# INFLUENCE OF VARIOUS ANTHROPOMETRIC CONSTITUTION OF PEDESTRIAN IN CASE OF VEHICLE-PEDESTRIAN IMPACT

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**KEYWORDS** - Impact, Pedestrian, Anthropometric data, Injury, Test, Simulation

**ABSTRACT** - The road traffic safety is a matter of great interest, which preoccupies more and more specialists from automotive and related industries, for increase the road safety and to reduce the traffic events. The road accidents statistics indicates that a very significant casualty’s percentage is given by the pedestrians and cyclists who are injured as a result of impact with a moving vehicle. Most of these injuries are caused by impact with the front of the vehicle. Most accidents occur in urban areas, where serious or fatal injuries can occur at low speeds, especially in the case of the children and senior citizens. To investigate the pedestrian anthropometry influence over the dynamics of vehicle-pedestrian impact, experimental tests and simulations were conducted. Pedestrian anthropometry data, as height and weight are important factors influencing the severity of injury after contact with the vehicle profile and with the place were the pedestrian is projected. Knowing the dynamics of the accident according to pedestrian anthropometry configurations is an important element in active safety features developments and vehicle safety regulations.

## INTRODUCTION

The road traffic safety is a matter of great interest, which preoccupies more and more specialists from automotive and related industries, for increase the road safety and to reduce the traffic events. Although the taken measures in this area have proved to be efficient, the road accidents number worldwide continues to increase. Irrecoverable life losses unconditionally require increased efforts to find common smart solutions accepted by all road users in order to reduce the effects of these problems by the end of the millennium.

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## INFLUENCE OF VARIOUS ANTHROPOMETRIC CONSTITUTION OF PEDESTRIAN IN VEHICLE-PEDESTRIAN IMPACT

To determine the influence of pedestrian anthropometry over the impact dynamics, an experimental vehicle/pedestrian impact test and simulations were made, using PCCrash 8.3 program.

### SIMULATION SCENARIO OF VEHICLE PEDESTRIAN IMPACT USING PCCRASH8.3

Simulation scenario was chosen because the most common vehicle/pedestrian accident cases are those where the time between the appearance of threatening state (seized by the driver) and the moment of onset of life-threatening processes that have relatively low values, lower or equal time required effective entry into operation of an avoidance maneuver. Situations requiring reactions known as "maximum emergency" can be found:

- sudden and unpredictable road crossing by pedestrians through one or more places unsuitable for this purpose;
- sudden onset of a pedestrian on the roadway whose vision was obstructed by another vehicle.

The driver can react with the available classical maneuvers, as braking energy; turn the bypass; sudden acceleration or a combination of all this maneuvers.

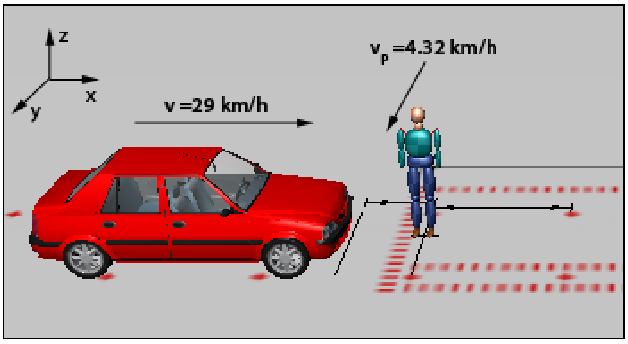


*Figure 1. Simulation scenario of vehicle-pedestrian impact.*

To make the pedestrian/vehicle impact simulation are considered:

- for pedestrian/vehicle impact situation in the unpredictable conditions of a pedestrian crossings, pedestrian speed is of 4.32 km/h.
- energetic braking reaction from drivers whose vehicles have a speed of 29 km/h on the impact moment.
- more simulations with different anthropometrical configurations witch corresponding to the following models: Hybrid III 98 percentile male, Hybrid III 50 percentile male, Hybrid III 5 percentile female, Hybrid III 10 year old and Hybrid III 6 year old.

*Table 1. Hybrid's III anthropometric data [5,6]*

| | Measure-ment units | Hybrid III 95th percentile male | Hybrid III 50th percentile male | Hybrid III 5th percentile female | Hybrid III 10 year old | Hybrid III 6 year old | Hybrid III 3 year old |
|---|---|---|---|---|---|---|---|
| Height | inch | 74.02 | 68.90 | 59.00 | 51.05 | 44.90 | 37.20 |
| | [m] | 1.88 | 1.75 | 1.50 | 1.30 | 1.14 | 0.94 |
| tol. ± | [m] | - | - | 0.25 | - | 4.06 | 1.27 |
| Weight | lbs | 223.00 | 171.30 | 108.03 | 77.61 | 51.60 | 35.65 |
| | [Kg] | 101.00 | 77.70 | 49.00 | 35.20 | 23.41 | 16.17 |
| tol. ± | [m] | - | 1.18 | 0.91 | 0.91 | 0.68 | 0.77 |

POSITION OF THE PEDESTRIAN IMPACT WITH THE VEHICLE HOOD AND WINDSCREEN

The most serious causes of pedestrian injuries are due to head trauma after the vehicle impact. After conducted simulations, is reveal that pedestrian head upon impact with the hood (or windshield) coordinates the focal point of pedestrian head change with data variation (height and weight) of the constitution of the Hybrid III 98 Percentile Male, the Hybrid III 6 Year Old, in that point of contact with the hood down.

| | | |
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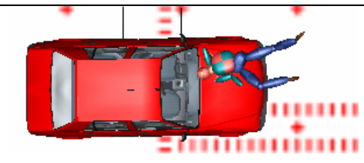
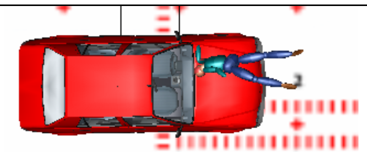
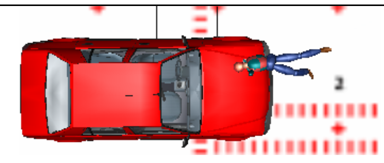
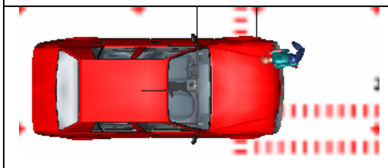
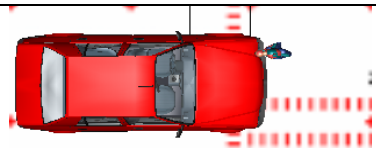
|  |  |  |
| t=0.35 s; H III 98 percentile male | t=0.31 s; H III 50 percentile male | t=0.22 s; H III 5 percentile female |
|  |  | |
| t=0.17 s; H III 10 year old | t=0.14 s; H III 6 year old | |

*Figure 2. Head impact position with the car (hood and windscreen).*

PEDESTRIAN THROW DISTANCES DEPENDING ON THE ANTHROPOMETRIC DATA AND CORRELATION WITH HIC

If the impact of pedestrian vehicle during braking, pedestrian separates from the vehicle, get on the roadway after the flight phase, which has a rotating and sliding movement, then gets in the resting position. The final pedestrian position is in the front of the vehicle. For different anthropometric pedestrian configurations results throwing pedestrian distances values and also their corresponding intervals (table 2.).

*Table 2. The pedestrian throwing distances*

| Pedestrian | Time of first impact with ground [s] | Distance Until first contact with ground [m] | Time of reaching in final position [s] | Throwing distanc e of pedestrian [m] |
|---|---|---|---|---|
| H III 98 percentile male | t1=1.18 | D1=5.85 | t2=1.82 | D2=7.00 |
| H III 50 percentile male | t1=1.23 | D1=6.00 | t2=1.89 | D2=7.00 |
| H III 5 percentile female | t1=0.85 | D1=5.20 | t2=1.98 | D2=8.20 |
| H III 10 Year old | t1=0.66 | D1=5.35 | t2=2.06 | D2=10.30 |
| H III 6 year old | t1=0.58 | D1=5.30 | t2=2.55 | D2=14.70 |

In terms of the pedestrian throwing distance on the performed simulations bases it results that with the decrease of pedestrian height and weight:

- decrease traveled distance by the pedestrian until the first impact with the ground (except the Hybrid III 6 Year Old data).
- increase time and distance traveled (sliding and flight phase) until the pedestrian reaches its final position.

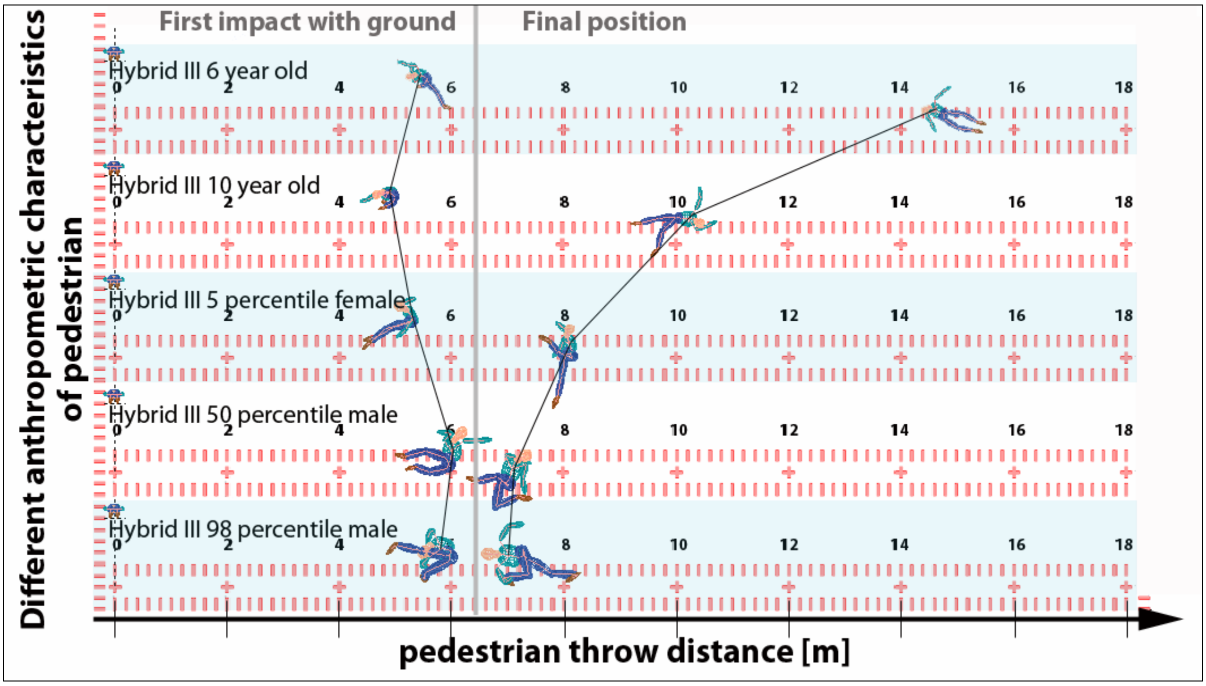



*Figure 3. Variation of pedestrian throw distance based on anthropometric data (height and weight) thereof*

*Table 3. The pedestrian throwing distances*

| Pedestrian | First time impact of head with the hood [s] | HIC max value on interval t (0…50) ms | First time impact of pedestrian with the ground [s] | HIC max value on interval t (50…150) ms |
|---|---|---|---|---|
| H III 98 percentile male | t=0.36 | HIC=495.646 | t1=1.18 | HIC1= 380.656 |
| H III 50 percentile male | t=0.31 | HIC=411.914 | t1=1.23 | HIC1= 459.312 |
| H III 5 percentile female | t=0.22 | HIC= 652.570 | t1=0.85 | HIC1=850.788 |
| H III 10 Year old | t=0.17 | HIC= 1640.035 | t1=0.66 | HIC1=1436.939 |
| H III 6 year old | t=0.14 | HIC= 1735.906 | t1=0.58 | HIC1=1950.675 |

If there is made a correlation between the time of head impact with the bonnet, the times of pedestrian impact with the ground and the HIC variation at the impact moment (Table 3) it will result that (as in fig.2 and fig.3).

For the first time impact of head with the hood HIC value reaches a maximum value on the t=(0…50)ms time interval, and will vary in HIC=496 for an adult pedestrian and HIC=1736 for child pedestrian 6 year old. In this case it is considered that influence up on the injury severity, is due the focal point of the with the hood (see fig.4 Stiffness distribution in the vehicle front), namely a distribution of pedestrian head orientation based on its height in those hood regions with a increases resistance.

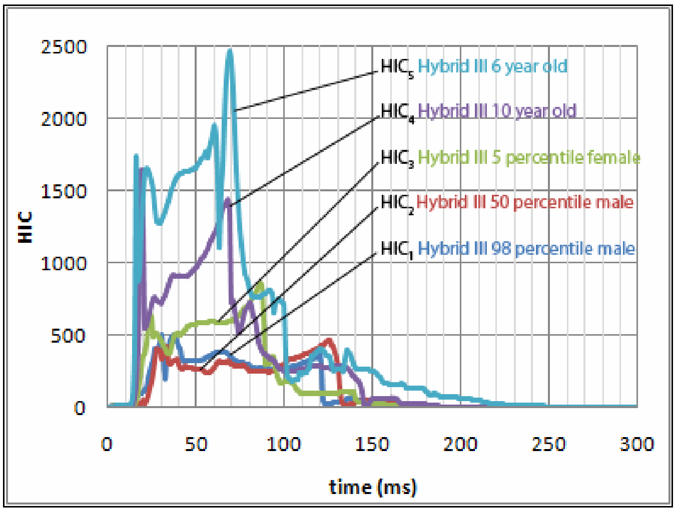



*Figure 4. HIC variation depend of anthropometric pedestrian data.*

For the pedestrian impact with ground HIC1 value reaches a maximum value on the t1=(50…150)ms time interval, and will vary in HIC1=380 for an adult pedestrian and HIC1=1951 for child pedestrian 6 year old . In this scenario of vehicle –pedestrian impact, for a vehicle impact speed 29km/h, and a pedestrian speed 4.32 km/h, value of HIC exceeds the damage limit HIC10 ms= 1000 and HIC36 ms =1500.

HIC criterion describes very well the moments of pedestrian contact with the vehicle impact phase and the impact to the ground phase after its separation from the vehicle. If we use HIC as a injuries evaluation criterion for the pedestrian, then it follows that pedestrians with lower height of 1.50 m and below 45 kg weight (features data according to age and constitution), serious injuries are more likely than persons whose anthropometric data ( height, weight) exceed these values.

## CONCLUSION

To investigate the pedestrian anthropometry influence over the dynamics of vehicle-pedestrian impact, experimental tests and simulations were conducted. Pedestrian anthropometry data, as height and weight are important factors influencing the severity of injury after contact with the vehicle profile and with the place were the pedestrian is projected. Knowing the dynamics of the accident according to pedestrian anthropometry configurations is an important element in active safety features developments and vehicle safety regulations. The most vulnerable pedestrians are children and elderly pedestrians, due to ability to see approaching vehicles or to appreciate distance and walking speed (in children cases), lack of agility (in the elderly people cases), and due to the anatomical configuration that in the case of a vehicle impact implies serious injuries. It found that as the anthropometric values (stature and weight) decrease, the greater is the risk of serious injury, also in case of a contact between pedestrian and vehicle and its contact with the ground in the post impact. This can be explained by the law of energy conservation if the pedestrian mass decreases results a speed increment, which implies a stronger impact of the vehicle's body and consequently to the ground.

After the simulations (according to the scenario) as the criterion of damage is found suitable HIC describe moments of pedestrian contact with vehicle body components and impact phase of the contact with the ground moments in the post impact. It is reveled that the highest HIC values were recorded in the pedestrian flying phase, after its separation from the vehicle and in the impact with the ground moment, in the slip phase. It found that the higher values of HIC were registered in the pedestrian phase of flight after its vehicle separation and in the moment of impact with the ground when occurs the slip phase. Because the main cause of fatality is the head injury is very important to develop new measures capable to protect all categories of pedestrians especially the most vulnerable. Using software to simulate traffic events offers a good correspondence of data with real events, allowing a series of tests on several such scenarios involving several types of vehicles. This can create databases that can be correlated with actual events thus creating new possibilities for solving traffic safety, and development of passive and active safety systems.

## ACKNOWLEDGEMENT

The paper was supported under the research grant ID_130/218/1.10.2007, with CNCSIS, Romania.

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