Evaluation of a Novel Test Setup to Assess Injury Risk for Standing Occupants in Underbelly Mine/IED Injury Risk Assessment Tests

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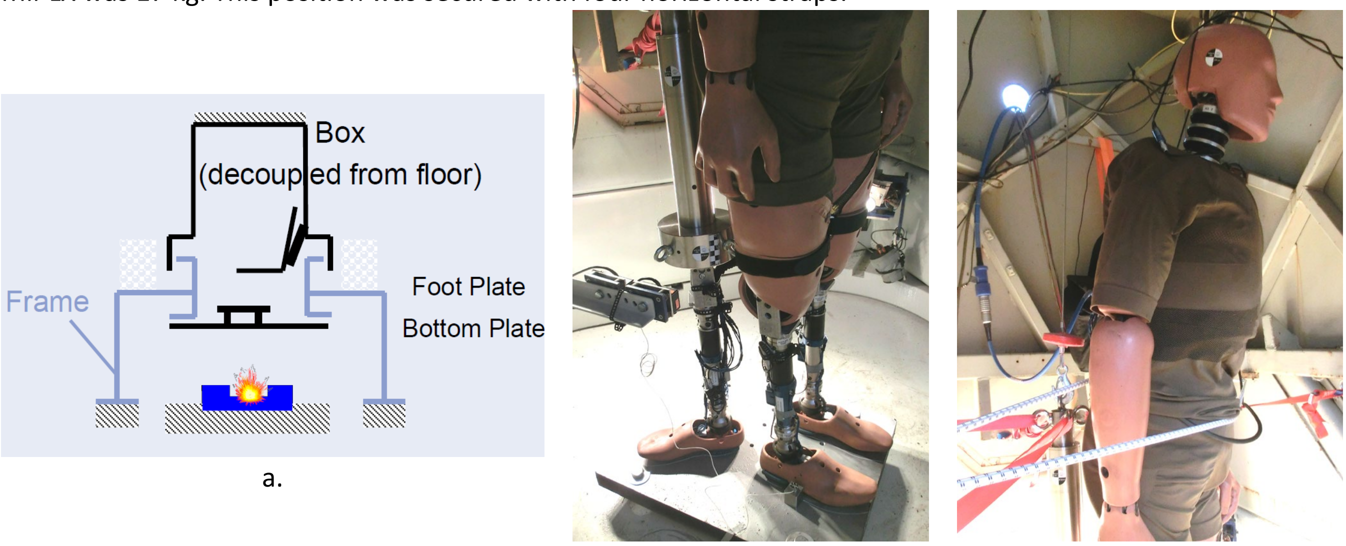
I. INTRODUCTION

TNO has developed a standalone standing lower leg test setup (St-Mil-LX) [1], using the Military Lower Extremity (Mil-LX), for assessing the protection level of standing positions in military vehicles against mine/Improvised Explosive Device (IED) Underbelly blast (UBB) threats. STANAG 4569, Protection Levels for Occupants of Logistic and Light Armoured Vehicles [2], requires full-scale vehicle testing with seated Anthropomorphic Test Devices (ATDs) but is lacking a requirement for standing occupants, which are common in some military vehicles. Previous trials to use the pedestrian 50th percentile Hybrid III (HIII-Ped) showed poor repeatability due to stabilising difficulties of the standing position in vehicle testing.

The effective mass of the HIII-Ped on the lower leg was previously determined by comparing tests of the HIII-Ped with the tests of the St-Mil-LX on the Mine Blast Simulator (MBS) [1]. Now, the response of the St-Mil-LX is further compared with the HIII-Ped in side-by-side tests in the Test Rig for Occupant Safety System (TROSS) to gain insight into the response of the St-Mil-LX in a loading scenario that has been used in the past to simulate actual vehicle responses to UBB.

II. METHODS

The HIII-Ped was fitted with two Mil-LX (HII-Ped-LX) and placed alongside the St-Mil-LX in the TROSS. The TROSS is a test rig that simulates full-scale vehicle floor plate responses to UBB, with detonations of scaled charges (Fig. 1a). The HIII-Ped-LX was placed standing, with tightened joints as worst-case scenario. Horizontal front straps were used to position the HIII-Ped-LX, while maintaining the full mass of the HIII-Ped on the two Mil-LX (Fig. 1b and 1c). Similarly, the St-Mil-LX was placed in the TROSS (Fig. 1b and 1c) and was vertically aligned using tilt sensors at the foot, distal and proximal end of the lower leg. The mass of St-Mil-LX, loading the Mil-LX was 17 kg. This position was secured with four horizontal straps.



a. b. c.

Fig. 1. a.) schematic view of the TROSS. b.) Lower part of St-Mil-LX (left) and HIII-Ped-LX (right). c.) Upper part of St-Mil-LX (left) and HIII-Ped-LX (right).

Both test objects were subjected to scaled detonations of five different charge masses, each one performed

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three times. These tests were performed by the WTD91 and IABG.

III. INITIAL FINDINGS

The average maximum upper tibia force of the St-Mil-LX and the HIII-Ped-LX versus the average peak floor velocity are reported (Fig. 2). The average upper tibia forces of the St-Mil-LX resulted in a +11 N; +0.58% (for 2.5 m/s) to +554 N; +15.8% (for 4.3 m/s) difference compared to the left leg of the HIII-Ped-LX. The average upper tibia forces of the St-Mil-LX resulted in -97 N; -4.9% (for 2.5 m/s) to +407 N; +11.1% (for 4.3 m/s) difference compared to the right leg of the HII-Ped-LX. The average upper tibia force differences between the left and right leg of the HIII-Ped-LX ranged from -253 N; -7.1% (for 3.6 m/s) to 56 N; +4.3% (for 1.8 m/s).

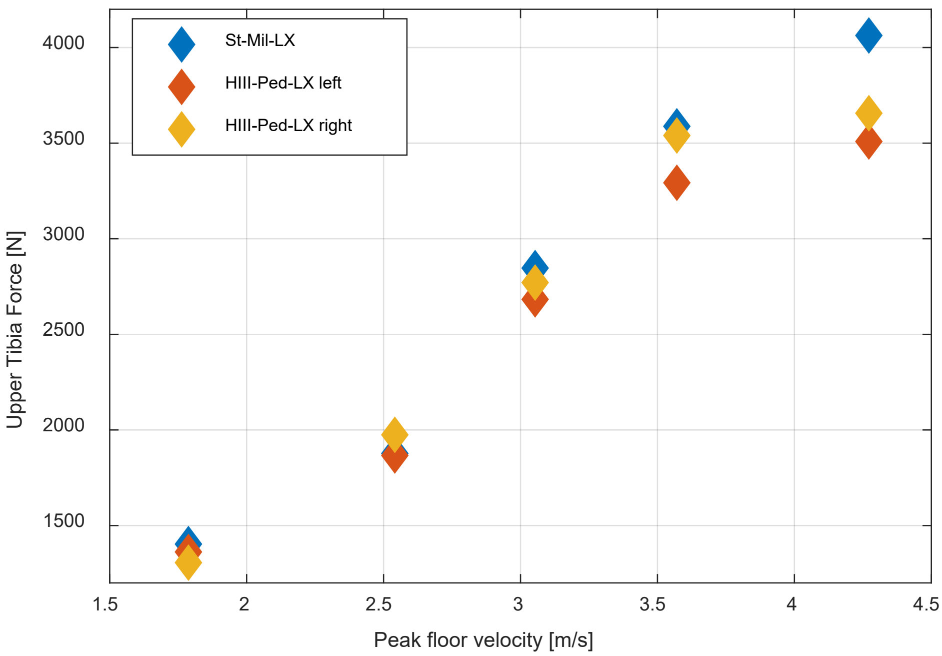

Fig. 2. Average upper tibia forces of the HIII-Ped-LX and St-Mil-LX

IV. DISCUSSION

These tests provided more insight into the response of the St-Mil-LX compared to the HIII-Ped-LX. These are the first tests using a different loading setup, as the mass of the St-Mil-LX was determined only on the MBS. The differences between the two setups below the 2.6 kN (proposed St-Mil-LX injury criterium [3]) are small. These results do show a larger difference between the St-Mil-LX and HIII-Ped-LX in average tibia upper forces compared to the MBS tests, which had a +1.8% to +4.6% difference [1]. It will have to be analysed why these differences between the MBS and TROSS tests occurred and what an acceptable difference would be between different loading setup, as well as the St-Mil-LX and HIII-Ped-LX.

The analysed tests do not include boots, while STANAG 4569 tests use boots for the seated ATD. While the Mil-LX is less sensitive to combat boots compared to the HIII lower leg [4], the setup needs to include the effect of boots in some way.

The repeatability of the St-Mil-LX has not yet been analysed in these tests. Further analyses of the test parameters are recommended to form conclusions about the repeatability. Furthermore, the reproducibility of the setup still needs to be investigated.

V. REFERENCES

[1] Westerhof, T. A. T., *IRCOBI*, 2020.
[2] NATO Standardization Agency, 2014.
[3] HFM-271, NATO Standardization Agency, to be published 2021.
[4] Pandelani, T., PASS, 2010