Why G Forces Are Dangerous

The nature of the problem can be summed up as follows. As the data from Szabo (Szabo TJ, Welcher JB. "Human subject kinematics and electromyographic activity during low speed rear impacts." 40th Stapp Car Crash Conference, SAE 962432.) show, head G forces can reach up to 17 G in a 9 mph rear-end collision. The human head weighes between 9-11 pounds. If we assume a head weight of 10 lb. as an average, the actual weight of the head becomes 10 x 17, or 170 lb.—all within 60 milliseconds, or .06 seconds. Imagine for a moment trying to support 170 lb. with your neck alone.

The crux of the problem in low speed collisions is the discrepancy between the acceleration of the head and the acceleration of the torso.

But this is not the whole story. The forces in a rear-end collision are not static, but change direction and speed constantly. Both the head and the body have inertia—that is they continue to stay moving in the same direction until a force moves them in another direction. What lies between these two large masses, of course, is the relatively fragile cervical spine. This explains why the neck is susceptible to injury in a "minor" rear-end collision.

First, it should be mentioned that the *absolute* G forces that occur in low speed collisions are not that severe—if the body is properly supported, these G forces are easily tolerable. The problem is that most of the time, as we shall see later, the body is not supported properly, and sometimes the design of the automobile is such that injury potential is *actually increased*. The crux of the problem in low speed collisions is *the discrepancy between the acceleration of the head and the acceleration of the torso*.

As we saw in Chapter 2, the torso of the passenger is pushed forward, while the inertia of the head leaves it behind. Pintar *et al* (Pintar FA, Myklebust JB, Yoganandan N, et al. "Biomechanics of human spinal ligaments." *Mechanisms of Head and Spine Trauma*, ed. Sances A, Thomas DJ, Ewing CL, et al.; 505-527.) wrote that in short duration forces on the cervical spine, the greatest areas of movement are at the upper and lower spine, while the middle portion acts more or less like a flexible bar. The points of flexion in this model are in the upper cervical spine (C1-C3) and the lower cervical spine (C5-C7). Thus, it is not surprising that the medical literature consistently reports that most whiplash symptoms are focused on these two areas of the spine, with the lower cervical spine often reported as the most symptomatic.

The constantly changing forces have a tremendous effect on the relatively fragile cervical spine. At about 120 ms into a typical low speed collision, the head is fully back and the torso is fully forward. At 11 Gs of force, the pull of the head on the cervical spine is about 110 pounds; at 17 Gs, 170 pounds. Remember, this is for a collision of only 6-9 mph. At a speed of 15 mph, head G forces could theoretically reach 23 Gs, with a resulting head weight of 230 pounds.

G forces are just one portion of the whole picture. What makes G forces dangerous in a rear-end collision is the movement that results from the force

§1130.19 The Long-Term Effects of Rear-End Automobile Collisions

One of the most common symptoms after rear-end collisions is neck pain; chronic whiplash pain, or the "late whiplash syndrome," usually consists of neck pain, headache, thoracic pain and fatigue.

A new study by a group of world-renowned researchers examined whether these are the only symptoms that distinguish long-term whiplash pain, or if rear-end collisions lead to other health problems as well.

The authors started with three groups of people: 232 individuals who had been in a rear-end collision and who reported whiplash pain afterwards; 204 who were exposed to a rear-end collision but who did not report whiplash pain; and 3,688 subjects who were insured by the same company as the other participants, but who had not been exposed to a rear-end collision. All claim reports were collected between November 1987 and April 1988. All of the test participants were mailed a follow-up survey seven years later, in 1994.

The questionnaire concerned general health, fatigue, depression, sleep disturbance, headache, neck pain, shoulder pain, thoracic pain, and lumbar pain. The survey also asked if the subject had ever been involved in a motor vehicle collision (MVC); however, to remove the potential of bias, the authors did not refer to the specific rear-end collision under study.

The table below shows the adjusted relative risk for both rear-end collision groups—the Whiplash Injured and Non-Whiplash Injured—as compared to unexposed individuals:

Complaint	Whiplash Injury/Unexposed Relative Risk	Non-Whiplash Injury/Unexposed Relative Risk
Headache	3.7	1.4
Thoracic Pain	3.1	1.7
Low Back Pain	1.7	.9
Ill Health	3.3	.9
Sleep Disturbance	2.4	.8
Stomachache	1.9	.7
Fatigue	1.6	.7
Depression	1.6	.6

As the table shows, the patients who reported whiplash immediately after the collision were much more likely to suffer from other health problems seven years later than were the unexposed individuals. The most dramatic of these effects were seen in headache (3.7 times more likely), thoracic pain (3.1 times), ill health (3.3), sleep disturbance (2.4), and low back pain (1.7).

Low Back Pain and Whiplash

Low back pain is a symptom that is often reported by whiplash patients, but hasn't been examined much in the scientific literature. This study included back pain as one of the symptoms and found that it was an issue for some patients:

> "Of the 183 subjects who were included in the analysis, 32 also reported injuries to the lumbar spine in connection with the MVC. The age- and gender-adjusted relative risk of future low back pain among subjects who together with whiplash injury also reported an injury to the lumbar spine was 2.9. The corresponding relative risk for subjects without reported lumbar spine injury together with whiplash injury was 1.5."

From these findings, it seems that back injury caused by a rear-end collision results in long-term back pain—even seven years after the collision.

The Complexity of "Late Whiplash Syndrome"

The authors also found that there really isn't one single set of symptoms associated with chronic whiplash pain:

> "Only four subjects with reported whiplash injury experienced the collection of persistent symptoms said to be included in the 'late whiplash syndrome' (i.e., neck pain, headache and depressive mode)…It is possible that earlier descriptions in the literature of the 'late whiplash syndrome' are too limited or too imprecise, and different combinations of persistent complaints may exist, such as neck pain alone, neck pain together with headache or thoracic pain, or other constellations."

This is the first study to examine the long-term health effects from a rear-end collision, and one of the most important findings from the study is that whiplash injuries seem to have an effect on much more than just the neck:

> "According to the present results, subjects who reported a whiplash injury in connection with a rear-end collision 7 years earlier not only had an increased risk of future neck pain, but also an increased risk of other health complaints compared with an unexposed group. These additional complaints included headache, thoracic and low back pain as well as fatigue, sleep disturbances and ill health with relative risks in the order of 1.6-3.7. We conclude that rear-end collisions resulting in reported whiplash injuries seem to have a substantial impact on health complaints even a long time after the collision."

Berglund A, Alfredsson L, Jensen I, Cassidy JD, Nygren A. "The association between exposure to a rear-end collision and future health complaints." Journal of Clinical Epidemiology *2001; 54:851-856.*

§1130.28 Risk Factors for Whiplash

In this study, researchers interviewed 251 drivers involved in rear-end collisions that occurred less than one year before the interview. The objective was to determine which accident and occupant variables determined whiplash symptomatology.

Of the interviewed drivers:

- 35% reported a whiplash injury arising from the collision.
- Consistent with numerous other studies, women were more likely to report whiplash symptoms than were men; 25% of men reported whiplash, while 44% of women did.
- Two thirds of the whiplash occupants had consulted a health care provider, **but only three drivers had gone to the emergency room after the accident.**
- 40% of the whiplash patients reported a restriction of their daily activities.
- 23% of the whiplash patients had symptoms for at least three months.

The researchers also found the following variables were more likely to result in whiplash injury:

- "Female sex and a history of neck injury were the only statistically significant predictors of 'whiplash' occurrence. **The relative risk of 'whiplash' occurring in drivers reporting a history of neck injury was more than twice that of drivers with no history.** For women, the risk of 'whiplash' was approximately twice that of men. Age, occupational status and educational attainment were not significant predictors of 'whiplash' occurrence."
- "Vehicle masses appeared to have an influence on the risk of 'whiplash' occurrence. The relative risk of occurrence in drivers of light vehicles (<1100 kg [2420 lb.]) was 1.43 times that for drivers of heavy vehicles ($1300 kg [2860 lb.]); this relative risk fell just short of statistical significance…**The relative risk estimates relating to the weight of the striking vehicle showed a pattern of decreasing risk on injury with decreasing mass of the striking vehicle**, and there was a positive association between the weight of the striking vehicle relative to the driver's vehicle and the risk of 'whiplash' injury, as indicated by the trend in the relative risks over the relative vehicle-weight categories." The relationship between striking vehicle vs. target vehicle mass has been hypothesized by engineers as a risk factor for injury, but this is the first study to actually see the relationship in a group of patients.
- "There was a 9 per cent increase in the risk of 'whiplash' injury in drivers who were not aware of the impending collision." Although it did not reach statistical significance, "Compared with drivers reporting two or more sources of forewarning, those who had only one source had a 17 per cent increase in incidence, while those who reported no forewarning had a 20 per cent increase." These findings are also consistent with the hypotheses of whiplash experts who predict that the absence of forewarning results in increased tissue damage because of low muscle tone.

Dolinis J. "Risk factors for 'whiplash' in drivers: a cohort study of rear-end traffic crashes." Injury *1997; 28(3):173-179.*

§1140.39 The Long-Term Effects of Rear-End Automobile Collisions

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§1220.39 Musculoskeletal Medicine and Primary Care Physicians

Musculoskeletal difficulties or injuries rate as the second most common reason for patients to consult with their primary care doctor. Yet, questions have been raised about the quality of primary care doctors' knowledge of fundamental musculoskeletal medicine. This study surveyed 85 recent medical school graduates in their first year of residency to determine their competency in musculoskeletal health, and to gain some background knowledge of their musculoskeletal health education while at medical school.

The test was administered at the Hospital of the University of Pennsylvania, and was designed by an orthopedic surgeon who was not involved in the study. The questions revolved around topics and concerns encountered frequently in a general practice, such as fractures and dislocations, low back pain, and arthritis. With questions such as, "Name two differences between rheumatoid arthritis and osteoarthrosis," and, "A patient has a displaced fracture near the fibular neck. What structure is at risk for injury?" the 25 questions covered the fundamentals of musculoskeletal medicine. The authors then sent the exam to 124 chairpersons of orthopedic residency programs in the US, asking them to rate the importance of each question and suggest a passing score that would demonstrate basic competency. The accepted mean passing score was 73.1%.

Seventy of 85 (82%) graduates failed the exam:

> "The current study clearly documents the inadequacy of medical school education with regard to musculoskeletal medicine. The duration of the residents' preparation in this area was inadequate. For the study population as a whole, the mean duration of instruction in orthopaedics was only 2.1 weeks. In addition, twenty-eight residents (33 percent) had graduated from medical school with no rotation, required or elective, in orthopaedic surgery; these residents had the lowest mean score (55.9%) on the examination and the highest rate of failure (93%)."

Medical school is generally the only training in musculoskeletal medicine. Furthermore, the prestigious school roster represented in the sample of graduates—Cornell University Medical College, Harvard Medical School, University of Chicago, the Schools of Medicine of John Hopkins University, and New York University as well as numerous other institutions—causes alarm due to the evident inadequacy in this area of training. The authors call for reform:

> "Our findings suggest the need for two educational reforms: an increase in instructional time and a revision of the content of the curriculum…An ideal required rotation in musculoskeletal medicine would be at least two weeks in duration and would emphasize common outpatient orthopaedic problems, orthopaedic emergencies, and physical examination for musculoskeletal problems."

Freedman K and Bernstein J. "The adequacy of medical school education in musculoskeletal medicine." The Journal of Bone and Joint Surgery *1998; 80-A(10):1421-1427.*

§2410 Sample Rebuttal Close

> First, I do not see – and the evidence does not show – that George had a preexisting condition. If you injure your back four, five, six years ago, and you have healed, it is not a preexisting condition. Assume you were injured several years ago, and still had minor discomfort, and then you get in a car wreck. The accident messes up your back. Is it fair to come in and say, "Well, you had symptoms before so you cannot recover"?
>
> I sprained my ankle. I do not know how many times I have sprained my ankle playing basketball, and stepping off curbs, many times. Assume I am walking down the street and I get run over in the

crosswalk. Light is green. The accident permanently damages my ankle. They argue I should only get a small amount because four, five, six years ago I hurt my ankle. Although it healed, I had symptoms. They argue, "You had these symptoms, and so you should not recover." That is like a truck driver hauling a full load of eggs. While stopped at a signal, someone negligently crashes into the truck and the whole load of eggs is smashed. Yolk drips from every opening in the trailer. Everyone knows what the inside of the trailer will look like when the door is opened. The argument the defendant's attorney just made is like saying to the truck driver, "Well, you had fragile eggs. You know they will break if they are hit. You should have been hauling concrete. If you had concrete, nothing would have broken. Even though we hit you, we should not have to pay because you were hauling eggs, not concrete. If you had concrete, we would not have broken all the eggs. So we should not have to pay because your eggs broke.

But the law says they must. [Insert relevant jury instruction, e.g., CACI 3927] is titled, "Aggravation of Preexisting Condition or Disability." The judge told you:

"George is not entitled to damages for any physical or emotional condition that he had before defendant's conduct occurred. However, if George had a physical or emotional condition that was made worse by defendant's wrongful conduct, you must award damages that will reasonably and fairly compensate him for the effect on that condition."

That is what the law is on the aggravation of any preexisting ailment or condition. A negligent driver is responsible for all injuries, even if a stronger person would not have been injured. The victim of the negligence did not choose to be hit, so the Defendant is not allowed to say, "You are weak, you were vulnerable to injury. I did not hit you hard enough to hurt most people, so I should not be responsible for your injuries. You are just weak." That is not the law. The law is, you take your victim as you find him. If you are negligent, you are responsible for all harm you cause, not just the harm you think is reasonable. Do you think defendant knew George had seen a chiropractor three and a half years before, and then was fine? Do you think Defendant knew that before she hit George? No, she did not. Well, you know, we do know one thing is undisputed from any of the evidence. C-7 radiculopathy equals pain. Their own guy says that. You think George laid around for three and a half years in pain not going to Dr. Soper, not going to Dr. Decker, just laying around hoping to get hit? C-7 radiculopathy equals pain. No symptoms for three and a half years. None, zero, zip, nada.

We have Dr. Soper, Dr. Decker, Dr. Weed. Treating physician, treating physician, treating physician. 28 years, 12 years, 2 years. Treats patients, treats patients, treats patients. Defendant brings Dr. Sleazy. Sleazy does exams for defense lawyers – doesn't treat. Spends fifteen minutes total seeing George. George's doctors told you what their diagnoses were: Permanent nerve damage, traumatic brain injury. Dr. Sleazy disagreed. Based on his limited examination, fifteen minutes, his opinion for the defense lawyer is, "Temporary soft tissue injury. It will go away."

Who are you going to believe? Dr. Sleazy admits C-7 radiculopathy causes pain. Couldn't explain why for three and a half years George had no symptoms, and admitted the best person to distinguish between muscle damage and nerve damage was Dr. Decker.

So based on Sleazy, Mr. Blackheart, the defense lawyer says, "Give him $3,000.00." A 40-year-old man who has to live with this for the rest of his life. You can see now why we are here. Sounds reasonable at first glance. Let us just say, though, we are looking at the Los Angeles Times, want ads—Job description: Pain, headache, constant; numb hands and feet; adjust sleep patterns, adjust life. Will you apply for that job? Who is going to apply for that job? Any takers? George did not have a choice. He now has that job the rest of his life. Okay. Well, he has that job. That job pays $3,000.00, one shot, once, the rest of your life. Will you accept that job?

That is the question. What is it going to take to compensate George for that job? You are going to set the salary. I asked for $_____. That is the only fair payment. This is George's only chance. He can't come back, and you can't either. In the future if you think to yourself, "I really didn't treat that poor man fairly. I did not give him enough," you can't come back to the judge and say, "Please let us meet again to decide if we were too conservative." This is George's only

chance and your only chance. Two months from now, if you see George in the local market, will you look away and act like you don't see him, because you are uncomfortable with what you did, or will you be able to walk up to him, greet him, tell him you are sorry about his injuries, and know in your heart that both you and George know justice was done. Justice in this case is $ _____. Thank you.