

Design and Build of a Portable Apparatus for Measuring Lace Tension

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Introduction

Athletic footwear has traditionally used laces to secure the foot inside the boot and enhance fit, comfort and performance. Quantitatively assessing the merits and effectiveness of lacing practices is technically challenging. Most measurement instrumentations lack portability and the ability to collect direct measurements across various types of footwear and laces while the footwear is secured on the foot.

Purpose

The purpose of the study was to design and build an apparatus to quantify lace tension in both laboratory and real-world environments. Design criteria included: (i) portable, and (ii) able to accommodate different footwear secured on the foot.

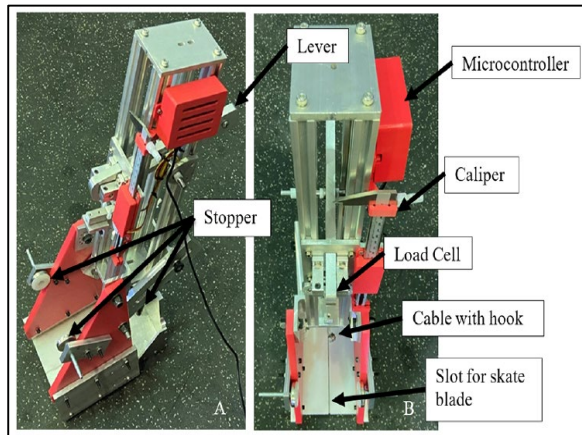


Figure 1. The apparatus consisted of a loadcell, a caliper for force and displacement measurements. (A) 45 deg view, and (B) frontal view of the apparatus.



Figure 2. Three laces used for stiffness assessment. Left to right: carbon fiber blend, non-waxed, waxed, and cable.

Method

The apparatus was designed to accommodate different types of footwear and measure displacement (mm) of the lace in response to an applied force (N). Three different lacing materials were assessed to demonstrate the apparatus's ability to reliably differentiate between stiffness properties of the laces. The interclass reliability coefficient across lace types revealed an alpha value of 0.84.

Results

Significant differences were revealed in lace stiffness across the three types of laces ($p < 0.05$); suggesting that the apparatus has the ability to differentiate between different lacing materials.

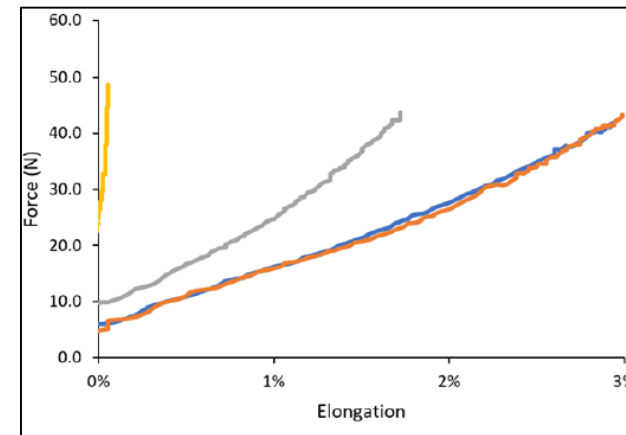


Figure 3. Force (N) vs. strain (% elongation) plot of stiffness across different types of laces. Blue: non-waxed, orange: waxed, grey: carbon fiber blend, yellow: cable (control).

Discussion

The lace tension measuring apparatus was able to reliably quantify tension of laces installed in footwear pre and post activities. All laces have the tendency to stretch and loosen over time, resulting in the potential for compromised performance and/or an increase in foot related injuries. It is envisioned that the apparatus can be used for ongoing investigations across different types of footwear and laces to further assess fit and function.