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Investigating the Influence of Neck Strength on Head Trauma in Rear Body-First Falls

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Abstract : A body-first fall is described as a fall where the head is not the first point of contact with the ground or surface. Body-first backward falls are a common cause of head trauma in daily life and sports, leading to injuries ranging from concussions to severe traumatic brain injuries. These falls result in rotational forces during head impact, a significant contributor to brain injury. However, current research on these falls predominantly focuses on direct impacts, limiting our understanding of body-first impacts on head-impact kinematics. Recent research identified that neck muscle stiffness during a body-first fall may significantly influence head impact kinematics and, consequently, the risk of brain injury. This research investigates the influence of neck stiffness on head impact kinematics during body-first backward falls, specifically examining whether neck stiffness affects peak rotational acceleration and, therefore, the risk of brain injury. This research used a 95th percentile Hybrid III (HIII) male headform mounted on an unbiased neck form within the uOttawa neck spring apparatus (UONSA). The unbiased neck form allows for free rotation in all planes. The UONSA was designed to simulate muscle activation by setting the tension in its springs to represent different levels of muscle contraction. There are three muscle groups represented by springs on the UONSA: upper trapezius, splenius capitis, and sternocleidomastoid muscle groups. Two impact velocities (3.5 m/s, 5.0 m/s) and two neck muscle stiffnesses (low, high) were investigated. The low (25%) and high (100%) maximal voluntary contraction forces were used to represent the neck stiffness by adjusting the spring stiffness in the UONSA. A 6.5 cm vertical offset was used to represent the average distance between the back and the back of the head in adult males for the body-first falls. The head form impacted a flat MEP anvil. The back impacted a piece of foam which had a 30% compliance with a 250-newton load to represent the compliance of the back. The dependent variables included peak resultant linear acceleration and peak resultant rotational acceleration, obtained using a 3-2-2-2 accelerometer array with an HIII headform. Peak resultant linear acceleration increased by approximately 60 g with each increase in impact velocity. The highest peak resultant rotational acceleration (22596 rad/s2(±377.86)) is reported for the highest velocity and highest neck stiffness in a body-first fall. In body-first rear impacts, high muscle tension resulted in a disproportionate increase in rotational acceleration, therefore increasing the risk of brain injury. Future research will focus on describing the relationship between neck muscle strength, impact velocity, and head impact kinematics for body first falls. The position of the neck and head before the back impact will be further investigated. This research aims to contribute to a better understanding of the biomechanics of body-first backward falls and inform the development of safer protective equipment, effective training programs for athletes to prevent injury, and more accurate reconstructions of body-first falls.

Keywords : body-first, concussion, head trauma, direct, kinematics, neck stiffness, biomechanics, rotational acceleration
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