Injury Biomechanics

Addressing Issues of Injury Causation

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Injury causation is a central issue in many personal injury claims. Over the last decade, some courts have limited accident reconstruction engineers from opining about injuries and medical doctors from opining about biomechanics.

Who then can address issues of injury biomechanics?

Enter the injury biomechanist: a professional who has training in both engineering mechanics and injury. The injury biomechanist is therefore qualified to calculate the forces applied to the body and compare these forces to the tolerance for specific injuries. Based on this comparison, an injury biomechanist can help prove or refute the causal relationship between the diagnosed injuries and the events alleged to have caused them.

Injury causation in the courtroom

To succeed in a personal injury claim, the plaintiff must prove the forces applied to them by the defendant's action (or inaction) caused or materially contributed to their injury. The defendant, on the other hand, can show that either the forces were insufficient to cause the plaintiff's injury or the forces from some other event or activity better explain the injury. Thus, both the plaintiff and defendant require experts qualified to analyze injury causation.

Accident reconstruction engineers commonly quantify the dynamics of an event experienced by the plaintiff, whereas medical doctors typically diagnose and treat the plaintiff's injuries. In the past, both professions have offered opinions regarding injury causation, but reconstruction engineers often lack formal training in anatomy, physiology and injury mechanics, and medical doctors often have no formal training in engineering mechanics, occupant loading and tissue tolerance (see Figure 1). Thus many reconstruction engineers and medical doctors potentially stray outside their areas of expertise when rendering opinions about injury causation.

Courts are increasingly recognizing the need for specialized knowledge to link the event to the claimed injury. In British Columbia, accident reconstruction engineers have been admonished for opining about injury,[1-4] and in one case the plaintiff was awarded special damages after a defense accident reconstruction engineer continued to opine about injury after multiple rebukes from the courts.[2] Medical doctors have also been admonished for offering biomechanical opinions outside their area of qualification.[5,6] In Alberta, biomechanics is not only a distinct area of expertise, but biomechanical evidence — due to its perceived complexity — is often used under the Jury Act to prevent cases from being heard by juries. Ontario Courts have not yet imposed such a distinction between reconstruction engineers, injury biomechanists and medical doctors, although in one judgment it was acknowledged that the reconstruction engineer was not qualified to offer an opinion on "the connection between the physical forces involved in the accident and [the plaintiff's] medical injuries."[7] In the United States, many jurisdictions draw relatively sharp distinctions between the three professions and opinions regarding injury causation are routinely given by injury biomechanists.

Qualifications for an injury biomechanist

Injury biomechanists have formal training in both engineering mechanics and tissue injury. How they acquire this training can vary. Often injury biomechanists have undergraduate engineering degrees with graduate degrees in biomechanics, kinesiology, or biomechanical/biomedical engineering with a focus on injury. Some injury biomechanists have medical degrees combined with degrees in engineering or biomechanics. Whatever combination of degrees, an injury biomechanist should have formal training in applying engineering principles to the failure of biological tissue. Just as you would expect an engineer analyzing bridge failures to have tested concrete and steel, you should also expect an injury biomechanist to have tested biological tissues.

From an engineering perspective, an injury biomechanist's training includes an understanding of how different parts of the human body react — and interact — to external forces, how stresses and strains develop in tissues during an impact, the failure mechanisms and tolerances of different types of tissues, and the wide variability in the mechanical properties of biological tissue. From a medical perspective, an injury biomechanist's training includes the anatomy and physiology needed to understand medical diagnoses, the different injury classification schemes, and the neuromusculature and reflexes that can exacerbate or attenuate the response to externally applied forces. This combination of engineering and medical knowledge is needed to properly understand the biomechanics of injury.

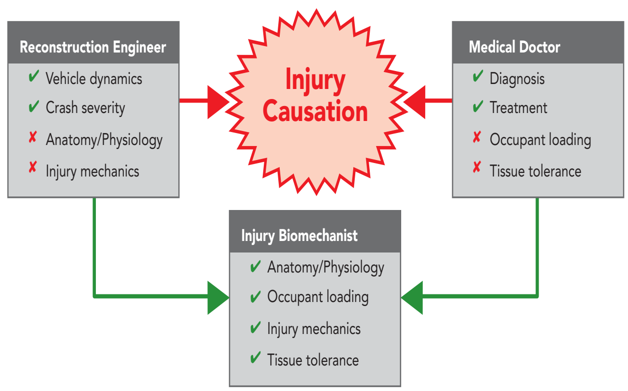


Figure 1. Typical areas in which training is (✔) and is not (✘) received. The dashed red arrows show injury causation being incompletely addressed by accident reconstruction engineers and medical doctors. The solid green arrows show the appropriate use of an injury biomechanist.

Biomechanical analyses of injury

Biomechanical analyses of injury examine the causal relationship between a specific event and a specific set of diagnosed injuries. A summary of the injuries is drawn from the medical records and reports, and in the case of car crashes, data regarding the crash direction and severity is drawn from the collision reconstruction report. Thus biomechanical analyses rely on the evidence of other experts, and accurate reconstructions and diagnoses are needed for sound biomechanical analyses.

The biomechanical analysis itself consists of two main steps: mechanism and magnitude. To assess injury mechanism, the direction and location of the forces applied to the body are first determined for each event in question. This information is then compared to the direction and location of the forces required to cause each injury. If the direction and location of the required and applied forces do not match, then a mechanism for the diagnosed injury does not exist and the injury was not caused by the event in question. If, however, the direction and location of the applied and required forces do match, then a mechanism for the diagnosed injury exists and the analysis proceeds to the second step.

To perform the second step of the biomechanical analysis, the magnitude of the forces applied to or through the injured area are calculated for each event in question. The magnitude of the applied force is called the exposure and the threshold force above which an injury occurs is called the tolerance. The tolerance values are drawn from scientific studies published in the peer-reviewed literature. If the exposure is greater than or equal to the tolerance, then the injury is consistent with the event. Alternatively, if the exposure is less than the tolerance, then the injury is not related to the event in question.

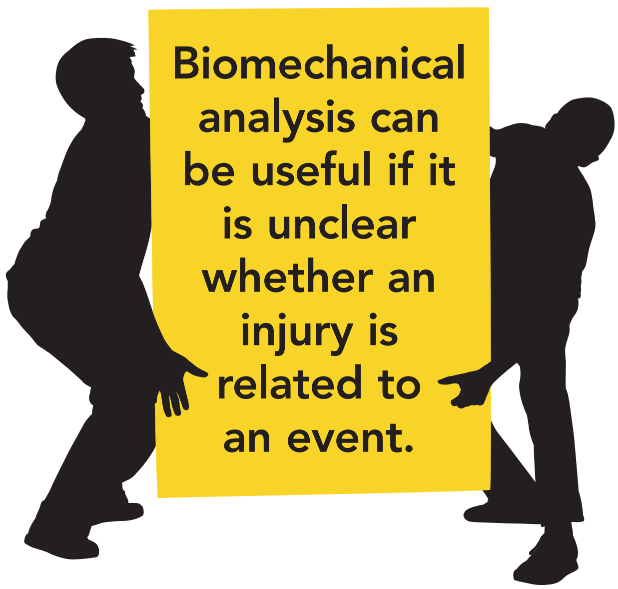
Although the mechanism and magnitude analyses are relatively simple in theory, there are numerous factors that can complicate an injury biomechanics analysis. First, the medical diagnosis is sometimes unclear, particularly for soft-tissue injuries where the specific tissue injury responsible for the plaintiff's symptoms is often not identified. Second, the forces applied to the occupant may be difficult to calculate, either because of the nature of the event (e.g., rollover collisions) or the lack of scientific data. Third, the tolerance values for some diagnosed injuries or conditions (e.g., fibromyalgia or carpal tunnel syndrome) and the tolerance values for individuals with some pre-existing conditions are not known. Finally, there is considerable variation in the tolerance values for some injuries. Thus the quality of the diagnosis and the state of the science for a specific injury play a large role in the quality of the answer an injury biomechanist can provide regarding injury causation.

Biomechanics in action

Biomechanical analyses can be useful if it is unclear whether an injury is related to an event, or if the severity of an injury seems inconsistent with the exposure. Biomechanical analyses can be particularly effective from a defense perspective when alternate events or occupational exposures are compared to the exposure alleged to have caused the injury. A few examples of cases that benefit from a biomechanical analysis are given below:

The right-front passenger of a pickup truck that underwent a severe frontal collision sustained a left femur fracture and right knee and hip fractures. Heavy knee loading against the dash ahead of the passenger seat caused these fractures and indicated the passenger was not wearing his seatbelt. Seatbelt use would not have prevented knee contact with the dash, but the biomechanical analysis showed that the knee loads with a seatbelt would have been well below the fracture tolerance data in the scientific literature. Thus the passenger's fractures would have been prevented with seatbelt use.

A lumbar disc herniation was alleged to occur during a rear-end collision with a speed change of about six to eight kilometres per hour. The medical records revealed multiple episodes of low back pain with radiation into the left leg following lifting activates both before and after the collision. The forces across the L4/5 vertebral joint were calculated for the collision and lifting tasks. The biomechanical analysis showed the published tolerance for this injury was greater than the force applied during the collision, but about equal to the force applied multiple times during the lifting tasks.



A bicyclist participating in a road race struck an unpadded lamp standard and sustained a fatal neck injury. A biomechanical analysis showed that for the speed at which the bicyclist struck the lamp standard, the neck loads were sufficient to cause the fracture even if the lamp standard had been padded. It was further shown that padding can increase the potential for pocketing or trapping the head, which increases rather than reduces the likelihood of neck injury.

A man carrying a cardboard box down wet stairs outside a residential apartment building slipped, fell down the remaining stairs and suffered a fracture/dislocation of his left ankle. Friction tests performed under both wet and dry conditions showed the available coefficient of friction was adequate for normal stair descent. The type of ankle fracture/dislocation was more consistent with slipping off the stair nosing due to poor foot placement than slipping on the stair tread because of low friction. Since the stair otherwise complied with local building codes, the injury was attributed to a misstep rather than a stair design or construction problem.

Other types of motor vehicle cases include seatbelt use and effectiveness, driver identification, motorcycle or bicycle helmet use and effectiveness analyses, and whiplash injury potential. In slip, trip and fall incidents, injury analyses can be used to define the plaintiff's pre-event behaviour, quantify the level of friction needed for specific tasks, and quantify reaction times and recovery strategies to unexpected mishaps. Injuries caused during sport or recreational activities can also be analyzed to assess the use and effectiveness of safety equipment (helmets, padding, etc.) and determine whether arena facilities or product failures contributed to the injuries. Miscellaneous cases involving assaults, police shootings, gait analyses and the limits of human performance can also benefit from the principles used for injury biomechanics analyses.

Determining causal relationship

Injury causation analyses are based on a comparison of the forces applied to the body (such as the exposure) and the forces required to cause the injury (such as the tolerance). Injury biomechanists have the formal training in both engineering mechanics and tissue injury needed to make this comparison. Injury biomechanists combine information from accident reconstruction analyses and medical diagnoses to determine whether there is a causal relationship between the diagnosed injuries and the event alleged to have caused them. 🍁

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1. *Gabriel v. Thompson, 22 November 1995, BC Provincial Court, Vancouver Registry No. C94-09360.*

2. *Heppner v. Schmand, 28 May 1996, Supreme Court of British Columbia, Campbell River Registry S1026 and S1530.*

3. *Homolka v. Harris, 22 April 2002, British Columbia Court of Appeal, Vancouver Registry CA027188 (2002 BCA 262).*

4. *Dahliwal v. Bassi, 25 April 2007, Supreme Court of British Columbia, Vancouver Registry M052338 (2007 BCSC 547).*

5. *Hughes v. Haberlin, 15 December 1997, Supreme Court of British Columbia, Vancouver Registry B950232 (1997 CanLII 2186 BCSC).*

6. *Rai v. Wilson, 17 March 1999, British Columbia Court of Appeal, Vancouver Registry CA023736 (1999 BCCA 167 (CanLII)).*

7. *Garratt v. Orillia Power, 13 April 2006, Ontario Superior Court, Barrie Court 03B5833 (2006 CanLII 11911 ONSC).*