

Comparison of the Kinematics and Dynamics of the THOR-50M Dummy and Elderly Volunteers in Low-Speed Frontal Decelerations

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I. INTRODUCTION

Advances in health care, technology, housing, nutrition and education have contributed to an increase in life expectancy worldwide. While in 2012 only 17% of Europeans were older than 65 years of age, this percentage is predicted to rise to 28% in 2020 [1]. In addition to the increased exposure to traffic, elderly road users are more fragile and frailer [2] and they experience a longer and more complicated recovery from injuries than younger car occupants, regardless of the affected body region [3]. The growing market introduction of advanced automated functions in contemporary cars suggests that crash speeds may be lowered in the near future. This study compares the kinematics and dynamics of elderly volunteers and the THOR-50M dummy in low-speed frontal decelerations.

II. METHODS

Experimental Testing

The test fixture used in the study approximated the seating position of a car occupant (passenger configuration) in a simplified manner that allowed the use of motion capture to quantify the occupant's kinematics. The fixture consisted of a rigid foot-restraint, a rigid non-flat seat, and a metal-wire flexible seat-back [4]. A three-point seat belt (non-force-limited, non-pretensioned) was used to arrest the forward motion of the test subjects (Fig. 1). All these parameters were designed within the SENIORS project. The sled deceleration pulse was chosen to ensure a safe environment for the volunteers [5]. It consisted of a trapezoidal pulse with a plateau around 3.5 g over approximately 60 ms and a total duration of 120 ms, resulting in a nominal delta-v of 8.8 km/h. The interaction between the occupant and the fixture was recorded using load cells under the seat pan and the footrest and three gauges measured the tension at three different locations on the seat belt. Volunteers were fitted with a head strap incorporating three linear accelerometers and three angular rate sensors. Approximately 40 data channels were recorded in the THOR-50M dummy. All data were acquired at 10,000 Hz and processed and filtered following SAE J-211 defined procedures.



Fig. 1. Initial position of test surrogates in the sled.

Volunteers and the THOR-50M dummy

Four male elderly volunteers (age > 65 YO) were recruited for this study. Recruiting and test protocols were reviewed and approved by CEICA (Ethical Commission for Clinical Research of Aragon), the official institution providing assessment for research involving human subjects in Aragon (Spain). Table I shows the main characteristics of the volunteers included in the study. Each volunteer and the THOR-50M dummy was exposed to three repeats of the same pulse. Data were mass-normalised to the size of a 50th percentile and are shown as average and standard deviation corridors.

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TABLE I
SUBJECT CHARACTERISTICS

Subject	Age	Stature (cm)	Weight (kg)
Vol 06	71	164.0	81.0
Vol 07	71	176.5	99.1
Vol 08	85	165.3	78.2
Vol 09	67	169.0	88.2
THOR-50M	--		82.0

III. INITIAL FINDINGS

Shoulder seat-belt forces

The THOR-50M dummy engaged slightly earlier with the seat belt and the peak average upper shoulder belt force was lower than that measured in the volunteers (1131 N vs 1252 N). Figure 2 (left) shows the average force value (solid line) and the corridor corresponding to ± 1 standard deviation, and illustrates that the corridors overlap for most of the duration of the deceleration.

Head kinematics in the sagittal plane

Figure 2 (right) shows that the THOR-50M peak forward excursion of the mid-point between the bilateral External Auditory Meatus (EAM) was substantially higher than that observed in the volunteer tests.

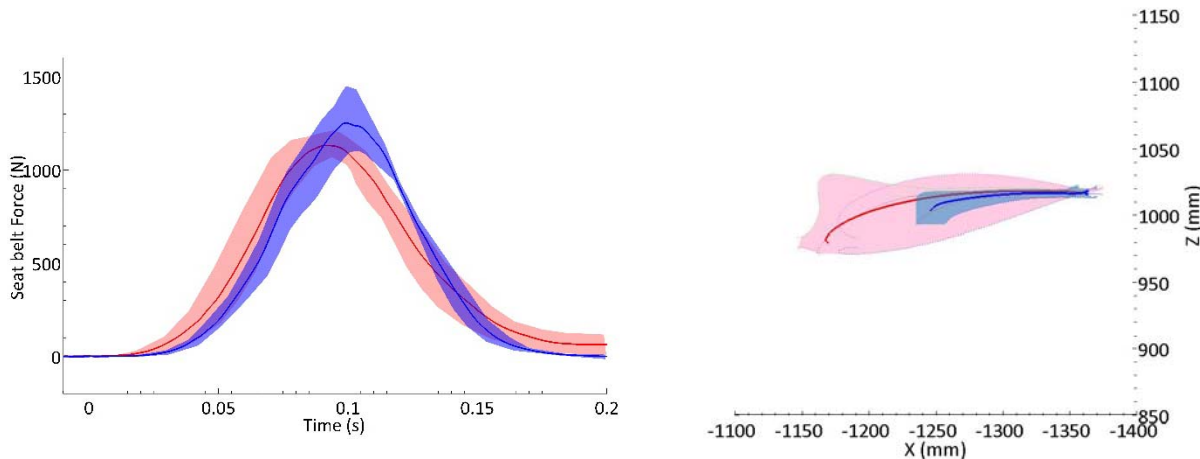


Fig. 2. Left: time history of upper shoulder-belt force. Right: comparison of sagittal trajectories of the head EAM. Both: THOR-50M (red) and volunteers (blue).

IV. DISCUSSION

The THOR-50M approximated accurately the shoulder-belt forces experienced by the elderly volunteers, but failed to capture the kinematics of the head in the sagittal plane. This is most likely due to the volunteers' neck muscle activity, which greatly influenced the trajectory of the head, especially at this low-speed configuration.

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VI. REFERENCES

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