WHIPLASH INJURIES

The first reported cases of whiplash were victims of train collisions, and with no ready explanation of why a person would be suffering from pain when there were no obvious injuries, railroad officials assumed that victims were faking their injuries for financial gain.

The U.S. Navy, however, could not blame their pilots for the serious disabilities that resulted from being launched by catapults from aircraft carriers. The forces were so violent that pilots would black out momentarily, and accidents would occur. The Navy quickly installed head restraints and harnesses to protect their pilots. 50 years later automobile manufacturers were required to install head restraints in automobiles. Clearly, there were forces at work causing these injuries, but more detailed analysis was needed.

So, in 1955, D.M. Severy Et Al did the first in-depth study of whiplash injury to live subjects, recording on film the actual events, timing and mechanisms by which these injuries occur.

More recently, high-tech cameras and accelerometers (devices for measuring and recording G forces) are used to precisely measure the events as they are demonstrated. Without going into a lengthy discussion of all the physics involved, let me try to put matters in more understandable terms.

There are basic laws of physics at work when 2 bodies collide, and the Conservation of Energy is chief among these principles. This principle states that energy is constant in any given physical phenomenon, and the energies of momentum, acceleration, and inertia will remain constant in a collision incident; that is, the energy that exists before a collision will exist afterwards, although there will be a transfer of energy from one vehicle (or body) to the other vehicle (or body). The conservation of momentum becomes critically important when dealing with collisions involving 2 vehicles of different masses, like a compact car (target car) being struck by a much heavier truck. In such a situation very large forces can be transferred at very low speeds. The same can be said for bullet vehicles traveling at higher speeds, due to the multiplying factor of velocity in the formula.

We are all familiar with the feeling of acceleration. Mathematically, acceleration is expressed as a change in velocity (speed) over a given period of time. Gravity or G force is expressed as an acceleration formula. The normal G force, or gravitational pull of the earth is 9.8 meters/second squared or 32.2 feet/second squared. The average human head weighs about 10 lb. at 1 G, or the normal resting force of gravity here on earth. The weight of our head is bearing primarily on our neck; a rather thin, flexible stalk made up of 7 bony vertebrae with cartilaginous discs in between, and held together by muscles, tendons and ligaments that seem to have been designed more for movement and flexibility than for weight bearing.

Inertia describes the fact that a body at rest will stay at rest unless acted upon by some external force, and a body in motion will remain in motion unless acted upon by external forces. Inertia describes the resistance of mass to changes in motion. Whiplash injuries are inertial injuries. It is the very **rapid, violent** movement of the head from a stationary position to a new position that results in most of the injuries in rear-end collisions. Keep in mind that the movement that is induced to the head and neck occurs over a very short span of time, typically $1/10^{th}$ of a second. The crux of the problem is the difference between the acceleration rates of the head and the torso; the head, neck and torso do not move in unison during a collision because of the differences in mass, so therefore react differently to acceleration, or G forces.

There are also differences in the amounts of G forces that are transmitted to the target car and to the head and neck of an occupant inside the target car. According to Severy Et Al, in a 9mph collision, an occupant's head is subjected to 2.5 times the acceleration or G force that the target vehicle absorbs. This is why the amount of damage to the target vehicle is not a reliable indicator of the level of injury for the occupants.

Much of the injury that occurs to the neck in a rear end collision is primarily due to extension, (chin up or looking upward) which can effectively stretch and tear muscles and ligaments in front of the cervical spine, and compress structures on the rear or back side of the C spine.

Injuries can also occur in flexion of the neck (chin down, into the chest) after the head rebounds off of the seat back or headrest, and particularly so when the target vehicle, first struck from the rear, is propelled into another vehicle in front, as in a chain-reaction injury.

There are also compressive forces that are imparted to the neck, simulating downward pressure, or G force pressing downward on the head. These axial compressive forces occur because of the different rates of movement of the torso and of the head, the natural curve of the C spine, and also due to other factors such as seat back position.

Things can get very complicated when the occupants head(s) are turned to the left or right, or when the impact occurs with no warning or the target vehicles' occupant is weak or frail. So far we have presented evidence of studies done with live subjects in relatively low velocity collisions. When researchers, (Szabo et al) discovered that target vehicle occupants were being exposed to G forces as high as 17 G's in a 9mph collision, they realized that the normal 10 lb. human head was suddenly exerting the force of a 170lb. head on the fragile neck. The human neck simply cannot support that amount of force, even momentarily, without injury. The Society of Automotive Engineers (SAE) sets the maximum allowable torque that can be applied to a human spine at 30.5 Newton meters, a force equivalent of 6.8 G's of acceleration. Calculations reveal that at 15mph, the G force on an occupants head could be 23 G's. These types of forces far exceed the ability of human tissues to withstand tensile (stretching) and compressive incidents without significant and perhaps life-altering injury.

Other factors that affect injuries are;
Tall people or headrest too low - can cause head and neck to 'ramp' over the top of the seat back/ headrest.

Occupants with less body mass- Women are 4.8 times more likely to suffer injuries then men in low velocity collisions.

Children are at the greatest risk because of their proportionally higher head/body ratio.

Flexed posture- sitting 2" forward of a normal sitting position can increase the torque on the neck by 50%; a seat back angled backward of a normal position can increase ramping and sitting distance from a headrest.

Headrest – the center of the headrest should be positioned at a level closest to the rearmost curvature of the back of the head to minimize the distance between the head and headrest.

Seatbelt and shoulder harness not fastened or improperly positioned.

Level of preparedness- the sight or sound of an impending collision, for even a very brief time, is time for our brain and nervous system to increase the tone of our musculature and mitigate (reduce) the effects.

Pre-existing conditions- scar tissue in previously injured soft tissues is weaker than the tissue it replaces.

Age- muscle weakness, slower reaction time, abnormal posture, osteoporosis, joint restrictions due to arthritic changes, etc.

Stooped posture while seated can greatly increase the compressive force on intervertebral discs in a collision incident.

Where does the Pain come from?

Injured tissues release chemical mediators that cause our nervous system to perceive pain, and trigger swelling (edema). One should use cryotherapy (ice pack) on areas of recent injury, for at least 48 to 72 hours. Heat will recruit more swelling to the area, so avoid heat in the early stages following an injury. Possibly the most detrimental factor affecting injured soft tissues (a term insurance adjusters love to use as it has the effect of downplaying an accident victims injuries) is **fibrosis** or **scar** tissue formation. Scar tissue (Fibrin) is a component of the fluid that makes up edemamatous fluid (inflammation). Fibrin will begin to infiltrate injured muscles, tendons and ligaments soon after injury, and if allowed to accumulate unchecked, scar tissue will lay down in a cross-hatched manner. This proliferation of scar tissue will effectively shorten these soft tissues, and in turn alter the way adjacent and affected structures articulate and interact together. All of this leads to accelerated degenerative changes; changes that may not appear or become symptomatic for several years after a case has been concluded. These changes, however, will occur. Proper treatment is aimed at minimizing the long term effects of these consequences. The good news is that research has proven that the most effective way to minimize scar tissue proliferation, soft tissue shortening, joint dysfunction, chronic pain and early onset degenerative changes involves proper therapy, rehab, and **movement, movement, movement!** Properly applied chiropractic care is absolutely the most effective method to alleviate and minimize the long term effects of whiplash, soft tissue injuries, and spinal trauma.

*References available upon request

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Reference Formulas for Whiplash Injuries:

- Momentum = mass x velocity - Ex: M=1000kg x 4.46 m/sec = 4,460kg.m/sec
- Acceleration = distance x time squared - Ex: A= 2.23m/sec = a = 22.3m/sec squared
- Normal gravitational force is expressed as an acceleration formula OR;

  Gravity = 9.8 meters/second squared or

  Gravity = 32.2 feet/second squared