The Biomechanics of a Traumatic Brain Injury Claim

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Dr. Jamie R. Williams, an expert in biomedical engineering as well as biomechanics and bioengineering, conducts forensic investigations into how the brain is injured and by conducting biomechanical analyses to determine the direction, duration, and magnitude of the forces generated during a incident. Dr. Williams utilizes her extensive background in soft tissue biomechanics to explain these difficult concepts in an easily understood way. Dr. Williams has been qualified to opine on the biomechanical causation of traumatic brain in state and federal courts and has published in the field of traumatic brain injury and biomechanics.

In the absence of skull fractures, the brain can still be injured. While traumatic brain injuries range from mild to severe, both the age and physical condition of the individual can greatly impact the short term and long term damages stemming from the original injury. In an adult, traumatic injury to the brain can result in diminished or loss of cognitive and or executive functions. In a young child, research has shown that damage to the brain may not result in the reduction or loss of functions they currently have, but rather a loss of the ability to develop the part of the brain that is injured. These issues, which surpass the initial injury itself, are an important focus when a jury is awarding damages, such as medical support, diminished earning capacity, and quality of life. The analysis and opinions of a biomedical or biomechanical engineer can bridge the gap between your liability experts and damages experts by establishing that the types of forces and the magnitude of the forces necessary to cause the diagnosed brain injury were present in the claimed incident.

First, what is biomedical and biomechanical engineering? Biomedical engineering is the application of mechanical, electrical and chemical engineering to a living system, and in this case the human body. Biomechanical engineering is a subset of biomedical engineering which focuses on the mechanical engineering concepts, the cause and effect relationship between internal and external forces and how the body responds to those forces. Biomechanical engineers can analyze how the whole body will respond to a force (a push or a pull) as in analyzing the occupant kinematics during a car crash. Biomechanical engineers are also able to analyze how a system within the body responds to forces, for instance how the skull deforms when it strikes the pavement with and without a helmet on. Finally, biomechanical engineers can investigate how individual tissues respond to loads, as is the case in determining whether or not a blow to the head generated sufficient force or energy to injure the brain.

A qualified biomedical/biomechanical engineer can investigate the causation of injuries that have been diagnosed by health care professionals. In other words, the biomedical/biomechanical engineer relies on the medical diagnoses by the physicians set forth in a plaintiff's medical records to define the injury that is to be investigated. Clinically, brain injuries are classified as either diffuse or focal. Diffuse traumatic brain injuries are broader based and are the result of acceleration/deceleration due to sudden movement of the head. Because of the differences in the inertial properties of the individual components, or structures, of the brain, the individual structures accelerate and decelerate differently, resulting in intracranial pressure gradients and the shearing and/or stretching of the vascular and neurological connections or bridges between the different parts of the brain. Diffuse traumatic brain injuries often include swelling, subdural hematomas and diffuse axonal injury (DAI). Focal injuries are those that are limited to a specific location and are the result of contact. Focal injuries include contusions, laceration and intracranial hemorrhage. A concussion is a traumatic injury to the brain occurring from impact. Impact to the brain can occur when the head impacts a hard surface, rapidly decelerating the skull. The skull is stopped, but the brain, floating in cerebrospinal fluid (CSF), moves and is injured.

But how does one establish that an incident, whether it be a slip and fall, a head strike from a falling object off of a store shelf, a fall from playground equipment, a physical assault or motor vehicle crash generated the forces necessary to cause the brain injury with which the individual has been diagnosed? Using the diagnosis documented in the medical record, the biomechanical engineer then applies physics, engineering and the scientific method to determine if the forces/energy in the fall or impact were sufficient and in the appropriate direction to have caused the diagnosed brain injuries. Having a sound diagnosis that is well documented in medical records is a crucial first step in conducting this type of analysis.

So how does a biomechanical engineer go about conducting such an investigation? In the circumstance such as a car crash, the biomechanical engineer will often rely on the reconstruction of the collision conducted by either an accident reconstructionist or the police department. Then, following the scientific method and applying universally accepted principles in the fields of engineering and biomechanics, the motions of the occupant are determined throughout the crash sequence using the results of the reconstruction, physics, physical evidence (i.e. points of contact within the vehicle), anatomy and physiology. Determining the magnitude of the forces the occupant was subjected to and energy absorbed by the individual's head during the fall or impact can be calculated applying Newton's Laws of Physics and the Conservation of Energy and Work Principles. The calculated values are then compared to the injury threshold values from biomedical/biomechanical peer reviewed literature which are part of a large body of medical and scientific literature aimed at studying how and why traumatic brain injuries are caused and the forces required to cause these injuries.

The injury thresholds defined by this body of peer-reviewed research literature are routinely applied to identify situations where individuals are susceptible to sustaining traumatic brain injuries and for developing protective measures to minimize the risk of injury. The results of this research are used by government agencies including the Consumer Product Safety Commission for determining the thickness of the impact attenuating material under playground equipment, the Department of Transportation for the approval of helmets for bicycles and motorcycles, the National Transportation Safety Administration for determining Federal Motor Vehicle Safety Standards and the Centers for Disease Control in identifying fall precautions for the elderly and new guidelines for identification of and prevention for young athletes who are susceptible to traumatic brain injuries.

Use versus Non-Use of Protective Equipment or Surfaces

In some venues, biomechanical engineers assist in determining if the use of a helmet, seatbelt, the required depth of playground mulch or other safety device would or would not have made a difference in the injuries sustained during an incident. This sort of analysis is conducted in much the same way as described previously. First, the analysis is conducted based on what occurred during the actual incident. A second analysis is subsequently conducted to determine if the use of a safety device would have changed the outcome. This is done by re-running the analysis with the inclusion of data regarding the energy dissipation provided by a helmet, the restrained motion expected from the use of a seatbelt or the energy management provided by having the recommended depth of mulch on a playground.

Subconcussive and Secondary Blows

Recently, the medical and scientific research has also begun to document the causal relationship between subconcussive blows and traumatic brain injury. The research indicates the exacerbation of a brain injury resulting from secondary blows to the head following an injury causing blow. In a situation where an individual is struck in the head and then falls down a set of stairs, the initial strike can be analyzed in addition to the subsequent impacts occurring during the stair fall. The subsequent impacts or blows may be subconcussive impacts (below the energy threshold for concussion), while resulting in further “sloshing” of the brain back and forth within the skull, exacerbating the brain injury.

A qualified biomechanical engineer can conduct an investigation to determine if a single fall/impact or an event resulting in multiple blows to the head generated the loading necessary to cause a diagnosed traumatic brain injury. A biomechanical analysis utilizes sound scientific methodologies, reliable engineering concepts, anatomy and physiology, in conjunction with the available physical evidence. This analysis can serve as the critical link between liability and the damages.