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Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

Precision and test-retest reliability of a large-scale British Pendulum designed to assess lateral edge shoe-surface friction at high impact velocities

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Lower-extremity injuries in sports, and lateral ankle sprains in particular, has been attributed with a heightened risk of occurrence when shoe-surface friction on the lateral edge is excessive. This was recently confirmed in a 510-athlete RCT, in which the application of a "low-friction" PTFE patch on the lateral edge of the shoes led to a 53% prevention of severe ankle sprain injuries. Surprisingly, no standard tests currently assess lateral shoe-surface friction, and simply reorientating the shoe in e.g., the slowly moving ISO:13287 test does not accommodate the high velocity impact motion associated with lateral ankle sprains. Therefore, the aim of this study was to design a shoe-surface friction tester that mimics the initial motion of a lateral ankle sprain injury. Our setup comprised of a rigid pendulum onto which a solid shoe-last was attached via a lockable spherical joint swinging above a P6000 force platform (BTS Engineering, Italy). We tested the 12 most popular shoe models worn by a prospective cohort of 1273 indoor sports athletes, from which ankle sprain injury data had been collected in season 2017/18 in Denmark. As a sub-measure to establish causality between lateral edge friction and ankle sprain injury risk, we facilitated an impact between the lateral edge and the surface - to mimic a typical ankle sprain situation. Each shoe was tested 10 times and ground reaction forces were collected at 1000 Hz, and subsequently low-pass filtered using a 4th-order Butterworth filter with a 100 Hz cut-off frequency. Our outcomes included initial contact coefficient of friction (COF) and COF at time of peak normal force (i.e., peak compression of shoe). The reliability of our test setup was assessed by conducting the same tests on two separate days and established using Pearson Correlation Coefficient. Standard deviation (SD) was used as a measure of test precision. Impact speed was 5.41 (0.04) m/s and contact time between shoe and platform was 0.02 (0.006) s on average. On day one, initial contact COF ranged from 0.93 (0.04) to 1.53 (0.1) and peak normal force COF from 0.70 (0.03) to 1.07 (0.02) between shoes. On day two, initial contact COF ranged from 0.95 (0.03) to 1.46 (0.09) and peak normal force COF from 0.63 (0.01) to 1.07 (0.03). The correlation coefficient was 0.4 for initial contact COF and 0.6 for COF at time of peak normal force. The precision of our test setup is considered excellent with very low standard deviations for especially COF at time of peak normal force (average of 0.02). However, the reliability is considered unacceptable when assessing initial contact COF, and only questionable ($\geq$0.6<0.7) when assessing COF at time of peak normal force. The poor reliability is most likely due to the manual height adjustment when changing between the different shoes.

Keywords: Footwear, sports, injury prevention, shoe-surface friction

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