J-NCAP: TODAY AND TOMORROW

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ABSTRACT

The New Car Assessment Program in Japan (JNCAP) was launched in 1995 in order to improve car safety performance. According to this program, installation conditions of safety devices and the results for braking performance and full-frontal crash tests are published every year. Introduction of JNCAP significantly increases the installation rate of safety devices and contributes much in enhancement of safety as seen in the decrease in the average injury severity of drivers and passengers. Side impact and offset frontal crash tests were introduced in 1999 and 2000, respectively. At present, the overall crash safety rating is carried out based on the results of the full-frontal, offset frontal, and side impact tests.

1.INTRODUCTION

The number of persons killed each year in traffic accidents in Japan is still over 9,000 though it has shown a decreasing trend for several years. The total number of casualties in traffic accidents has reached as many as a million persons. Casualties who were in the cars make up approximately 60% of this total and the rate is increasing year after year. In order to reduce the number of victims from traffic accidents, the Ministry of Land, Infrastructureand Transport(the former Ministry of Transport) has considered it should be indispensable for Japan to employ the NCAP (New Car Assessment Program) that is implemented by government organizations in many overseas countries. Under the initiative of the Ministry of Transport, the National Organization for Automotive Safety & Victims' Aid (OSA) started in 1991 to study the type of information to be offered to the users to help them choosing safer cars. Based on this study, the first report of JNCAP containing results of full-frontal crash tests was published in FY1995. The sixth report of JNCAP published in April 2001 contains results of full-frontal, offset frontal, and side impact tests as well as overall crash safety rating derived from these tests.

This paper describes reasons why respective tests were introduced, trends seen in the test results and objectives to be aimed at by JNCAP in the future.

2.PURPOSE OF JNCAP

All cars sold in Japan meet the safety standard. However, comparison by models reveals differences among them in the rate of equipping safety devices or in performance of safety devices provided. Thus, JNCAP, as a neutral organization, aims at helping users to choose safer cars by offering information obtained from comparison tests on safety done by models.

This activity of JNCAP will not only promote wider use of safer cars through users' selection but also encourage automobile manufacturers to undertake more research and development effort in producing safer cars. JNCAP is also offering information on correct use of safety devices in order to enhance users' awareness and correct understanding on safety

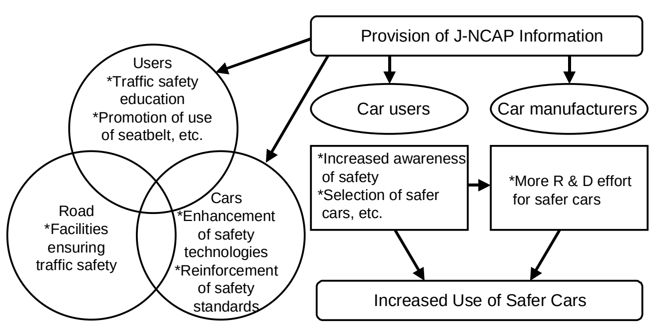

Figure 1 Objectives of J-NCAP

(see Figure 1).

3.CONTENT OF CAR SAFETY INFORMATION

3.1 History of J-NCAP

Prior to start of actual information provision activity in 1995, OSA began a review in 1991 on what types of information are to be offered and what kinds of tests are to be conducted to collect necessary information. OSA reviewed items relating to braking performance and visibility performance during the two years of 1991 and 1992, and then proceeded to study items relating to collision safety in 1993 and continued this up to 1994. After reviewing these topics from various aspects, OSA concluded that more information relevant to collision safety should be offered because users are most concerned about this subject.

In 1995 JNCAP began to offer information on safety performance of cars such as collision safety, on a trial basis, then began full-scale provision of information using findings obtained from brake tests and full-frontal crash tests. The side impact test was added in 1999. In 2000, the offset frontal crash test was added and the program launched an overall crash safety rating based on three collision tests (full-frontal, offset frontal, and side impact).

JNCAP selects models of cars to be tested starting with the best selling one. Models requested by manufacturers can be added to the test, as well. However, the maximum number of models allowable was limited to six per manufacturer in 2000 so that the number of models tested may be fairly shared among manufacturers. The test was started in 1995 with 8 cars combining small and regular passenger cars. This became 10 in 1996 including a mini-van and then gradually increased to 11 in 1997 and 18 in 1998. The target was expanded to mini-sized cars and light-vans in 1999 implementing the test on 27 cars. In 2000, the test was conducted on 7 mini-sized cars, 12 small/regular passenger cars, and 5 one-box mini-vans.

3.2 Increased Application of Safety Devices and Their Correct Use

JNCAP runs statistics in its report on how safety devices such as ABS and airbags are provided on respective models of cars sold in Japan. JNCAP also offers information on how to use these devices correctly. JNCAP reported in 1998 statistics on the brake assist and seatbelt force limiter that were determined by the user survey as subjects of the highest concern to users. Table 1 shows the percentage of respective safety devices installed. The JNCAP report included in 1998 an article on correct

Table 1 Trends in Safety Devices Installed in Domestic Passenger Cars (excluding mini-sized cars, cab-over and multi-purpose cars)

Safety device	Number of models surveyed and survey years (end of December)				Increase from 1995 (point)
	1995 148 models	1996 142 models	1997 146 models	1998 156 models	
Anti-lock brake system	38.5%	69.7%	89.0%	90.3%	51.8
Brake assist	-	-	-	29.5%	-
Airbag (driver's seat)	61.3%	93.6%	96.4%	97.5%	34.4
Airbag (front passenger seat)	17.4%	56.7%	82.6%	87.3%	69.9
Side airbag	-	3.5%	16.4%	17.9%	14.4 (1996)*
Adjustable belt anchor	73.2%	75.0%	77.2%	79.6%	-
Seatbelt pretensioner	-	7.7%	38.4%	52.5%	44.8 (1996)*
Seatbelt force limiter	-	-	-	68.6%	-
Seatbelt with child seat fastening function	-	-	58.9%	78.8%	19.9 (1997)*
Seat with built-in child seat	-	-	0.7%	0.6%	-0.1 (1997)*

Note 1: "-" indicates that the subject safety device is not surveyed
Note 2: (1996)* or (1997)* represents percentage points increased from 1996 or 1997

use of car navigation systems and child seats which were being promoted by the Ministry of Transport.

3.3 Comparison Test on Safety Performance

(1) Braking test

In order to avoid accidents, brakes must be capable of stopping cars in a short traveling distance and also stopping cars while maintaining them in stable posture. This test measured stopping distances of cars with two passengers in the front seat on dry (road surface temperature at 35.0+/-10.0°C) and wet (road surface temperature at 27.0+/-5.0°C) road surfaces. The brake was applied suddenly to the cars tested while they were running at 100 km/h. Deviation from the 3.5-m wide traveling lane was also checked.

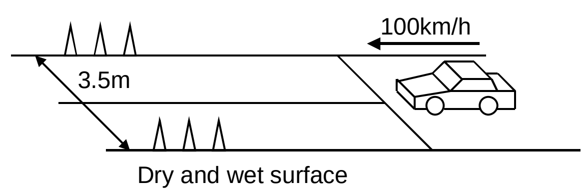

Figure 2 Braking Test

The Braking test has been conducted in and after 1995 on cars with ABS. Figure 3 shows average stopping distance broken down by category of car. Stopping distance of passenger cars becomes shorter as the size becomes larger. Average stopping distance of one-box cars (mini-vans) is larger than that of passenger cars. Figure 4 shows yearly trends in the average stopping distances. One-box cars, mini-sized cars and light-vans are excluded to eliminate the influence of these categories. The average stopping distance exhibits a decreasing trend both on dry and wet road surfaces. No vehicle so far has deviated from the traveling lane.

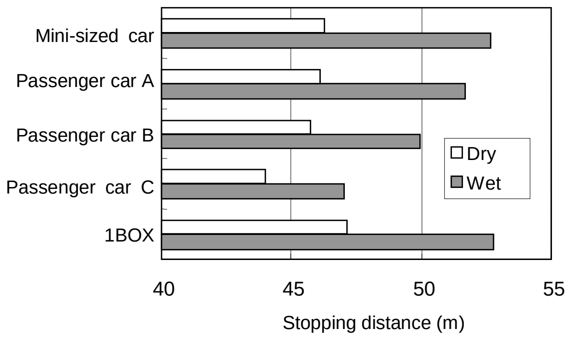

Figure 3 Categories of Cars and Average Stopping Distance (engine displacement of passenger car A is less than 1500cc, passenger car B is from 1500cc to less than 2000cc and passenger car C is 2000cc or above)

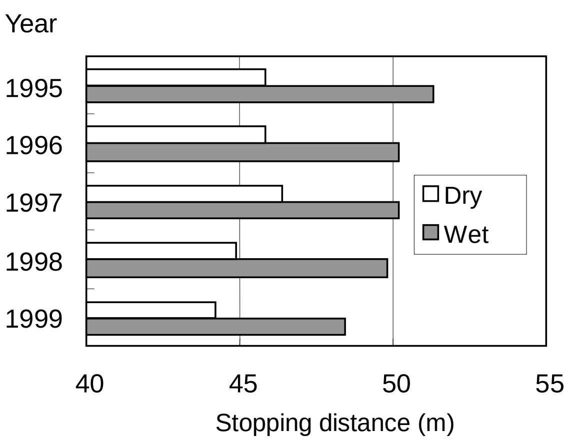

Figure 4 Yearly Trends in Average Stopping Distance (excluding one-box cars, light-vans and mini-sized cars)

(2) Full-frontal crash test

The purpose of the collision tests of JNCAP is to compare the safety of cars among various models in order to reduce injury severity, in particular death and serious injuries, of drivers and passengers resulting from collision. Higher vehicle acceleration employable in the full-frontal crash test enables evaluation of restraint system and vehicle structure making it suitable for assessing serious injuries to the head and chest. The full-frontal crash test has been incorporated into the safety standards since 1994 and JNCAP has employed this test since it started to publish safety information in 1996. In order to determine the difference in safety performance by models more clearly (to ensure higher discriminating capability), JNCAP employs an impact velocity 55 km/h faster than that used in the safety standards.

In this test, cars equipped with HYBRID III (AM50) in the driver's and front passenger seats are impacted against the rigid wall. From 1996 to 1999, injury severities of drivers and passengers were categorized into six classes (AAA, AA, A, B, C and D) based on the dummy's injury values in the head and chest. In addition to the above, assessment using the five-grade system is also being conducted from 2000. It takes into account injury values on other portions of the body (neck force, neck moment, chest deflection, femur force, and Tibia Index) as well as deformation of cars (protrusion of the steering and brake pedal). Cars are also checked for ease of door opening, ease of rescue operation of the driver and passenger, and fuel leakage after collision.

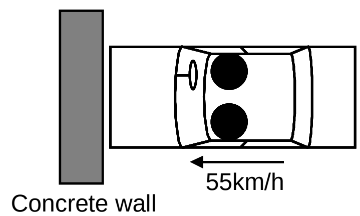

Figure 5 Full-frontal crash Test

Figures 6 and 7 show the distribution of HIC and chest acceleration of the driver and that of the passenger obtained from the 1998 and 1999 tests. Some injury values are higher with one-box cars. It is considered that higher values result from their limited crushable zone compared with that of passenger cars.

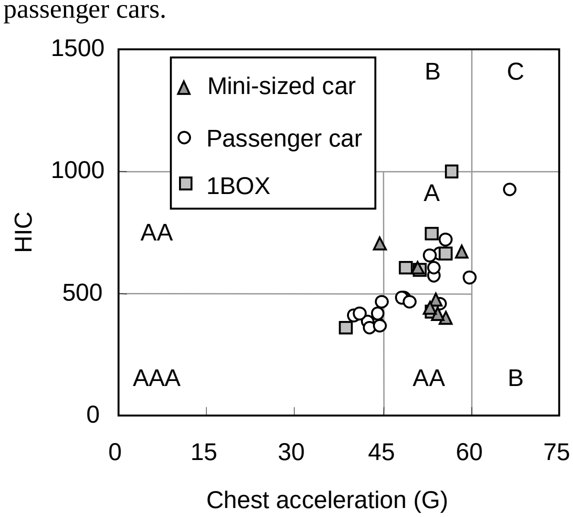

Figure 6 Distribution of Injury Values of Person in Driver's Seat (1998 and 1999)

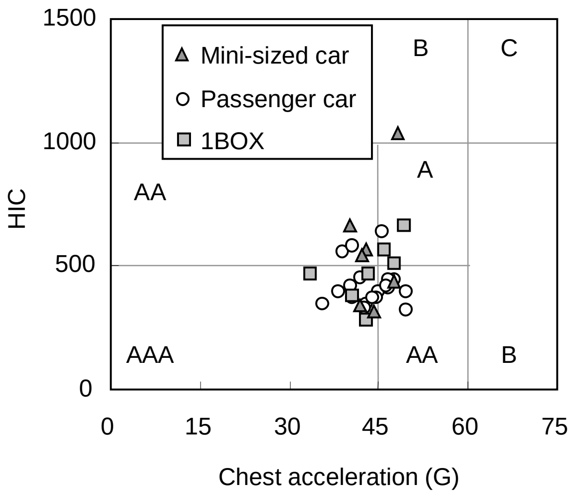

Figure 7 Distribution of Injury Values of Person in Frontal Passenger Seat (1998)

Figures 8 and 9 show trends in injury values of the driver and passenger in full-frontal crash tests recorded between 1995 and 1999. Most of the cars are evaluated as "A", the grade lower than the standard injury value, even when 55 km/h of impact velocity is employed. In 1998, many of the cars are accredited with the best evaluation AAA. Overall injury for the car occupants exhibits an improving trend as seen in the figure. In particular, that of the passenger in the front seat was significantly improved in 1998. The percentage of A remained unchanged but decrease of AAA and increase of AA were recognized in 1999, possibly because of the increase in cars provided for offset collision and expansion of target models of the test.

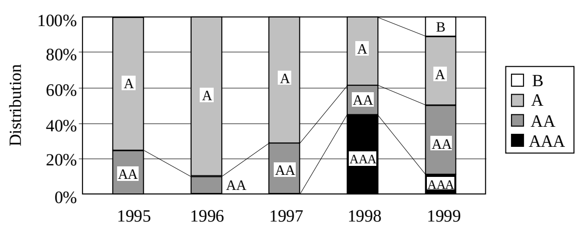

Figure 8 Trends in Passenger Injury Assessments (passenger in driver's seat)

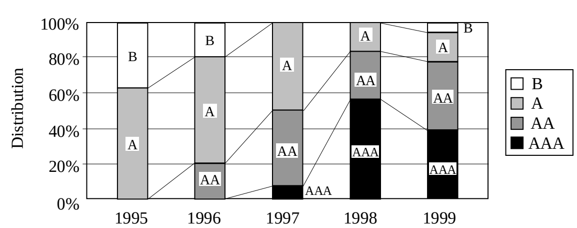

Figure 9 Trends in Passenger Injury Assessments (passenger in front seat)

Figures 10 and 11 show yearly trends from 1995 to 1998 in the average injury values of driver's seat and front passenger's seat. The HIC values and the chest accelerations decreased up to 1998, however those of the driver recorded a rebound in 1999.

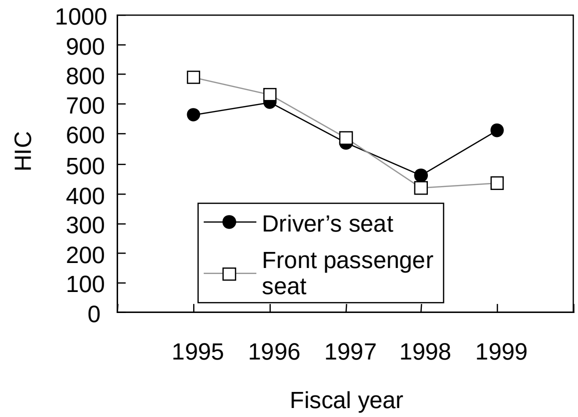

Figure 10 Trends in Head Injury Value HIC in Full-frontal crash (passenger cars alone, excluding mini-sized cars)

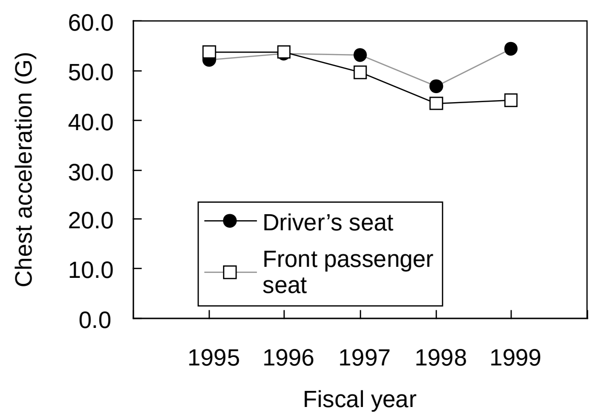

Figure 11 Trends in Chest Injury Value in Full-frontal crash (passenger cars alone excluding mini-sized cars)

(3) Offset frontal crash test

Employment of the frontal offset collision test by the ECE directives, Euro NCAP, and IIHS helped wide spreading necessity of this test. JNCAP commenced on study of the offset frontal crash in 1999.

Using accident data, JNCAP determined the relationship between the overlap ratio and frequency of occurrence in frontal collisions of cars. Figure 12 shows the results broken down by injury severity of drivers. As seen from the figure, offset collisions of 31% to 70% overlap-ratio are causing serious injury of AIS 3+ as frequently as full-frontal collisions proving the importance of the offset frontal crash test.

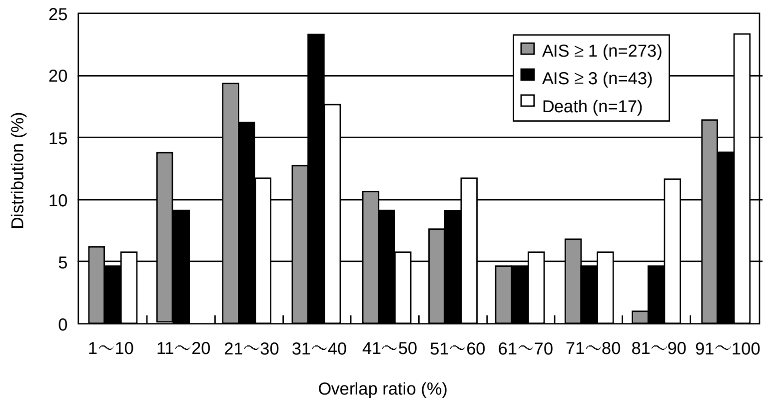

Figure 12 Overlap Ratio and Frequency of Occurrence in Frontal Collisions (study)

In order to determine the crash worthiness of cars against offset frontal collisions, JNCAP conducted the offset frontal crash test using small-size cars A and B and then compared the results with data obtained from the full- frontal crash test. Figure 13 shows injury values measured at the driver's seat. For car A, the injury value resulting from the full-frontal crash test is higher than that of the offset frontal crash test. The values measured with car B were the reverse of the above. The car A survived the collision but the car B was significantly deformed resulting in the higher injury value. This test result indicates that cars should not be optimized to only one of full-frontal or offset frontal collisions so that they may maintain a well-balanced collision performance. It also makes us recognize the necessity for both tests. A series of the above studies proved that this test has sufficient repeatability and discriminating capability. Based on these studies, JNCAP introduced the offset frontal crash test in 2000 succeeding to full-frontal crash test.

In the JNCAP's offset frontal crash test, cars are collided with the honeycomb prepared in compliance with ECE R94 at 40% overlap ratio and 64 km/h of impact velocity. It simulates a car-to-car offset collision at 55 km/h of impact velocity and 50% overlap ratio. HYBRID III dummies are seated in the driver's seat and front passenger's seats. Since this test applies an impact to front body structure, deformation resulting in the body becomes significant, making the test suitable for evaluating the body structure and damages caused in the cabin as well as assessing injury to the lower legs caused by impacts applied inside the cabin. Just as in the full-frontal crash test, five-grade scores are computed using the dummy injury values (HIC, neck force, neck moment, chest deflection, chest acceleration, femur force and Tibia Index) and magnitude of body deformation (protrusion of the steering and brake pedal). It also

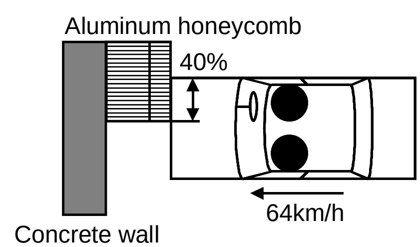

Figure 14 Frontal offset crash test

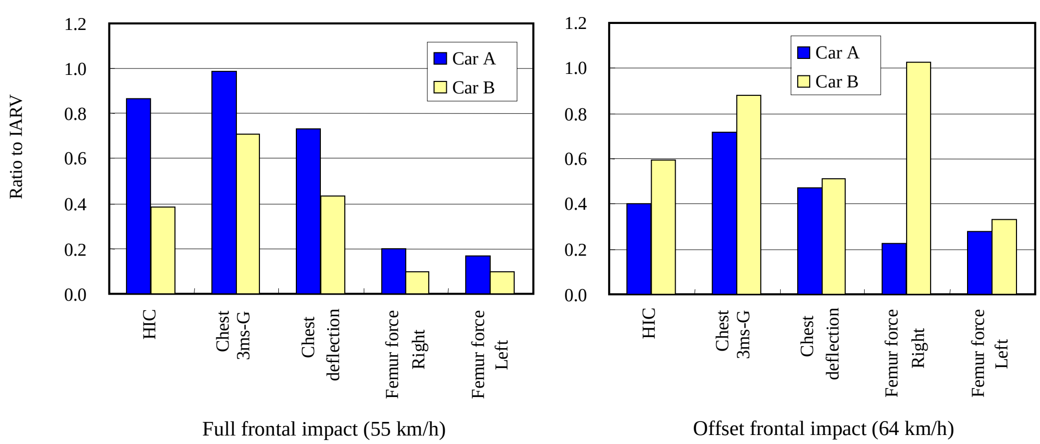

Figure 13 Comparison of Results derived from Full-frontal crash tests and Offset frontal crash tests (study)

checks the ease of opening doors and rescue operations as well as fuel leakage after the collision. Target models of the offset frontal crash test are limited to passenger cars because it is difficult to reproduce body deformation resulting from car-to-car collision in this test with commercial vehicles provided with a frame. Expansion of the target models is one subject that requires further study.

(3) Side impact test

Among fatalities in traffic accidents in Japan, those resulting from side collisions of vehicles make up approximately 24% - a large figure. In order to reduce and prevent such accidents, JNCAP conducted studies on side collisions in 1998.

Since side collisions occur more frequently between vehicles, testing by use of a moving deformable barrier (MDB) is considered suitable for this purpose. Figure 15 shows the distribution of impact velocities. Risk recognition speeds up to 55 km/h make up more than 90% of minor injuries or more and more than 60% of serious injuries or more.

Factors that can affect the dummy injury value include speed, stiffness, weight, structure, and road clearance. Considering that factors other than the speed are MDB-unique problems, JNCAP focused its study on speed. Figure 16 shows results of the side impact tests conducted on the small cars A and B at

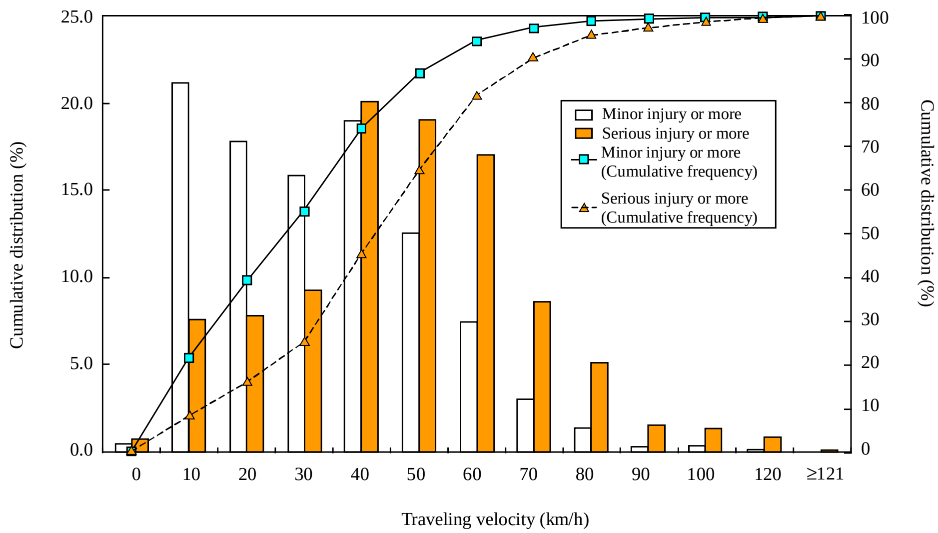

Figure 15 Distribution of Traveling Velocities at which Risk was recognized in Car-to-Car Collision (research survey)

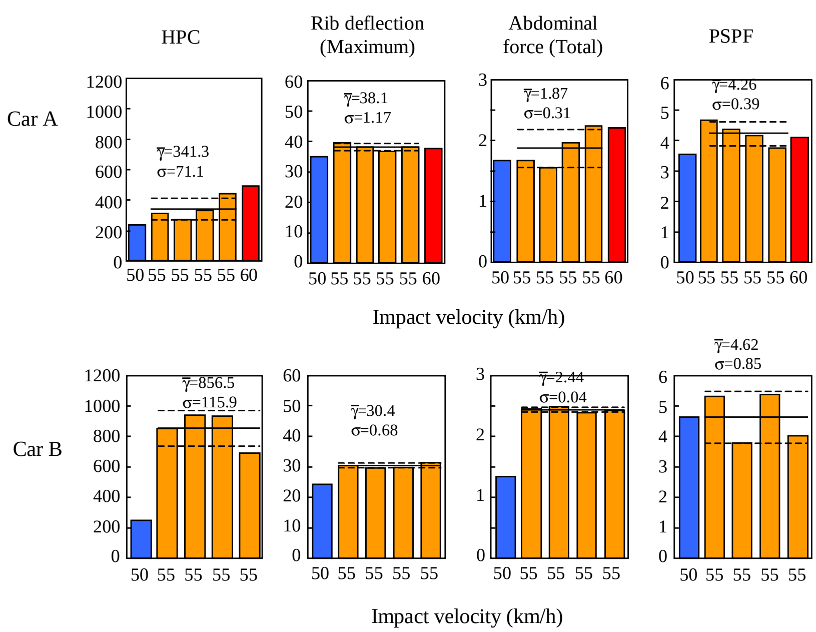

Figure 16 Impact Velocity and Injury Values of Passenger in Side Impact Tests (research survey)

impact velocities of 50, 55 and 60 km/h. When the impact velocity is set at 55 km/h, injury values at various portions of the dummy increase compared to results obtained at 50 km/h, making it easier to determine differences between models. At impact velocity of 60 km/h, however, no significant differences were observed in injury value on the dummy compared with 55 km/h. To make matters worse, a problem occurred in the test. Namely, deformable elements on MDB were used and this could not simulate the front side stiffness of the car anymore during the test. At any rate, 55 km/h was selected as the impact velocity based on these studies and this test was added to JNCAP in 1999 and is used to this day.

JNCAP's side impact test method is developed based on the safety standards (equivalent to ECE R96) (see Figure 17). Weight and road-clearance of MDB are 950 kg and 300 mm, respectively. EUROSID-1 seated in the collision side of the front seat assesses injury severity for driver's seat based on HPC, chest deflection, abdominal force and force to waist.

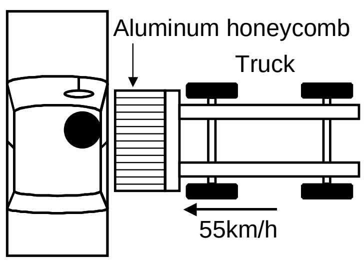

Figure 17 Side Impact Test Method

Figure 18 shows results of the test conducted in 1999. High HPC values result from contact between the head and B-pillar. Chest deflection is mostly distributed around the standard value. It is considered that injury values can be significantly affected by the relationship between MDB and the dummy's seat height or position of the armrest. These values are smaller in one-box cars.

The five-grade assessment system was started from 1999 computing scores based on these injury values. Ease of opening the doors, ease of rescue operations, and fuel leakage after collision are also checked. Further studies will be continued on how to describe tipping over in the record, how to test one-box cars (vans) and how to modify test items other than speed.

3.4 Overall Crash Safety Rating by Models

It was considered necessary to present an overall assessment based on two or more collision tests to the users in order to ensure wider use of information available from JNCAP. Thus, in 2000 JNCAP started the overall crash safety rating based on the full-frontal, offset frontal and side impact tests.

Dummy injury values obtained from the respective tests are converted into scores based on the probabilistic injury scale and, further, they are weighted taking into consideration of the frequency of the injuries occurring to respective portions on the body. For instance, scores ratio of the head, neck, chest, and lower legs in the frontal crash is 4:1:4:4. In the side impact, scores ratio of the head, chest, abdomen, and waist is 4:4:2:2, totaling 12 points. In the full-frontal or offset frontal, a computed score is modified by the steering and brake deflection in order to take influences from the body deformation.

Taking into consideration of frequency of accidents occurring in each collision type, full-frontal, offset frontal, and side collision are weighted by 1: 1: 1, respectively. Overall crash safety rating of the driver's seat is rated out of 36.

4.STUDY

4.1 Child Seat Safety Assessment

Use of a child seat for children aged less than 6-year old has become mandatory since April 2000. In order to determine safety performance of child seats and reliability of installing them, their assessment is urgently required. Dynamic impact test and the static test to check ease of handling will be conducted to evaluate child seats. Preliminary research is to be completed during 2000. Test results will be published from 2001.

The study recommends employing the sled test using a cut body of production car. Sled acceleration or delta V (50 or 55 km/h) will conform to the safety standard (equivalent to ECE R44). In order to ensure fidelity to the human body, a study on injury values is conducted using an P3/4 dummy and Hybrid III 3YO dummy. Referencing information obtained from these tests, studies have been continued to solve problems involved in implementing the assessment test (such as the belt and seat replacement frequency), usefulness of the test (usefulness of the data generated), reproducibility of the results, and the test's capability of discerning differences among the child seat products.

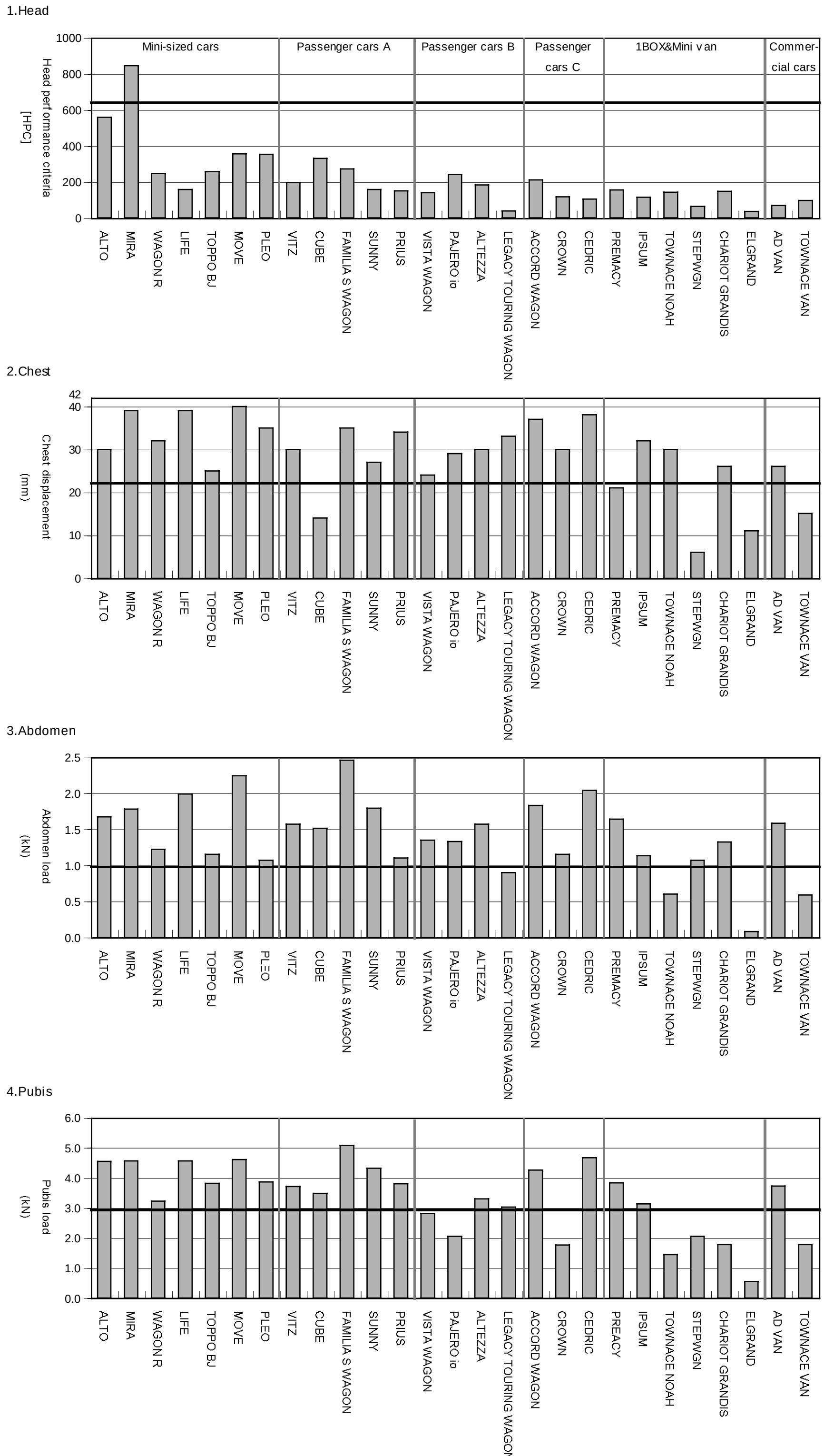

Figure 18 Results of Side Impact Test (fiscal 1999)

4.2 Death and Injury Rate by Models

In order to ensure reliability of the test and assessment methods employed, as well as to determine the effectiveness of JNCAP, it is important to compare the occupant injury assessments derived from JNCAP's collision tests to the ocuupant injury rate resulting from actual accidents. Research in this field will be continued to refine the accident-data based methods for analyzing death and injury rate as well as to improve the JNCAP test assessment methods.

5.FUTURE J-NCAP

It is now six years since the first car safety information was published. During the course of these years, safety measures for cars against frontal collisions have been improved as exhibited by the increase of models accredited with the AAA rating. Introduction of the frontal offset collision test, side collision test, and overall assessment will help to increase the number of suitable models provided for various types of collisions.

In Japan, minor injuries are increasing year after year. In particular, the percentage of whiplash sufferers from rear-end collisions is becoming large, requiring a significant amount of social costs. Pedestrians make up approximately 27% of those killed in traffic accidents. Thus, another critical subject to be addressed urgently is how to protect pedestrians. JNCAP is now planning a test for pedestrian protection along with one for verifying the head restraint. Expanding coverage of safety information will help to promote a wider distribution of safer cars and to reduce the number of victims from accidents.

6.CONCLUSION

JNCAP has been contributing to improving automobile safety against collisions since it was first published in FY1995. We are going to expand test items and implement overall assessments better suited to real world accidents so that information from JNCAP may become more helpful to users and more effective in reducing the number of victims from traffic accidents.

Table 2 JNCAP's Tests and Agenda(Fiscal year)

	1995	1996	1997	1998	1999	2000	2001	2002
Full-frontal crash	Published	←	←	←	←	←	←	←
Offset frontal crash					Study	Published	←	←
Side impact				Study	Published	←	←	←
Child seat						Study	Published	←
Pedestrian protection test							Study	←
Head restraint								Study
High-speed brake	Published	←	←	←	←	←	←	←
Death rate by models						Study	←	