Effects of Running Shoes & Finger Shoes on Tibial Shock Attenuation

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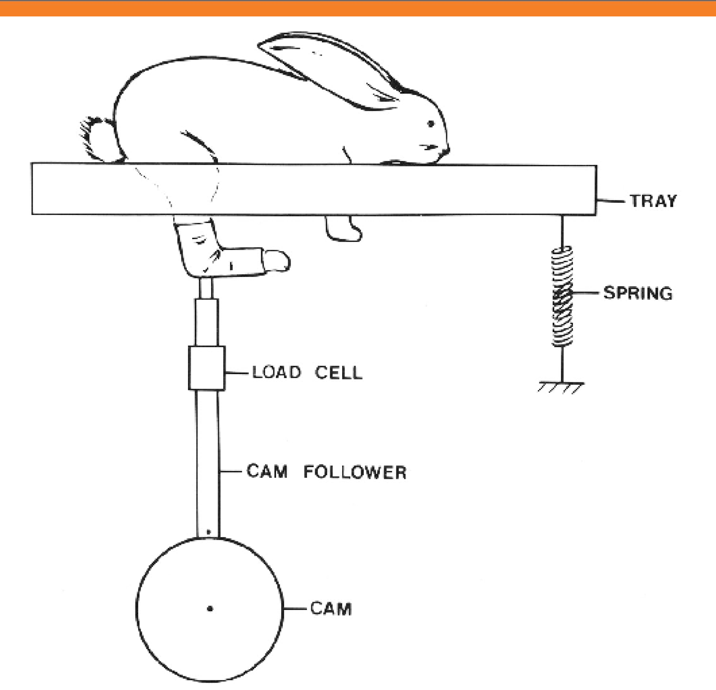
INTRODUCTION

"Humans have engaged in endurance running for millions of years, but the modern running shoe was not invented until the 1970s (Lieberman, 2010)." Runners who run barefoot, or in minimal footwear, tend to avoid "heel-striking" and instead by landing on the middle or front of the foot. Thus, potentially avoid the injury rate of the lower extremity injuries caused by running and lessening the impact force generated from heel-strike. There is lack of data on the force attenuating characteristics of minimal footwear for running. It is well known that excessive tibial impact forces causes deterioration of articular cartilage which then leads to an increased risk of osteoarthritis, see Figure 1.

Figure 1



Radin (1973) demonstrated that 36 days of daily 1 hr impact loading resulted in knee osteoarthritis: articular cartilage thinned, subchondral bone stiffened and cancellous bone became brittle. From Radin EL, et al. J Biomech, 6:51-57, 1973.

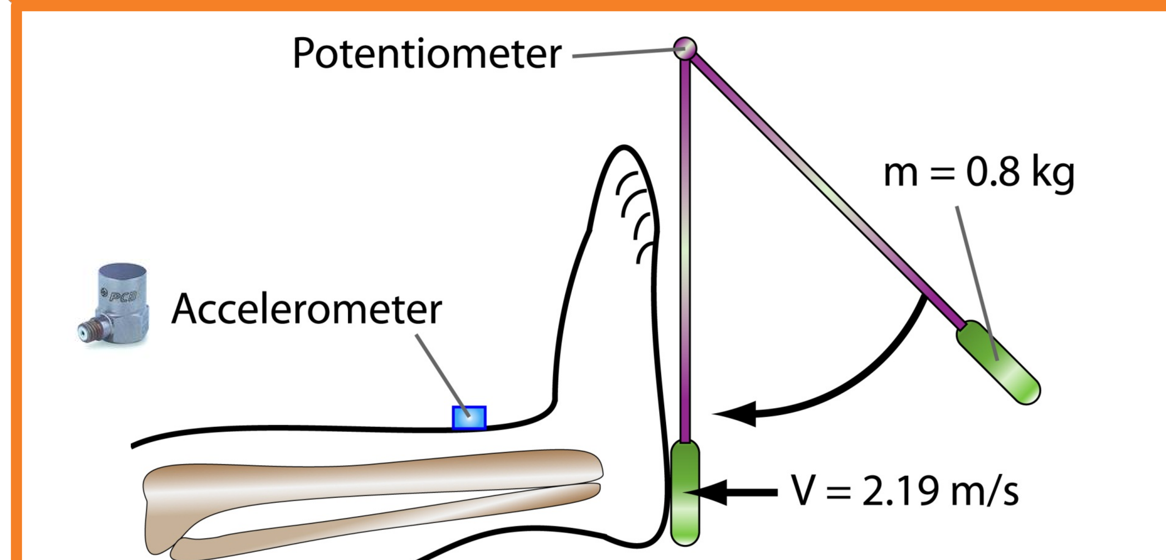
PURPOSE

The purpose of this study was to compare the effects of running shoes and finger shoes on tibial shock attenuation. We hypothesized that tibial impacts would be higher in the finger shoes.

METHODS

- Tibial shock was measured in 23 college age subjects.
- 5 ballistic impacts were delivered to the heel of each shoe (running, finger) with the order counterbalanced.
- A PCB single axis accelerometer was rigidly attached on the distal medial tibia, see Figure 2.
- The angular position of the pendulum was measured with an electronic potentiometer.
- The accelerometer and potentiometer signals were sampled at 5,000 Hz using a Visual C# program.
- Dependent variables: peak tibial shock (g), time to peak tibial shock (ms), average rate of tibial shock (g/s), peak rate of tibial shock, and medial frequency of the tibial shock (Hz).
- Dependent t-tests were used to compare shoe conditions with alpha set at 0.05.

Figure 2 Ballistic Impact Pendulum

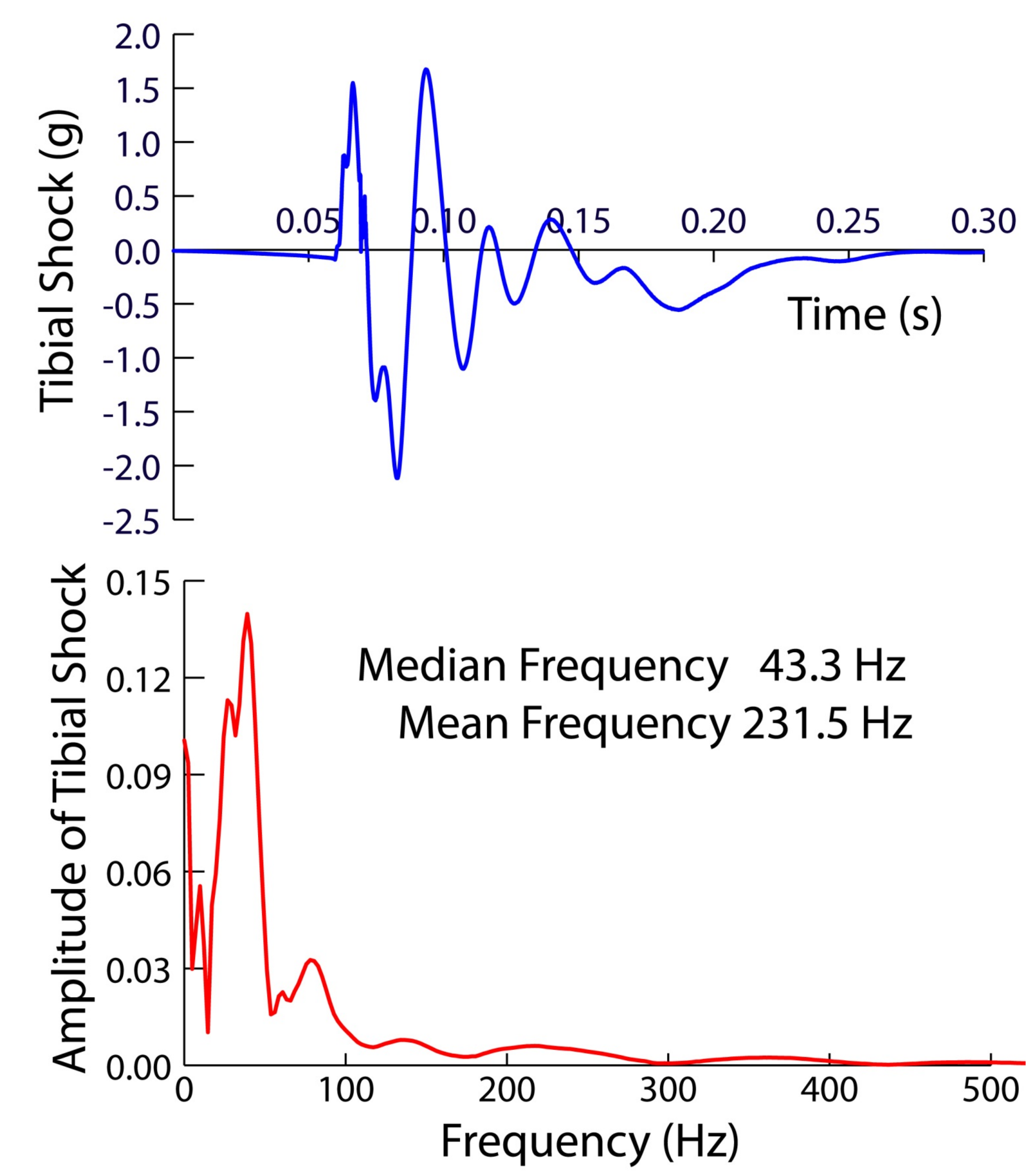


Tibial shocks were delivered using a ballistic impact pendulum with an 0.8 kg mass suspended by a 0.27 m pendulum arm and a 10 cm circular impact surface. The impact pendulum stuck the subject's heel with a velocity of 2.19 m/s delivering an input energy of 1.92 J. The impact pendulum was instrumented with potentiometer to measure the rotational velocity. A PCB low mass accelerometer was rigidly attached to the distal medial aspect of the subject's right tibia to measure tibia shock. The accelerometer and potentiometer signals were sampled at 5,000 Hz.

RESULTS

A typical trial of tibial shock and the frequency spectrum of the tibial shock signal induced by the ballistic impact pendulum is shown in Figure 3.

Figure 3



RESULTS

- The results for the tibial shock dependent variables by shoe condition are shown in Table 1.
- The peak tibial shock was significantly lower in the running shoe than the finger shoe, $t(23) = 6.15$, $p = 0.001$, with an effect size of 1.26.
- The average rate of tibia shock was significantly lower in the running shoe than the finger shoe, $t(23) = 2.15$, $p = .042$, with an effect size of 0.44.
- The median frequency of the tibial shock signal was significantly lower in the running shoe than the finger shoe, $t(23) = 2.68$, $p = 0.013$, with an effect size of 0.55.

Table 1

Variable	Running Shoe	Finger Shoe	p
Tibial Shock (g)	1.97 ± 0.34	2.40 ± 0.46	.000
Time to Peak Shock (ms)	8.99 ± 2.88	9.19 ± 3.40	.730
Ave Rate of Shock (g/s)	243.25 ± 94.2	292.34 ± 100.8	.042
Peak Rate of Shock (g/s)	1005.6 ± 578.3	1270.0 ± 666.1	.145
Median Frequency (Hz)	35.18 ± 7.76	42.36 ± 15.41	.013

CONCLUSIONS

Running in finger shoes exposes runners to significantly higher magnitude, rate and frequency of tibia shock. It has been well documented that long term exposure to high magnitude, rate and frequency of tibial loading results in a higher incidence of osteoarthritis.