Footwear Engineered to Reduce Ankle and Knee Injuries

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Objective

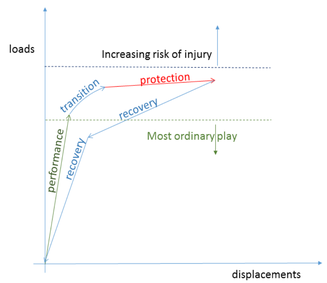
- Produce a new athletic shoe that will reduce ankle and knee injuries without diminishing player performance

Hypothesis

- Injuries caused by loads transmitted through equipment can be mitigated by adsorbing energy in the equipment, e.g., ski bindings and shoes

In basketball, for example, the high friction that the player's foot has with the court easily transfers loads foot resulting in injuries to the ankle and knee (e.g., ACL)

Ski bindings that are effective at reducing tibia shaft injuries fail to protect the ACL



Axiomatic Design Decomposition

- Nam P. Suh, Principles of Design 1990

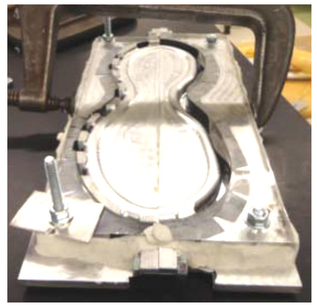
0	FR	Mitigate shear loads that cause ACL injuries in the x-y plane	DP	System that contains two beams	
1	FR	Maintain normal shoe function during normal play	DP	Beam 1 system	
1.1	FR	Maintain contact between Chamfer 1 and Beam 1	DP	Band/material that connects chamfer to beam	
1.2	FR	Prevent full bending of beam under normal play	DP	Dimensions and material of beam that prevent unnecessary	
1.3	FR	Prevent shear motion in the medial direction	DP	Wall on the inside of the shoe	
1.4	FR	Prevent motion in the z direction	DP	Two parallel faces that transmit forces in the z direction	
2	FR	Absorb injurous loads	DP	Beam 2 system	
2.1	FR	Maintain contact between Chamfer 2 and Beam 2	DP	band/material that connects chamfer to beam	
2.2	FR	Allow for easier motion of shear layer when beam is activated	DP	Material and dimensions of beam that allow further motion of	
2.3	FR	Allow bending of beam	DP	Space behind beam to allow full bending of beam	
3	FR	Allow shearing forces to be applied to beam 1	DP	Chamfer 1	
3.1	FR	Direct chamfer to proper location on beam 1	DP	Angle and position of chamfer 1	
3.2	FR	Prevent motion of chamfer in the z direction	DP	system that contains shearing mechanisms	
4	FR	Allow shearing forces to be applied to beam 2	DP	Chamfer 2	
4.1	FR	Direct chamfer to proper location on beam 2	DP	Angle and position of chamfer 2	
4.2	FR	Prevent motion of chamfer in the z direction	DP	system that contains shearing mechanisms	
5	FR	Return system to normal playing configuration	DP	System that returns system to normal playing conditions	
6	FR	Attach system to shoe	DP	System that attaches shearing device to shoe	

- This kind of functional modeling provides robust design solutions and avoids unwanted interactions and unintended consequences

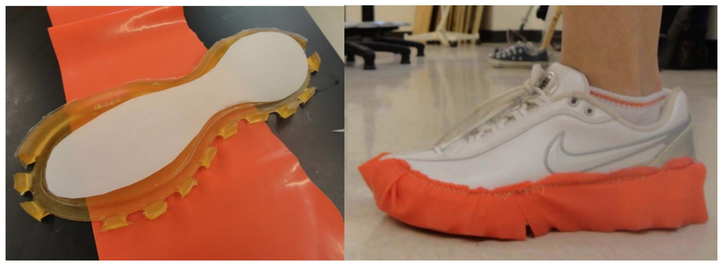
This technology could also provide injury protection in other situations like during military training and operations including parachuting, hiking, and skiing.

Prototyping

- The main function of the design is based on the absorption of energy during periods of high loading
- This is done by creating displacement between two separated, spring loaded soles
- The final product is intended to be produced using injection molded parts



- Initial designs used a set of spring beams around the edges of the shoe to provide the required feedback
- A protective layer was placed around sole interface to keep out water and dirt



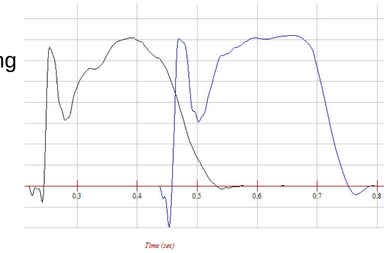
- The next prototype incorporated the spring mechanisms within the sole of the shoe, making it more discrete than the external spring system

- The internal system contains easily interchangeable components so that the maximum level of playing loads can be adjusted quickly
- A system for vertical absorption will be added to provide protection during potentially injurious landings

Analysis and Testing

- On-foot testing was conducted with the first prototype to measure the reaction forces as the player made a cutting movement

- Testing will be conducted on the integral components using a force plate dynamometer
- Multiple trials will be performed to measure the effects of different materials and dimensions



- Force sensors will be placed within athletic shoes and used to measure playing loads

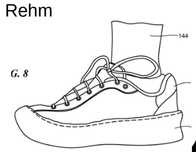
Patents

US Patent 9,730,486 Self-recovering impact absorbing footwear, Brown; Christopher, Workman; Nicholas, Doyle; Michael, Shelsky; Jessica

US Patent 9,089,763. Skate boot force absorbing appliance
28 Jul. 2015 Brown, Christopher A., Karin E. Greene, and Devon L. Rehm

US Patent 9,358,447 RAPID RESPONSE SKI BINDING
6-7-16 Christopher A. Brown, John M. Madura

US patent 9,339,719 Ski Binding Plate (to reduce ACL injuries)
5-17-16 Christopher A. Brown, John M. Madura



Moving Forward

- More prototypes and testing are planned in the next months
- Currently being developed at WPI with the support of Sports Engineering Inc., founded by outside investors and owned partly by WPI and Brown.
- Other investors and developers should contact us (brown@wpi.edu)