Influence of the additional inertial load of the torso on the mine blast injury

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I. INTRODUCTION

Currently, the majority of underbelly blast test of vehicles is carried out according to STANAG 4569 with the use of 50th percentile male anthropomorphic test device Hybrid III and DRIz criterion based on the acceleration profile [1]. Another important measure of injury risk is the axial force and acceleration rate [2]. In practice, the soldiers often wear additional equipment increasing their weight, such as massive bulletproof vests. The influence of such additional load of the torso on the DRIz and axial force values was investigated.

II. METHODS AND RESULTS

The effect of occupant weight and additional inertial load of the thorax was initially examined with the use of an analytical model based on DRIz for idealized acceleration profiles. Three blast attenuation strategies were tested (Fig. 1): the constant damping force set for 50th percentile occupant (F=const), the constant damping force proportional to the real mass of occupant *M* (F~M), and constant damping force proportional to the measured total mass of the occupant with additional mass of the vest *m* (F~M+m). The risk variation was calculated as the ratio of actual strain of spine R_1 to the strain of spine for 50th percentile occupant without additional mass R_0. The influence of the mass of the bulletproof vest on DRIz values also was checked numerically on 50th percentile ATD in LS-Dyna. The response of the ATD wearing 18kg vest for acceleration up to the velocity 5m/s is depicted in figure 2 in comparison to the ATD without additional mass.

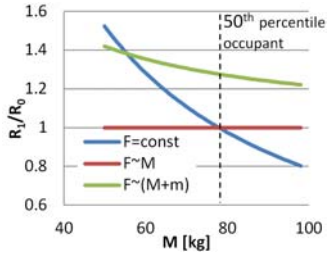

Fig. 1. Increase in the strain of spine as a function of the occupant mass *M*

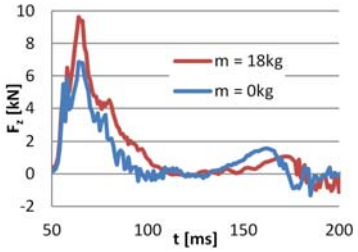

Fig. 2. Axial force in ATD lumbar spine with and without a vest

Table 1. DRIz values and axial spine forces (LS-Dyna)

	vest mass		
	0kg	18kg	
DRIz	20.7	19.1	-7.7%
F_z [kN]	6.87	9.63	+40%

The risk is independent from the mass of the vest for the blast attenuating seats with constant damping force adjusted for 50th percentile occupant, but increases for lighter occupants. The damping force adjusted for the actual mass of the occupant offers a constant level of the risk. In the case of the damping force adjusted automatically for the measured weight of the occupant (with the vest), the risk is the highest in almost full range of the occupant mass. Because of the vest weight, the damper is adjusting for an occupant heavier than the actual one.

Numerical simulations indicate that increasing mass of the torso by 18kg causes 40% increase in spine load for similar load conditions, while DRIz value measured by the STANAG test decreases (Table 1).

III. DISCUSSION

The standard STANAG 4569 test of the spine protection during blast events can underestimate the risk of the spine injury. Usage of the heavy bulletproof vest increases the effective mass of the torso and compression of the spine. The blast attenuating seats with damping force automatically adjusted to the measured weight of the occupant are dangerous for soldiers wearing heavy bulletproof vests.

IV. REFERENCES

[1] NATO AEP-55, Procedures for evaluating the protection level of logistic and light armoured vehicle for mine threat, 2006

[2] Stemper B., Baisden J., Yoganandan N. Effect of Loading Rate on Injury Patterns During High Rate Vertical Acceleration, IRCOBI Conference, 2012

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