Relative contribution of bulk, stiffness, & load weight of PPE on soldier performance

3rd ICSPP Soldier Burden Conference Abstract

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Introduction. Enemy threats and counter-insurgency operations have dramatically increased the focus on soldier personal protective equipment (PPE) and its critical role in ensuring survivability, vulnerability to enemy threat, and mission outcome. While soldier ensemble provides essential protection, it can also interfere with a soldier's ability to tactically manoeuvre and accomplish mission critical tasks. Significant knowledge gaps persist, with respect to the relative contributions of load weight, bulk, and stiffness associated with soldier ensemble design to operational task performance. *Load weight* refers to the skin-out weight and load distribution carried by a solider; *Bulk* is defined as the additional spatial volume of equipment; and *Stiffness* refers to the malleability or elastic properties of material and/or equipment. These attributes can be difficult to isolate, quantify and evaluate their individual contribution to performance and mobility. Little is known about the performance degradation or costs of the cumulative or inter-dependent effects of these physical stressors on the soldier. **Objective**. The objective of this work was to differentiate and quantify the effect of bulk, stiffness and load weight, each systematically donned about the soldier's torso, on operational task performance. **Methods**. The effects of encumbrance on military representative tasks were quantified by the Canadian Load Effects and Assessment Program (CAN-LEAP) of 17 infantry and combat engineer soldiers of the Canadian Armed Forces (CAF) with a range of body sizes. Participants donned a baseline condition of fatigues only, followed by an experimental vest filled with soft ballistic fills: i) a Bulk Fill that was 20 mm in thickness, and ii) a Stiff Fill that was 6 mm. Both fills had a mass of 2.8 kg and equivalent ballistic protection; conversely, the malleability of the fills differed significantly. Load weight conditions comprised of the addition of a tactical vest equipped with full fighting order and a C7 weapon (total weight of 14.4 kg) to the two fill levels of experimental vests. **Results**. A 2-factor, repeated measures analyses of variance (ANOVA) demonstrated that total course time was sensitive to the difference between bulk (282.1± 48.7 sec) and stiffness (274.4 ± 49.2 sec) effects in the presence of a load weight, but not as isolated, independent effects (Bulk Fill: 198.5 ± 34.1 sec; Stiff Fill: 198.6 ± 29.7 sec). Individual obstacle times differed between the load weight conditions, with and without the experimental vest, irrespective of the soft armour fill. In comparison, the subjective ratings of the perceived "bulk" and "mobility" of the test conditions did differ significantly between the Bulk and Stiff fills, both with and without the additional load weight. **Conclusion**. Sensitivity of the CAN-LEAP course to differences of bulk, stiffness and load weight donned on the torso reveal an interaction between these effects with respect to soldier operational task performance. Subjective ratings indicate that participants perceive the differences in material properties at a higher fidelity than the results indicate from the course and obstacle performance times.

DRDC-RDDC-2014-N30