DOES WEARING A CYCLE HELMET INCREASE THE RISK OF A CHILD SUSTAINING A ROTATIONAL HEAD INJURY?

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INTRODUCTION
The wearing of cycle helmets has continued to increase in popularity since their introduction in the 1970s, with many studies showing that head injury can be significantly reduced by their use [1]. Less is known, however, about the benefits or even risks of wearing a helmet on specific types of head injury, for example, does wearing a helmet, whilst protecting the head from translational injury, predispose the head to a greater risk of rotational injury? Wearing a helmet increases the effective diameter of the head and thus, creates a potentially greater rotational moment about the centre of rotation, during an oblique impact. Review of the literature confirms that doubts exist, amongst the scientific community, as to how well a cycle helmet can protect the head from rotational injury [2]. Previous studies cannot categorically state that cycle helmets pose no increased risk, since the response of the un-helmeted human head is unknown, during an oblique impact. Thus, this study was conducted, to investigate and compare both the response of a child’s un-helmeted and helmeted head during simulated oblique impact, with a view to determining whether there is an increased angular acceleration associated with helmet use, and if so, whether there is a significantly increased risk of rotational head injury.

METHODS
The peak incidence of cycle accidents, with respect to age, occurs at around 10 years, with the vast majority of children being male. To develop an appropriate biofidelic head model, data was obtained from Mertz et al [3] to create a headform corresponding to a 50th percentile male 10-year-old. Solidworks™ was used to create a 3D model headform, which was imported into the simulation software MSC ADAMS™. Properties including mass, inertia, centre of gravity, and impact characteristics were obtained from the literature, and validated by simulation in ADAMS™. The headform was validated against previous data, by relating the drop height to the induced linear acceleration. Two market leading cycle helmets, representing the lowest and highest cost, were investigated, that is, the Bell Jumpstart™ and Bell Faction™, respectively. Three-dimensional CAD helmet models were developed and subsequently imported into ADAMS™. This method was chosen over physical testing, since physical test values were available in the literature [2], and simulation would allow a greater number of test perturbations to be investigated, compared with physical tests, with no associated destruction of the helmets. Individual parameters were easily changed to provide a wide range of test scenarios. Thus, validation of contact parameters was performed, by comparing previously acquired values from physical helmet tests with simulated scenarios. Three oblique contact scenarios were created; the orientations were chosen to represent the three different anatomical planes, about which the head could theoretically rotate during an impact, i.e., nose-down impact, side impact and vertex impacts, shown Figure 1.

RESULTS AND DISCUSSION
Peak angular and linear accelerations were measured and their corresponding Head Injury Criterion (HIC) values calculated for oblique impacts, shown in Figures 2 and 3, respectively. Inclusion of cycle helmets was observed to lower the magnitude of both the linear and angular accelerations of the head compared to the un-helmeted head. Helmet use, reduced linear acceleration values by an average 54 g and angular acceleration values by an average 3295 rads². Since the reduction in angular acceleration, between helmeted and un-helmeted head forms, was not particularly great, it is recommended that oblique helmet impact tests be introduced into current cycle helmet standards. Additionally, cycle helmets with a low coefficient of friction, for helmet against anvil, yet larger mass, offered the best protection against both rotational and translational head injuries. Optimisation is suggested by further research, to establish a more accurate representation of head friction, including hair and scalp movement and chin-strap interaction.

CONCLUSIONS
It was found that for oblique impacts, the use of a cycle helmet reduces the magnitude of both linear and angular accelerations of the head. As the difference in angular acceleration between helmeted and un-helmeted headforms was not particularly great, it is advised that an oblique helmet impact test be introduced into current cycle helmet standards. Cycle helmets with a low coefficient of friction, yet larger mass, were observed to offer greater protection against both rotational and translational brain injuries. Further research is recommended to establish a more accurate approximation of head friction, including hair and scalp movement; thus improving the biofidelity of both un-helmeted and helmeted headform simulations.

REFERENCES
Figure 1: Three oblique impact scenarios.

Figure 2. Peak angular accelerations observed for each impact scenario.

Figure 3. Peak linear accelerations observed for each impact scenario.