# How Well does the Latest Anthropomorphic Test Device Mimic Human Impact Responses?

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One of the goals of the NASA Occupant Protection Group is to understand the human tolerance to dynamic loading. This knowledge has to come through indirect approaches such as existing human response databases, anthropometric test devices (ATD), animal testing, post-mortem human subjects, and models. This study investigated the biofidelity of the National Highway Traffic Safety Administration's ATD named the THOR (test device for human occupant restraint). If THOR responds comparably to humans, then it could potentially be used as a human surrogate to help validate space vehicle requirements for occupant protection.

The THOR responses to frontal and spinal impacts (ranging from 8 to 12 G with rise times of 40, 70, and 100 ms) were measured and compared to human volunteer responses (95 trials in frontal and 58 in spinal) previously collected by the U. S. Air Force on the same horizontal impact accelerator. The impact acceleration profiles tested are within the expected range of multi-purpose crew vehicle (MPCV) landing dynamics. A correlation score was calculated for each THOR to human comparison using CORA (CORrelation and Analysis) software. A two-parameter beta distribution model fit was obtained for each dependent variable using maximum likelihood estimation.

For frontal impacts, the THOR head x-acceleration peak response correlated with the human response at 8 and 10-G 100 ms but not 10-G 70 ms. The phase lagged the human response. Head z-acceleration was not correlated. Chest x-acceleration was in phase, had a higher peak response, and was well correlated with lighter subjects (Cora = 0.8 for 46 kg vs. Cora = 0.4 for 126 kg). Head x-displacement had a leading phase. Several subjects responded with the same peak displacement but the mean of the group was lower. The shoulder x-displacement was in phase but had higher peaks than the human response.

For spinal impacts, the THOR head x-acceleration was not well correlated. Head and chest z-acceleration was in phase but had a higher peak response. Chest z-acceleration was highly correlated with heavier subjects at lower G pulses (Cora = 0.86 for 125 kg at 8 G). The human response was variable in shoulder z-displacement but the THOR was in phase and was comparable to the mean peak response. Head x- and z-displacement was in phase but had higher peaks. Seat pan forces were well correlated, were in phase, but had a larger peak response than most subjects.

The THOR does not respond to frontal and spinal impacts exactly the same way that a human does. Some responses are well matched and others are not. Understanding the strengths and weaknesses of this ATD is an important first step in determining its usefulness in occupant protection at NASA.