ENERGY RETURN OF DIFFERENT SHAPES OF TRACK SPIKES

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Different track spike designs (pin, pyramid, post, Christmas tree, and modified Christmas tree) are all touted as being advantageous for track and field performance, but these claims have not been tested and reported in peer-reviewed literature. The purpose of this study was to examine how track spike design impacted energy return on a Mondo track surface. Load-deformation curves of the spikes driven by a machine into the track surface were determined and the energy absorbed and the energy returned by each spike was calculated. On the Mondo track surface, the modified Christmas tree design generated significantly more energy return than the other spike designs while the pin spike absorbed (and therefore returned) significantly less energy than the other spike designs. This information could useful for athletes and coaches looking to enhance performance on a Mondo track.

KEY WORDS: sprinting, kinetics, energy.

INTRODUCTION: Competition track shoes, commonly referred to as “spikes”, have metal or ceramic pins of varying shape and length, also referred to as “spikes” screwed into the soles. Track and field athletes, from sprinters to long-distance runners and to those involved in the jumps and throws wear track shoes fitted with spikes. The use of spiked track shoes became popular in England in the 1860s and sparked the trend in America (Janssen, 1888, p.126). Advances in technology and design have generated changes to the traditional spike. Today, there are a number of different spike shapes, the four most common being needle, pyramid, post, and Christmas tree and modified Christmas tree (the last two are also referred to as “compression tier”) (see Figure 1).

Figure 1: Types of Spikes; A-Needle or Pin, B-Pyramid, C-Post, D-Christmas Tree and E-Modified Christmas tree.

Running magazines, product advertisements, coaches and manufacturers make claims about the potential effects of each type of spike design and their use in different situations. Omni-Lite, a manufacturer of track spikes, touts that their spikes do not destroy track surfaces, provide adequate traction, weigh less and help return energy to the athlete (Omni-Lite Industries, 2012). USA Track & Field even ban the use of certain spikes on specific tracks. According to the manufacturers the shape of the Christmas tree spike was made to avoid tearing up the track. Theoretically, the compression spikes do not penetrate the track surface thereby allowing some energy to be returned to the athlete (Lee, 2010; Tweedie et al, 2002). Track surface manufacturer Mondo suggests using 6mm long pyramid or Christmas tree type spikes to reduce damage to the track surface (Mondo Technical Department). To our knowledge, these types of claims and other information regarding spikes or track surface, have not been tested and reported in the peer-reviewed literature. The purpose of this preliminary study was to examine whether different shaped spikes elicit quantifiable differences in energy return on a <u>Mondo track surface</u>, the most commonly used at track venues. The research hypothesis is that the spike shapes that do not puncture the track surface, if that were the case, will provide the highest measures of energy return. Results from this study could help coaches and athletes choose the best spike shape for the Mondo surfaces that they commonly compete on. Using the correct spike could help athletes not only conserve energy but also increase running velocity and acceleration.

METHODS: Five different shaped spikes all 7mm in length were used in this study (see Figure #1). The spikes chosen are those commonly used by athletes on various indoor and outdoor track surfaces. Samples of the Mondo track surface were requested from the manufacturer and used to test the spikes (Figure #2)

Figure 2: Bose Electroforce 3200 with track sample

The load-deformation between the spikes the track was measured using a Bose Electroforce 3200 (Eden Praire, MN) testing device (see Figure #2). Each spike was screwed into a spike holder and lowered so that the spike just touched the surface with a force between 1 to 2 N. The ram arm of the testing device was pre-programmed to perform 10 strokes into the track surface. The stroke length was 5 mm and at a speed of 20 mm/sec. Upon completion of the 10 strokes, the spike holder was raised so the track sample could be repositioned on another spot. The spike holder was again lowered to the track surface with 1 to 2 N of force and another trial of 10 strokes was performed. This procedure was repeated with each spike on each track surface such that 10 trials had been performed with each spike on each track surface. Only the first stroke for each trial was used in the analysis. Once the spike penetrated the track the load-deformation curves of the following strokes were slightly lower.

Figure 3. shows a typical load-deformation curve. A MATLAB program was developed to calculate the energy absorbed and energy returned of the spike-track interaction. The energy absorbed was calculated as the area between the loading and the unloading portion of the load-deformation curve and the energy returned was the area under the unload portion of the load-deformation curve (see Figure 3.). OneWay ANOVAs using Sigma Plot 10.5 (Systat Inc., Richmond, CA) were performed to test for significant differences between spikes. Tukey post-hoc comparisons were performed at the p=0.05 level.

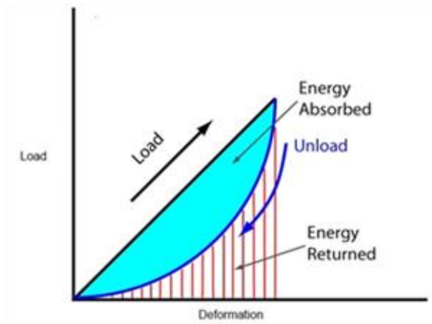

Figure 3: Load-deformation curve

RESULTS: Figure 4 shows the typical load-deformation curves for the five different type spikes on the Mondo track. Figure 5 and 6 show the results of the OneWay Anova's for energy returned and absorbed.

Figure 5 shows the ANOVA results [F (4,49)=54.78, p<.001] and Tukey post-hoc comparison for the energy returned. The MTREE spike generated the greatest amount of energy returned and was significantly different from the other spikes (p<=0.05). The PYRA spike generated second largest amount of energy returned and was significant different from the PIN and POST spikes. The PIN or needle spike, as expected, had the least amount of energy returned. All spikes penetrated the track surface.

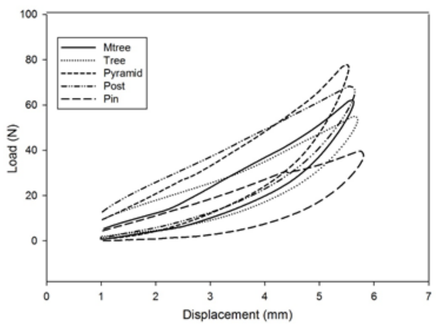

Figure 4: Load-Deformation graph of different types of spikes on Mondo track surface.

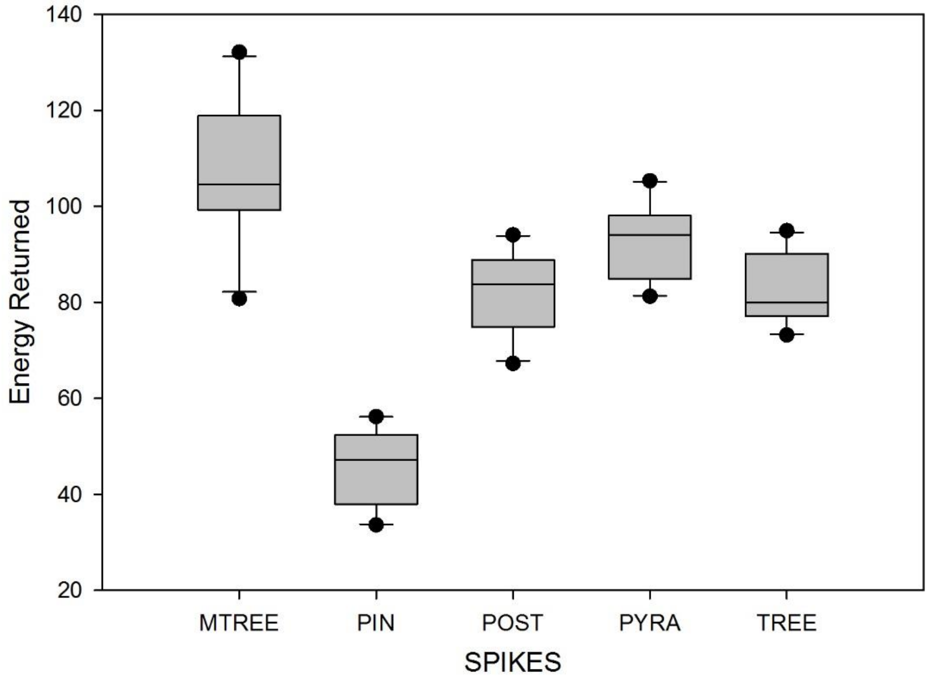

Figure 5: Mean Energy Returned

Figure 6 shows the ANOVA results [F (4,49)=6.31, p<.001] and Tukey post-hoc comparison for the energy absorbed by the spikes. The only significant results were between the POST spike and the PIN and PYRA spikes. Overall, as expected the PIN spike absorbed the least amount of energy while the other four compression spikes absorbed greater amount of energy. Although the compression spikes absorbed more energy they also were able generate greater energy return values.

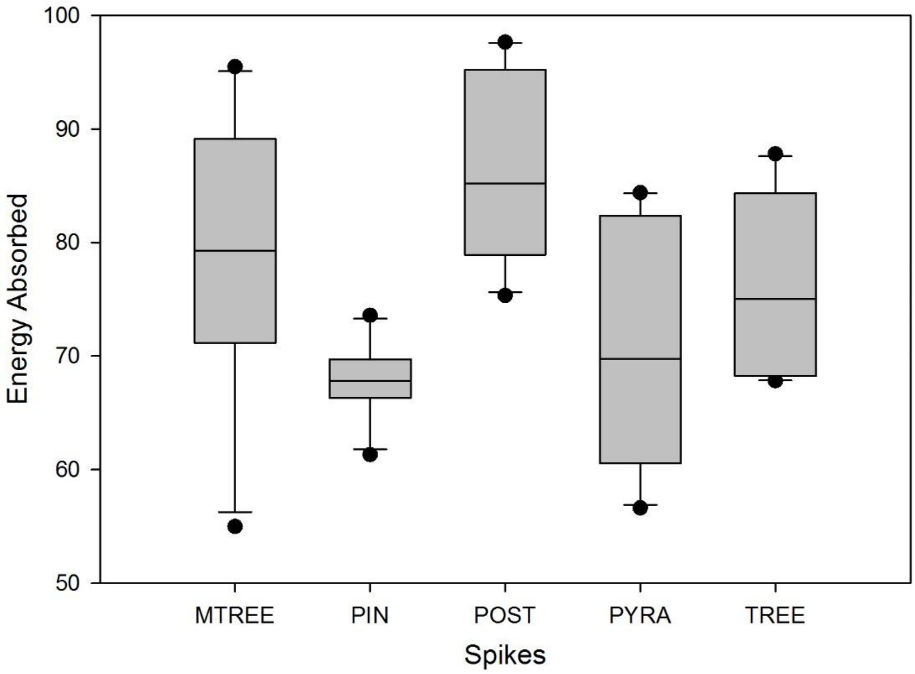

Figure 6: Mean Energy Absorbed values

DISCUSSION: The purpose of this preliminary study was to examine whether different shaped spikes elicit quantifiable differences in energy return on a Mondo track surface and to corroborate manufacturer claims of energy return and spike-track penetration. The notion that compression spikes have less track penetration is unfounded. All the spikes tested penetrated the track under loads less than 105 N. Considering that vertical ground reaction force (GRF) increases linearly during walking and running from 1.2 BW to approximately 2.5 BW at 6.0 m s^{-1} and remains constant during forward lean sprinting at higher speeds, the likehood of any of the tested spikes not penetrating the Mondo track surface seems improbable (Keller et al., 1996). For the Mondo track the spike with the largest energy return was the MTREE design. This MTREE provided the largest spike surface area, which helped it to compress the track. The common PIN design provided the least energy return but absorbed the least amount of energy. All the compression spikes seem to provide larger amounts of energy return when compared to the PIN. The measured energy returned by the various spikes is relatively small (N*mm). However, for this study, the energy return was determined for only one spike while most sprint shoes have a sole plate with up to 10 mounted spikes. While it is difficult to assess how much of the energy returned in the spike-track surface interaction might actually aid the sprinter, these findings are nevertheless noteworthy. It is not uncommon for results in sprint races to be separated by only thousandths of a second, where even small levels of energy return could potentially make the difference between winning or losing a race.

CONCLUSION: This study shows that spike design affects the amount of energy returned and absorbed by a Mondo track surface. While all of the spikes tested penetrated the track surface, the modified Christmas tree design returned the most energy on the Mondo surface. Knowledge of which spike design offers the highest energy return on the various track surfaces that athletes compete on could be useful to coaches and athletes, as well as, spike and track manufacturers and thus is worthy of further investigation.

REFERENCES:

Janssen, F. W. (1888). A History of American Amateur Athletics and Aquatics: With the Records (p. 126). New York: Outing Company.

Keller, T. S., Weisberger, A. M., Ray, J. L., Hasan, S. S., Shiavi, R. G., & Spengler, D. M. (1996). Relationship between vertical ground reaction force and speed during walking, slow jogging, and running. Clinical Biomechanics, 11(5), 253-259.

Lee, Jimson (January 10, 2010). Track Spikes – using Pins, Pyramids, and Christmas Trees. SpeedEndurance.com. Retrieved from http://speedendurance.com/2010/01/10/track-spikes-using-pins-pyramids-and-christmas-trees/ .

Mondo Running tracks (Super X and Mondotrack): Maintenance Guidelines (Outdoor) (p. 6). Retrieved from http://www.kieferfloors.com/professionals/maintenance

Omni-Lite Industries (2012). Store. Retrieved from http://www.omni-lite.com/cart/ .

Tweedie, C., Rajter, R., Ybarra, I., & Reinharth, D. (2002). Design. Team 3 - HyperLite Fiber-Epoxy Spikes. Retrieved from http://web.mit.edu/3.082/www/team3_f02/pages/design.html .

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