INFLUENCE OF AGEING PROCESS AND ANTHROPOMETRIC DATA ON THORACIC AND PELVIC INJURY TOLERANCE

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ABSTRACT

Thoracic and pelvic side impact tests with fresh unembalmed cadavers were analysed in order to assess the influence of age and anthropometric data on human injury risk. Statistical methods (linear and logistic regression models) were applied to evaluate the resultant data.

Injury risk prediction was improved by up to 26 percentage points by introducing age, bone condition (ash mineral content) and thoracic and pelvic breadth respectively into the statistical formulae in addition to the usual figures concerning impact intensity (impact velocity and mass).

The models estimated here can serve as a basis for the further analysis of realistic human injury thresholds.

THE AIM OF THE STUDY was to improve the prediction of injury outcome and the estimation of injury risk by introducing age and anthropometric data in addition to the parameters for impact intensity (impact velocity and mass). Passenger car restraint systems can only be adapted to the individual if individual human injury thresholds are known.

The ageing effect was analysed in several studies in the last few years by means of basic research on specimen and cadaver tests for the prediction of injury outcome. Yamada (1970) examined hard and soft human tissue and found a remarkable decrease of resistance to ultimate tensile stress with higher age. Sacreste et al. (1982) proved that age is an insufficient parameter for characterising rib resistance and determined the bone condition factor (BCF) as an indicator for thorax resistance. The BCF was validated later on a sample of cadavers in lateral impact. In a study based on 42 cadaver tests, Marcus et al. (1983) found that the number of fractured ribs and the thorax AIS show a linear relation with age and increase with advancing years. For the prediction of the number of rib fractures, Eppinger (1976) proposed formulae composed of combinations of either normalised belt force and age or relative anterior-posterior compression of the thorax and age. In a statistical study based on 63 side impact tests, Kallieris et al. (1994) showed that age has a more decisive influence on the severity of thoracic injury than criteria like acceleration and deformation measured during the impact. Furthermore, they found that the *TTI* (Thoracic Trauma Index) has the best correlation with the thorax *AIS* and the number of fractured ribs. Unfortunately, none of these studies analysed systematically all predictors of anthropometric data with regard to their influence on injury outcome and on the estimation of injury risk. In the present study this systematic analysis is carried out on the basis of thoracic and pelvic side impact test.

MATERIALS AND METHODS

TEST SET-UP - Three different types of side impact test were analysed: thoracic impactor tests, thoracic sled tests (rigid wall) and pelvic impactor tests. The four thoracic impactor test series were performed by INRETS-Bron (MRT - 5 tests; LCT - 9 tests), General Motors Company (GM - 10 tests) and the Association Peugeot Renault (APR - 2 tests). The thoracic sled test series was conducted at the University of Heidelberg (I-HRM - 44 tests) and the two pelvic test series by INRETS-Bron (MRB - 10 tests; LCB - 9 tests) (Table 1).

Table 1: Test and anthropometric data separated by test series

Test Series	Type[1]	*Meff* [kg]	*VEL* [m/s]	*AGE* [years]	F/M[2]
APR (n = 2)	T-I	23.4	4.5 - 6.7	57 - 69	0/2
GM (n = 10)		23.4	3.6 - 9.7	29 - 76	3/7
MRT (n = 5)		23.4	3.2 - 5.7	38 - 78	1/4
LCT (n = 9)		12 - 16	5.3 - 8.5	53 - 93	2/7
all (n = 26)		12 - 23.4	3.2 - 9.7	29 - 93	6/20
H-IRM (n = 44)	T-S	24.9 - 44.5	11.1 - 16.9	19 - 65	10/34
MRB (n = 10)	B-I	23.4	6.4 - 6.8	38 - 86	1/9
LCB (n = 9)		12 - 16	9.5 - 13.7	53 - 93	2/7
all (n = 19)		12 - 23.4	6.4 - 13.7	38 - 93	3/16

[1] Type of Impact: T-I: thoracic impactor test; T-S: thoracic sled test; B-I: pelvic impactor test
[2] F/M: number of female/male cadavers

For all side impact tests unembalmed human cadavers were used shortly after rigor mortis had passed off (t_{pm}<96 h). The anthropometric data were taken and recorded, the cadavers were kept in cold-storage chambers until a few hours before the test and had an ambient temperature during impact. The injuries were ascertained by autopsy, the total number of fractured ribs *TNFR* and the thorax *AIS* (*TAIS*) as well as the total number of fractured bones *TNFB* and the overall *AIS* for the pelvis-hip-region *BAIS* were taken down. Of the anthropometric data, age *AGE*, body mass *MAS*, height *HEI*, Body-Mass-Index *BMI*, thoracic breadth *THB* and pelvic breadth *LBC* respectively and – if determined – the ash mineral content of the bones *CAL* were analysed for their possible influence on the prediction of injury outcome and injury risk.

Impact intensity was quantified by impact velocity *VEL* and mass *Meff*. In impactor tests this mass is equal to the impactor mass, for sled tests Roberts et al. (1991) defined 48.9% of the total body mass *MAS* as effective mass *Meff* for the impact.

For the thoracic impactor tests performed by INRETS-Bron (MRT, LCT) a linear impact hammer was used which was accelerated horizontally to the pre-set impact velocity *VEL* by elastic strips. The impact mass was *Meff* = 12 kg to *Meff* = 23.4 kg, the striking surface being flat and rigid. For the impact, the subject was seated on a horizontal Teflon® plate on a height adjustable support. The body was suspended by the head, kept in the correct seating position by means of an electromagnet and released a few milliseconds before impact.

The data of other thoracic impactor test series were obtained from the ISO-database and include tests performed by the General Motors Company (GM) and the Association Peugeot Renault (APR). For these, the striking surface was also flat and rigid, the impact mass being *Meff* = 23.4 kg.

For the pelvic impactor tests, carried out by INRETS-Bron (MRB, LCB), the same test set-up was used as for the thorax side impact tests (*Meff* = 12 kg to *Meff* = 23.4 kg, striking surface flat and rigid).

The thoracic sled tests were performed on a decelerated sled at the University of Heidelberg (H-IRM – 44 tests). The subjects were positioned on a Heidelberg-type seat fixture (illustrated in Marcus et al., 1983) mounted on a horizontally accelerated sled. After having been accelerated to the set test speed (*VEL*), the sled is rapidly decelerated to zero velocity. Thanks to the low friction surface (Teflon®) of the seat, the specimen continues to translate laterally before impacting the flat and rigid wall of the sled fixture.

STATISTICAL METHODS - Regression analysis was performed for modelling injury outcome and estimating injury risk.

Linear Regression was applied to assess the relation between injury outcome (*TNFR* for the thoracic and *TNFB* for the pelvic impact tests) and possible predictors. Models were selected by means of the adjusted determination coefficient $adjR^2$, which takes into consideration the number of the variables in the model. This prevents "over fitting" due to random effects. Statistical significance of each predictor was proofed by the Student's t-test. The quality of fit was assessed by means of the correlation coefficient R between predicted and real injury outcome.

Logistic Regression was used to estimate injury risk, e.g. the probability of an injury severity $TAIS \geq 4$ (Hosmer et Lemeshow, 1989). A stepwise regression procedure based on a calculation of the likelihood ratio test (using the statistics -2log$L$) was applied. For the selection of variables, the pre-specified significance level of $\alpha = 0.1$ was used. For assessment, the likelihood ratio test was performed. As a measure of the strength of the relation between an explanatory variable and the dependent variable, the estimated odds ratio was added.

Considering all pairs of input observations with different responses (i.e.

EVENT or NO EVENT), the concordance is the proportion of pairs where the response EVENT has a higher predicted probability than the response NO EVENT.

RESULTS

INJURY OUTCOME PREDICTION - Injury outcome – in total number of fractured ribs *TNFR* for the thoracic impact and total number of fractured bones *TNFB* for the pelvic impact – was predicted as a function of impact intensity and anthropometric data by linear regression. Models with a varying number of predictors were tested for statistical significance as shown by their adjusted determination coefficient $adjR^2$. The highest $adjR^2$ indicates the best adapted model.

Thoracic impactor tests - Injury outcome as a function of impact intensity and anthropometric data was analysed for the 26 thoracic impactor tests with an impact mass from *Meff* = 12 kg to *Meff* = 23.4 kg. The following model with 5 variables presents the best adaptation of all models predicting injury outcome *TNFR* (App. Table 2 - Type T-I):

$$pTNFR = 1.68*VEL+0.242*Meff+0.105*AGE+0.0246*THB-5.25*CAL-22.1$$

A significant model improvement was achieved by including *AGE*, thoracic breadth *THB* and ash mineral content *CAL* into the model containing impact velocity *VEL* and mass *Meff* ($R = 0.89$; Figure 1).

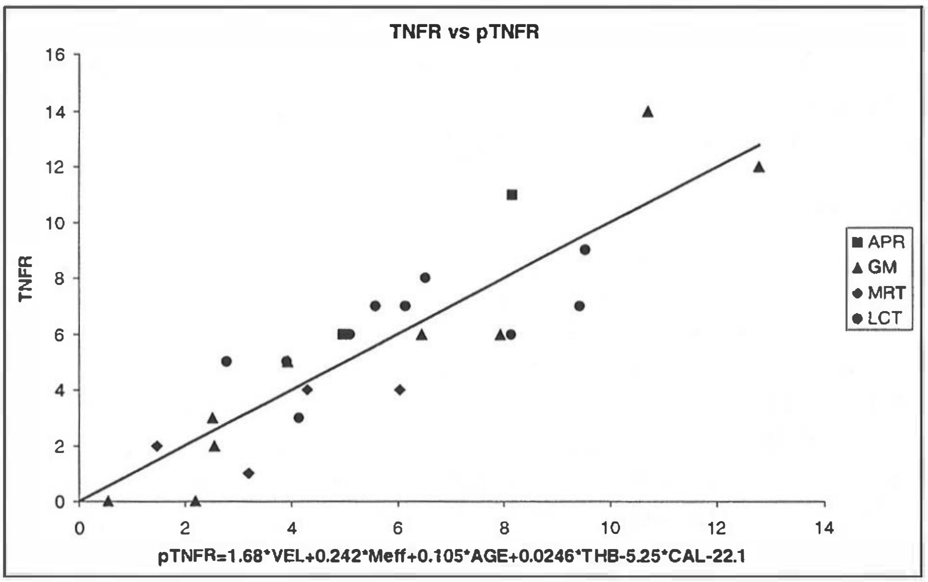

Figure 1: Linear plot of total number of fractured ribs *TNFR* vs. predicted total number of fractured ribs *pTNFR* (n = 26)

Thoracic sled tests - The data of 44 thoracic sled tests were analysed without regard to ash mineral content *CAL* and impact mass *Meff*, this being a percentage ($p = 48.9\%$) of the body mass *MAS*. A regression model with 4 parameters best predicted the total number of fractured ribs *TNFR* ($R = 0.81$; App. Table 2 - Type T-S):

$$pTNFR = 0.860*VEL+0.181*AGE+0.0405*THB-24.0$$

Pelvic impactor tests - For the 19 pelvic impactor tests, the best model in the sense of the fixed methodology predicted the total number of fractured bones *TNFB* as a function of impact speed *VEL* as well as height *HEI* and pelvic breadth *LBC* (App. Table 2 - Type B-I):

$$pTNFB = 0.295*VEL-3.31*HEI+0.0265*LCB-3.68$$

The model has a correlation coefficient of $R = 0.81$, with neither impact mass *Meff* nor *AGE* showing statistical significance.

INJURY RISK ESTIMATION - Logistic regression estimates injury risk as a function of impact intensity – quantified by impact energy E – and additional anthropometric data. To quantify injury risk, the probability of incurring an injury of a certain severity (e.g. $TAIS \geq 4$) is calculated.

For the thoracic impact tests, the best model estimates injury risk $p(TAIS \geq 4)$ as a function of impact energy E according to the following formula (concordance of 70%; Figure 2):

$$p(TAIS \geq 4) = \frac{e^{0{,}00305*E-1{,}87}}{1 - e^{0{,}00305*E-1{,}87}} \qquad \text{model T-I-E}$$

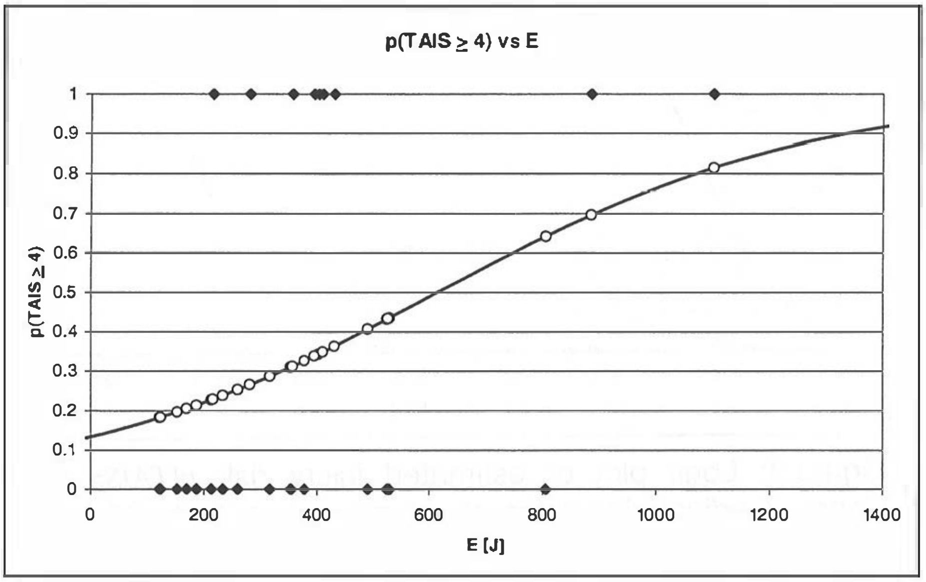

Figure 2: Logit plot of estimated injury risk $p(TAIS \geq 4)$ vs. Energy E (n = 26)

According to the chosen model, a 50%-probability of incurring an injury of $TAIS \geq 4$ is given at an energy of $E = 615$ J, a 25%-probability at $E = 255$ J.

This estimation of injury risk can be improved by adding anthropometric data as further predictors to the regression model. Statistical significance in the sense of the fixed methodology was achieved for *AGE* and ash mineral content *CAL* (App. Table 3 - models T-I). The odds ratio signifies the factor of variation of injury risk, values higher than 1 indicate a positive correlation with the probability of the occurrence of an injury severity $TAIS \geq 4$, values below 1 indicate a negative correlation. The increase of ash mineral content ΔCAL = 0.05 g/cm reduces injury risk by a factor of approximately 3.5 (OR = 0.28), the risk rises by 4.7 for 10 years of age.

The model for estimating injury risk $p(TAIS \geq 4)$ as a function of energy E and ash mineral content CAL is calculated according to the following formula:

$$p(TAIS \geq 4) = \frac{e^{0,0111*E-25,1*CAL+1,33}}{1-e^{0,0111*E-25,1*CAL+1,33}} \quad \text{model T-I-E+CAL}$$

To show the probability of $p(TAIS \geq 4)$ as a function of energy E, this energy has to be adjusted to a fixed value for the second predictor. Figure 3 shows these risk-estimation-curves for three different ash mineral contents (CAL = 0.15 g/cm, CAL = 0.30 g/cm and CAL = 0.60 g/cm). The rise of the ash mineral content CAL makes the curve shift to higher energies, showing the protective influence of this predictor. A decrease of ash mineral content CAL results in a corresponding shift to lower energies. The concordance is 90%.

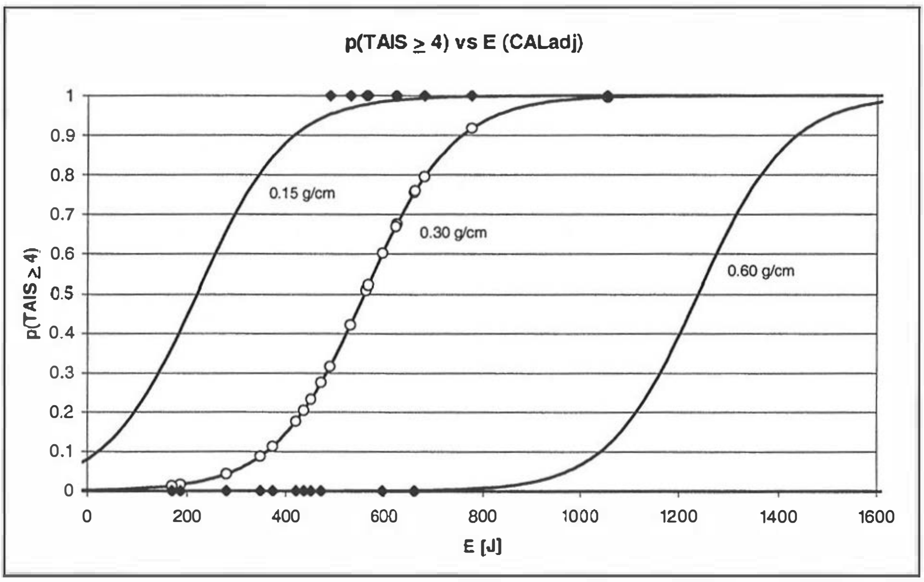

Figure 3: Logit plot of estimated injury risk $p(TAIS \geq 4)$ vs. Energy E adjusted to different ash mineral content CAL (n = 26)

For the thoracic sled tests, the risk of incurring an injury equal to or higher than $TAIS$ 4 as a function of energy E is best estimated by the following model (concordance of 69%):

$$p(TAIS \geq 4) = \frac{e^{0,00102*E-2,30}}{1-e^{0,00102*E-2,30}} \quad \text{model T-S-E}$$

A 25%-probability of $TAIS \geq 4$ is reached at an energy of E = 1180 J, for an energy of E = 2250 J the risk is 50%.

As for the thoracic impact tests, injury risk estimation can be improved by including anthropometric data as additional predictors. The two anthropometric parameters AGE and thoracic breadth THB were found to be statistically significant, the p-value of the total model decreases with the additional variables. A rise in age of 10 years increases injury risk $p(TAIS \geq 4)$ by a factor of 7.3, an increase in thoracic breadth of 10 mm (ΔTHB = 10 mm) results in a rise in risk by 1.5 (App. Table 3 - models T-S).

The following model was chosen to demonstrate this improvement of the estimation of injury risk by an additional predictor, concordance was increased by 26 percentage points to 95%. The probability $p(TAIS \geq 4)$ on the basis of energy E and AGE is calculated according to the following formula:

$$p(TAIS \geq 4) = \frac{e^{0,00165*E+0,199*AGE-11,0}}{1 - e^{0,00165*E+0,199*AGE-11,0}}$$ model T-S-E+AGE

Figure 4 shows the risk-curves of this model as a function of energy E adjusted to three different ages (AGE = 20 years; AGE = 40 years and AGE = 60 years). The influence of age is recognisable in the shifting of the risk-curves to the right, i.e. to higher energies by decrease of age and to lower energies by an increase of age.

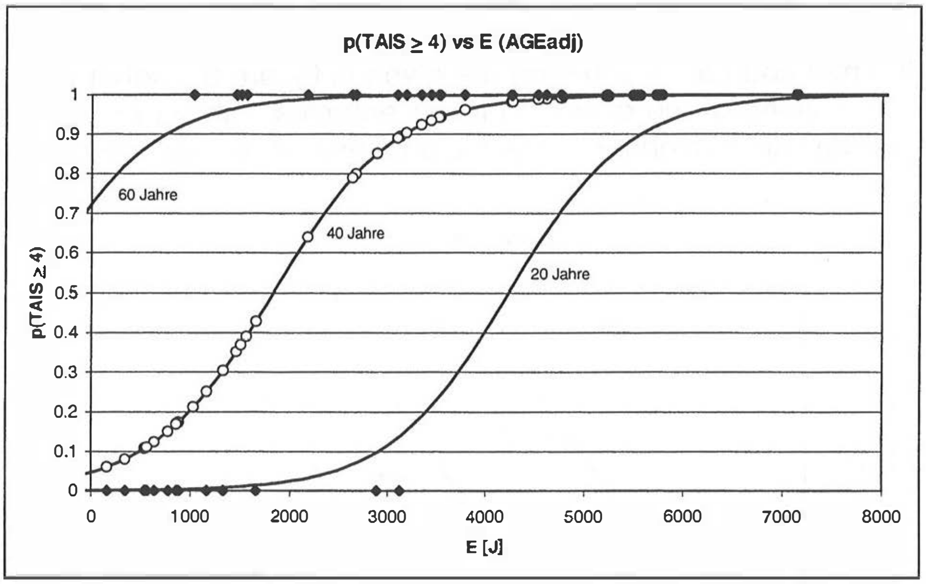

Figure 4: Logit plot of estimated injury risk $p(TAIS \geq 4)$ vs. Energy E adjusted to different AGE (n = 44)

Pelvic impactor tests - The critical injury level for the pelvis-hip-region for the pelvic impactor tests was fixed at $BAIS$ 3. This divides the collective into one group of 10 tests with minor injuries equal to or less than $BAIS$ 2 and another group of 9 tests with severe injuries of a level of $BAIS \geq 3$.

The model for the best estimation of injury risk $p(BAIS \geq 3)$ based on impact energy E with a concordance of 77% has the following formula:

$$p(BAIS \geq 3) = \frac{e^{0,00102*E-2,30}}{1 - e^{0,00102*E-2,30}}$$ model B-I-E

A 50%-probability of incurring an injury with an injury level equal to or higher than $BAIS$ 3 is given at an energy of E = 680 J, the probability is less than 25% for an energy of less than E = 500 J.

An improvement of outcome estimation is achieved by adding anthropometric parameters as further predictor in the same way as for thoracic side impact. The three additional and statistically significant predictors are *AGE*, height *HEI* and pelvic breadth *LCB* (App. Table 3 - models B-I). Despite the reduced influence of *AGE* (p_{var} = 0.19; no diminution of p_{model}) this predictor fulfils the criteria of the statistics -2log*L*. The injury risk is 2.3 times higher for a person 10 years older and increases by a factor of 2.2 when pelvic breadth is ΔLBC = 10 mm higher. Injury risk is about 5 times higher for a decrease of ΔHEI = 0.10 m.

Injury risk $p(BAIS \geq 3)$ as a function of impact energy *E* and pelvic breadth *LBC* is calculated using the following formula:

$$p(BAIS \geq 3) = \frac{e^{0,00772*E+0,0780*LBC-28,8}}{1-e^{0,00772*E+0,0780*LBC-28,8}} \qquad \text{model B-I-E+LBC}$$

Concordance is raised by 7 percentage points to 84% by this model. The probability-curves for the estimation of injury risk $p(BAIS \geq 3)$ as a function of energy *E* adjusted to three different pelvic breadths (*LBC* = 275 mm, *LBC* = 300 mm and *LBC* = 330 mm) are given in Figure 5. Higher pelvic breadth results in a shifting of the curves to lower energies with an increase of risk. A corresponding shift to higher energies is observed for lesser pelvic breadth.

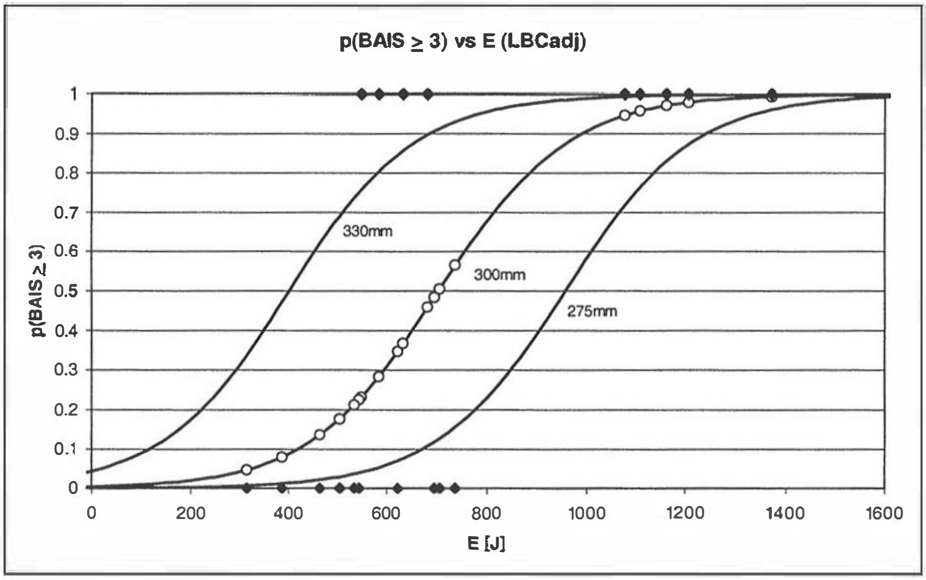

Figure 5: Logit plot of estimated injury risk $p(BAIS \geq 3)$ vs. Energy *E* adjusted to different pelvic breadth *LCB* (n = 19)

DISCUSSION

Thoracic and pelvic side impact tests with fresh unembalmed cadavers were evaluated, this being the only way to quantify the influence of ageing effects and anthropometric data. Neither dummy nor volunteer tests can yield comparable findings. Once the influence of age and anthropometric data is known, individual human injury thresholds can be defined and fixed, which in turn might help to achieve a higher biofidelity of dummies. The advantages of tests with impactors and sleds are the standardised test conditions, which lead to a good reproducibility and a minimisation of interfering factors. Thus an exact definition of the impact energy to the human cadaver is practicable with the best possible quantification of the influence of age and anthropometric data.

Anthropometric predictors - The influence of some anthropometric predictors was demonstrated. The effect of ageing was shown and explained in various other studies (e.g. Kallieris et al. 1994) and has been the subject of basic research (e.g. Yamada, 1970).

The influence of thoracic breadth *THB* on injury risk needs further clarification. On the one hand, a larger thorax has a higher mass. This higher inertia leads to the absorption of a bigger part of the impact energy and thus to a higher injury outcome. On the other hand, the shape varies with thoracic breadth. A larger thorax has a higher curvature that is modified to a greater extent under the same compression, which in turn leads to a higher fracture risk. Lastly, injury risk is influenced by the inclination of the ribs. Ribs positioned on a more horizontal plane – seen during inspiration or, pathologically, in an emphysema thorax – absorb the impact by changing their curvature whereas inclined ribs have a lower fracture risk because they can also respond by increasing inclination.

The influence of ash mineral content *CAL* is known from experimental studies (Yamada, 1970) as well as from clinical pathology osteoporosis, and a higher fracture risk for lower bone density can be confirmed. Yet the determination of ash mineral content has some disadvantages. Firstly it is an invasive method and not practicable in vivo, secondly, it is susceptible to influence by divers factors such as post-fracture callus growth. There is therefore an urgent need for more precise and non-invasive methods such as Quantified Computed Tomography (QCT) or Dual Energy X-ray Absorptiometry (DEXA).

Pelvic breadth *LBC* influences injury outcome in the same way as thoracic breadth. The argument concerning the influence of mass and shape seems to apply for pelvic breadth also.

The explanation for the influence of height *HEI* is less evident and only found by correlation with other anthropometric data. Younger people are on average taller than old ones, so that lesser height corresponds with higher age. Also women, usually smaller than men, tend to have a lower bone density, a factor already shown to increase injury risk. Although sex itself has no statistical significance, it helps to explain the influence of height as a predictor.

All three types of tests have demonstrated that impact intensity alone is not sufficient for the prediction of injury outcome – even in combination with age. The need to include age, thoracic breadth *THB* and pelvic breadth *LBC* respectively, and, if determined, ash mineral content *CAL* in the regression models to improve the prediction of injury outcome in thoracic and pelvic side impact was demonstrated. For the pelvic impact tests, the influence of the impact mass *Meff* and age could not be proved to be statistically significant, but the correlation of age with height *HEI* explains the absence of this predictor in the model (model B-I-VEL+AGE+LBC: $R^2 = 0.61$, $adjR^2 = 0.54$).

For the estimation of injury risk, prediction was improved by introducing anthropometric data (age, known bone condition (ash mineral content) and thoracic and pelvic breadth respectively) into the statistical models in addition to energy as parameter for impact intensity.

The concordance of injury risk predictions for the thoracic side impactor tests was improved by 20 percentage points to 90% by adding ash mineral content to the model. This is shown by the increased steepness of the risk-curves in Figure 3 in comparison with Figure 2. The increase of ash mineral content CAL results in a shifting of the energy-dependent risk-curves to higher energies, and correspondingly to lower energies for lower ash mineral content. A 50% risk of incurring severe injury $TAIS \geq 4$ is given at an energy of $E = 560$ J for a person whose bones have an ash mineral content of $CAL = 0.30$ g/cm. The same risk is reached at the energy of $E = 1260$ J if the ash mineral content is $CAL = 0.60$ g/cm, corresponding to an energy difference of $\Delta E = 600$ J or $\Delta E(\Delta CAL) = 2330$ J/(g/cm) as difference per unit of change. On the other hand, risk varies for the same impact energy E as a function of ash mineral content. Thus for an energy of $E = 500$ J, injury risk is at 96% for an ash mineral content of $CAL = 0.15$ g/cm and at less than 0.1% for $CAL = 0.60$ g/cm (Figure 3).

Similar facts were established concerning age. Concordance was improved by 20 percentage points, a difference of the impact energy per years difference of age of $\Delta E(\Delta AGE) = 27$ J/years was found.

By adding the predictor age to the model estimating injury risk based on impact energy for the thoracic side impacts by sled tests, concordance was improved by 26 percentage points to 95%. This results in a good prediction and shows the importance of considering anthropometric data in prediction models. The difference of impact energy per years difference of age is $\Delta E(\Delta AGE) = 120$ J/years (Figure 4). Concordance for the prediction of injury risk by thoracic breadth THB was improved to 79%. The difference of the impact energy per mm difference of thoracic breadth was determined as $\Delta E(\Delta THB) = 26$ J/mm.

For pelvic side impact by impactors also an improvement of injury risk prediction was obtained by adding anthropometric data to the model. The addition of age improved the concordance of the prediction of injury risk only from 77% to 78%, the difference of the impact energy per years difference of age is $\Delta E(\Delta AGE) = 12$ J/years. The addition of one of the other two additional predictors improves the concordance of injury risk estimation to 84%. The difference of the impact energy E as a function of the differences of pelvic breadth LBC and height HEI respectively are $\Delta E(\Delta LBC) = 10$ J/mm and $\Delta E(\Delta HEI) = 2150$ J/m (Figure 5).

The concordance of injury risk predictions was improved by up to 26 percentage points by introducing age and other anthropometric data into the statistical formulae in addition to the usual figures for impact intensity, so that the calculation of the risk of incurring severe injury ($AIS \geq 4$ for the thorax, $AIS \geq 3$ for the pelvis) as a function of impact energy was improved. The need to include these parameters in the prediction of injury outcome in thoracic and pelvic side impact was thus clearly demonstrated. The models obtained are offered as a basis for establishing more realistic and individually adapted human injury thresholds.

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APPENDIX

Table 2: $adjR^2$ and R^2 for models with different predictors for thoracic impactor (T-I), thoracic sled (T-S) and pelvic impactor (B-I) tests

Type	Predictors in model	$adjR^2$	R^2
T-I	*VEL Meff AGE*	0.71	0.75
	VEL Meff AGE CAL	0.74	0.78
	VEL Meff AGE THB CAL	**0.75**	**0.80**
	VEL Meff AGE SEX THB CAL	0.74	0.81
T-S	*VEL AGE*	0.57	0.59
	VEL AGE THB	**0.63**	**0.66**
	VEL AGE MAS THB	0.63	0.66
B-I	*VEL AGE*	0.43	0.49
	VEL HEI LBC	**0.58**	**0.65**
	VEL Meff HEI LBC	0.56	0.65

Table 3: Regression coefficient β, odds ratio OR and p-value p_{var} of the variables and p-value of the total model p_{model} for thoracic impactor (T-I), thoracic sled (T-S) and pelvic impactor (B-I) tests

model	variable	β	*OR* (uoc)[1]	p_{var}	p_{model}
T-I-E	Intercept	-1.87	-	-	0.097
	E	0.00305	1.4 (100 J)	0.013	
T-I-E+AGE	Intercept	-13.0	-	-	0.0008
	E	0.00570	1.8 (100 J)	0.083	
	AGE	0.154	4.7 (10 years)	0.026	
T-I-E+CAL	Intercept	1.33	-	-	0.0008
	E	0.0111	3.0 (100 J)	0.036	
	CAL	-25.1	0.28 (0.05 g/cm)	0.038	
T-S-E	Intercept	-2.30	-	-	0.0179
	E	0.00102	2.8 (1000 J)	0.053	
T-S-E+AGE	Intercept	-11.0	-	-	<0.0001
	E	0.00165	5.2 (1000 J)	0.034	
	AGE	0.199	7.3 (10 years)	0.0012	
T-S-E+THB	Intercept	-15.1	-	-	0.0022
	E	0.00145	4.3 (1000 J)	0.060	
	THB	0.0378	1.5 (10 mm)	0.024	
B-I-E	Intercept	-4.13	-	-	0.0143
	E	0.00608	1.8 (100 J)	0.054	
B-I-E+AGE	Intercept	-10.1	-	-	0.0158
	E	0.00657	1.9 (100 J)	0.084	
	AGE	0.0817	2.3(10 years)	0.19	
B-I-E+LBC	Intercept	-28.8	-	-	0.0074
	E	0.00772	2.2 (100 J)	0.12	
	LBC	0.0780	2.2 (10 mm)	0.099	
B-I-E+HEI	Intercept	21.5	-	-	0.0090
	E	0.00719	2.1 (100 J)	0.038	
	HEI	-15.5	0.21 (0.10 m)	0.12	

[1] *OR* calculated with respect to the given unit of change (uoc)