Special issue: neck injuries in rear-end crashes

STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

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The seats and head restraints in many vehicles don't protect people's necks, but new designs show promise

As early as the 1960s, research indicated that head restraints could prevent whiplash injuries in rear-end crashes. But to be effective, a restraint has to be positioned behind and close to the back of a person's head. Even back then, researchers correctly predicted that adjustable restraints often would be left in the lowest, or down, position where they wouldn't protect many people. This knowledge didn't lead to the adoption of fixed head restraint designs, however, and the problem is pretty much the same now as it was then — most head restraints are adjustable, and they're left in the down position. This fact goes a long way toward explaining why whiplash injuries in rear-end crashes still constitute a big problem worldwide. But there's progress. Researchers know more about what causes whiplash injuries (see p.3). A new crash test dummy and injury criterion are allowing more sophisticated assessments of seatback/head restraint performance (see p.5). And some new restraint designs promise improved protection (see p.10).

Snapshot history of HEAD RESTRAINTS shows better ones needed — and may be on the way

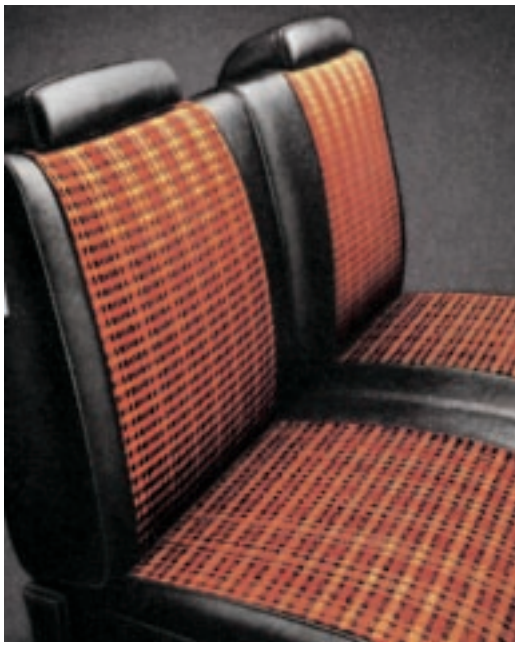
When head restraints were mandated in 1969, the federal rule permitted adjustable designs and specified a minimum height in the highest, or up, position. However, no minimum height was specified for the down position. The results were restraints like those in the 1971 Plymouth Duster (shown top, near right) and 1975 Chevrolet Caprice (top, far right).

In the down position, these and most other head restraints in cars of the 1970s were nowhere near high enough or close enough to the backs of many people's heads for effective protection in rear crashes. Even if the restraints had been adjusted to the up position, the height requirement was such that many occupants still wouldn't have been protected.

A better design is one that extends higher, fits close to the back of an occupant's head, and is fixed in place so it doesn't have to be adjusted upward. Objections to such restraints were that they would impair drivers' vision and cause motion sickness among people in rear seats — notions that weren't true but still held sway so most manufacturers stayed with the adjustable kind.

Saab broke the mold in the 1970s, introducing fixed head restraints that addressed the concerns about visibility. Volvo followed shortly thereafter with head restraints like those in the 242 model (shown right). But U.S. automakers didn't follow suit, and most cars today still are being equipped with head restraints that would have been judged inadequate based on research findings available in the 1960s.

Better head restraints are needed, starting with good geometric designs in all cars. More sophisticated systems like the active seatback/head restraint combination in the 1999 Saab 9-5 (inset) are likely to become more common (see p.10).



Understanding the FUNDAMENTALS of whiplash injuries points toward effective prevention strategies

When a driver suffers neck pain after a rear impact, the popular description for the injury is "whiplash." There's universal acceptance that the cause is sudden differential, or whip-like, movement of the head and neck relative to the torso. What isn't known for many of these injuries is the biological cause of the pain.

Understanding whiplash injuries has become a priority among researchers around the world. A number of symposia have been convened including a special meeting of the International Research Council on the Biomechanics of Impact, a World Congress on Whiplash-Associated Disorders, and Whiplash 1998 sponsored by the Society of Automotive Engineers. Reports from these conferences give researchers a lot more information, but the issue of whiplash still is complicated because most reported injuries cannot be verified with available diagnostic medical tests. Instead, there's only a patient's report of the symptoms, so it isn't surprising that several hypotheses have been advanced to explain such symptoms.

While the hypotheses advanced so far haven't been verified, it's generally agreed that there's more than one cause of the symptoms. It's also accepted that the description, "whiplash," identifies a range of associated disorders.

Duration of symptoms: Disorders associated with whiplash "are medically benign, self-limited problems that usually resolve spontaneously or with very conservative treatment in a short period of time. Disability, if any, generally lasts only a few days." This is the conclusion of the Quebec task force, a group of medical and traffic safety experts convened by the Quebec Automobile Insurance Society in the early 1990s (see *Status Report*, Sept. 16, 1995).

Despite the good prognosis for most people, 1 in 10 occupants who reports a neck injury to an insurance company is still reporting symptoms a year after the collision, according to a Swedish study. A recent Institute study (see p.7) found that 26 percent of drivers of rear-struck vehicles reported neck injuries, and 2 to 3 percent of all drivers in the study still were being treated six months after the crash.

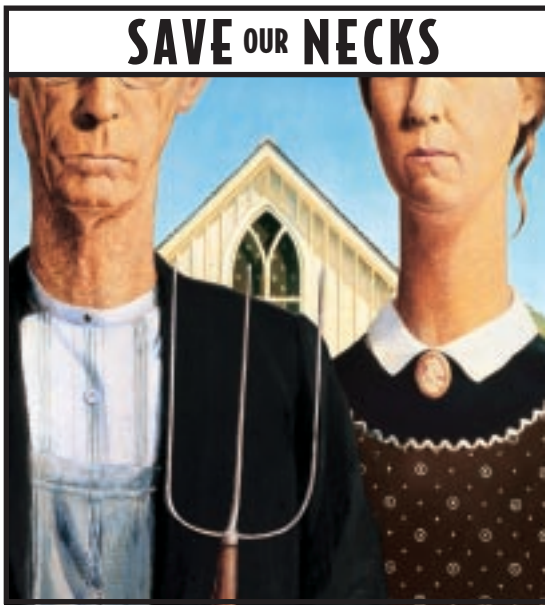
Another Swedish study focused on long-term whiplash injury symptoms, comparing a group of people not involved in collisions with a group involved in rear-end crashes. Some of the crash-involved occupants reported whiplash injuries and some didn't. The group not in crashes served as a comparison because neck pain frequently is reported even among the general population. At a follow-up seven years later, reported neck or shoulder pain was 30 percent more likely in the group involved in crashes. Among those who had reported a whiplash injury seven years earlier, the risk of neck or shoulder pain was nearly three times higher than the risk in the comparison group.

A study from Folksam Insurance of Sweden also focused on long- versus short-term symptoms, finding that women, who are more likely than men to report a whiplash injury (see p.8), also are more likely to develop long-term symptoms. Thirty-eight percent of the men who suffered whiplash injuries went on to develop long-term symptoms compared with 55 percent of the women.

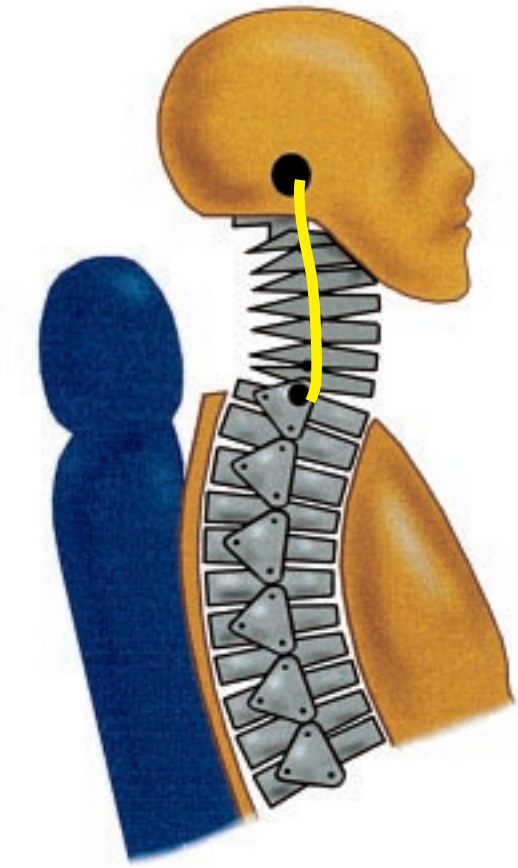
How the injuries occur: While there's still debate about the causes of both long- and short-term symptoms, there's general agreement that, if the relative motion of an occupant's head and torso in a rear-end collision can be kept to a minimum, a whiplash injury is unlikely to occur. This is why a head restraint that's positioned behind and close to an occupant's head during a rear-end collision is the necessary first step toward effective prevention of whiplash.

A vehicle that's struck in the rear is accelerated forward, causing its seat to push

If the relative motion of the head and torso can be kept to a minimum, whiplash injuries are unlikely. A properly positioned head restraint is the first step

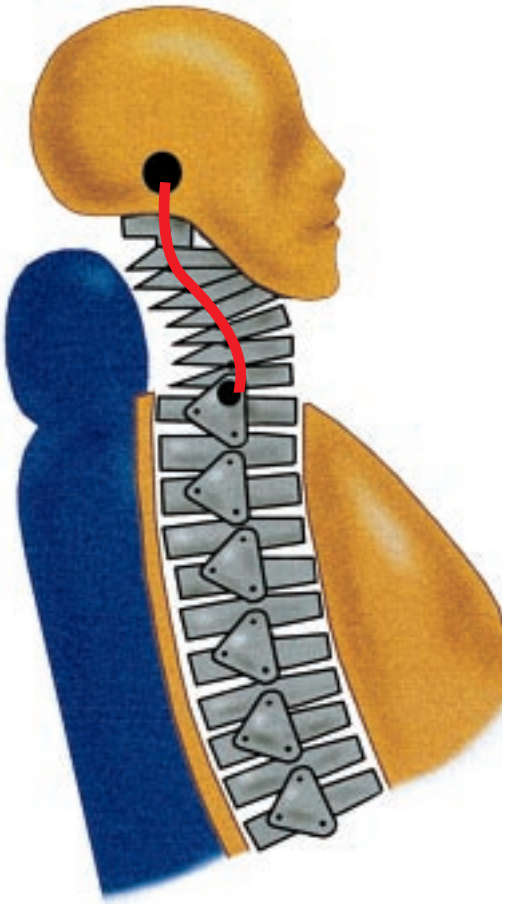


toward reducing the relative motion, but it's not all that's needed. Vehicles with stiff rear-end structures and/or stiff seatbacks produce greater torso accelerations in rear impacts. This, in turn, makes it harder to keep the head and torso moving together, so whiplash is more likely.



Left: Normal position of the neck in relation to the spine and torso before a rear crash.

Right: During a rear impact, as the movement of the head lags behind the torso the neck changes shape, first taking on an s-shape (shown) and then bending backward. The head later catches up with, and then passes, the torso. In its extreme form, this motion resembles the lash of a whip.



against an occupant's torso, accelerating it forward. If the motorist's head isn't restrained, it lags behind the torso, causing the neck to change shape. First the neck takes on an s-shape (see illustrations), and then it bends backward. Eventually, the forces on the neck accelerate the head, which catches up with, and then passes, the torso. This head motion, which in its extreme form resembles the lash of a whip, gives the resulting neck injury its popular name.

A good head restraint isn't all that's involved in preventing the sudden differential movement of an occupant's head and torso that's associated with whiplash injury. Vehicles with stiff rear-end structures and/or seatbacks produce greater torso accelerations, making it harder to keep a motorist's head and torso moving together. This means whiplash injury is more likely to occur.

According to a Swedish study by Mats Y. Svensson, in a rear-end crash in which a head restraint is positioned behind an occupant's head, the head/neck movement is influenced, first, by the initial distance between the motorist's head and the restraint. Relative head/torso movement also is influenced by the stiffness and elastic properties of both the seatback and head restraint.

The maximum head/torso displacement increases as horizontal distance between the occupant's head and the restraint increases, Svensson found. Greater stiffness of the seatback frame results in increased maximum head/torso displacements. But when this was combined with a stiffer lower seatback cushion and a deeper upper seatback cushion, the head/torso displacement was reduced. "These two changes resulted in the elimination of the head to head restraint gap early on in the crash," Svensson says.

The findings of Svensson's study indicate that, besides good head restraints, vehicle seats can be important in improving protection against neck injuries in rear-end collisions. As the researcher noted, "a close fit between the head and the head restraint in combination with well chosen stiffnesses of the different seatback components would virtually exclude all extension motion of the cervical spine and thus minimize the neck injury during rear-end collisions."

Understanding whiplash injury mechanisms leads to new injury criterion and A BETTER DUMMY to assess injury likelihood

For a long time, extreme hyperextension of the neck was thought to be the cause of whiplash injuries. Such hyperextension — which can lead to strains and tears of neck muscles, tendons, and ligaments — may explain many of the injuries with symptoms that last only a few days or weeks. However, evidence is growing that neck hyperextension doesn't account for all whiplash injuries, particularly the ones with symptoms lasting longer than a few weeks. These are likely to involve more complex mechanisms that result in damage to nerve tissue and/or the joints of the vertebrae.

One hypothesis is that as the head moves rearward, relative to the chest, the surfaces of the vertebrae may be damaged where the facets rub against each other. The facets at the rear of the vertebrae are heavily innervated, and the damage can lead to joint pain that may last a long time due to slow healing.

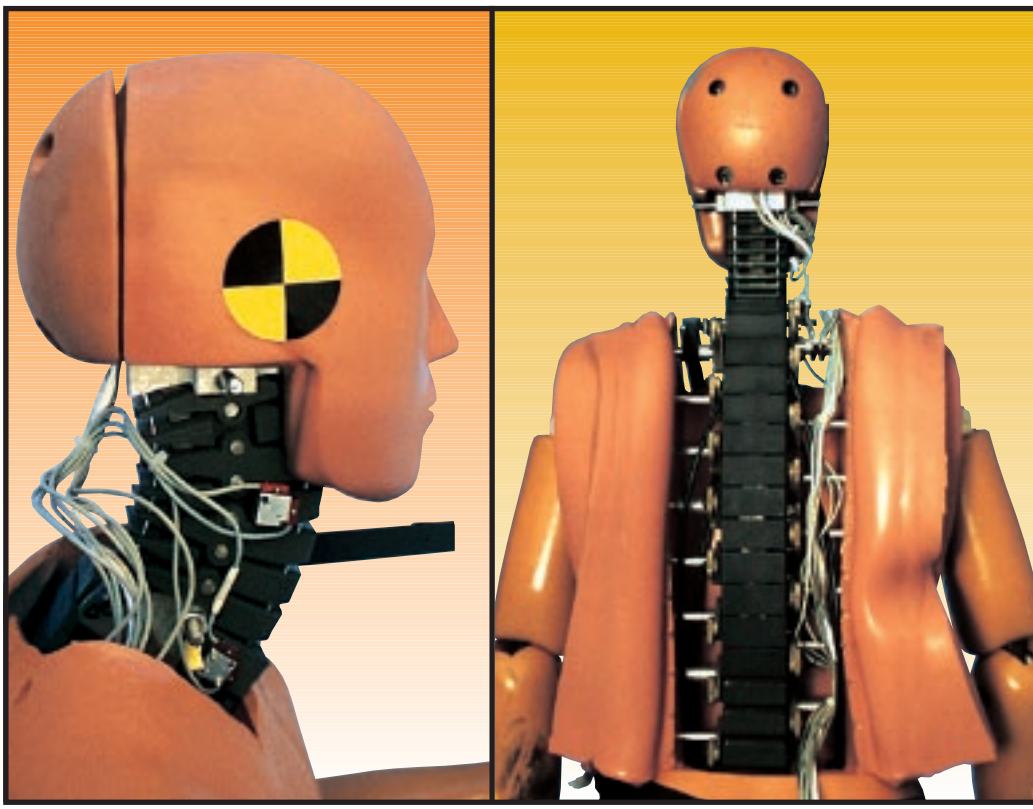
Another hypothesis points to direct nerve damage. Injury to the nerves entering the spinal column can occur with rapid changes in spinal column pressure. When an occupant's head moves back, relative to the torso, the shape of the neck changes. This increases or decreases the interior volume of the spinal column. Because spinal fluid is incompressible, changes in spinal column volume result in pressure changes.

Suddenness of the neck motion: Under normal circumstances, like when you nod your head, there's time for the fluid to move into or out of the spinal column to equalize the pressure, and no injury occurs. But in a rear impact, changes in spinal column volume can be too rapid for normal fluid exchanges, and the resulting pressure may damage the nerve fibers where they enter the spinal column. Research from Chalmers University of Technology in Sweden indicates that a critical issue isn't the extent of the neck motion relative to the torso — it's how suddenly the neck assumes the s-shape (see p. 4).

Assessing the influence of head restraint designs, seat characteristics, and vehicle structure on relative head/torso motion in rear-end crashes requires dynamic tests using appropriate dummies and relevant injury measures. But such tests have been limited until recently because existing dummies such as the Hybrid III have spines and necks that aren't very much like a human's. Nor have there been widely adopted dummy measures to assess whiplash injury risk.

This is changing, especially in Europe. A new neck injury criterion has been proposed, and a prototype advanced crash test dummy has been developed.

New injury criterion: The neck injury criterion (NIC) compares the speed and acceleration of the head at the top of the neck with speed and acceleration at the first thoracic vertebra at the bottom of the neck. Expressed in terms of meters per second squared (m^2/s^2), this comparison indicates how much the movement of the head is delayed behind the torso. A lower NIC value is better because it indicates a shorter delay and, therefore, less likelihood of a whiplash injury.



The new BioRID dummy's segmented neck and flexible spine are more like a human's than the neck and spine of other crash dummies. Its segmented neck can produce the s-shape observed in humans during rear-end collisions (see p.8 for more about BioRID).

An indicator of potential spinal column pressure changes, NIC is based on tests involving pigs. Chalmers researchers recorded significant pressure changes in tests that also caused nerve damage to pigs — the type of damage that could explain long-term whiplash symptoms. Based on research with both pigs and humans, these researchers proposed a value of 15 as the threshold below which *(cont'd. on p.8)*

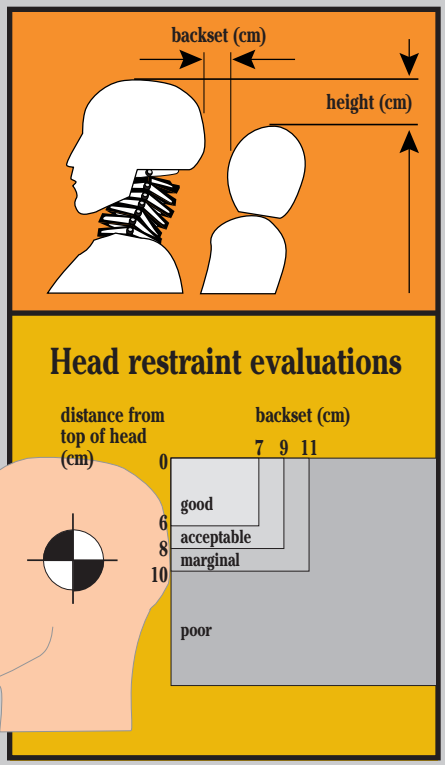
Head restraint HEIGHT, DISTANCE from back of head determine geometric fit

The necessary first attribute of an effective head restraint is good geometry. Institute researchers routinely evaluate the geometry of head restraints in passenger vehicles based on the height and backset relative to an average-size male (see *Status Report*, April 12, 1997). A restraint should be at least as high as the head's center of gravity, or about 9 centimeters (3.5 inches) below the top. The backset, or distance behind the head, should be as small as possible. Backsets of more than 10 centimeters (about 4 inches) have been associated with increased symptoms of neck injury in crashes.

New research indicates that the Institute ratings are good predictors of how well people will be protected in rear-end crashes. Drivers with restraints rated good are less likely than those with poor restraints to claim neck injuries (go to ratings).

Institute researchers have measured and rated the head restraints in hundreds of new passenger vehicles. These ratings are listed by vehicle make and series. For each series, various seat/head restraint combinations are rated, but not every available seat was measured for every series.

Each restraint is classified into one of four geometric zones defined by its height and backset. The restraints were measured with the angle of the torso at about 25 degrees, a typical seatback angle.



Head restraint RATINGS

The rating for a fixed head restraint is straightforward — the zone into which its height and backset place it also defines its rating.

The rating for a head restraint that adjusts in height and/or backset depends on whether it locks in the adjusted position. If it doesn't, its rating is defined by the zone for height and backset in the down and/or rear position. If it does lock, height and backset are measured in two positions — down and the most favorable locked position. The final rating is the better of the two, except that if the adjusted rating is used it's downgraded a category because so few motorists adjust their restraints. Many vehicle models have more than one seat option and, if seat differences affect a model's head restraint rating, more than one rating is shown.

Legend

- good
- acceptable
- marginal
- poor

Head restraints with GOOD GEOMETRY reduce neck injuries in on-the-road collisions

It's one thing to measure the height and distance of a head restraint from the back of an average-size male's head and then rate the restraint good, acceptable, marginal, or poor based on its geometry. The Institute has been doing this for a number of years (see page **6**). It's quite another thing to look at what happens in thousands of real-world crashes and determine whether the head restraints in vehicles with better ratings actually provide improved protection in rear impacts.

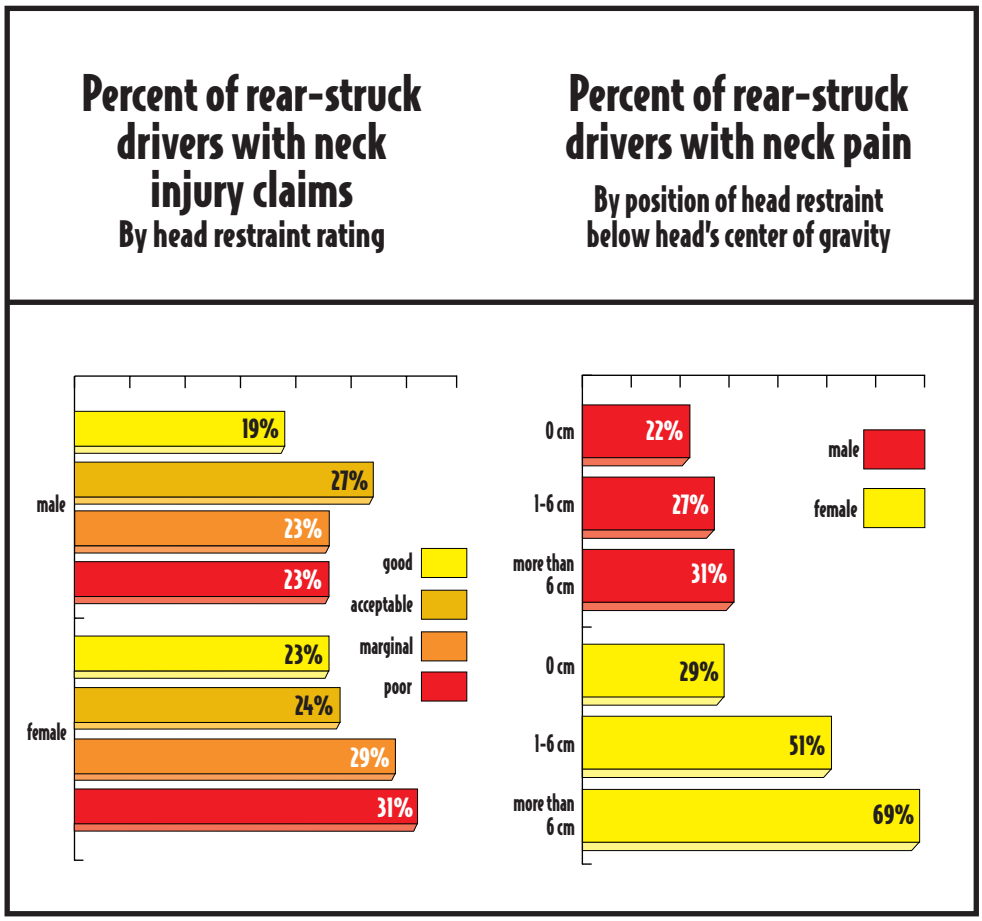
They do. Two new Institute studies indicate that the fit of restraints to people's heads matters a lot. In one study, researchers analyzed more than 5,000 State Farm Insurance claims in 38 states and determined that, all other factors being the same, drivers with head restraints rated good are 24 percent less likely than drivers with poor head restraints to sustain neck injuries in rear-end crashes. Restraints with acceptable geometry also reduced the likelihood of insurance claims for neck injuries among female, but not male, drivers in rear-end crashes.

It has been hypothesized, but not proven, that apparent differences in head restraint effectiveness for women versus men are because women are shorter, on average, than men. This means a given restraint design may be more likely to be positioned adequately for a woman. Available information in the State Farm study didn't enable researchers to determine head restraint positions for individual motorists, but this issue is addressed in another Institute study.

For the second study, researchers measured the vertical and horizontal positions of drivers' head restraints in relation to their heads. This survey included 585 drivers in the Rochester, New York, area who had been in rear-end crashes. For the measurements, each driver assumed a normal position in the vehicle, with the head restraint in the same position as it was when the crash occurred. The findings support the hypothesis that head restraints positioned behind the head are just as effective for men as for women. The risk of neck pain was reduced more than 40 percent by restraints with good, acceptable, or marginal geometry in relation to the individual drivers' heads. The statistical significance of this finding is stronger for women than for men, but it holds true regardless of gender.

Head restraint height is the primary factor that determines effectiveness. The percentages of both male and female drivers reporting neck pain in the Rochester study increased as head restraint height decreased below the head's center of gravity. Researchers found no further benefit for restraints higher than the head's center of gravity.

For a copy of "Relationship of Head Restraint Positioning to Driver Neck Injury in Rear-End Crashes" by Charles M. Farmer et al. or "Neck Pain and Head Restraint Position Relative to the Driver's Head in Rear-End Collisions" by Janella F. Chapline et al., write: Publications, Insurance Institute for Highway Safety, 1005 North Glebe Road, Arlington, VA 22201.



Almost every study that has looked at gender differences reports that women are at greater neck injury risk than men. New research from Germany finds women 1.8

to 2.2 times more at risk. A Swedish study finds women more likely to report whiplash injuries and more likely to develop long-term symptoms. Three Institute studies, one from the early 1970s plus two recent ones, confirm that women are at greater neck injury risk than men.

(cont'd. from p.5) the chance of whiplash injury with prolonged symptoms is low.

A number of studies have assessed NIC's validity, and the results are positive. After one series of low-speed rear sled tests involving 70 volunteers and 28 cadavers, researchers concluded that NIC predicts impact conditions that can result in soft tissue neck injuries with "acceptable accuracy .... a high NIC is always related to extensive relative motion between the head and neck."

In another validation study, subjects seated in a car were rear-ended by another car to produce speed changes of about 2 or 5 mph. Although none of the volunteers' NICs exceeded the proposed threshold value of 15, whiplash symptoms were reported in a third of the tests. The symptoms were of short duration, however, and the researchers speculate they might have been minor muscle injuries rather than the pressure-related nerve damage that NIC measures.

New crash test dummy: Tests involving volunteers are valuable, but they have to be conducted at speeds slow enough that lasting injury is unlikely. Good crash test dummies are required for evaluating head restraints and seatbacks in collisions of greater severity.

To study relative head/neck motion in rear crashes, BioRID, or biofidelic rear impact dummy, was designed by a consortium of Chalmers University, restraint manufacturer Autoliv, Saab, and Volvo. This dummy's spine is composed of 24 vertebra-like pieces, its neck moves more like a human's, and its segmented spine interacts with vehicle seats in a more humanlike way than the Hybrid III's rigid spine. Plus BioRID's segmented neck can produce the s-shape observed in human necks during rear-end collisions (see p.4).

The purpose of developing and validating BioRID and NIC is to use them in dynamic tests (see p.10). From such testing, researchers can learn more about how seatbacks, head restraints, and other vehicle characteristics influence the likelihood of whiplash injury.

MAGNITUDE

of the whiplash injury problem worldwide; compensation systems influence injury reporting

In the United States, neck strains and sprains are the most serious injury reported in 30-40 percent of auto insurance claims. Such injuries cost at least $7 billion a year.

The problem isn't confined to the United States. Neck injuries from car crashes represent an international problem. For example, two studies conducted in Japan in 1991 and 1994 say such injuries account for about half of all crash injuries.

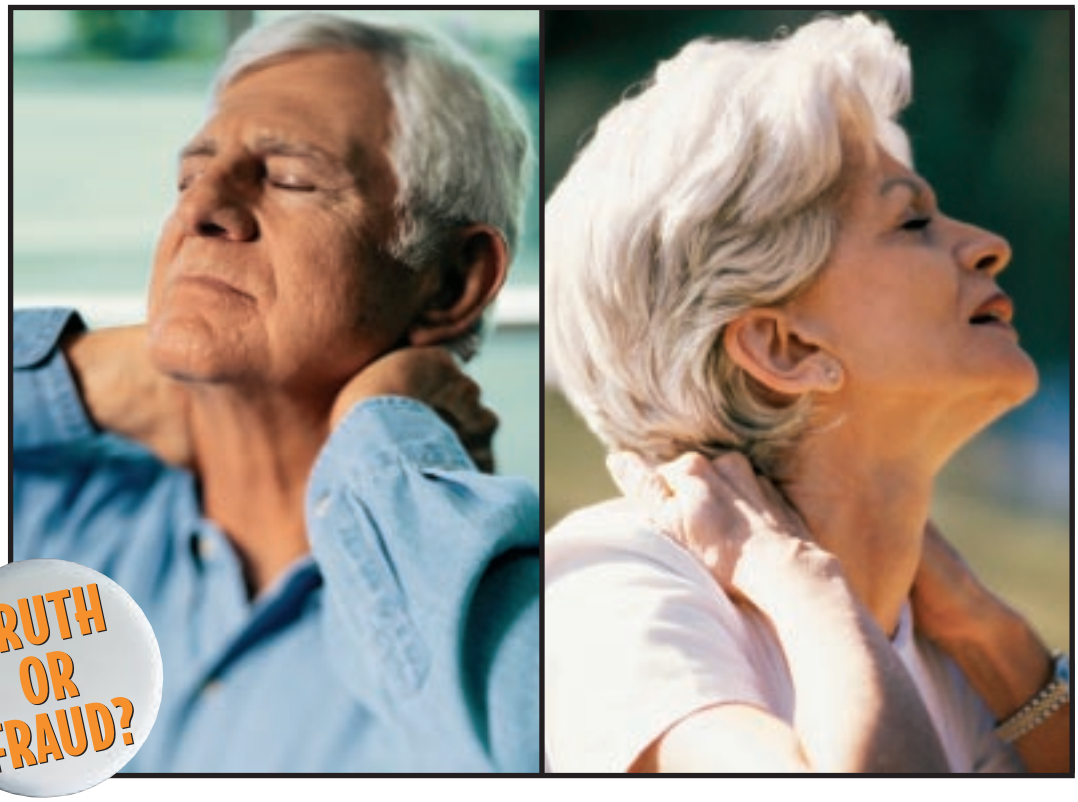
Research from England indicates that the rate of reported injuries to the soft tissues of the neck doubled in less than 10 years, from a rate of 11 percent of people in crashes in 1984 to 23 percent in 1991. During a recent 20-year time span in Germany, neck injuries were the second most frequently claimed type of injury from crashes. Such injuries grew from a rate of 20 percent in 1969 to 35 percent in 1990.

A second study from Germany has determined neck injury risk rates from a database of 1987-96 crashes of all types. Researchers computed the proportion of occupants with neck injuries, finding it increased from about 9 percent in 1987 to about 17 percent in 1996. The highest risk was in rear impacts, in which about 25 percent of people using belts sustained neck injuries, while the lowest risk (10 percent) was in side impacts.

Women versus men: Almost every study that has looked at gender differences reports that women are at greater neck injury risk than men. The Institute noted this difference in 1971, based on nearly 7,000 front-into-rear crashes reported to State Farm Insurance. In passenger vehicles with and without head restraints, more women than men reported whiplash. Two new Institute studies provide further evidence of gender differences (see p.7).

Recent research from Germany notes the same phenomenon, finding women 1.8 to 2.2 times more at risk of neck injury in all types of collisions. The researchers evaluated potential risk factors besides gender, including people's ages, heights, and weights. They found greater neck injury risk "from about 20 to 50 years than in the lower and higher age groups." Height was more of a risk factor among women than men, but weight didn't appear to affect injury risk in either group.

The Insurance Research Council says the number of claims for neck strains and sprains in the United States varies according to the type of state insurance system. Excessive claims for soft-tissue injuries (a category including whiplash) most often occur in jurisdictions with fault-based tort liability systems, under which an injured person can seek compensation for economic losses like medical costs and for noneconomic losses often referred to as "pain and suffering." This was a main finding of a 1995 study by the RAND Institute of Civil Justice (see *Status Report*, Sept. 16, 1995). About three-quarters of U.S. states have fault-based tort liability systems.



Influence of compensation systems: The way people are compensated for whiplash injuries varies widely. These differences influence the rate of insurance claims for neck injuries, making it hard to reliably quantify the true scope of the whiplash problem. Insurance claims typically run the gamut from actual injuries accompanied by symptoms to injuries with exaggerated symptoms and outright fraudulent claims. "The absence of an objective test to identify the real injuries makes them relatively easy to fake or exaggerate," Institute president Brian O'Neill points out.

In about a quarter of the states, dollar-threshold no-fault insurance prohibits people from filing claims for pain and suffering unless the medical costs exceed a specified amount. The idea is to eliminate many of the minor injuries from the tort system while still providing reimbursement for medical bills. Unfortunately, the dollar threshold often becomes a target for claimants to exceed so they can sue under the tort system.

Florida, Michigan, and New York have "verbal" no-fault systems, under which people may seek pain and suffering awards only in conjunction with an explicit list of injuries that tend to be serious. Such injuries include death, dismemberment, loss of a body part, loss of one of the senses, or a fracture. Incentives to exaggerate soft-tissue injury claims are limited in Michigan and New York where the verbal thresholds are tougher. Michigan is included in a recent study of insurance claims (see p.7), from which researchers found that neck injury claim rates in this state are significantly lower than in states with tort liability-type systems — 13 percent versus 26 percent.

Saskatchewan experiment: A new study from Canada indicates that when a tort system is changed to true no-fault that eliminates awards for pain and suffering, whiplash claims go down. Saskatchewan Government Insurance is the province's only insurer for traffic injuries. On January 1, 1995, this province changed from tort to no-fault, and an ongoing study became, in the words of one researcher, a "natural experiment of traffic compensation systems."

The six-month cumulative incidence of whiplash claims was calculated for the last six months of the tort system and for the first and second six-month periods of no fault. Preliminary analysis shows the number of whiplash claims decreased under no fault — "the drop was most pronounced in younger persons and males" — even though the number of vehicle damage claims increased. The "median time to claim settlement" also dropped from 433 days under the tort system to 194 days during the first six months of no fault and to 203 days during the second six months.

Going beyond geometry: ADVANCED DESIGNS of head restraints and seatbacks promise to reduce whiplash injuries

After years of neglect, more automakers finally are taking head restraint designs seriously. Some improvements are as simple as adding a lock so a restraint will remain in the up position and won't be pushed down when an occupant's head loads it in a crash or when a rear-seat occupant rests a hand on it. In other cases, head restraint geometry — height and backset — is being improved.

The most encouraging advancements go beyond geometric improvements, incorporating the vehicle seatback into a more complete restraint system. Using the newly developed rear impact test dummy and neck injury criterion (see p.5), the Institute has evaluated some of these new designs in 15 mph crash tests involving a 4,000 pound movable barrier with a rigid front end hitting the rears of cars with the new BioRID dummy in the front seat.

Volvo's innovation: The first test series consisted of three impacts of 1999 Volvo S80 models. In each test there were two different front seats, one the original-equipment S80 seat with a new design called WHIPS, or whiplash injury prevention system. The hinge at the base of this seatback yields and partially rotates when an occupant's torso loads it in a rear impact. This design, which includes a fixed head restraint with good geometry, is intended to reduce forward acceleration of the torso so that even the limited relative head/torso movement allowed by Volvo's good fixed restraint occurs more gradually than with a conventional seatback.

To compare with this WHIPS design, the other front seat in each test was from a Volvo S70 with a fixed back and head restraint with good geometry. The WHIPS seat produced lower neck injury criterion (NIC) values.

Advanced designs in Grand Prix, Saab: A second series of Institute crash tests involved a 1997 Pontiac Grand Prix — it's equipped with a seatback/head restraint designed to meet new General Motors geometry and stiffness criteria — plus a 1999 Saab 9-5 with an energy-absorbing seatback and active head restraint designed to move up and forward as an occupant's torso loads the seatback in a rear-end collision.

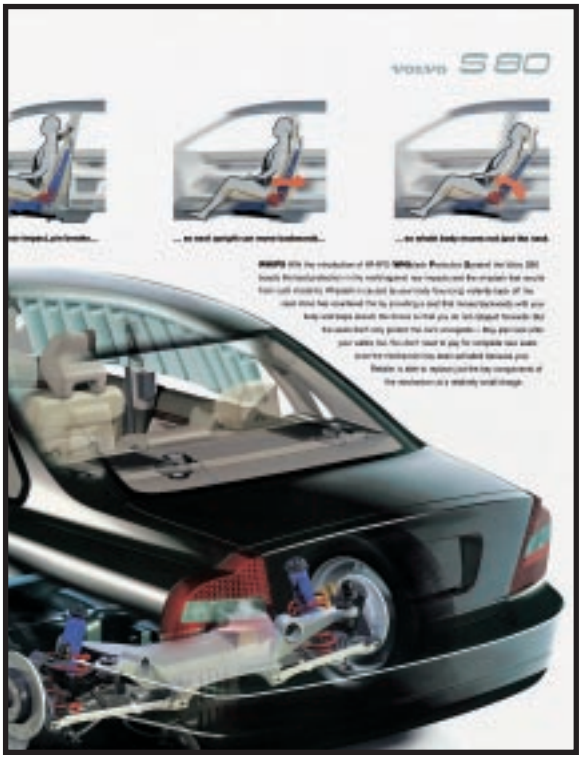
The head restraints in both models are adjustable, both have good geometry in the up position (although the Grand Prix's restraint doesn't lock in this position), and both have poor geometry in the down position. The restraint in the Grand Prix was tested only in the up position, and it produced a low NIC. Saab's active head restraint has geometry that improves during a collision as the restraint moves up and forward. Because of this active feature,

NIC results (m^2/s^2) in 15 mph rear-end crash tests

	1999 Volvo S80: WHIPS seat	1999 Volvo S80: S70 seat
1st test	14	24
2nd test	12	29
3rd test	13	22

	Head restraint position: down (lowest)	up (highest)
Pontiac Grand Prix	no test	16
Saab 9-5	22	12

Note: A NIC of 15 is the proposed threshold below which the chance of serious whiplash injury is low.



General Motors, Volvo, and Saab are promoting new seatbacks and head restraints designed to reduce neck injuries in rear impacts. Institute tests indicate the effectiveness of several of these new systems.

the restraint in the 9-5 was tested in both up and down positions. Recorded NICs, especially in the up position, were good.

The WHIPS seat has the advantage of a fixed restraint with good geometry. Performance is good in 15 mph impacts, and its good geometry should mean it will prevent many whiplash injuries in crashes at lower speeds when occupants' torsos don't activate the adjustment features. This restraint was developed in collaboration with Autoliv, which is marketing it to other automakers as AWS, or anti-whiplash system.

Results from tests involving the Grand Prix indicate that even traditional head restraints can produce good results in dynamic tests if — and this is still a big if — the restraint is positioned correctly. Unfortunately, Grand Prix head restraints don't lock in position, nor do they have good geometry for many occupants in the down position.

The improved geometry and stiffness of the Grand Prix head restraint eventually will be found throughout the General Motors line, the company says. Plus a "catcher's mitt" design, available in 2000 model Buick LeSabres and Pontiac Bonnevilles, has a self-aligning restraint that's the same as Saab's. It "uses the rearward movement of the occupant's upper torso in a crash to rotate the head restraint closer to the head," a General Motors spokesperson explains.

A similar design is being offered by the auto seat division of European-based Faurecia. In a rear impact, this seat is activated by an occupant's pelvis, triggering the forward and upward movement of the seatback/head restraint unit.

Rear-impact airbag protection is being marketed by BSRS Restraint Systems. In a rear crash, an airbag located inside the seatback inflates. The airbag also deploys from the top of the vehicle seat to support an occupant's head and neck. The manufacturer of this system says it "reduces relative velocity between the head, neck, and torso, minimizing injuries and occupant rebound."

SAVE OUR NECKS

The most encouraging advancements in head restraint design go beyond simple geometric improvements, incorporating the vehicle seatback into a more complete restraint system. These are beginning to appear in new cars now.

STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

Special issue

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This special issue focuses on neck injuries in rear impacts. Recent special issues have focused on the following subjects:

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Amwest Insurance Group
Auto Club South Insurance Company
Automobile Club of Michigan Group
Baldwin & Lyons Group
Bituminous Insurance Companies
Brethren Mutual Insurance Company
Brotherhood Mutual
California Insurance Group
California State Automobile Association
Cameron Companies
CGU Insurance
Church Mutual
Colonial Penn
Concord Group Insurance Companies
Cotton States
Country Companies
Erie Insurance Group
Farm Bureau of Idaho
Farm Bureau of Iowa
Farmers Insurance Group of Companies
Farmers Mutual of Nebraska
Fidelity & Deposit
Foundation Reserve
Frankenmuth
The GEICO Group
General Casualty Insurance Companies
Grange Insurance
Harleysville Insurance Companies
The Hartford
Heritage Mutual Group
Kansas Farm Bureau
Kemper Insurance Companies
Liberty Mutual Insurance Group
Merastar
Mercury General Group
Metropolitan Property and Casualty
Middlesex Mutual
Montgomery Insurance Companies
Motor Club of America Insurance Company
Motorists Insurance Companies
Motors Insurance
Mutual Service Insurance
National Grange Mutual
Nationwide Insurance Enterprise
North Carolina Farm Bureau
Northland Insurance Companies
Oklahoma Farm Bureau
Old Guard Insurance Company
Oregon Mutual Group
OrionAuto
Pekin Insurance
PEMCO Insurance Companies
The Progressive Corporation
The Prudential
Response Insurance
Royal & SunAlliance
SAFECO Insurance Companies
SECURA
Shelter Insurance Companies
Southern Heritage
State Auto Insurance Companies
State Farm Insurance Companies
The St. Paul Companies
Tokio Marine Group
United Auto Insurance Company
USAA
Virginia Mutual Insurance Company
Warrior Insurance
Wisconsin Mutual
Yasuda Fire and Marine of America
Zurich U.S.