



*BOOMERANG  
SIX FLAGS MARINE WORLD  
VALLEJO, CA  
Photo by AP/Wide World Photos*

## **Are Amusement Park Thrill Rides Lethal? August 2003 Cover**

**Do breakneck speeds and high-g turns push thrill rides to a  
lethal new level?**

Published in the August 2003 issue.

[http://www.popularmechanics.com/science/health\\_medicine/1281111.html?page=2](http://www.popularmechanics.com/science/health_medicine/1281111.html?page=2)

**PopularMechanics**

New roller coasters crop up every year that are bigger, faster and wilder than ever. Tower rides are dropping us farther. Flat rides are spinning us with unimaginable new twists. It all seemed like good clean fun until two years ago. On June 2, 2001, a 28-year-old woman was found unconscious after a 3-minute ride on the Goliath roller coaster at Six Flags Magic Mountain in Valencia, Calif. Paramedics rushed her to a nearby hospital, where she was pronounced dead. The Los Angeles County coroner determined the cause of death to be a pre-existing condition, a brain aneurysm that could have burst spontaneously or been triggered by the excitement of the ride. Rather than settle the issue, the coroner's ruling set off a controversy that may simmer for years to come. The death was one of 15 fatalities or serious brain injuries that had occurred over the previous 10 years among otherwise healthy people who had just taken thrill rides. One individual to take notice was U.S. Rep. Edward Markey (D-Mass.), who seemed to capture the unspoken fear generated by the Goliath episode. "This is a rapidly growing problem that will soar out of control if the industry does not wake up to its responsibility to the riding public," he said. "The average roller coaster riders are not graduates of astronaut training like John Glenn or Sally Ride, and they surely should not be placed in a situation where the forces of the ride test the limits of human endurance." If that is the case, have roller coasters really reached the breaking point of human endurance? Have thrill rides become kill rides?

By the tens of thousands, visitors line up for thrill rides designed to provide the extreme physical sensations you just don't get walking down the street. To find out whether these riders need to be as fit as jet pilot to experience the thrill of aerobatic flying, POPULAR MECHANICS put that question to one of the people best qualified to answer, Capt. David L. Steinhiser, a flight surgeon for the U.S. Air Force Thunderbirds. "We fly visiting media representatives who are everyday people in our jets and subject them to g-forces in excess of those found on roller coasters. We have not had any instances of brain trauma. It doesn't happen." But Steinhiser adds an important caveat. "We do screen these people beforehand to be sure they're healthy. We don't do brain scans, but do apply some common sense criteria. We won't fly those who have suffered heart attacks, have excessive high blood pressure, or take certain medications. We want them to experience the Thunderbird jet flight, but they have to be healthy. As fliers, we train to handle and tolerate the heavy g-forces, as high as 9 g's. Our visitors will experience sustained g-forces of more than twice the forces found on a roller coaster with no lasting ill effect."

### **G-Forces At Work**

Whether Air Force-style preflight medical screening would have saved any of those who died soon after coaster rides will always remain a matter of unscientific speculation. But it does raise the question of whether more controls are needed on thrill rides. The amusement industry doesn't think so, and the scientific evidence that exists appears to concur.

The latest evidence to support the amusement industry's position appeared in the October 2002 issue of the peer-reviewed *Journal Of Neurotrauma*. Dr. Douglas H. Smith and David F. Meaney coauthored the article, "G-Forces, Roller Coasters, And Brain Trauma: On The Wrong Track?" Smith is a brain trauma researcher who studies head accelerations such as those encountered in an automobile crash. Meaney is a bioengineer who studies the biomechanics of brain trauma. Both are at the University of Pennsylvania, and their investigation was supported by grants from the National Institute of Health and the Centers for Disease Control and Prevention.

"According to our data," says Smith, "it is unlikely that amusement rides cause brain injuries. We took g-force data from three high-g-force roller coasters and plugged that into a model of head accelerations, compared that to known thresholds for various types of head injuries, and found that the highest estimated peak head accelerations calculated from roller coaster rides were far below the minimum thresholds for various types of injuries, including bleeding from the brain."

The roller coasters used in the study were the Rock 'n' Roller Coaster at the Disney-MGM Studios in Lake Buena Vista, Fla.; Speed--The Ride at the Sahara Hotel in Las Vegas, Nev., and Face/Off at Paramount's Kings Island. Both the Rock 'n' Roller Coaster and Speed--The Ride feature high-speed catapult launches. Face/Off, in Paramount's King's Island, Ohio, park, is an inverted-seating shuttle coaster that turns riders upside down six times.

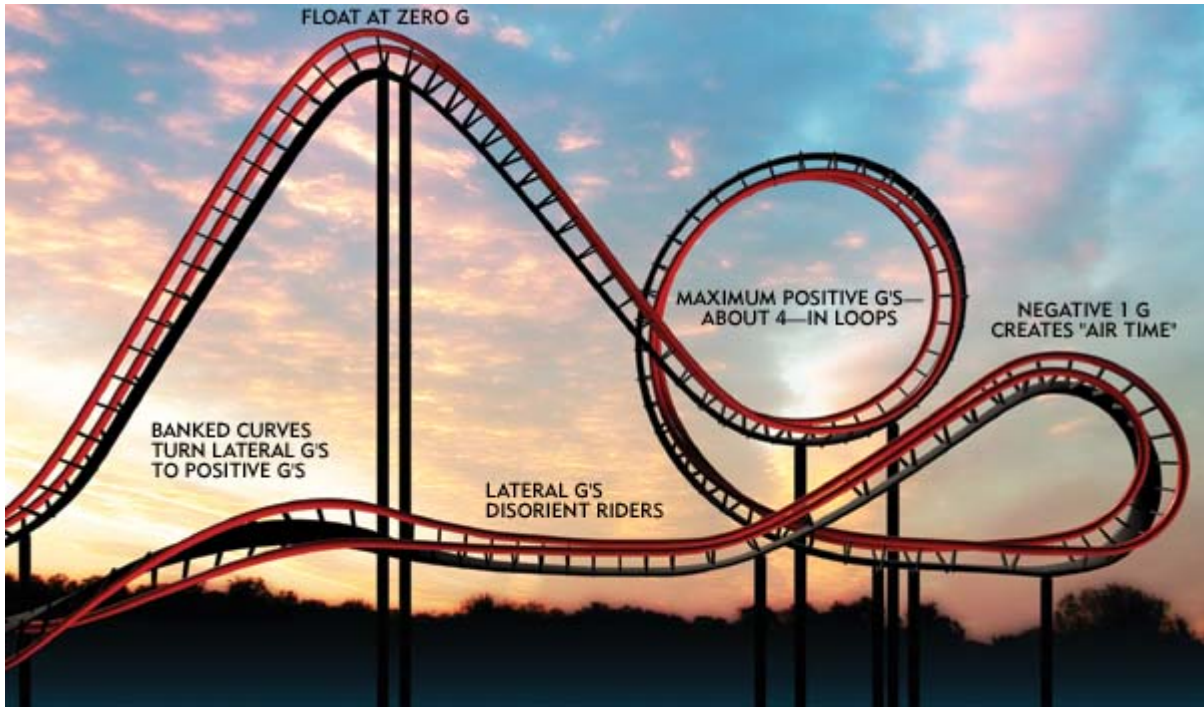
"There's simply no evidence or risk of brain trauma," Smith says. "While waiting for this issue to resolve itself we highly recommend that all roller coaster riders use a proven method to reduce the risk of brain injury--make sure your seatbelts are buckled at all times when driving to an amusement park."

U.S. Consumer Product Safety Commission (CPSC) statistics support both Smith and Meaney's findings and the industry's position. Injuries and occasional fatalities do occur, primarily as a result of a ride malfunction or from rider horseplay. But amusement parks are still one of the safest places to have fun. According to the most recent data provided by the CPSC and the National Sporting Goods Association, in the year 2000 there were far fewer emergency room-treated injuries per 1000 visits at amusement parks than there were for many other recreational activities. In that year, the CPSC estimates, there were 6594 emergency room-treated injuries related to fixed-site amusement rides--most were minor bruises, strains and sprains. In comparison, each year an estimated 20,000 people are treated for injuries sustained at music concerts, and 200,000 preschool and elementary school children visit emergency rooms for injuries sustained on a playground.



*TIMBER WOLF  
WORLDS OF FUN  
KANSAS CITY, MO  
Photo by AP/Wide World Photos*

Since 1978, the American Society for Testing and Materials (ASTM) has worked with numerous members of the U.S. amusement industry in the development of exacting ride safety standards. These companies have helped establish various standards on design and manufacture, testing, operation, maintenance, inspection and quality assurance, all of which have enhanced the safety and security of the amusement industry. Furthermore, the manufacturers and the ASTM have collected data on g-forces (one "g" is equal to the pull of Earth's gravity) and applied this biodynamic knowledge to the design and construction of rides.



### *FEEL THE FORCE*

*G-force loads can feel intense, but doctors say that they do not expose thrill seekers to stresses long enough to cause physical harm.*

*ILLUSTRATION BY DANILO DUCAK*

One important area has to do with the relationship between g-forces and the height and speed of the coasters. The somewhat counterintuitive fact is that there is no relationship. G-forces are created by how tightly one changes direction while on a ride. When a coaster train goes faster, it also goes through a larger radius turn in order to maintain the same g-force as a slower train rolling through a tighter curve. And so, even though technological advances have led to the development of faster and more thrilling rides, overall g-force levels on roller coasters have not dramatically changed in the past two to three decades because riders' tolerance levels have not changed. What is more, unlike the coasters that our parents and grandparents rode, today's machines are designed with the benefit of [computer](#) programs that calculate g-force loading along every yard of the ride. If you look at the new, faster generation of coasters, you will notice that one of its distinctive features is a wide curve. It is not there for decoration, but to maintain g-forces at about the same levels experienced on rides designed 30 years ago.

### **Time Matters**

When discussing the effects of g-forces on the body, time emerges as one of the

most critical factors. When it comes to the higher-g sections of amusement rides (see the illustration above right), exposure to high g-forces lasts only a fraction of a second. Blackouts and other health problems associated with g's require exposure to g-forces that are either greater in magnitude or of much longer duration than those achieved by today's amusement rides.

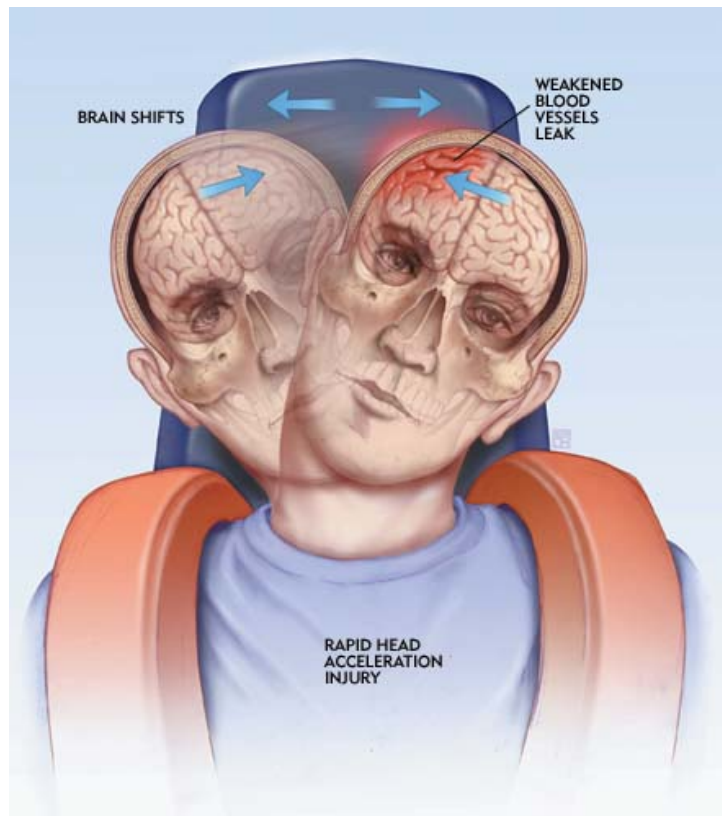
The issue of g-forces on the body was explored in detail in a classic medical study published nearly a decade ago in the medical journal *Spine*. In their investigation, doctors and engineers found that the normal movements we go through every day subjects us to far greater gravitational pull than that felt on any amusement park ride. According to the study, you experience 10.4 g's when you plop down into a chair. Hopping off a step generates 8.1 g's. A cough is a 3.5 g experience, a sneeze generates 2.9 g's. By comparison, 4-g amusement rides are wimpy.

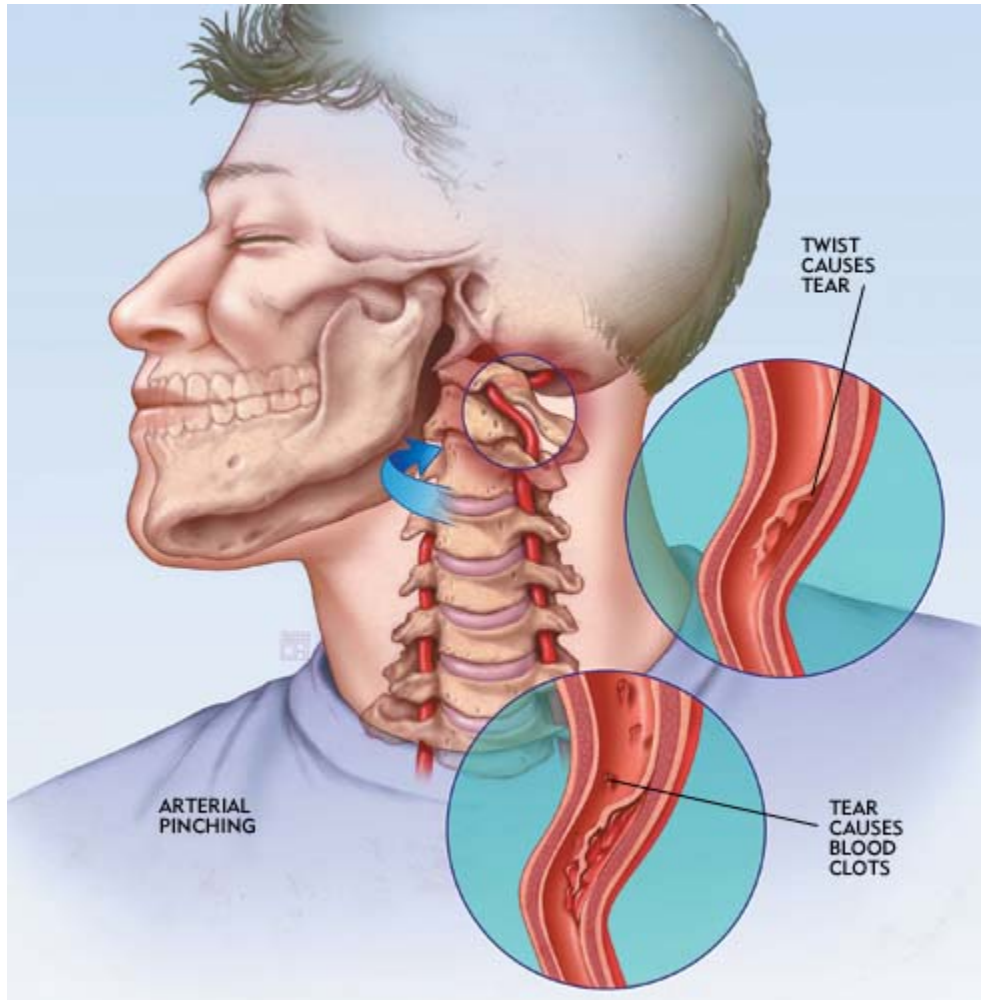
"High g-forces are common and well tolerated during many daily activities," says Smith. "Fighter pilots have high g-forces of long duration, causing pooling of blood. G-forces alone are a very poor measure of a risk of brain trauma. Pilots can endure fairly high g-forces, as much as 8 or 9 g's, for an average of 43 seconds, as opposed to the brief g-forces found on coasters," Smith says. "Pilots may pass out from these extended high g-forces, but that's not found on roller coasters, and pilots are not the victims of brain injuries as a result of those g-forces. Unconsciousness is not from brain injury, but from lack of blood flow."

"The key to producing brain trauma is head accelerations that can be caused by g-forces," Smith says. "In an auto accident, sudden stopping creates extremely high g-forces, causing brain deformation. If the brain is deformed rapidly, various types of injuries to the brain will occur, including ruptured blood vessels. We see auto crashes well documented, but that's been extrapolated to roller coasters without any scientific link. There have been no studies done that indicate an increased risk. We aren't seeing any numbers that concern experts, especially considering that bleeds in the brain from pre-existing aneurisms is not an uncommon thing. The woman's death in the Southern California incident is typical. Aneurisms commonly rupture, even during sleep. Her death could have been a coincidence, it could have been from the excitement of the ride increasing blood pressure, or it could have been from g-forces, but that's not proven. There simply is no evidence."



*SHOCKWAVE  
PARAMOUNT'S KINGS DOMINION  
DOSWELL, VA  
Photo by AP/Wide World Photos*





### *HEAD-JARRING INJURIES*

*The amusement park industry says research has ruled out rapid head acceleration (top) and artery pinching (above) as culprits in unexplained coaster deaths. Nevertheless, emergency room doctors treating these patients ask if they have recently ridden on thrill rides.*

*ILLUSTRATIONS BY KO STUDIOS*

Nevertheless, Markey and more than a dozen other House and Senate leaders approached the Brain Injury Association of America (BIAA), enlisting the organization in an investigation of a recent spate of brain injuries they claim have been associated with roller coasters and other amusement park rides. They suspect that these rides have such powerful g-forces that park patrons are injured, sometimes fatally, even when the rides operate as intended and no accident occurs. They cite documents from both the National Institute of Neurological Disease and Strokes and the *Annals Of Emergency Medicine* that support an increase in brain trauma cases associated with amusement park rides.



In response, the International Association of Amusement Parks and Attractions (IAAPA), the trade association representing parks around the world, cites Neuro-Knowledge, a program of the American Association of Neurological Surgeons and Outcome Sciences, a healthcare information service. It had a panel of experts review many of the cases listed in Rep. Markey's report and came to very different conclusions.

"Neurosurgeons have repeatedly affirmed that no clear mechanism has been shown to link brain injuries to normal operation of amusement park rides," says IAAPA president Clark Robinson. "The congressman's posting of unreviewed and unconfirmed cases and declaring that they are 'apparently caused' by amusement park rides is misleading and irresponsible."

Has a causal relationship been established between amusement rides and brain injuries? "Obviously not," concludes Smith, of the University of Pennsylvania. "There is no data out there that suggests a link, only anecdotal case reports. However, it may appear that injuries are becoming more common, but that's only because of increased attention by the general press."

Because the causal relationship between brain injuries and amusement rides has been widely questioned, the BIAA set up a panel of neurologists and other experts to assess the situation and provide guidance concerning what is safe and healthy when it comes to g-forces on roller coasters. Their conclusion, issued in winter 2002-03, is that it is safe to ride. Not everyone is convinced.

"The industry is playing a very dangerous game if it pretends that all is well on some of these rides," Markey observed early in 2002. "We need tough, tight, enforceable g-force standards, and we need them now."

Smith disagrees. "It would be very misguided even to suggest g-force limits," he says, "because g-forces are a very poor measure of any kind of brain trauma." Thus far, Smith's advice has been ignored. Following Markey's remarks, one such g-force standard was enacted, but it appears to be superfluous. New Jersey established mandatory regulations in the absence of voluntary action by the industry, but Smith derides it as "paparazzi science." The limits in New Jersey require that the rider is not subjected to more than 5.6 g's for more than 1 second per instance. This is in line with the voluntary standards created by the ASTM, which the industry supports. However, all amusement park rides in the United States meet this requirement, and have for many years. There may be a few rides in development that might match or exceed this limit, but they have yet to appear and probably never will.



*DOUBLE LOOP  
SIX FLAGS WORLDS OF ADVENTURE  
AURORA, OH  
Photo by Joel Rogers/Coastergallery*



*WILD WONDER  
GILLIAN'S WONDERLAND PIER  
OCEAN CITY, NJ  
Photo by AP/Wide World Photos*



*ZOOMERANG - LAKE COMPOUNCE - BRISTOL, CT  
Photo by AP/Wide World Photos*



*SUPERMAN RIDE OF STEEL - SIX FLAGS NEW ENGLAND  
AGAWAM, MA  
Photo by AP/Wide World Photos*



***TOP GUN***  
*PARAMOUNT'S GREAT AMERICA*  
*SANTA CLARA, CA*  
*Photo by James A. Sugar*

## **Deadly Rides 1997-2002**

In the past five years, fatalities have occurred on the following rides:

### **Double Loop**

Six Flags Worlds of Adventure  
Aurora, OH

### **Goliath**

Six Flags Magic Mountain  
Valencia, CA

### **Shockwave**

Paramount's Kings Dominion  
Doswell, VA

### **Top Gun**

Paramount's Great America  
Santa Clara, CA

### **Wildcat**

Bell's Amusement Park  
Tulsa, OK

### **Wild Wonder**

Gillian's Wonderland Pier  
Ocean City, NJ