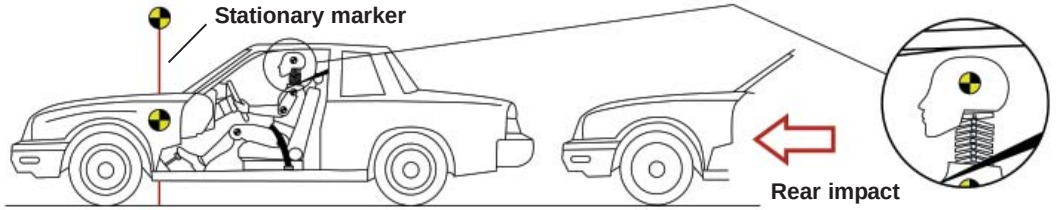
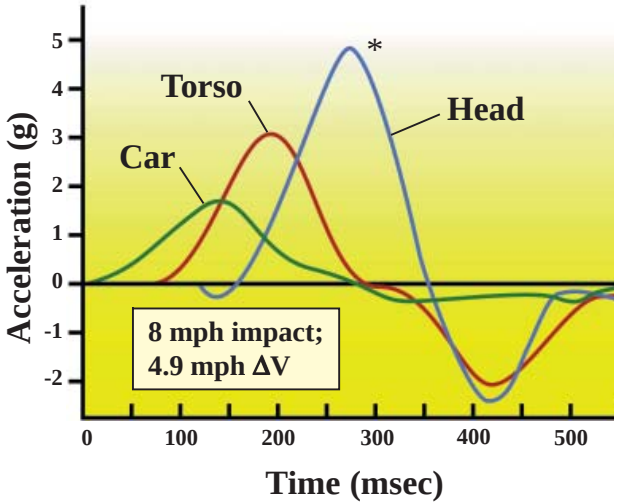
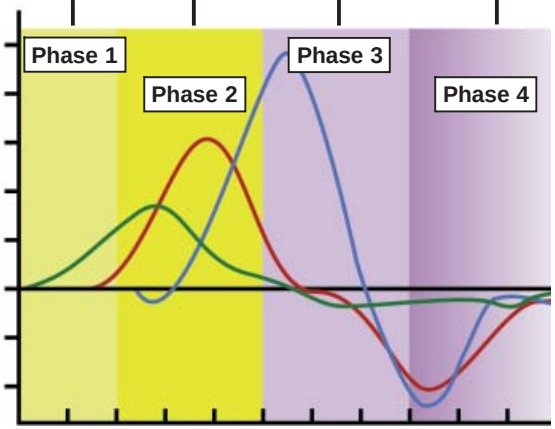
Whiplash Injuries

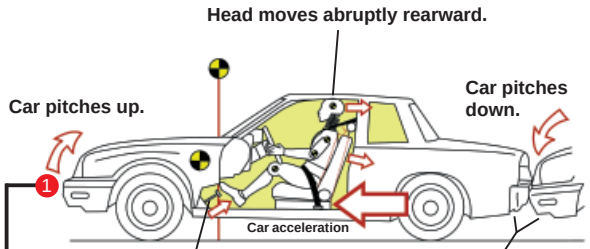


Acceleration Curve

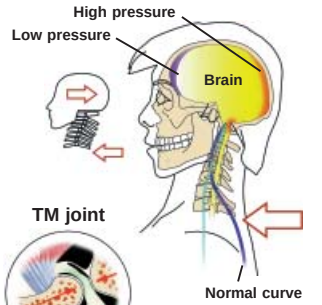
Human Volunteer tests



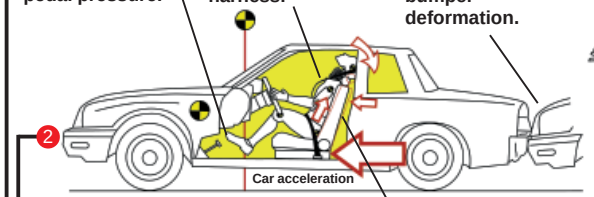




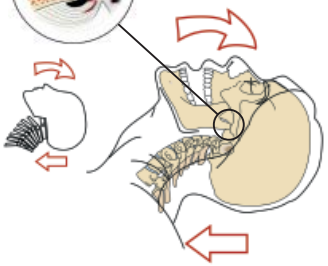
Phase 1 (0-100 msec)



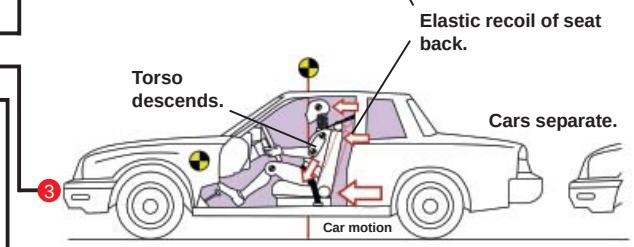
- Back and torso load the seat.
- Torso acceleration begins.
- High shear forces develop in neck.
- Spinal curves straighten; spine is compressed.
- High pressure gradients develop in brain; high brain stem shear forces.



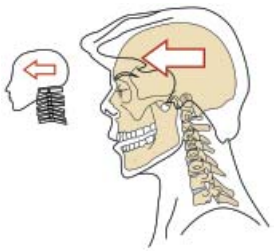
Phase 2 (100-250 msec)



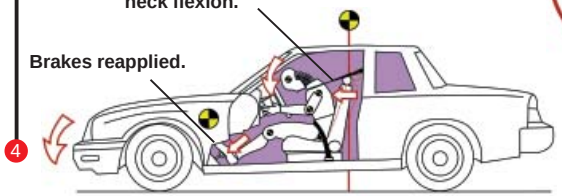
- Vertical motion of torso and straightening of spine allow vertical rise of 3.5 inches.
- Head snaps into full extension, extends over head restraint and collapses it.
- Restraint acts as a fulcrum.
- TMJ injury is possible with high compression in joint.

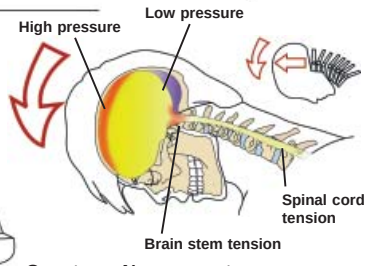


Phase 3 (250-400 msec)



- The head begins in its forward motion.
- The torso descends in the seat.
- Seat back bounce <u>increases</u> occupant velocity to 30-70% <u>more than that of car.</u>
- Slack is taken out of shoulder harness.





Car stops. No apparent structural damage to car.

Phase 4 (400-600 msec)

- Full deceleration of head, neck, and torso; aggravated by shoulder harness.
- High tension and shear forces in spine.
- High brain stem, spinal cord, and nerve root tension.
- Posterior ligamentous complex tension.

*Note: Some researchers have measured peak acceleration to the head of more than 10 g in similar crashes.