Fit and Positioning of Bicycle Helmets for Children

Tom Whyte, Peter Cripton, Lynne Bilston, Julie Brown

I. INTRODUCTION

Head injuries are the leading cause of death and disability for children older than 1 year of age and one of the most common reasons for paediatric presentation to the emergency department [1]. Pedal cycling accounts for more than 10% of head injury hospitalisations among Australian children [2]. Children from 2 to 9 years old (yo) have the highest levels of cycling participation in the population [3] and child bicycle seats and trailers designed to transport children from as young as 1yo are becoming increasingly common [4].

Poor helmet positioning (Fig. 1) when a head impact occurs can leave the wearer's head unprotected, particularly the most commonly impacted frontal and temporal regions. Misuse of helmets, leading to poor helmet positioning, is very common among children. Up to 87% of children misuse helmets, including posterior positioning observed on 40% of child bicyclists and incorrect chinstrap fastening on 60% [5]. Only 4% of children could achieve correct helmet use at a regular health checkup, even when helped by a parent [6]. Children are twice as likely to have their helmet incorrectly worn compared to adults [7].

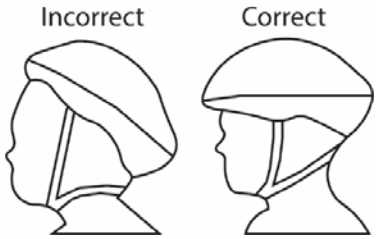

Fig. 1. Helmet misuse (left) and correct placement (right).

Poor helmet position in an impact can stem from a number of sources: an initial poor helmet position; active mispositioning by the wearer during normal use (e.g. due to discomfort); and/or passive mispositioning prior to impact (e.g. due to improper sizing or incorrect chinstrap fastening). The underlying issues include poor cranial fit, poor chinstrap design and chinstrap misuse (poorly adjusted, loose or unfastened).

Helmets designed for children are typically adult helmets scaled down to child head circumferences [8]. However, head shape, neck size and facial structure development is complex and not linearly related to head circumference. Currently available helmet liners and retention straps may not have been designed using appropriate anthropometric data. Discomfort is one of the most commonly cited barriers to bicycle helmet use among children [9], pointing to a clear consumer need for improved fit.

The aim of this study is to investigate the fit of bicycle helmets for children and the factors affecting helmet positioning during normal use.

II. METHODS

Helmet fit

Children aged 1–9yo who had recently been bicycle operators or passengers and who have their own standards-approved bicycle helmet were recruited from the local community. A handheld 3D surface scanner (Structure, Occipital Inc.) was used to scan the head and neck of participants to produce surface meshes in up to three conditions: as they normally wear their helmet; with their helmet positioned correctly (if different from the normally worn position); and unhelmeted. In the unhelmeted position, participants wore a polyester swim cap on their head to conform to their head shape and flatten hair. 3D surface scans were also obtained for the helmets (both interior and exterior).

The helmeted head surface meshes were used to register the location of the individual unhelmeted head and helmet meshes. Once positioned, the helmeted head mesh was removed and the helmet fit examined by taking cross-sections of the helmet and head meshes and examining the difference in head-helmet shape and size.

Helmet positioning

Video monitoring equipment, which was attached to the bicycle of either a child passenger or child bicyclist,

T. Whyte (t.whyte@neura.edu.au, +61 410 063 508) is a postdoctoral fellow and L. Bilston is Senior Principal Research Scientist at Neuroscience Research Australia. P. Cripton is Professor of Mechanical and Biomedical Engineering at the University of British Columbia. J. Brown is Head of the Injury Division at the George Institute for Global Health.

focused on the child as they rode or were carried by bicycle. Paediatric bicycle operators rode their bicycle in a local bicycle track for 15 minutes. Adult operators carrying child passengers undertook a standardised 15-minute ride on a predefined route in the local area, primarily on separated and shared bicycle paths. Child passengers were carried in either a rear-mounted bicycle seat attached to a standard bicycle or seated behind the adult operator on a cargo bicycle. Observations regarding helmet positioning were made from the video footage. For example, observations were related to the degree to which the helmet moved on the head or the chinstrap changed from being correctly adjusted during normal activity (passive mispositioning) and whether the participant moved or adjusted the helmet shell or chinstrap (active mispositioning).

III. INITIAL FINDINGS

At present, data have been collected from a sample of child bicycle riders and passengers (n=11). Suboptimal helmet-wearing position was observed for several participants (e.g. Fig. 2). Analysis of the head-helmet fit in cross-sections related to the as-worn and correct positions (Fig. 2) indicates that the helmet provided a better fit when incorrectly positioned posteriorly based on a closer match between helmet length and head length in this position (176 mm) compared to the longer head length when in the correct position (192 mm). Preliminary observations during the riding tasks indicate passive mispositioning can occur among bicycle operators, while active mispositioning may play a role for child passengers (Fig. 3).

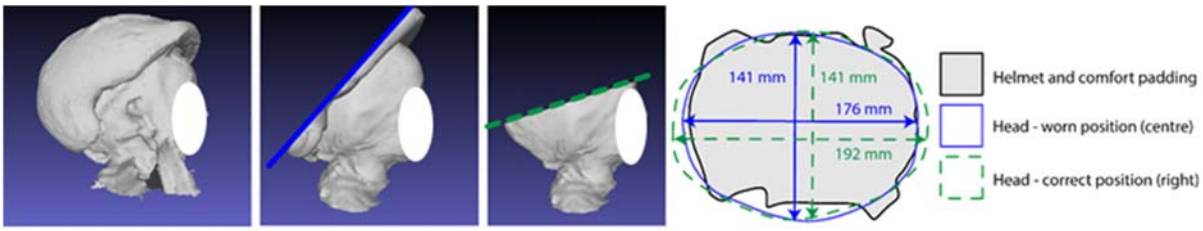

Fig. 2. Helmeted head 3D surface scan (left), cross-sections in the as-worn (solid blue line) and correct (dashed green line) helmet positions and cross-section profiles of the helmet and head in each condition (right).

Fig. 3. Poor helmet position and chinstrap misuse developed during normal riding (left, passive mispositioning) and intentional helmet movement while carried as a passenger on a cargo bike (right, active mispositioning).

IV. DISCUSSION

This study identifies potential deficiencies in helmet designs for children that may negate the protective benefits of the helmet (i.e. if it is not engaged during a head impact event). Upon collection of more data and continuing work to define measures explicitly identifying poor fit and poor positioning, it may be possible to link specific head-helmet fit factors to user behaviour (prevalence of active mispositioning), thus providing targets for addressing helmet misuse. Development of child-specific helmet specifications to improve fit and comfort and to reduce the potential for developing a poor helmet position may reduce the burden of paediatric head injury.

V. REFERENCES

[1] Faul, M., *et al.*, CDC report, 2010.
[2] Bierbaum, M., *et al.*, *Health Promot J Austr*, 2018.
[3] Munro, C., Austroads report, 2017.
[4] Oxley, J., *et al.*, *Traf Inj Prev*, 2016.
[5] Klug, C., *et al.*, IRCOBI, 2015.
[6] Parkinson, G. W. & Hike, K. E., Pediatrics, 2003.
[7] Thai, K. T., *et al.*, *Traf Inj Prev*, 2015.
[8] Olvey, S. E., *et al.*, Motorsports Engineering Conference & Exposition, 2006.
[9] Finnoff, J. T., *et al.*, Pediatrics, 2001.