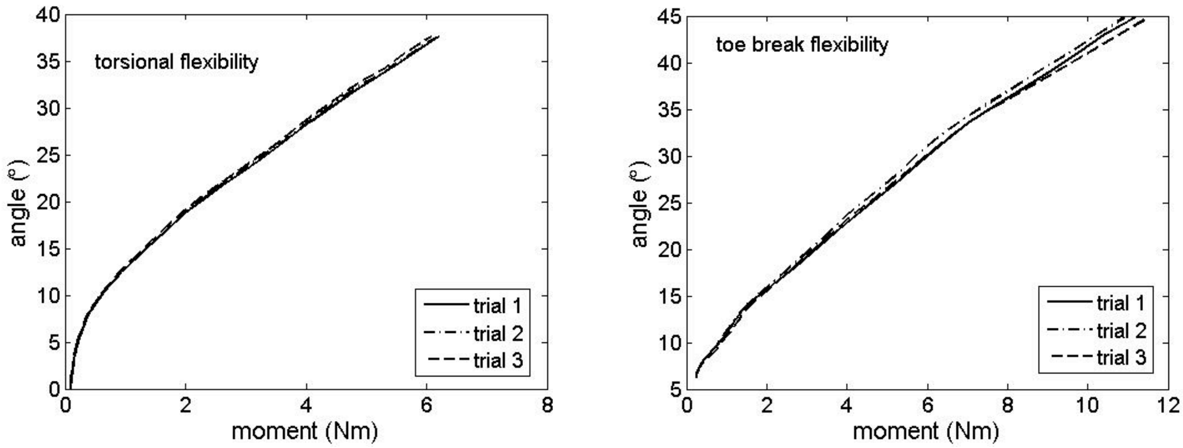

Figure 2. Typical torsional and toe break shoe flexibilities (angle vs. moment slopes).

RESULTS AND DISCUSSION

Twenty trials of torsional and toe break flexibility were performed on a Birkenstock Arizona sandal (European size 41). Flexibility was defined as the approximate slope of the angle versus moment curve. (Figure 2). For torsional testing, the first ten trials were required to precondition the shoe while the following three were analyzed. The average of the three trials was 5.99 °/Nm (+/- 0.05°/Nm). For toe break testing, the sandals were preconditioned after the first five trials with the subsequent three trials analyzed. The average of the three trials was 3.55 °/Nm (+/- 0.08 °/Nm). The low standard deviations indicated the consistency of the test. The primary application for shoe flexibility testing will be to provide shoe specific structural data that may be correlated to lower extremity function.

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