A Physical Test Method to Evaluate Pelvis Protection for Motorcyclists

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I. INTRODUCTION

Pelvic injuries are sustained by approximately 13% of crash-involved motorcyclists [1]. These injuries have the potential to lead to significant long-term health impairments, such as chronic pain and reduced quality of life [2].

The primary mechanism for pelvic injury to riders is contact with the fuel tank, which is attributed to 85% of pelvis injury cases [3]. This is most evident in frontal motorcycle crashes, where clear damage and markings on the fuel tank are often observed. Previous work has shown that injury severity occurs across a spectrum from soft tissue injury to severe, complex pelvic fractures related to impact speed, with greater speeds associated with more complex injuries [3]. This suggests that there is potential to prevent or to reduce the severity of pelvic injury to riders by better managing energy during pelvic/fuel tank impacts.

Impact protection within motorcycle clothing is a measure designed to protect motorcyclists when they crash. The intention of impact protection is to redistribute and absorb the impact energy transferred to the rider's body to reduce the load below tissue tolerances. Impact protectors are usually worn on the knees and lower legs, elbows, shoulders, hips and back. To our knowledge, there has not yet been any attempt to provide impact protection to the pelvic region of motorcycle riders.

The aim of this study was to develop a physical test method for investigating the potential for motorcyclist impact protectors to mitigate the risk of pelvis injury in a frontal crash. The focus was on low-speed (20 km/h) frontal crash impacts that are expected to result in soft tissue injury to the pelvic region.

II. METHODS

A sled-on-sled test setup was designed to simulate the interaction between the pelvis and a motorcycle fuel tank in a frontal motorcycle crash (Fig. 1). A wood fuel tank surrogate was constructed to mimic the fuel tank shape and angle of a common sports motorcycle in Australia (Honda CBR) and to provide a repeatable impact opponent to evaluate impact protection. The fuel tank surrogate was affixed to the sled table of a deceleration sled. A mini-sled was also affixed to the main sled table. A pelvis surrogate was mounted to the mini-sled by a steel frame. The pelvis surrogate included the upper legs, pelvis, abdomen and lumbar spine components of the THOR anthropometric test device. New soft tissue components for the pelvis and upper legs, separating these components, were moulded from a silicone rubber previously used to replicate the impact response of human thigh tissue [4]. Two triaxial accelerometer arrays were mounted to the pelvis surrogate at the rear of the lumbar spine components.

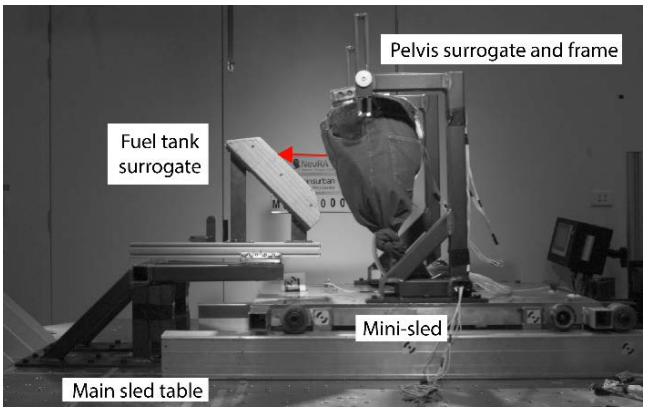

Fig. 1. Physical test method components and direction of travel of pelvis surrogate into fuel tank surrogate (red arrow).

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The main sled table was accelerated to 20 km/h before being decelerated. The mini-sled and pelvis surrogate continued at 20 km/h toward the fuel tank, resulting in an impact. The frame on the mini-sled allowed the pelvis surrogate to rotate and translate upward from the sled table. The pelvis surrogate was clothed with standard jeans, without any impact protection, for initial testing.

III. INITIAL FINDINGS

The kinematics of the pelvis/fuel tank impact can be seen in Fig. 2. The change in resultant translational velocity and sagittal plane rotational velocity of the pelvis surrogate is pictured in Fig. 3.

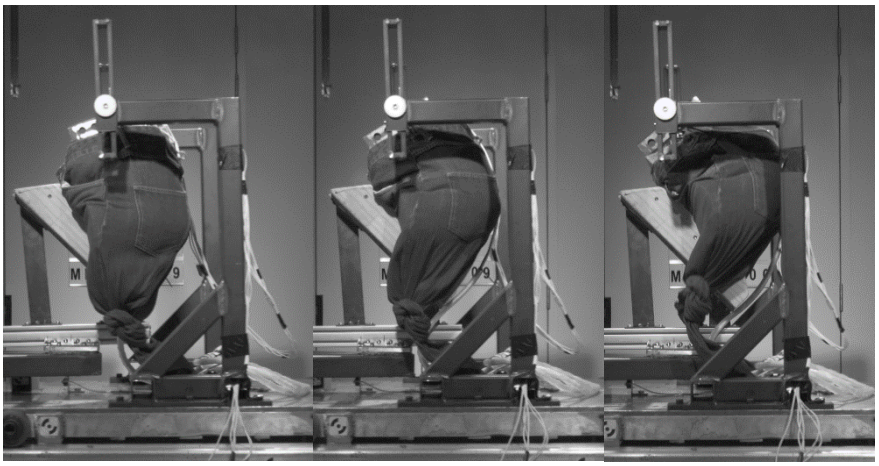

Fig. 2. Sequence of images at 10 ms, 20 ms and 30 ms (left to right) from initial contact between the tank and pelvis surrogates.

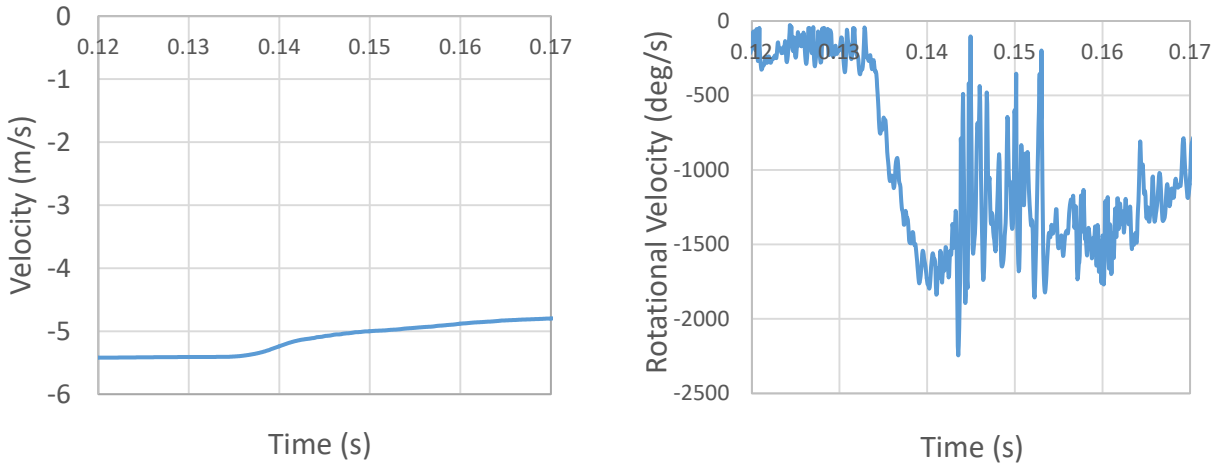

Fig. 3. Resultant translational velocity (left) and sagittal plane rotational velocity (right) response of the pelvis surrogate.

IV. DISCUSSION

There are many uncertainties at present, given the current limited knowledge of the biomechanical response and injury tolerance of the pelvis in this load condition, as well as limited study on the dynamic kinematics resulting from fuel tank impacts. Nevertheless, this physical test method provides a starting point for examining the potential for impact protection to reduce the risk of pelvis injuries to motorcyclists in a frontal crash. A collection of pelvis protector prototypes made from different materials and thicknesses will be evaluated in upcoming testing.

V. REFERENCES

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