Tougher and more flexible material for sports protective gears

INTRODUCTION

It is a well-known fact that sports is good for our body and mind, but there is a also a risk of injuries. To protect us from cuts, bruises and fractures from sports such as skateboarding (Figure 1) and rollerblading, we should wear sports protective gears. Unfortunately, the sports protective gears available on the market today are often bulky and uncomfortable, so people, especially children and adolescents resist wearing them. In support for the United Nation's third Sustainable Development Goal "Ensure healthy lives and promote well-being for at all ages", more research should be put into developing tougher and more flexible material for sports protective gears.

Figure 1. Common sports for sports injuries, such as skateboarding

https://sdgs.un.org/goals/goal3

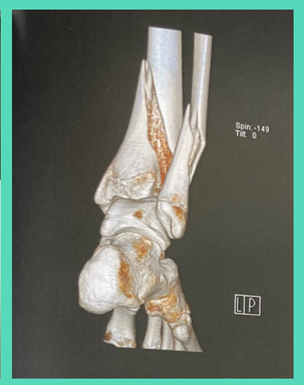
SPORTS INJURIES IMPACT

There are two common types of sports injuries that can happen. The first type is single impact injuries. The second type is repetitive stress injuries (Micheli & Klein, 1991). Children and adolescents are more prone to such injuries along or near growth plates in the skeleton due to growth.

A study showed that the sports responsible for most injuries in children and adolescents were either explosive and/or high-speed movements or physical contact with apparatus, equipment, or other players (Watkins J and Peabody P).

My own injury was a classic case for adolescents: single impact, high-speed physical contact with equipment and another skateboarder. The result was triplane fracture of the distal tibia near the growth plate on my right foot. I had knee and elbow protective gear on, but they did not cover the area of impact.

Figure 2. My own injury from skateboarding: triplane fracture of the distal tibia



PROTECTIVE GEAR - CURRENT PROPERTIES

The protective gear on the market today provides inadequate protection. They are inflexible, too tight, too hot (non-breathable material), move around too much, so children and adolescents do not like wearing them. Sometimes even when they are worn, they cannot really protect the wearer due to ill-fitting.

Common material used in off-the-shelf sports protective gears on the market today are:
• Foam • Pads • Gels • Metals • Plastics

PROTECTIVE GEAR - DESIRABLE PROPERTIES

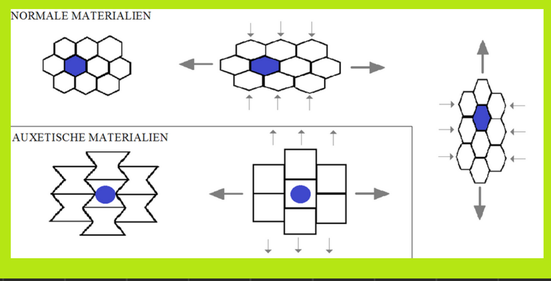
The proper use of protective gear with good fitting can reduce predisposition to trauma (Shuman & Meyers).

Good protective gear should be tough, flexible (do not hinder movement), adjustable, not move away from area needing protection, lightweight, and if possible, expend to protect the wearer at the impact site, like the airbag in a car - auxetic materials can do just that!

Current research of auxetic materials highlights its potential as personal protective equipment for sports apparel with enhanced properties such as conformability, superior energy absorption and reduced thickness (Moroney, Alderson, Allen, Sanami & Venkatraman).

Figure 3. Auxetic material when relaxed and stretched (Sanamia, Raviralaa, Aldersona & Alderson)

Figure 4. Normal material vs Auxetic material when stretched (Auxetics



AUXETIC MATERIALS

Auxetic materials are fascinating materials which, when placed under tension in one direction, become thicker in one or more perpendicular directions, as shown in Figure 3 and Figure 4, (Sanamia, Raviralaa, Aldersona & Alderson).

In mathematical terms, an auxetic material has a negative value of Poisson's ratio. Poisson's ratio is a measure of the Poisson effect, the phenomenon in which a material tends to expand in directions perpendicular to the direction of compression. When a rubber band is stretched, it becomes noticeably thinner and the Poisson ratio will be the ratio of relative contraction to relative expansion (a positive value). In contrast, auxetic materials expand when stretched which gives a negative value of the Poisson ratio (Poisson's ratio).

Figure 5. Poisson's ratio (Poisson's ratio)
Table 1. Poisson's ratio values for different materials (Poisson's ratio)

$$\nu = -\frac{d\varepsilon_{trans}}{d\varepsilon_{axial}} = -\frac{d\varepsilon_y}{d\varepsilon_x} = -\frac{d\varepsilon_z}{d\varepsilon_x}$$

where

- ν is the resulting Poisson's ratio,
- ε_{trans} is transverse strain
- ε_{axial} is axial strain

and positive strain indicates extension and negative strain indicates contraction.

Material	Poisson's ratio
Rubber	0.4999
Steel	0.27-0.30
Concrete	0.1-0.2
Foam	0.1-0.5
Auxetic material	< 0

In sports protective gear, if auxetic materials are used rather than foam, when the gear is are impacted with a concentrated load – such as a rock, stud or sports ball - they contract inwards, so material 'flows' to defend the impacted area (Allen, Winwood, Duncan, Adams, Karaganeva & Sabir).

CONCLUSION

Auxetic material may be the perfect answer for tougher and more flexible material for sports protective gears. More research and development should be done in order to support the United Nation's third Sustainable Development Goal "Ensure healthy lives and promote well-being for at all ages", and at an affordable price too.

REFERENCES

- L J Micheli and J D Klein. Sports injuries in children and adolescents. Br J Sports Med. 1991 Mar; 25(1): 6–9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1478799/pdf/brjsmed00025-0010.pdf
- Watkins J and Peabody P. Sports injuries in children and adolescents treated at a sports injury clinic. The Journal of Sports Medicine and Physical Fitness, 01 Mar 1996; 36(1):43-48. https://europepmc.org/article/med/8699837
- Kristin M. Shuman &Michael C. Meyers. Skateboarding injuries: An updated review. The Physician and Sportsmedicine Volume 43, 2015 - Issue 3. https://www.tandfonline.com/doi/abs/10.1080/00913847.2015.1050953
- Charlotte Moroney, Andrew Alderson, Tom Allen, Mohammad Sanami and Praburaj Venkatraman. The Application of Auxetic Material for Protective Sports Apparel. Presented at the 12th Conference of the International Sports Engineering Association, Brisbane, Queensland, Australia, 26–29 March 2018. Proceedings 2018, 2(6), 251; https://doi.org/10.3390/proceedings2060251. Published: 23 February 2018. https://www.mdpi.com/2504-3900/2/6/251
- Mohammad Sanamia, Naveen Raviralaa, Kim Aldersona, Andrew Alderson. Auxetic materials for sports applications. Procedia Engineering 72 (2014) 453 – 458. https://www.sciencedirect.com/science/article/pii/S1877705814005955
- Auxetics https://en.wikipedia.org/wiki/Auxetics
- Poisson's ratio https://en.wikipedia.org/wiki/Poisson%27s_ratio
- Tom Allen, Keith Winwood, Olly Duncan, Caroline Adams, Raya Karaganeva, Tasneem Sabir. Safety Equipment for Sport. https://www.mmu.ac.uk/research/our-impact/case-studies/safety-equipment-for-sport