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USING TPE TOW IN SOLES:
Increasing Stability

Injury Prevention • Keywords: tow, 3D Printing,
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ABSTRACT

Professional basketball athletes suffer from ankle injuries and specifically sprained ankles due to player-to-player contact. Sprained ankles are the most common type of lower body injury damaging athletes' medial forefoot (MF), central forefoot (CF), and lateral ligament complex (LLC) [1]. These three-foot components are damaged when athletes land from vertical and lateral movements.

High top shoes tried to address this issue, but high-top shoes restrict ankle movements more than provide support. Because of this, low top basketball shoes were analyzed. The sole was 3D printed with TPU to provide a soft and absorbent cushion for the athlete. A supportive TPE tow was strategically placed within the sole to stabilize the MF, CF, and LLC. A carbon fiber plate was added to the sole to return energy back to the athlete and increase the speed at which they can run. These three changes help athletes decrease their risk of ankle injuries.

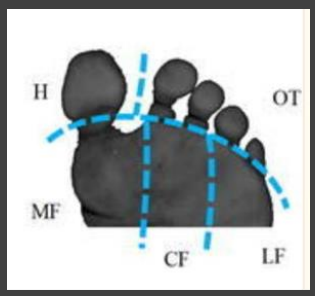

Fig. #1 MF and CF foot components

Fig. #2 LLC foot components

PROJECT OVERVIEW

In creating a new shoe, the RESEC team needed to analyze existing failures of modern athletic shoe designs. Most notably, basketball and volleyball shoes have evidenced flaws in ankle injury prevention. According to a National Library of Medicine study for documented basketball and volleyball injuries, 58% and 63% are due to ankle complications respectively [2]. An NCAA study determined that these injuries typically occur during a sharp cut or physical contact while jumping, leading to an awkward landing [3]. In the past, high tops were seen as a potential remedy to this issue as they restrict the motion of the ankle joint to prevent rolling. However, recent research has found that high tops have negligible effects on ankle injuries and that these shoes may increase injuries to other areas, such as the heel or knee, because the ankle restriction directly reduces the energy dissipation of the ankle joint on impact. For this reason, the use of high tops in the NBA has substantially dropped in recent years as only half of the NBA currently plays in high tops [4]. The decline of high tops has been countered with the rise of ankle taping because 80% of NBA players tape their ankles. This has been shown to better stabilize the ankle without preventing motion [4]. Additionally, Nike has introduced new shoes with a carbon fiber plate. This has demonstrated an increase in torsional stiffness and a smoother force distribution from heel to toe upon landing [6]. The team plans to incorporate the stabilization principles of both taping and fiber plates into one cohesive shoe.

Fig. #3 Carbon fiber plate placement

PROJECT METHOD AND RESULTS

PREVIOUS DESIGNS

This project is a continuation of a previous shoe design that used shear thickening fluid (STF) in the sole to dampen jump landing sequences but provide stiffness for takeoff. This design was altered to a plastic tow path shoe design to provide more stability in target areas. The current prototype is designed to work longer term than the STF design.

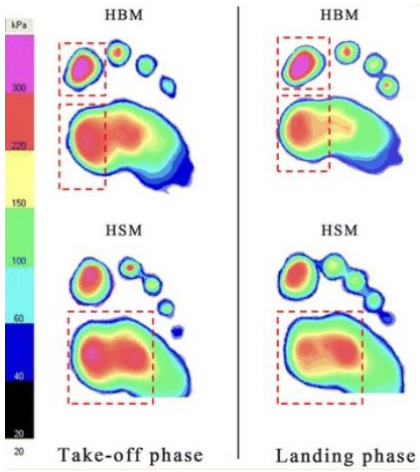

Fig. #4 Force distribution for jumping and landing

PROJECT METHODS AND RESULTS CONT.

To make the prototype, 3-D models were made on a modeling software. The prototype incorporated open area for the plastic tow to run through and a carbon fiber plate to sit in. The prototype was assembled in multiple parts all glues together around the TPE tow and carbon fiber plate. The material from the top of another shoe was used to form the TPE tow around the laces. The shoe is tightened up through TPE eyelets formed by heating the tow. One pair of eyelets is near the bottom of the front of the shoe, one pair is in the middle of the shoe, and the final pair is by the ankle. These points target stability of the ankle and the majority of force load when jumping and landing. This method allows the tow to be tightened to the foot when the laces are tied, as well as aiding in form fitting to the foot more as well.

Fig. #6 Prototype side view

ANKLE STABILITY

With the vast majority of basketball and volleyball injuries being ankle related, the main focus of stability for this design is preventing ankle injury. The most common mechanism for ankle injury is the outward rolling of the foot. This injures the anterior talofibular ligament (ATFL, located on the outside of the foot) with a torsional strain. The solution presented in this design is to run TPE tow from the heel to the laces along the ATFL to provide stability. This tow would run perpendicular to this joint to limit outward rolling of the ankle.

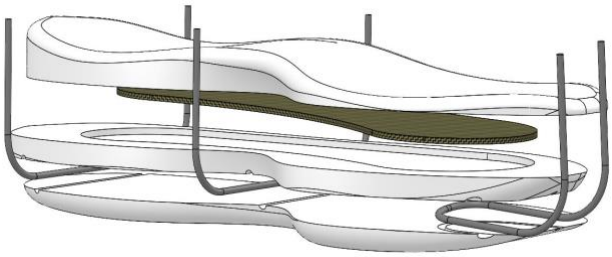

Fig. #5 3-D model of sole prototype

CONCLUSIONS AND FUTURE WORK

Conclusions

- Printing multiple sections of the shoe is required to run TPE in the correct sections under the foot
- The most common injuries in basketball and volleyball are ankle injuries. Supporting the ankle provides critical stability
- A carbon fiber plate provides torsional stiffness which is inserted above the tow paths

Future Work

- Assemble fabric of shoe around sole prototype
- Map out tow paths in fabric of shoe
- Test stability of the shoe adhesion and the effectiveness of ankle stability
- Test different shoe thicknesses for desired comfort and stability

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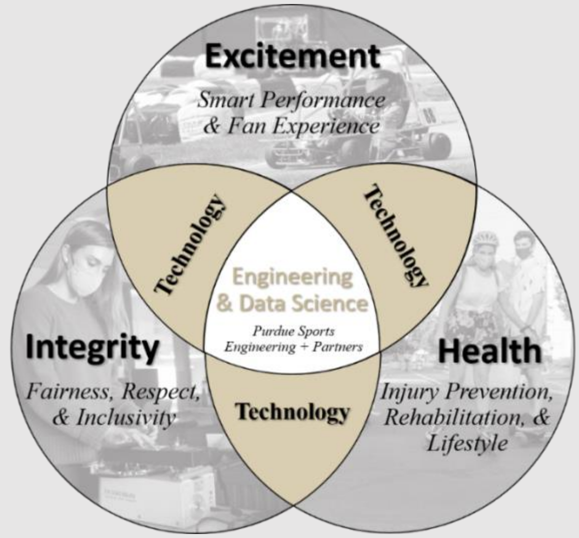
ABOUT RESEC

The Ray Ewry Sports Engineering Center (RESEC) was launched as a joint collaboration between Purdue College of Engineering and Purdue Intercollegiate Athletics, highlighting Purdue's reputation as the Cradle of Quarterbacks and Astronauts.

Sports have the power to unite, to teach, to challenge, and to initiate change, and those are our goals for RESEC. We are driven by our passion for sport and a deep understanding of the influence it has in shaping society. As technology continues to advance, there is enormous room for opportunity to rethink how athletes train, coaches coach, fans engage, and event organizers plan events. We collaborate closely with partners in athletics, industry, academia, and more to create the solutions that will help bring sports into the future, specifically in the three key research areas highlighted below.



Smart Performance & Fan Experience

Injury Reduction & Rehabilitation

Sports Integrity, Fairness, & Societal Integration

WHAT IS SPORTS ENGINEERING?

Sports engineering is a global, fast-paced, and multidisciplinary industry that brings people from different backgrounds, cultures, and experiences together. It is an industry that is heavily influenced by advances in other sectors as well as societal pressures and shifts, making working as a sports engineer very exciting. However, it also means being keenly aware of how these innovations and discoveries can be integrated and applied, especially as digitalization expands and what people – the athletes, fans, coaches, governing bodies – expect from sport evolves.

Engineering and data science are at the center of excitement, health and safety, and the integrity of sport, and by bringing a data-driven, human-centered approach to this industry, we can address the growing need and desire to increase participation and engagement of athletes and fans.

WHO IS RAY EWRY?

A Boilermaker track and field athlete, Ewry (1873-1937) won eight gold medals in three Olympic Games from 1900 to 1908. But his story is relatively unknown: at the age of five he became an orphan, and at seven he contracted polio and was confined to a wheelchair. Doctors had little hope he would be able to walk. Later nicknamed "The Human Frog," Ewry won gold in the standing long and high jumps and standing triple jump. By the end of the 1908 Games, Ewry had set a medal count record that lasted more than 100 years.

Fig. # caption: unitedsans reg med size 8