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Could THAT have caused a concussion?

A biomechanical perspective

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With increasing media coverage of concussions comes increased awareness of the incidence and consequences of this often misunderstood injury. Concussions, also known as mild traumatic brain injuries, typically resolve in days or weeks, but can have long-term effects in a small percentage of injured individuals. When concussion forms part of a personal injury claim, the causal relationship between the injury and the insurable event can be at issue. From a biomechanical perspective, it is sometimes possible to confirm or refute causation and thereby contribute to resolving the claim.

Concussions can produce symptoms that are similar to those generated by other injuries or conditions such as traumatic injuries to different parts of the body, chronic pain, or a variety of psychological health disorders. The diagnosis of a concussion is thus a medical opinion and relies on clinical judgement, advanced imaging and neuropsychological testing. Even when a concussion is diagnosed, however, the lawyer or adjuster may ask whether the event alleged to have caused the concussion was indeed responsible.

Concussions require that the head experience sufficient trauma to transiently affect brain function. To determine whether a traumatic event had the potential to cause a concussion requires a reconstruction of the event to characterize and quantify the type and magnitude of forces that were applied to the head. The applied forces are then compared to the forces that cause concussion. These forces are often quantified as linear acceleration (reported in units of gravitational force, g) and rotational acceleration (in units of radians per second^2) of the center of mass of the head.

A biomechanical engineer or biomechanist is uniquely qualified to answer the question of whether a concussion could have occurred during a specific event. Unlike other injuries such as orthopedic injuries or more severe head injuries, there is often little in the diagnosis of a concussion to help reconstruct the event. Clinically, concussions are not described by observable damage to the head or brain but rather by different symptom clusters and symptom durations that scientific studies have yet to link to the different biomechanical parameters of the concussive event.

To reconstruct a head impact, a biomechanical engineer or biomechanist relies on physical evidence such as external trauma to the head (e.g., lacerations or extracranial swelling), damage to contacting structures (e.g., a dent in a wall or vehicle hood), and overall scene geometry (e.g., dimensions of a staircase or vehicle interior measurements). Witness evidence can also be used to estimate factors such as posture, pre-impact activity and relevant environmental variables. To estimate impact forces, data from scientific studies of instrumented surrogate headforms (dummies) or cadavers are used to determine the forces applied during the proposed concussive event. If published data are not available, then case-specific tests can be performed to determine the head impact exposure.

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Once the exposure has been estimated, it can be compared to published thresholds for concussion. This comparison establishes whether the alleged traumatic event is severe enough to cause a concussion. In the past, this analysis was complicated by a lack of published data on the thresholds for concussion. Recently, head impact exposure and concussion incidence have been characterized through reconstruction and in situ measurements of head accelerations in professional, collegiate, high school, and youth sports. Although most head impacts do not generate concussions, biomechanical risk curves have been developed from impacts that have caused concussion. These data are analogous to the introduction of "black boxes" in motor vehicles that provided the first real-world data on the relationship between collision exposure and whiplash injury. Similar to whiplash, the percentage of individuals that sustain a concussion is low compared to the number of exposures, so it is important to understand that exposure to forces above concussion thresholds is necessary but not sufficient to cause a concussion. Armed with threshold data, biomechanical engineers or biomechanists may be able to rule out the possibility that a particular traumatic event was capable of causing a concussion.

In summary, the specific circumstances of a case can be used to determine the forces applied to the head and the resulting accelerations experienced by the head. This exposure can be compared to data characterizing the exposure and incidence of sport-related concussions to determine whether a traumatic event could have caused a concussion. While the current state of the science on concussions provides a means of evaluating the possibility of a concussion based on exposure to linear and rotational accelerations of the head, research is ongoing. Our growing understanding of the link between forces applied to the head and the occurrence of concussion continues to improve our ability to answer questions presented by the unique circumstances of each case.

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