

Evaluation of the Acceleration Severity Index Threshold Values Utilizing Event Data Recorder Technology

Douglas Gabauer

Research Engineer
Department of Mechanical Engineering
College of Engineering
Rowan University
201 Mullica Hill Road
Glassboro, NJ 08028-1701
Phone: (856) 256 – 5352
Fax: (856) 256 – 5241
E-Mail: gabauer@rowan.edu

Hampton C. Gabler

Associate Professor
Department of Mechanical Engineering
College of Engineering
Rowan University
201 Mullica Hill Road
Glassboro, NJ 08028
Phone: (856) 256 – 5346
Fax: (856) 256 – 5241
E-Mail: gabler@rowan.edu

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Abstract

The Acceleration Severity Index (ASI) is used to evaluate the potential for occupant risk in full-scale crash tests involving roadside safety hardware. Despite its widespread use across Europe, there is a lack of research relating this metric to occupant injury in real-world collisions. Recent installation of Event Data Recorders (EDRs) in a number of late model vehicles presents a different perspective on the assessment of the validity of occupant risk based on the Acceleration Severity Index. EDRs are capable of electronically recording data such as vehicle speed, brake status and throttle position just prior to and during an accident. Of particular interest is the EDRs ability to document the deceleration of a vehicle during a collision event. This paper utilizes EDR technology to investigate the correlation between the ASI threshold limits and the potential for occupant injury in crash events. The longitudinal ASI is found to be a good predictor of overall injury and the intent of the current recommended threshold value of 1.0 appears valid. Limitations include investigation of the longitudinal direction only, lack of injuries in excess of AIS 3, and no control for occupant compartment intrusion.

INTRODUCTION

Full-scale crash testing has been the traditional method used to evaluate roadside safety hardware. The goal of crash testing procedures is to evaluate hardware performance in representative worst-case impact scenarios. Although there are minor differences between US and European (CEN) procedures, both test protocols evaluate devices based on vehicle behavior, the response of the device, and the potential for injury to vehicle occupants. The US procedures are prescribed in NCHRP Report 350 (1), while the CEN procedures are presented in EN-1317 (2).

Because the goal of roadside hardware is to perform its intended task while minimizing injury to vehicle occupants, the assessment of occupant risk is crucial to the full-scale crash test evaluation of these devices. Unlike vehicle crashworthiness testing, crash tests of roadside safety devices do not utilize a crash test dummy. Roadside hardware collisions typically involve an oblique impact and, to date, no crash test dummies have been validated for use in oblique crash loadings. Instead, occupant risk is based on metrics derived from vehicle kinematics measured during the crash test. Since 1981, the US procedures have calculated occupant risk with the flail space model. The CEN procedures use a variant of the flail space model in conjunction with the Acceleration Severity Index (ASI) to assess occupant injury risk.

Although there is evidence that the ASI originated in the US in the late 1960's, current US procedures do not utilize this acceleration-based model for the assessment of occupant risk. The currently underway NCHRP Project 22-14[2], however, will provide an update to the NCHRP 350 procedures. The preceding project, NCHRP 22-14[1], recommended the need for an update to these procedures. Findings from this study suggest the potential inclusion of an acceleration-based occupant risk metric, such as ASI, in the update assuming sufficient evidence supporting its effectiveness (3). To date, there is little research relating the ASI to actual occupant injury in collision events and the biomechanical basis for the threshold values is not well documented.

OBJECTIVE

The purpose of this study is to investigate the correlation between the ASI threshold limits and the potential for occupant injury in crash events.

BACKGROUND

The Acceleration Severity Index

Using measured vehicle acceleration information, CEN test procedures (2) indicate the ASI is computed using the following relationship:

$$ASI(t) = \left[\left(\frac{\bar{a}_x}{\hat{a}_x} \right)^2 + \left(\frac{\bar{a}_y}{\hat{a}_y} \right)^2 + \left(\frac{\bar{a}_z}{\hat{a}_z} \right)^2 \right]^{\frac{1}{2}}$$

where \bar{a}_x , \bar{a}_y , and \bar{a}_z are the 50-ms average component vehicle accelerations and \hat{a}_x , \hat{a}_y , and \hat{a}_z are corresponding threshold accelerations for each component direction. The threshold accelerations are 12 g, 9 g, and 10 g for the longitudinal (x), lateral (y), and vertical (z) directions, respectively. Since it utilizes only vehicle accelerations, the ASI inherently assumes that the occupant is continuously contacting the vehicle, which typically is achieved through the use of a seat belt. The maximum ASI value over the duration of the vehicle acceleration pulse provides a single measure of collision severity that is assumed to be proportional to occupant risk. To provide an assessment of occupant risk potential, the ASI value for a given collision acceleration pulse is compared to established threshold values. Although a maximum ASI value of 1.0 is recommended, a maximum ASI value of 1.4 is acceptable (2). Note that if two of the three vehicular accelerations components are zero, the ASI will reach the recommended threshold of unity only when the third component reaches the corresponding limit acceleration. If more than one component is non-zero, however, the unity threshold can be attained when the components are less than their corresponding limits. According to the EN-1317 (2), the ASI preferred threshold corresponds to "light injury, if any". No corresponding injury level, however, is provided for the ASI maximum threshold.

Although the CEN procedures do not provide detail regarding the basis for ASI threshold values, the computation of the ASI is identical to the "severity index" proposed by researchers at Texas Transportation Institute investigating injury in slope-traversing events in the early 1970's (4). The maximum threshold values proposed in the TTI study for the longitudinal, lateral, and vertical directions are shown in TABLE 1, based on the level of

occupant restraint. Note that the “lap belt only” limits correspond to those utilized in the current version of the ASI. According to Chi (5), these limits are based principally on a military specification for upward ejection seats (6) and a study done by Hyde in the late 1960’s (7). Chi also notes that neither study provides any “supporting documentation or references” for the presented information.

TABLE 1 Tolerable Acceleration Limits (4)

| Restraint | Maximum Acceleration (G) | | |
|-----------------------|--------------------------|---------|----------|
| | Longitudinal | Lateral | Vertical |
| Unrestrained | 7 | 5 | 6 |
| Lap Belt Only | 12 | 9 | 10 |
| Lap and Shoulder Belt | 20 | 15 | 17 |

Correlation to Injury

Although the ASI is used to indicate occupant injury potential in the CEN procedures, there has been little research to date characterizing the model’s relationship to occupant injury. Previous research has utilized real-world accident data since the occupant injury information is available. Because real-world accident data lacks detailed vehicle kinematics data, however, the correlation to occupant injury remains tenuous at best.

Stewart and Council (8) utilized accident data in an attempt to link occupant risk (as calculated in crash tests) to actual injury attained in collisions. The procedure matched instrumented full-scale crash tests with similar vehicle characteristics (make, model and year), crash characteristics (object struck, impact location on vehicle, etc.), and crash severity (as measured by vehicle deformation) in actual crashes. An analysis based on approximately 200 matched cases, the authors indicated a lack of strong relationship between the 50-ms lateral and longitudinal average accelerations and driver injury. The peak 50-ms criterion was utilized in the pre-flail space model roadside hardware test procedures (9,10) to evaluate occupant risk. To assess occupant injury potential, limits are placed on the maximum 50-ms longitudinal and lateral vehicle accelerations as well as the total of the two directions. Although this criterion does not transform tri-axial accelerations into a single quantity, it does utilize the 50-ms average acceleration concept as in the ASI.

More recently, Shojaati (11) attempted to correlate the ASI to risk of occupant injury via the Head Injury Criterion (HIC), a metric used by NHTSA to assess head injury potential. For nine lateral sled tests, the HIC determined from a Hybrid III dummy was plotted against the ASI as determined from the measured vehicle acceleration. The available data suggested an exponential relation between HIC and the ASI but did not provide a direct correlation to occupant injury. One interesting finding was that an ASI of 1.2 in the lateral direction corresponded to a HIC value of 200. Note that a HIC value of 1000 is considered the threshold for serious occupant head injury.

EDR Technology and the Rowan University EDR Database

Recent advancements in vehicle technology have allowed for an unprecedented opportunity to obtain information during a highway traffic collision. One such technology is Event Data Recorders (EDRs), which are being installed in numerous late model vehicles in conjunction with the advanced occupant safety systems. EDRs are similar to “black boxes” in airplanes as they record information in the event of a highway collision. Information typically stored by these manufacturer-specific devices includes seat belt status, deployment of the airbag, and vehicle speed prior to impact (12). Of particular interest to this study is the EDRs ability to record the vehicle velocity profile during a collision event.

Under sponsorship of the National Highway Traffic Safety Administration (NHTSA), Rowan University is developing a first-of-a-kind database of EDR data collected from traffic collisions in the United States (13). Currently, the database consists of EDR data for over one thousand (1000) cases, all of which are GM vehicles. These EDRs have the ability to store a description of both the crash and pre-crash phase of a collision. The crash parameters in the database include longitudinal velocity vs. time during the impact at 10 ms intervals (shown in FIGURE 1), airbag trigger times, and seat belt status for the driver. Pre-crash data includes vehicle speed prior to impact, engine throttle position as well as brake status for five seconds preceding the impact. As these cases were

collected in conjunction with National Automotive Sampling System (NASS) studies, the corresponding NASS information is matched to the EDR data. NASS case investigators collect in-depth information about each crash including details regarding injury to the occupants.

METHODOLOGY

The NHTSA EDR database was first searched to identify those cases suitable for analysis. Suitable cases adhere to the following criteria:

1. Airbag deployment
2. Recorded EDR velocity data
3. Available injury data for either the left or right front seat occupant
4. Belted occupants only
5. Comprised of a single impact only
6. Frontal collision
7. No vehicle rollover

In an attempt to utilize cases that have a higher potential for occupant injury, the data was narrowed to include only deployment events. Note that the typical velocity change threshold for airbag deployment in frontal collisions is approximately 5 m/s (11 mph) (14). Limiting the data set to belted occupants ensures that the vehicle accelerations are transferred to the occupant as assumed by the ASI. Reduction of the data set to include only single impact collisions ensures that the EDR velocity data corresponds to the injury-producing event. As the GM EDR only measures velocity information in the longitudinal direction, the data set has been constrained to frontal collisions only. A frontal collision, for the purpose of this study, is defined as damage to the front of the vehicle and a principal direction of force (PDOF) of 0 degrees plus or minus 10 degrees. An intrinsic requirement of both the US and CEN crash test procedures is that the vehicle remains upright; thus, vehicle rollover is not permitted.

A total of 138 cases have been identified as suitable for analysis; 107 left front seat occupant cases and 31 right front seat occupant cases. Note that there is potential overlap in the available cases. For instance, one vehicle may have injury information for both left and right front seat occupants, resulting in two suitable cases for analysis. The final data set includes both frontal vehicle-to-fixed object (17%) and frontal vehicle-to-vehicle collisions (83%). If there is indeed a relationship between the ASI and injury severity, it should be as equally relevant to vehicle-to-vehicle crashes as to vehicle-to-fixed object crashes.

To provide a gauge of overall severity of the suitable cases, the NASS and EDR longitudinal delta-V values are examined. Of the cases with known NASS delta-V values (105 of 138), the mean value is 17 mph with a range from 5 mph to 35 mph. The same range is found for the EDR delta-V values (138 known) but the mean is slightly higher at 19 mph. Note that the NASS statistical weights are not utilized for the selected cases. The study approach is a dose-response analysis of the correlation between ASI and occupant injury. Although the NASS weights would be useful in estimating the distribution of ASI values in the fleet, they are not necessary for this study which is mainly concerned with evaluating the potential for occupant injury given a particular ASI value occurs.

The frontal collisions considered in this analysis are assumed to have negligible accelerations in the lateral and vertical directions such that the ASI computation involves only the longitudinal component and associated 12 G threshold. The following procedure was used to compute the longitudinal ASI for the suitable cases:

1. Using the measured EDR velocity data, calculate the 50-ms average acceleration values by computing the difference in velocity at points 50-ms apart and dividing by 0.05 seconds.

$$\bar{a}(t_i) = 50 \text{ ms moving average} = \frac{\sum_{i-5}^i a(t_i)}{\Delta t} = \frac{\sum_0^i a_i - \sum_0^{i-5} a_i}{\Delta t} = \frac{v_i - v_{i-5}}{0.05s}$$

2. Choose the largest absolute 50-ms acceleration value and convert to G units.
3. Divide the largest 50-ms acceleration by the longitudinal threshold value of 12 G.

The 50-ms averages are only computed for known velocity points. For instance, if a pulse is 50 ms in duration, only a single 50-ms average acceleration is computed from the EDR data (0-50 ms). Similarly, because the GM EDR provides the velocity information in 10 ms increments, the 50-ms averages step in 10 ms increments until the end of

the velocity pulse. FIGURE 1 illustrates the longitudinal ASI computation for a sample case based on the shown EDR vehicle change in velocity versus time. Note that the first 50-ms average point is the average acceleration from 10 to 60 milliseconds. The remaining points proceed in a similar manner.

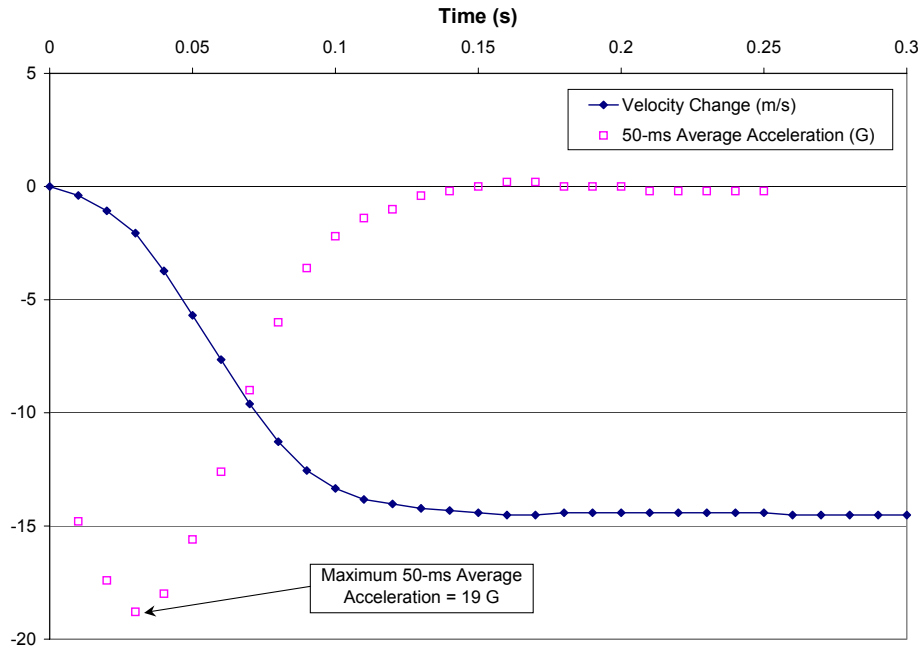


FIGURE 1 Longitudinal ASI Computation

Since cases with incomplete velocity (e.g. not converging to a constant velocity) were not initially eliminated from the suitable cases, the 50-ms average pulses for each case were plotted and examined to ensure a sine-like pulse with single maxima. A total of 18 cases were eliminated as a result of this restriction, 6 of which had a “complete” velocity profile. The rationale is that even if the velocity pulse is not complete, the maximum 50-ms acceleration may have been captured by the EDR.

To investigate the potential for error in the proposed ASI computation method, six New Car Assessment Program (NCAP) frontal barrier tests were examined. Each car tested had GM EDR data available in conjunction with the more detailed vehicle acceleration data typically recorded for the test. As shown in TABLE 2, there is reasonable agreement between the EDR and NCAP-determined ASI values. Although the EDR-determined value typically underestimates this quantity, the value is within 10 percent of the value calculated with the NCAP accelerometer data.

TABLE 2 NCAP and EDR ASI Comparison

| Test Designation | EDR ASI Value (G) | NCAP ASI Value (G) | % Error |
|------------------|-------------------|--------------------|---------|
| 4487 | 24.81 | 26.18 | -5.2 |
| 4472 | 19.50 | 20.30 | -3.9 |
| 4244 | 24.87 | 26.89 | -7.5 |
| 4198 | 24.21 | 26.61 | -9.0 |
| 3952 | 25.81 | 26.19 | -1.4 |
| 3851 | 22.01 | 21.15 | +4.0 |

For the quantification of occupant injury, the Abbreviated Injury Scale (AIS) is used as illustrated in TABLE 3 (15). The AIS scale is an injury severity metric that measures threat to life. The NASS data, collected in parallel with the EDR data, rates the severity of each occupant injury using this scale. Note that for the purpose of this study the phrase “light injuries, if any” is interpreted to correspond to the ASI recommended limit of 1.0 and an AIS 1 injury or below.

TABLE 3 The Abbreviated Injury Scale

| AIS Value | Injury Characterization |
|------------------|--------------------------------|
| 0 | No Injury |
| 1 | Minor |
| 2 | Moderate |
| 3 | Serious |
| 4 | Severe |
| 5 | Critical |
| 6 | Maximum/Fatal |

RESULTS

Maximum Occupant Injury

To investigate the threshold values in terms of overall injury, NASS maximum abbreviated injury scale (MAIS) values are plotted as a function of the longitudinal ASI. FIGURE 2 is a plot for the 120 suitable cases with the recommended and maximum allowable thresholds plotted as dashed vertical lines for comparison purposes. Based on the assumption that the ASI is proportional to occupant injury, more severe injuries should occur as the ASI value increases. As such, most points would be expected to fall within a diagonal band from the origin to the upper right corner of the plot. Examining FIGURE 2, any indication of an increasing diagonal trend appears masked by the scatter of the data. Note, however, the median values for each AIS severity level exhibit a linearly increasing trend suggesting that ASI is at least generally indicative of occupant injury in the frontal collision mode.

For MAIS levels 0, 1, 2, and 3, the median values for the data set are 0.63, 0.83, 1.13, and 1.44, respectively. An inspection of the median values implies that the current ASI thresholds may be reasonable. For the recommended threshold, the median values for the MAIS 0 and MAIS 1 injury levels fall below while the median values for the MAIS 2 and MAIS 3 injury levels exceed the recommended threshold. Based on the available data, the median value for the MAIS 3 injury level is approximately equal to the maximum threshold.

FIGURE 2 also presents the cumulative frequency of maximum injury as a function of the longitudinal ASI. Note that the cumulative frequencies (0 to 100) have been scaled to fit the AIS scale (0 to 6). Approximately 25 percent of the available “light injury, if any” cases (MAIS ≤ 1), occur above the recommended ASI limit of 1. The remaining 75 percent fall below the recommended threshold suggesting that the limit is reasonable, at least within this data set. Conversely, though, approximately 35 percent of the severe injuries (MAIS > 1) occur below the recommended threshold value. In terms of the maximum threshold, approximately half of the more severe injuries (MAIS > 1) fall above the maximum threshold while 90 percent of the “light injuries, if any” (MAIS ≤ 1) occur below the maximum threshold. Additional higher injury severity cases are needed to provide more insight to the injury level that corresponds to the maximum ASI threshold.

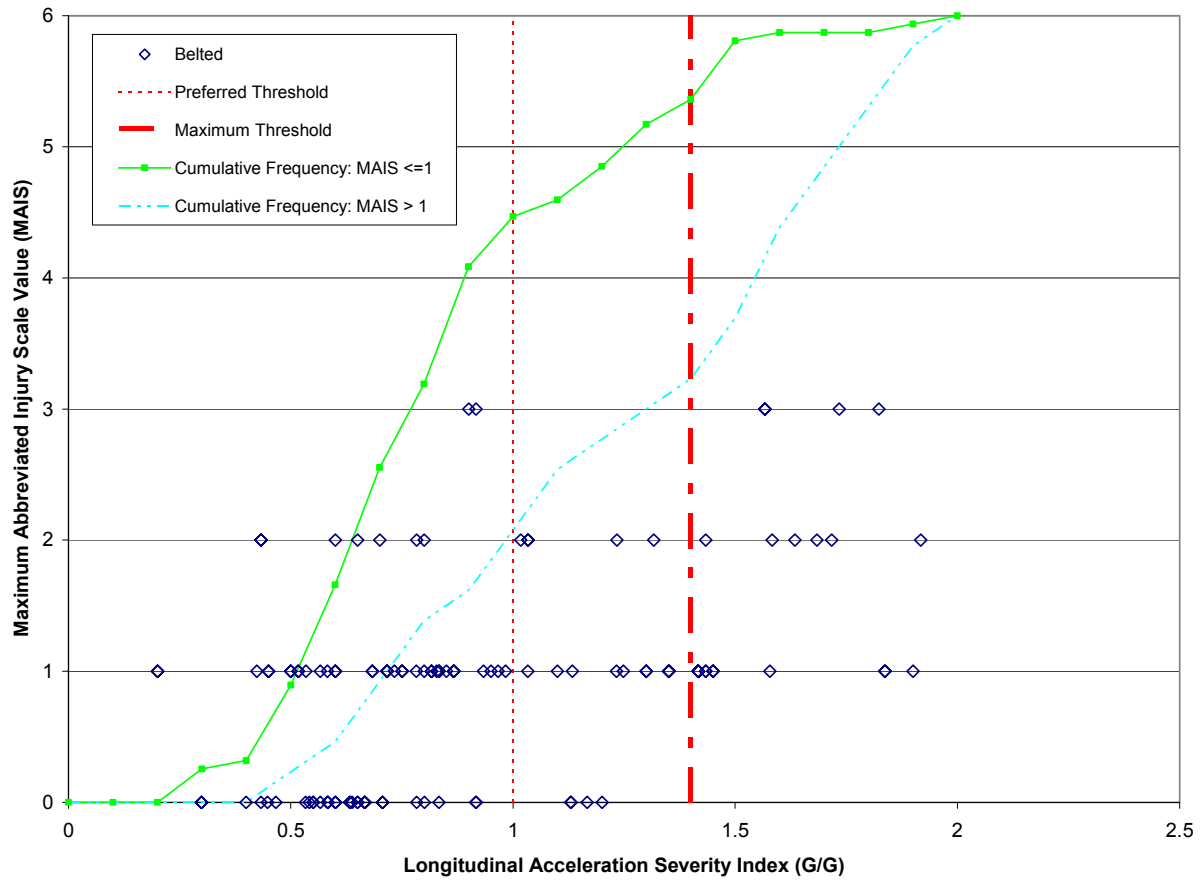


FIGURE 2 Maximum Occupant Injury In Single Event Frontal Collisions

Occupant Injury by Body Region

Chest Injury

FIGURE 3 presents occupant chest injury as a function of longitudinal ASI for the suitable cases with the recommended and maximum thresholds are plotted as dashed vertical lines. Also included in the plot is the cumulative frequency data for light chest injury (MAIS ≤ 1). Scatter similar to the maximum injury plot is evident, however, there is a lack of higher severity chest injuries with only 2 cases in excess of AIS 1. The median values for AIS 0 and AIS 1 injuries are 0.91 and 1.21, respectively. These median values indicate the anticipated diagonal trend but straddle the recommended ASI threshold. This suggests that low severity chest injury in restrained occupants involved in frontal collisions may occur at higher ASI values than injury to other body regions. Based on the cumulative frequency information, approximately 65 percent of light chest injury (MAIS ≤ 1) cases in the available data occur below the recommended threshold while 80 percent fall below the maximum threshold.

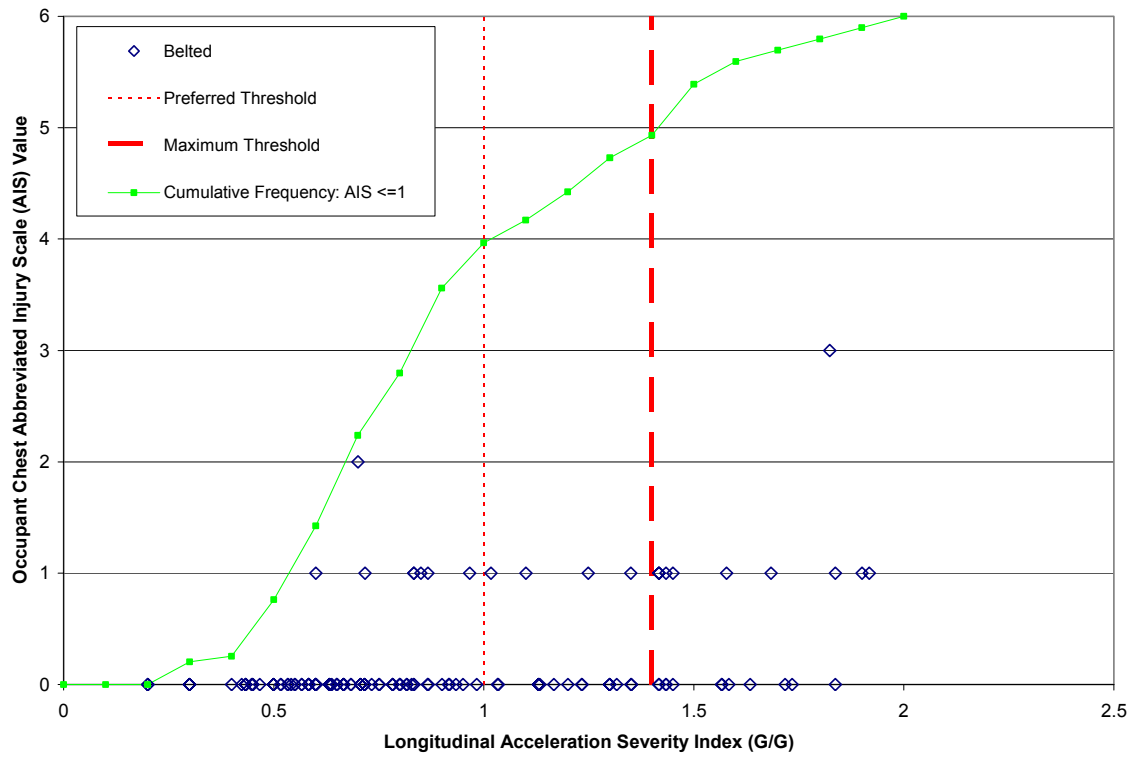


FIGURE 3 ASI and Occupant Chest Injury

Head Injury

FIGURE 4 presents occupant head injury as a function of longitudinal ASI with the recommended and maximum thresholds plotted as dashed vertical lines. The cumulative frequency data is also included on this plot. The median values for AIS 0, AIS 1, and AIS 2 injuries are 0.82, 1.23 and 0.63, respectively. As with chest injury, the median values for AIS 0 and AIS 1 straddle the recommended threshold, however, the median value for AIS 2 is the lowest of the three values. Although this suggest a weaker correlation of the ASI to head injury, this observation may simply be exclusive to this small data set. As with chest injury, median value for the light injuries is 0.82. Also, the proportions of light injury occurring below the maximum and recommended thresholds are equivalent to that found for chest injury.

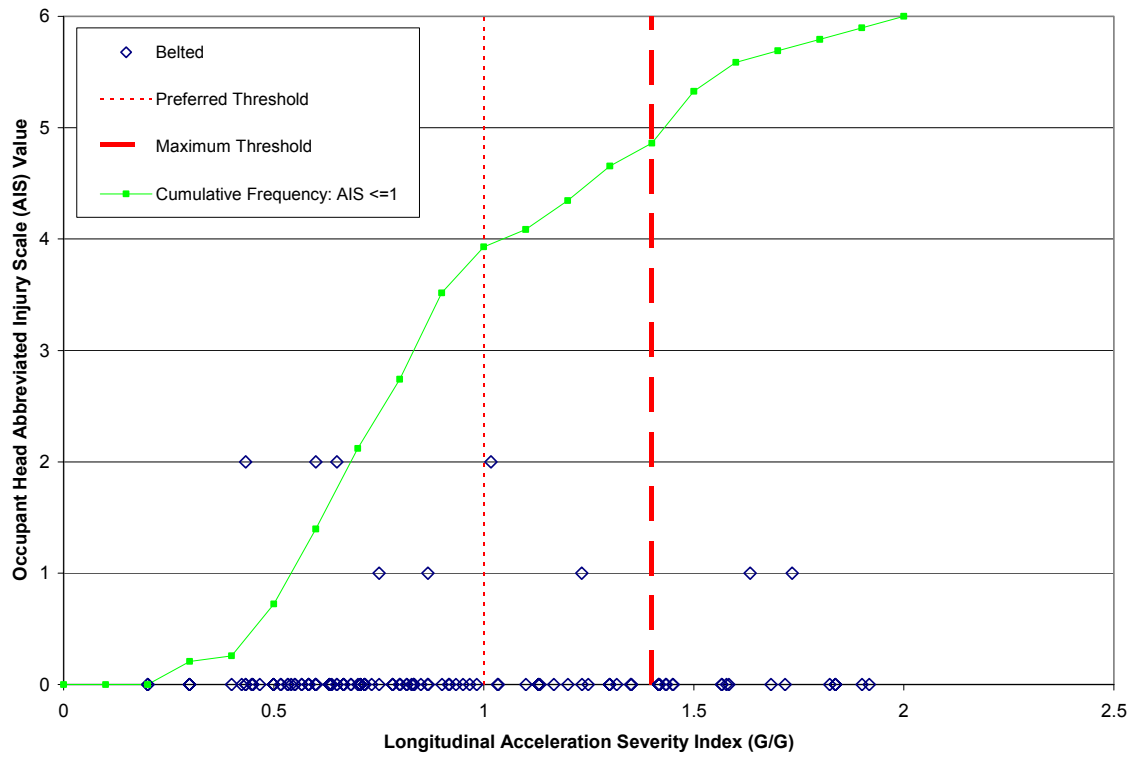


FIGURE 4 ASI and Occupant Head Injury

Extremity Injury

FIGURE 5 and FIGURE 6 present occupant upper extremity and lower extremity injury, respectively, as a function of longitudinal ASI. Again, the recommended and maximum thresholds plotted as dashed vertical lines for comparison purposes. Also the cumulative frequency data has been included and is scaled from 0 to 6. For this data set, the largest incidence of higher occupant injury occurs in the extremity body regions. The median values for AIS 0, 1, 2, and 3 upper extremity injuries are 0.72, 0.83, 1.48, and 1.13, respectively. The median values for AIS 0, 1, 2, and 3 lower extremity injuries are 0.68, 1.01, 1.23, and 1.57, respectively. With the exception of the AIS 2 and AIS 3 upper extremity median values, the median ASI values increase with increasing injury severity. In terms of the recommended threshold, both upper extremity median ASI values are beneath the threshold while the lower extremity median value is approximately equal to the threshold. Consistent with chest and head injury, the median value for the light upper and lower extremity injuries is approximately 0.80. Also, the proportions of light injury occurring below the maximum and recommended thresholds are approximately equivalent to that found for the other body regions.

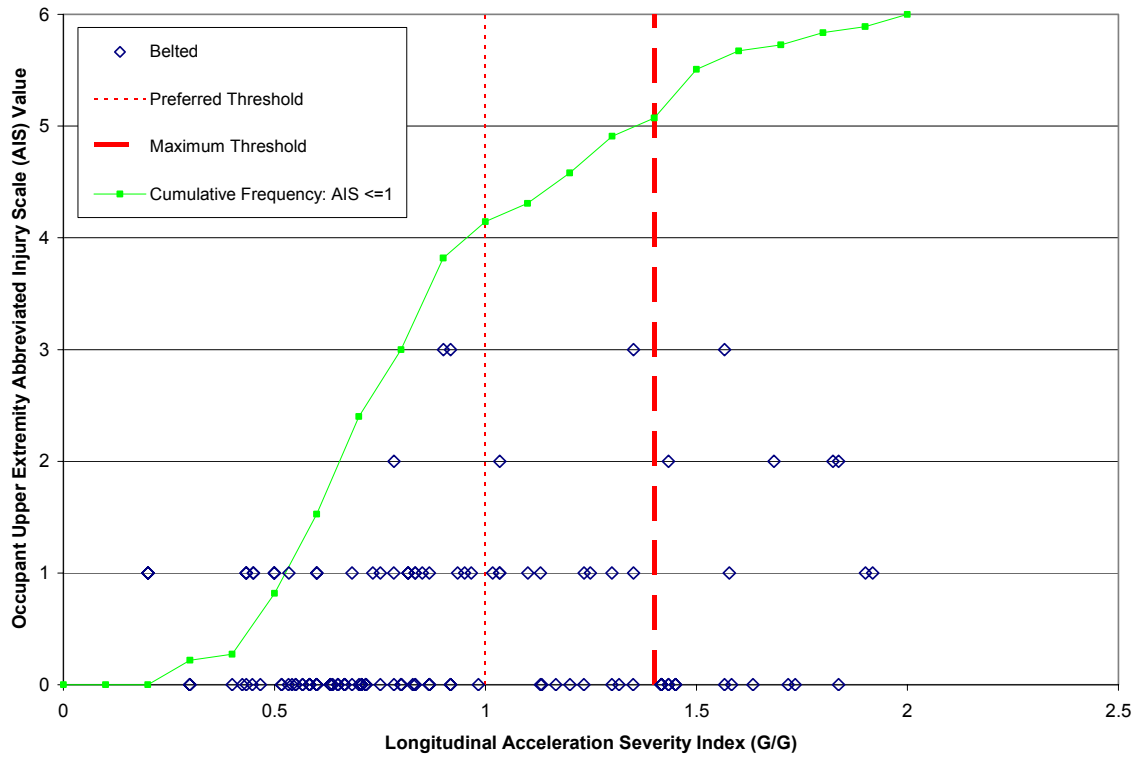


FIGURE 5 ASI and Occupant Upper Extremity Injury

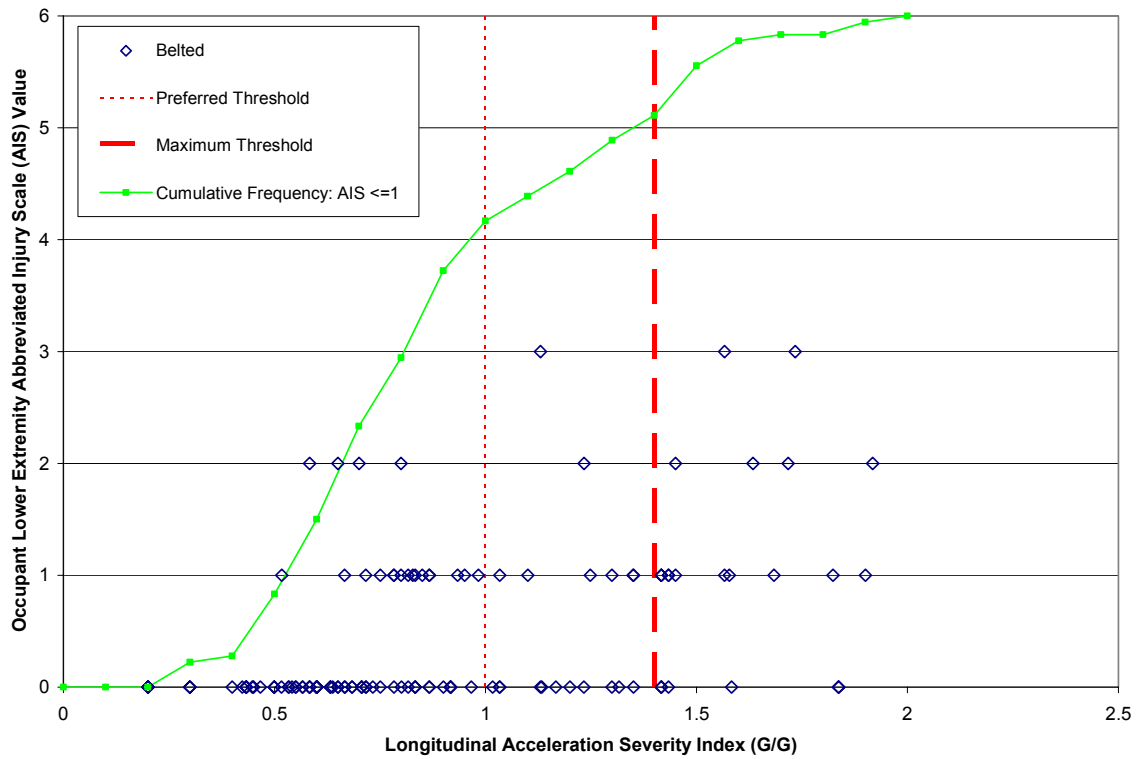


FIGURE 6 ASI and Occupant Lower Extremity Injury

STATISTICAL ANALYSIS

Statistical measures are employed to further investigate the correlation between the ASI and occupant injury. To test the applicability of the preferred ASI threshold, 2 x 2 contingency tables were generated for each body region. The data was classified into four possibilities: (1) an ASI value ≤ 1.0 and a corresponding AIS injury value ≤ 1 , (2) an ASI value ≤ 1.0 and a corresponding AIS injury value > 1 , (3) an ASI value > 1.0 and a corresponding AIS injury value ≤ 1 , and (4) an ASI value > 1.0 and a corresponding AIS injury value > 1 . TABLE 4 provides a summary of the cell counts for each category as well as the statistical results based on Fisher’s exact test. Note that the chi-square test could only be applied to the maximum injury data. The resulting chi-square value was 14.38 with a p-value of 0.0001, suggesting that maximum injury is dependent on the ASI value. Based on the p-values in TABLE 4, the preferred ASI threshold value appears applicable to maximum injury, upper extremity and lower extremity injury (alpha significant to 0.05).

TABLE 4 Contingency Table Analysis Results

| Body Region | ASI ≤ 1, AIS ≤ 1 | ASI ≤ 1, AIS > 1 | ASI > 1, AIS ≤ 1 | ASI > 1, AIS > 1 | P-Value (Fisher’s Exact) |
|--------------------|---|---|---|---|-------------------------------------|
| All (Maximum) | 70 | 9 | 24 | 17 | 0.0002 |
| Chest | 78 | 1 | 40 | 1 | 0.454 |
| Head | 76 | 3 | 40 | 1 | 0.395 |
| Upper Extremity | 76 | 3 | 34 | 7 | 0.015 |
| Lower Extremity | 75 | 4 | 33 | 8 | 0.014 |

An attempt was made to generate logistic regression models for each of the body regions. Of the five body regions, only the maximum and lower extremity injury regions produced significant models. Each model has proportional odds assumption p-value greater than 0.05 (the hypothesis that the cumulative logit regression lines are parallel cannot be rejected) and have likelihood ratio test statistic values significant to the 0.0001 level. Based on these models, the probability of a particular AIS injury level is predicted based on ASI values equal to the preferred and maximum threshold values. The results are summarized in TABLE 5. Given the occurrence of an ASI 1.0, there is a predicted 80 percent probability that the maximum injury will be AIS 0 or 1. Likewise, for the lower extremity region, the model predicts that 92 percent of injuries will be AIS 0 or 1.

TABLE 5 Logistic Regression Model Results

| Body Region | ASI Value | AIS Value | Model Predicted Probability |
|--------------------|------------------|------------------|--|
| Maximum | 1.0 | 0 | 0.203 |
| | | 1 | 0.590 |
| | | 2 | 0.154 |
| | | 3 | 0.053 |
| | 1.4 | 0 | 0.090 |
| | | 1 | 0.508 |
| | | 2 | 0.277 |
| | | 3 | 0.126 |
| Lower Extremity | 1.0 | 0 | 0.605 |
| | | 1 | 0.311 |
| | | 2 | 0.065 |
| | | 3 | 0.018 |
| | 1.4 | 0 | 0.356 |
| | | 1 | 0.442 |
| | | 2 | 0.152 |
| | | 3 | 0.049 |

LIMITATIONS

As with any study of this nature, the results should be considered in parallel with the limitations inherent to the available data and methodology utilized. These include, but may not be limited to, the following:

1. Size of the available data set: The analysis is limited to 120 suitable cases.
2. Distribution of Injury Severity: There is a general lack of cases with higher occupant injury severity. For maximum occupant injury, less than ten percent of the cases fall in the MAIS 3 category and none exceed the MAIS 3 severity level. Also note that all cases involve airbag restrained occupants, which may produce a different distribution of injury than observed in the current vehicle fleet.
3. Longitudinal Information Only: A complete analysis of the linkage between the ASI and occupant injury requires information regarding the lateral and vertical motion of the vehicle.
4. EDR Data Recording Interval: Although vehicle acceleration is sampled every 0.312 milliseconds (16), the GM EDR only records vehicle velocity changes every 10 milliseconds. This coarse recording interval a potential source of error into the ASI computation since the peak acceleration may occur between recorded data points.
5. GM Vehicles Only: The Rowan University EDR database only contains information regarding GM vehicles. Although a large deviation between vehicle manufacturers is not expected, further analysis should include information from other vehicle manufacturers.
6. Occupant Compartment Intrusion: This analysis did not control for occupant compartment integrity. Of the 120 cases, 83 cases had no intrusion, 34 cases had intrusion, and intrusion was unknown in the remaining 3 cases. For the 34 intrusion cases, minor occupant injury (MAIS \leq 1) was noted in 23 instances, moderate injury (MAIS 2) in 9 cases, and serious injury (MAIS 3) in the remaining 2 cases.

CONCLUSIONS

This study provides a first indication at the relation between the ASI and injury to airbag-restrained occupants and has established a methodology for future studies. Specific conclusions include the following:

1. The ASI, at least with respect to the preferred threshold, is a good indicator of occupant injury to belted and airbag-restrained occupants involved in frontal collisions.
2. The available data supports the notion that the preferred limit of 1.0 corresponds to “light injury, if any” (i.e. AIS 0 or AIS 1 injury). This is especially true for overall and occupant extremity injury.
3. Given the occurrence of an ASI of 1.0, the available data suggests an 80 percent probability of an MAIS 0 or MAIS 1 injury.

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