Evaluating the Protective Capacity of Novel Compliant Flooring Systems During Simulated Head Impacts Using a Surrogate Human Headform

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ABSTRACT

Novel compliant flooring systems (NCFs) are a promising approach for reducing fall-related injuries in seniors based on evidence that they attenuate peak force by 25-50% during simulated hip impacts while having only minimal influences on balance. This study aimed to determine the 'worst-case' head orientation, and the protective capacity of NCFs, during impacts with a surrogate headform. To determine a 'worst-case' orientation, a mechanical drop tower was used to impact the front (F), back (B), and side (S) of a NOCSAE headform onto a traditional Commercial Carpet at 1, 2, and 3 m/s. The headform's peak acceleration (gmax) and Head Injury Criterion (HIC) were determined using a triaxial accelerometer, while peak force (Fmax) was measured with a load cell. B impacts were conducted onto three additional traditional floors (Vinyl, Residential Carpet, Berber Carpet) and two NCFs (SmartCell, Kradal) at 1, 2, and 3 m/s. ANOVAs indicated head orientation was associated with gmax, HIC, and Fmax ($p<0.001$). Tukey's post-hoc demonstrated that, compared to F impacts, B and S impacts consistently yielded higher scores for all variables (p always <0.01). B impacts at 3 m/s produced HIC and Fmax values that were greater than during S impacts ($p<0.001$). At each impact velocity, ANOVAs indicated flooring type was associated with gmax, HIC, and Fmax ($p<0.001$). Compared to Commercial Carpet, Dunnett's post-hoc revealed that all variables were significantly smaller (25-80%) for the NCFs at all impact velocities ($p<0.001$, Table 1). This study demonstrates that, compared to traditional floors (vinyl, carpet), NCFs can provide substantial force and acceleration attenuation during worst-case impacts on the back of the head. When considered alongside reports of minimal influence on balance, these findings further support the potential of NCFs as an effective strategy for reducing fall-related injuries including skull fractures and traumatic brain injuries.