A novel soccer headgear design to reduce concussion risk in head-to-head collisions

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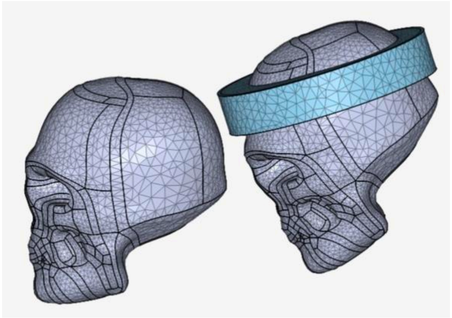
PURPOSE / OBJECTIVES

Soccer players can wear headgear that absorb energy during head-to-head collisions and thereby reduce concussion risk. Previous studies have explored headgear designs that consist of one layer of energy-absorbing polymeric foams. We propose a headgear design that integrates an inner layer of expanded polystyrene (EPS) and an outer layer of expanded polypropylene (EPP). This two-layer EPS-EPP design is hypothesized to optimize energy absorption by integrating the material properties of both foams.

METHOD

We evaluate the two-layer EPS-EPP design through finite element analysis. The EPS-EPP design was first contoured to a human skull. This skull was simulated to collide with a second skull at a velocity of 4 m/s, which represented a realistic head-to-head collision (Figure 1). Finite element analysis of this collision was conducted with a mesh of 160k cells and 35k nodes. Additionally, one fully EPS-based and one fully EPP-based headgear design was modeled and simulated in the same way.

Figure 1. Meshed geometries



RESULTS

Peak linear acceleration and peak von Mises stress values were calculated for each of the three headbands because they are strong predictors of concussion. The skull fitted with the EPS-EPP headgear had the lowest peak linear acceleration of 513 m/s^2 and lowest peak von Mises stress of 23,500 N/m^2 (Table 1).

Peak linear acceleration was further utilized to calculate concussion risk based on a concussion threshold curve (Table 2). The EPS-EPP headgear's peak linear acceleration of 513 m/s^2 translated to a concussion risk of below 25%.

Table 1. Simulation results

Headband Design	*Peak Linear Acceleration (m/s^2)*	*Peak Von Mises Stress (N/m^2)*
EPP	635	2.52e+04
EPS	791	3.78e+04
EPS-EPP	513	2.35e+04

Table 2. Concussion threshold values

Peak Head Linear Acceleration (m/s^2)	559	778	965
Probability of Concussion (%)	25	50	75

CONCLUSIONS

The EPS-EPP headgear was superior at absorbing energy and reducing concussion risk compared to the single-layer headgear designs. Ultimately, this study demonstrates the feasibility of a two-layer soccer headband design that integrates two polymeric foams — EPP and EPS — to maximize energy absorption. With further research, similar two-layer headband designs have the potential to be worn by soccer players in real life, hopefully reducing the incidence of concussions and transforming soccer into a safer game for all.

UHN
10th Annual Concussion Research Symposium
Update on Research and Care for the Concussion Spectrum of Disorders
Friday, April 21, 2023 | Hybrid: Zoom & BMO Education & Conference Centre