

VIRTUAL EVALUATION OF A NOVEL FOLDABLE AND PRE-INFLATED HELMET CONCEPT

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1. Introduction

Helmet use reduces road traffic injuries and deaths [1]. However, inconvenience is a significant barrier to helmet use, particularly for users of shared micro-mobility vehicles [2]. To overcome this barrier, a novel concept called ‘pre-inflated helmet’ was developed relying on computer methods. It folds into a compact size, inflates with air using a manual or electric pump before use, and remains pressurised during use, Fig 1(a). We demonstrate its safety performance via virtual evaluation.

2. Materials and Methods

A virtual prototype of full-face, pre-inflated helmet was designed in CLO 3D software. Explicit dynamic analysis was conducted using LS-DYNA (LST, Livermore, CA, USA). To simulate the fully inflated helmet, the uniform-pressure technique was used, and no air leakage was assumed. The designated pressure was 220 kPa. The friction coefficients for both the helmet interior/headform and the helmet exterior/anvil were set at 0.6. The virtual evaluation adopted the same test method as Folksam’s consumer testing of bicycle helmets in Sweden [3] with both linear and oblique impact tests, Fig 1(b).

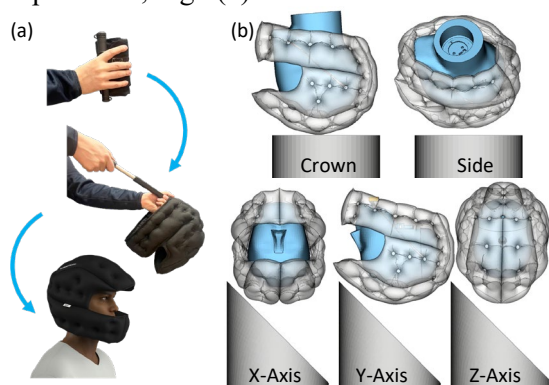


Figure 1: (a) pre-inflated helmet concept, (b) virtual evaluation under two linear impact and three oblique impact tests.

Simulations were run for 100 ms to allow head kinematics being fully captured even after impact. The head peak linear acceleration (PLA) and BrIC—kinematic predictors for skull fracture and brain injury, respectively—were computed and compared with results from 58 modern bicycle helmet models tested by Folksam in 2020, 2021 and 2023.

3. Results

The pre-inflated helmet performed well in linear impact tests, equivalent to the second and third best helmet model tested by Folksam; oblique impact tests led to mixed results, Fig 2.

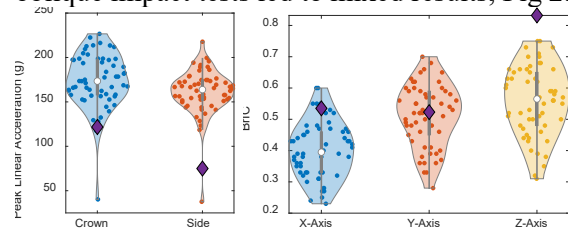


Figure 2: Virtual evaluation results of pre-inflated helmet (indicated by the diamond sign ♦) overlaid on the violin plots from 58 helmet models.

4. Discussion and Conclusions

The safety performance of the novel helmet concept was successfully demonstrated. Given its excellent portability and tunability (by pressure), the concept might remove barriers to helmet use and to increase head safety worldwide. Future work will evaluate the concept using human body models in omnidirectional impacts.

5. References

- Vecino-Ortiz AI et al., The Lancet. 2022 Jul 16;400(10347):237-50.
- Serra GF et al., AAP. 2021 Dec 1;163:106430.
- Stigson H et al., IRCOBI. 2017. p. 173-181.