AN INNOVATION TO SPORTS RELATED CONCUSSION PREVENTION

INTRODUCTION

Concussions occur when you hit your head hard causing your brain to rattle back and forth quickly. This motion causes brain tissues to stretch, resulting in less firing potential from neurons. The brain is surrounded by cerebrospinal fluid which circulates around the hollow cavities and helps the brain stay protected. But, the fluid can only do so much. There are around 300,000 concussions/brian injuries due to sports every year, and this is the leading cause of all head traumas. Out of all sports, soccer and football are the two athletic activities that yield the highest rates of traumatic brain injuries (Gessel et. al.).

Concussions can have many short term and long term effects. Short term concussion symptoms include dizziness, nausea, headaches, lack of focus, blurry vision, etc. Whereas long term symptoms may range from brain tumors, suicidal tendencies, alcohol/drug abuse, etc (University of Utah Health).The consequences of concussions are most publicly observed in the news with athletes who have sustained major head trauma injuries during their careers that had detrimental effects later on. A prime example is Matthew Gee, a former collegiate football player at the University of Southern California, who passed away at the age of 49 due to repeated blows to the head (Harris). Phillip Adams, a former NFL player, killed six people and ended up killing himself. It was found that his brain chemistry was changed due to repeated trauma to the head and his family tried to argue that the killings were due to his medical condition (Dys). Daniel T'eo-Nesheim was found dead at one of his friends' homes and toxicology results revealed he had passed away from mixing alcohol and painkillers. Neuroscientists later deemed that Daniel had chronic traumatic encephalopathy, a degenerative disease which affects those who have sustained repeated concussions and traumatic brain injuries (Indiana University School of Medicine).

Current sport head injury preventatives include mouth guards, neck guards, helmets, rule changes, and headbands. Some sports require protection like football and hockey, while others, like soccer and field hockey, leave players exposed to an increased concussion risk. The concussion prevention, concussion headbands, that is available to soccer players is limited and not required. Although many sports have preventative measures, very few athletes take advantage of these devices which is unfortunate because sports/athletic activity is the number one cause of concussions (Cleveland Clinic). Only 35.49% of subjects in a study were found to wear headgear while the other 65.41% wore no protective headgear (Jeffries et. al.)

Concussion headbands have been found to be ineffective and incentivizes rougher game play (UPMC Health Beat). Arguably most importantly, concussion headbands that don't work may create false senses of security for athletes which could worsen their head traumas because they are under false impressions that they are untouchable (SportsSafe).

The University of Wisconsin-Madison conducted an experiment on headband effectiveness with 88 high schools and assigned half of the schools to headbands and the other half to wear nothing. Within the course of their seasons the control schools with no headbands allowed less concussions than the schools who wore the protective gear. They pushed the idea that maybe headbands aren't effective after all and there needs to be an improvement.

PROBLEM STATEMENT

Around 3.8 million concussions occur in the United States, many of which occur during participation in sports. As concussions can have detrimental effects on an individual's short and long term health, an innovation to prevent concussions during sporting events is necessary.

MY INNOVATION

Current concussion headbands are made of hard foams, hard plastics, and weak polyester fabrics which have minimal shock absorbency (Unequal Halo 3). Whereas, lattice patterns have been found to be strong and have a high energy absorption while maintaining a low density, which is perfect for sports (Chen et. al.). Lattice structures create less strain on one specific area creating an approximately 10% increase in force absorption (Nam et. al.).

The innovation explores the redesigning and improvement processes of current concussion headband by utilizing lattice technology and flexible plastics. The prototypes created and tested use two types of 3D printed materials (TPU plastics and UV resin) constructed in a lattice pattern instead of using hard foams/plastics. The lattices are backed with a thin layer of foam and covered in an aramid fabric.

The prototypes were tested for force absorption in a comparison study between the three variables of no headband, the new headband (TPU and UV resin), and the old headband (hard foams and plastics).

METHODOLOGY

Force Test. A current concussion headband (Full 90) was obtained and a new concussion headband was constructed with 3D printed TPU, a thin layer of foam, and athletic fabric for testing. A pressure sensor connected to a computer was used to measure the Newtons of force exerted on the headbands during testing. A soccer ball (.4 kg) was used to drop on the headbands from three different heights (1ft, 3ft, and 5ft). A control test was performed, where the soccer ball was dropped straight onto the force plate without a headband. The drop test was then performed on both headbands by placing one headband on the force plate and dropping the ball on it from one of the three heights. The head bands were moved around so all sides of the band were tested. Each test (control, current model, and innovation) had 30 drops performed at the 3 different distances in the air (30 at 1ft, 30 at 3ft, and 30 at 5ft). Newtons of force for each test were recorded as force exerted onto a Google Sheet.

Statistical Analysis. For each test at each height, the average was found and a Two Sample T test was performed to compare the treatments (ie: Control at 1ft vs Current model at 1ft). The variances of each set of trials was found first, then the variances were compared in order to find out if a one-tailed or two-tailed test was needed. After finding that, T Tests were performed using google sheets.

Current | Improved

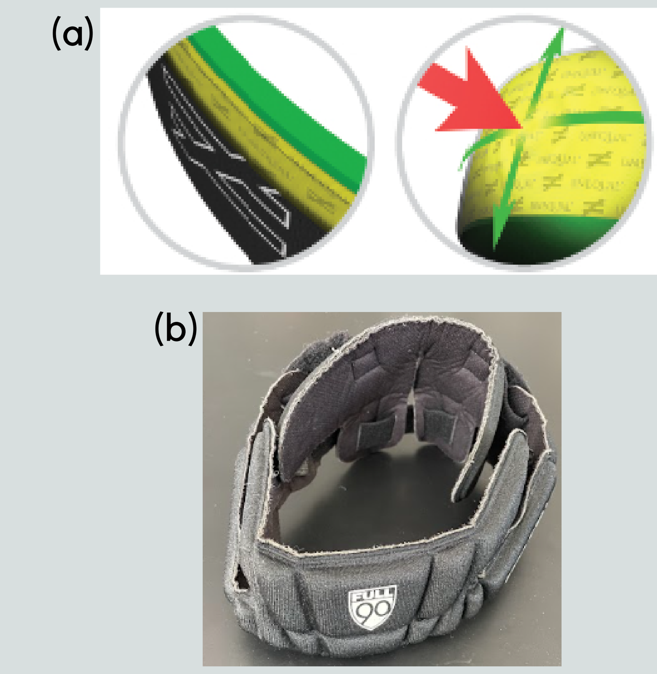

Figure 1. (a) Animated image of the thick foams inside old headbands (b) The old headband used in experimental trials

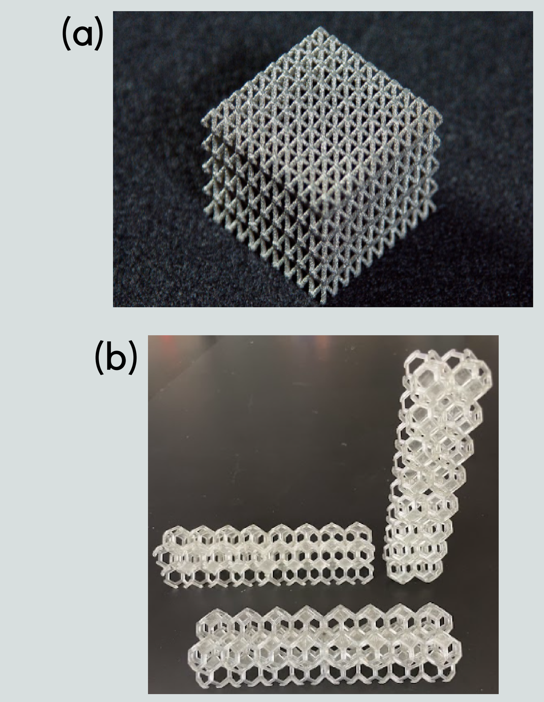

Figure 2. (a) Image of lattice cubed structure (b) The actual TPU and UV Resin blocks used inside the new headband

TRIAL DESIGN

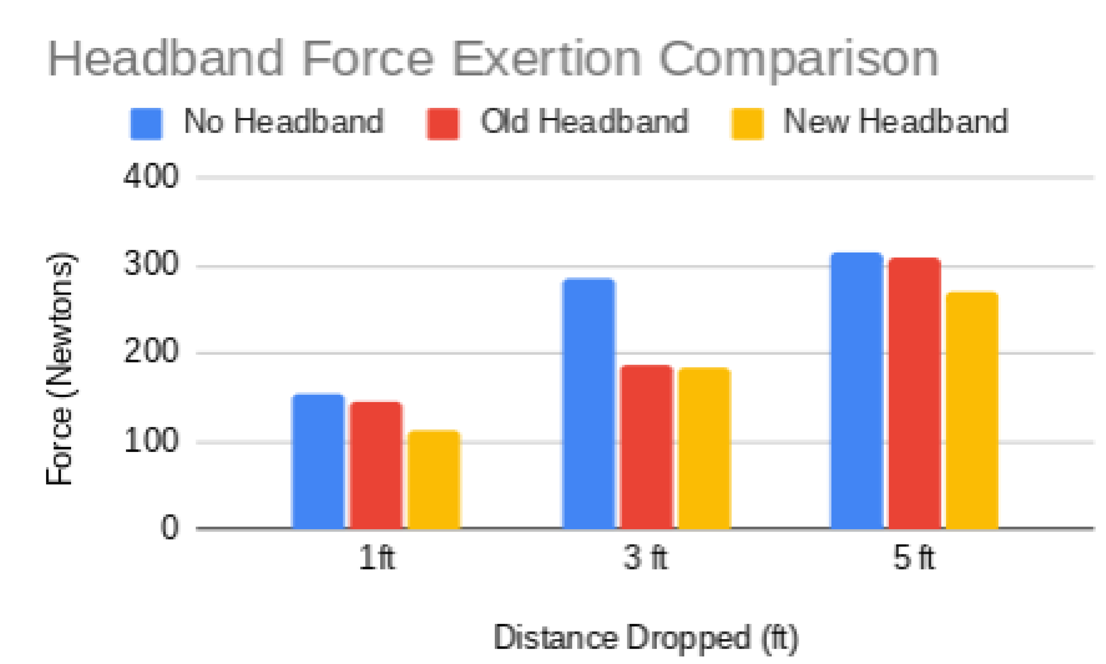

Figure 3. Multi-category bar graph displaying the difference in averages of force exerted from each of the three treatments tested

			No Headband	Old Headband	New Headband
	Average (N)	1ft	155.5333333	144.4	113.4
		3ft	286.3333333	186.1666667	183.8666667
		5ft	315.9	310.4	272.4333333
p-value	1ft	NO Headband		0.666979001	0.1520088387
		Old			0.1340586004
		New			
	3ft	NO Headband		0.01329389637	0.02318154343
		Old			0.9375262098
		New			
	5ft	NO Headband		0.8252455763	0.07877119052
		Old			0.07040742356
		New			

Figure 4. Chart comparing p-values between different treatments alongside their averages

RESULTS

Figure 3. (See figure section pg.5)

The treatment with the highest force with a 1 foot drop was the control (155.5 N) followed by the current model (144.4 N), while the lowest was the innovation (113.4 N). The treatment with the highest force with a 3 feet drop was the control (286.3 N) followed by the current model (186.17 N), while the lowest was the innovation (183.9 N). The treatment with the highest force with a 5 foot drop was the control (315.9 N) followed by the current model (310.4 N), while the lowest was the innovation (272.43 N).

Figure 4. (See figure section pg.5)

When comparing the 1 ft trials, the p-value comparing the old headband to no headband was 0.66698, the p-value comparing new headband to no headband was 0.15201, and the p-value comparing the new headband to the old headband was 0.13406. For the 3 ft trials, the p-value comparing the old headband to no headband was 0.01329 (reject null at alpha=0.05), the p-value comparing the new headband to no headband was 0.02318 (reject null at alpha=0.05), and the p-value comparing the new headband to the old headband was 0.93753. For the 5 ft trials, the p-value comparing the old headband and no headband was 0.82525, the p-value comparing the new headband to no headband was 0.07877 (reject null at alpha=0.1), and the p-value comparing the new headband to the old headband was 0.07041 (reject null at alpha=0.1).

ANALYSIS

Figure 3. (See figure section pg.5)

Overall, the force exertion comparing the two variables is as follows: From 1 ft the new headband absorbed 21.53% more force than the old headband, from 3 ft the new headband absorbed 1.075% more force than the old headband, and from 5 feet the new headband absorbed 12.23% more force than the old headband. For each of the thirty trials at differing heights, the new concussion headband performed slightly better than the control variable of no headband and the new headband variable. The amount of force exerted onto the plate was being measured to demonstrate how much force would be exerted onto the head in sports related (soccer in this case) collisions.

Figure 4. (See figure section pg.5)

For the statistical analysis portion, an alpha value of 0.05 (95% confidence) or 0.1 (90% confidence) was used to determine whether or not the null was rejected (ie. A p-value of 0.08 would mean failure to reject the null at an alpha of 0.05 but the null would be rejected with an alpha of 0.1). The null hypothesis was that there is "no difference between the two treatments" and the alternative hypothesis is that "there is a difference between the treatments". For the 1 ft p-values, all p-values were larger than alpha (0.1), so the results were not significantly significant. There was no evidence that the new headband performed better at absorbing force than the old headband or no headband. For the 3 ft p-values, the comparison between the old headband vs no headband and new headband vs no headband were both statistically significant. There was evidence that both headbands absorb more force than no headband. But, the comparison at 3 ft for the old headband vs new headband was not significant (p-value 0.93753 > alpha value 0.1). There is no convincing evidence that the new headband absorbs more force than the old headband at 3 ft. For the 5 ft p-values, the comparison between no headband and the old headband was not statistically significant because the p-value (0.82525) was greater than the alpha value (0.1). There was no convincing evidence that the old headband absorbed more force than no headband at 5 ft. But, the comparison of no headband vs new headband and new headband vs old headband yielded p-values that were statistically significant (0.078 & 0.07). So, there is evidence to suggest that the new headband absorbs more force that no headband and the old headband at 5 ft (alpha 0.1).

CONCLUSION

There is evidence to suggest that the force absorbed by the new concussion headband is slightly better that the force absorbed by the old headband. The combination of high shock absorbing structures and thicker fabrics clearly have the ability to put the head under less duress which is shown in the bar graph displaying the average forces exerted (figure 3).

While some of the results were not statistically significant, some of them were which shows that the new headband with different construction and materials did yield positive results that can be further built upon in the future. One way to possibly change the shock absorption power would be to look into and test different matrix densities. Also different materials should be looked into such as Elasto Plastics, a new flexible material by Shapeways (Starr, 2013)

Errors may have included an issue with the pressure sensor by not picking up correct measurements of force, not dropping the balls from the exact same height each time, hitting different spots on the pressure sensor, the headband being made of two different plastics/the drop test switching between the two, and the environment for testing was different.

In the future, there needs to be more testing performed with different velocities towards the variables. Different materials should be tested to find the most efficient one and differing thicknesses of lattice structures should be tested as well.

There are millions of kids and adults who play high level sports and the need for an improvement of concussion headbands is at an all time high. My innovation will allow people to play with a true sense of security.

RELATED LITERATURE

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PROJECT PROPOSAL

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