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## NEWTON'S LAWS OF MOTION & WHIPLASH INJURIES

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Newton's laws of motion are three physical laws that together laid the foundation for classical biomechanics of whiplash injuries. They describe the relationship between a body and the forces acting upon it, and its motion in response to said forces. They have been expressed in several different ways over nearly three centuries, [1] and can be summarized as follows from the pure scientific perspective:

**First law:** An object at rest remains at rest unless acted upon by a force. An object in motion remains in motion, and at a constant velocity, unless acted upon by a force. [2][3]

**Second law:** The acceleration of a body is directly proportional to, and in the same direction as, the net force acting on the body, and inversely proportional to its mass. Thus,  $F = ma$ , where  $F$  is the net force acting on the object,  $m$  is the mass of the object and  $a$  is the acceleration of the object.

**Third law:** When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction to that of the first body.

The three laws of motion were first compiled by Isaac Newton in his *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy), first published in 1687.[4] Newton used them to explain and investigate the motion of many physical objects and systems.[5] For example, in the third volume of the text, Newton showed that these laws of motion, combined with his law of universal gravitation, explained Kepler's laws of planetary motion.

Whiplash is a non-medical term describing a range of injuries to the neck caused by or related to a sudden distortion of the neck[1] associated with extension.[2] The term "whiplash" is a colloquialism. "Cervical acceleration-deceleration" (CAD) describes the mechanism of the injury, while the term "whiplash associated disorders" (WAD) describes the injury sequelae and symptoms.

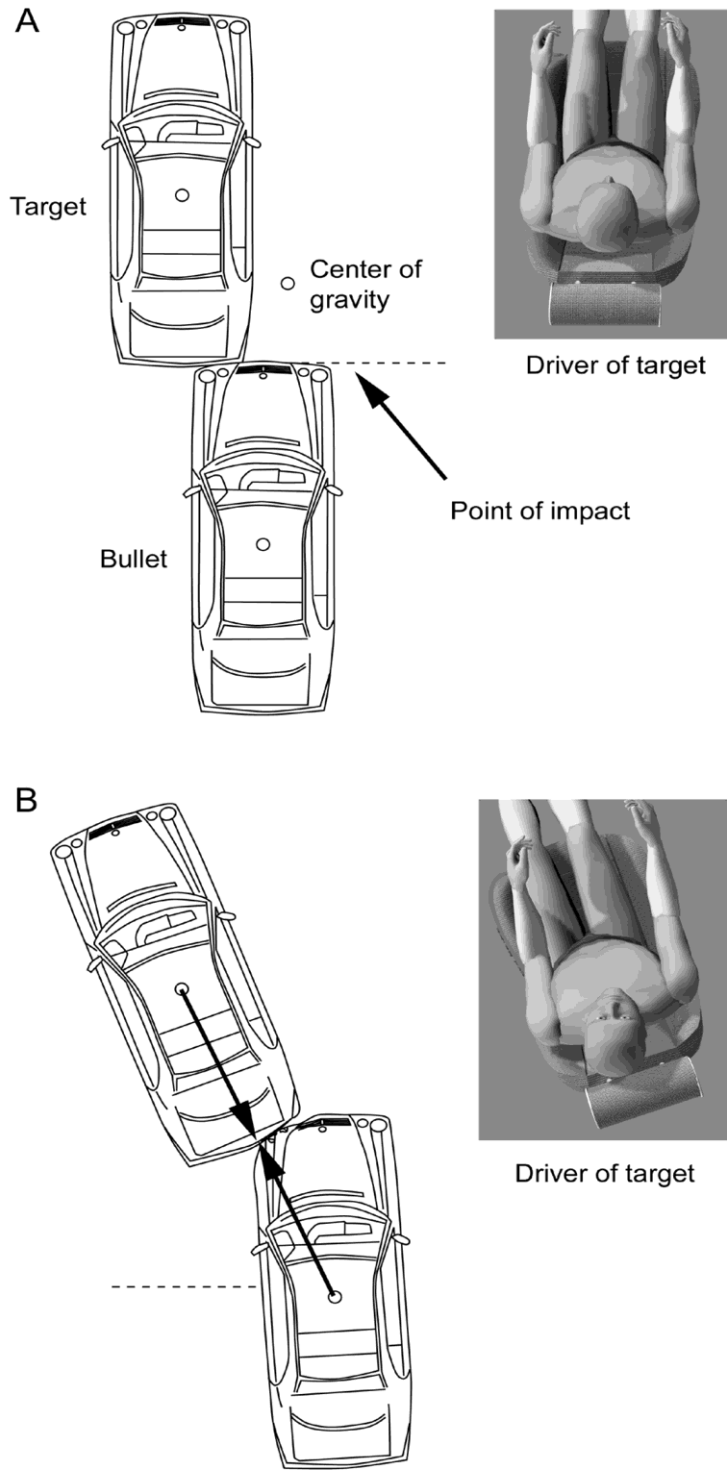


Figure: In the case of offset rear impact, the target vehicle, depending on crash speed and road condition, may rotate around its own center of gravity. The occupant will experience both linear

and rotational acceleration; A. Rotation of the vehicle to the left would produce the same neck loads as would a non-offset rear impact vector crash in which the occupant's head was rotated to the right, B. (Adapted from reference Croft AC: Biomechanics. In Foreman SM, Croft AC (eds): Whiplash Injuries: the Cervical Acceleration/Deceleration Syndrome (3rd edition). Baltimore, Lippincott Williams & Wilkins, 2002)

Whiplash is commonly associated with motor vehicle accidents, usually when the vehicle has been hit in the rear;[3] however, the injury can be sustained in many other ways, including head banging, bungee jumping and falls.[4] It is one of the main injuries covered by the car insurers.[citation needed] In the United Kingdom, 430,000 people made an insurance claim for whiplash in 2007, accounting for 14% of every driver's premium.[5]

Before the invention of the car, whiplash injuries were called "railroad spine" as they were noted mostly in connection with train collisions. The first case of severe neck pain arising from a train collision was documented around 1919.[6] The number of whiplash injuries has since risen sharply due to rear-end motor vehicle collisions. Given the wide variety of symptoms associated with whiplash injuries, the Quebec Task Force on Whiplash-Associated Disorders coined the phrase 'Whiplash-Associated Disorders'.[6]

Whiplash is the term commonly used to describe hyperflexion and hyperextension,[7] and is one of the most common nonfatal car crash injuries. More than one million whiplash injuries occur each year due to car crashes. This is an estimate because not all cases of whiplash are reported. In a given year, an estimated 3.8 people per 1000 experience whiplash symptoms.[8] "Freeman and co-investigators estimated that 6.2% of the US population have late whiplash syndrome".[9] The majority of cases occur in patients in their late fourth decade. Unless a cervical strain has occurred with additional brain or spinal cord trauma mortality is rare.[8]

Whiplash can occur at speeds of 2.5 miles per hour or less according to sigmond et. al.; it is the sudden jolt, as one car hits another, that causes ones head to be abruptly thrown back and sideways. The more sudden the motion, the more bones, discs, muscles and tendons in ones neck and upper back will be damaged. Spinal cord injuries are responsible for about 6,000 deaths in the U.S. each year and 5,000 whiplash injuries per year result in quadriplegia.[7]

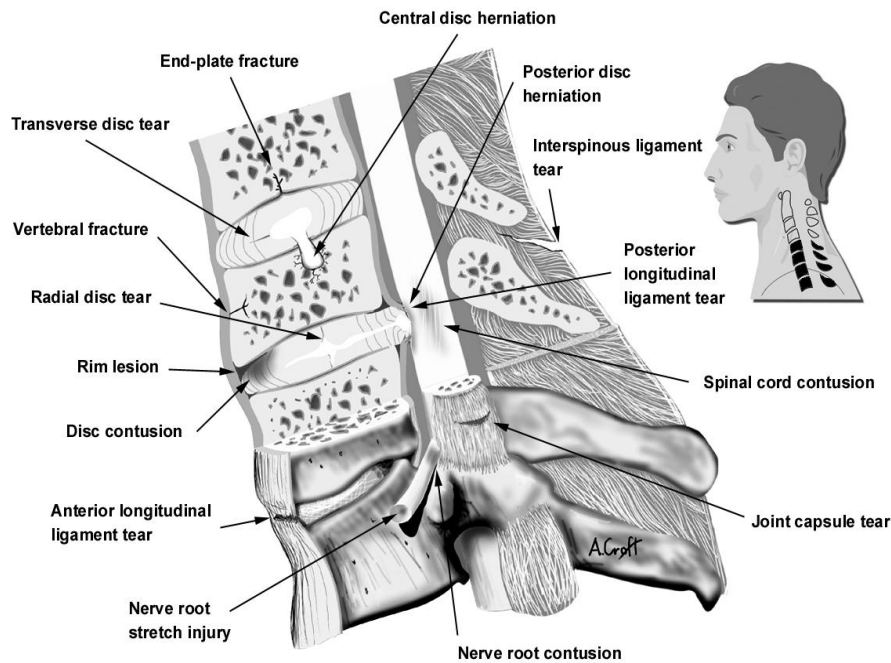


Figure: This is an illustration of part of the cervical spine (black portion of inset). Part is cut in half for better viewing. This illustrates all of the lesions that have been reported to occur in whiplash trauma. With permission from Whiplash! A Patient's Guide to Recovery. San Diego, (c) Spine Research Institute of San Diego, 1999.

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Most cases of whiplash occur among Caucasians 66.1%, as compared to 27.1% for African Americans, 8.1% for Hispanics, and 2% for Asians, as seen in figure A. After 12 months, only 1 in 5 patients remain symptomatic, only 11.5% of individuals were able to return to work a year after the injury, and only 35.4% were able to get back to work at a similar level of performance after 20 years. Estimated indirect costs to industry are \$66,626 per year, depending on the level and severity. Lastly, the total cost per year was \$40.5 billion in 2008, a 317% increase over 1998.[7]

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