ANTHROPOMETRY AND TRAUMATOLOGY OF THE PELVIS OF CHILDREN

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ABSTRACT

In the case of child road users the pelvis shows the lowest risk of injury compared to other body regions. Being also located near to the body's centre of gravity, the pelvis is particularly suitable for the diversion of mass forces.

For this reason, an analysis will be given of the traumatology, the biomechanics and especially the anthropometry of the child's pelvis, taking the following items into consideration:

- typical contact region of exterior road users under lateral load
- contact region of restrained passenger car occupants under frontal load
- geometrically relevant construction in the case of anthropometric dummies.

Using frontal (anterior - posterior) and lateral X-ray photographs of the pelvis with children - given by post mortem examinations -, the typical geometry of the pelvis depending on physiological age is deduced. In addition to this, these results are compared with data of anthropometric dummies.

Furthermore, an analysis of the traumatology of the child's pelvis is carried out with regard to type, severity and risk of injuries based on in-depth single-case analyses of real road accidents. The aim of this is to improve the understanding of the special injury mechanisms of this body region respectively to round off the level of knowledge by describing the general biomechanics of the pelvis.

INTRODUCTION

The traumatology of road accidents shows that the child's pelvis region is marked by a low risk of injury (1). Particularly in the case of child pedestrians (1) it becomes apparent that among the body regions in question struck by a blunt lateral load at the same impact speed, the Relative Traumatic Degree (combination of injury frequency and injury severity) of the pelvis region is lowest.

Therefore this region is of special importance:

- as a lateral contact area to be aimed for in the case of pedestrians and, to some extent, also two-wheel-riders

- as a frontal contact zone for a lap belt for older children

- with regard to the design of anthropometric dummies.

TRAUMATOLOGY

In order to demonstrate the special injury mechanisms of the pelvis region, the traumatic degree as well as the severity and type of injuries observed are explained in the following.

On the basis of in-depth single-case analyses of real road accidents in which children were involved, it turns out concerning the degree of endangerment (Traumatic Degree) compared to other body regions, the pelvis region can be classified as follows:

- in the case of pedestrians (1) approx. rank 8

- in the case of restrained and unrestrained car occupants (1) approx. rank 9 respectively 5

- in the case of two-wheel-riders (2) approx. rank 5

The severity degree of the injuries caused to children is on average approx. AIS 2 (3) for pedestrians, AIS 1 for restrained passenger car occupants, approx. AIS 2 for unrestrained occupants (1) and AIS 1 to 2 for two-wheel-riders (2).

Among 49 cases with injuries of the pelvis region, the majority, i.e. 29 children, had soft tissue injuries, and the larger part of these (n = 23) suffered bruises and, in some cases, haematomas. Pelvic bone injuries have been observed in 19 cases as follows:

- in eight cases a pubis fracture and of these one case with burst of the symphysis (AIS 2 to 3)

- in four cases a pelvis girdle fracture, of these two cases with joint pan participation (AIS 3)

- in four cases a palm fracture (AIS 2)

- and in three cases an ischial fracture, two cases of these from type of a double fracture (AIS 3)

BIOMECHANICS

A description of some facts of the general biomechanics of the pelvis is added to round off the level of knowledge of this body region. The child pelvis is relatively soft and small and up to the age of 10 no iliac spinae have yet developed (4).
The rounded pelvis palms, together with the thick subcutaneous tissue, produce a negative submarining effect of the child's pelvis and urogenital region under a lap belt (5). This is only partly compensated for by the lordosis of the lumbar vertebrae.

DERIVATION OF CHILD PELVIS GEOMETRY

Using frontal (anterior - posterior) and lateral X-ray photographs of the infant pelvis (sources: Hannover Medical University, Institute for Forensic Medicine of Heidelberg University) from post mortem examinations, the typical geometry of the pelvis can be derived depending on physiological age.

Ten children between 2,10 and 11,8 years of age are documented (see Figure 1). In order to assess the position of the children examined in the general spectrum, apart from sex, the following data have been recorded:

- Body mass
- Height
- Sitting height
- Circumference of chest
- Circumference of upper arm
- Circumference of wrist
- Circumference of calf

The knowledge of these anthropometric data and the use of relevant literature (6) (7) makes it possible to derive a physiological age (8) which describes the state of physical development (growth and shape) and whose mean value - as calculated from the two sources - is given in Figure 1. As a result, the age group to be examined reaches from approx. 2,10 to 14,5 years of age.

To calculate the enlargement of the pelvis image or part thereof on the X-ray photographs, the following setting data for the X-ray equipment have been registered in addition:

- Distance between focus and object
- Distance between focus and plate
- Distance between focus and film

Figure 2 provides a frontal and lateral view of the documented pelvis regions. The following geometrically significant dimensions (see also Figure 3) - documented in Figure 1 - can be derived from this view:

y_B lateral width of the pelvic brim

y_C lateral distance between the anterior superior iliac crests

y_T lateral clearance between the tuber of the ischium

x_{CS} anterior/posterior distance between anterior superior iliac crest and sacrum

z_{TP} vertical distance between tubers of the ischium and proximal pelvis palms

z_{TC} vertical distance between tubers of the ischium and anterior superior iliac crest

RESULTS

From Figure 2 can be taken, that the rounded pelvis palms respectively the not or incomplete developed iliac spinae produce a negative submarining effect under a lap belt the younger the children are.

A description of the derived anthropometric data of the pelvis region versus physiological age is given in Figure 3. Since the individual cases are not scattered linearly over the physiological age, it has not been possible to supply data direct for every age group. For this reason, linear regression analyses have been carried out (correlation coefficients 0,83 - 0,96) which make it possible to read off characteristic anthropometric pelvis data of 3-, 6- and 10-year-old children as shown in Figure 4.

Figure 3 and 4 also contains the respective data of anthropometric dummies, namely of the Alderson VIP 3c and 6c whose pelvis region is also shown in Figure 2 laterally and in a/p view. In addition Figure 3 shows the charateristic data of the Hybrid II dummy.

The geometrical dimensions of the pelvis of child dummies differ slightly or considerably from those of the documented children. For instance, the vertical height of the pelvis (z_{TP}) as well as the a/p distance between anterior superior iliac crest and sacrum (x_{CS}) is considerably greater in the dummies, whereas the lateral distance between the anterior superior iliac crests (y_C) is in some cases much too small.

In the case of the child dummies discussed here, the lower pelvis region (tubers of the ischium, lower region of the pelvis palms) is not shaped anthropometrically. As compared to reality positioning of a lap belt and compression in the seat area is expected to be different as well as there is no frontal support in the lower region of the pelvis palms.

DISCUSSION

The analysis of traumatology of the pelvis region of infants shows that the pelvis region appears to be more suitable for the diversion of mass forces than other body regions in the case that there is no great surface loading.

Using a lap belt it has to be concidered that the not or incomplete developed iliac spinae produce a negative submarining effect under a lap belt.

In some items the construction of the pelvis region with dummies does not correspond to that of children. In distinction to the adult dummy (Hybrid II), the pelvis of the child dummy is only imperfectly designed. Consequently, drawbacks in simulation quality must be expected due to the partly limited representativity of the actual design of the pelvis region.

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living age (y,m)	sex (m,f)	body mass (kg)	stature (cm)	sitting height (cm)	chest circum- ference (cm)	upper arm circumf. (cm)	calf circum- ference (cm)	wrist circum- ference (cm)	physio- logical age (y,m)	y_B (cm)	y_C (cm)	y_T (cm)	x_{CS} (cm)	z_{TD} (cm)	z_{TC} (cm)	case N. (/)
2,10	m	-	-	-	-	-	-	-	2,10	~150	~136	~40	-	~102	~81	1
3,6	f	13	98	58	52	16	20	10	3,9	159	140	51	52	115	104	2
5,2	f	17	107	63	51	17	20	12	4,10	158	~150	49	67	118	99	3
5,7	m	17	109	65	51	17	22	11	5,2	166	~155	56	59	118	106	4
6,11	f	~30	142	66	64	19	24	12	9,1	201	190	71	~66	140	~93	6
7,11	f	25	127	65	59	17	21	11	6,9	184	170	62	87	136	99	5
8,2	f	32	144	79	65	20	28	13	11,1	203	170	55	96	158	122	7
11,5	f	41	147	82	80	26	34	14	14,5	236	220	70	106	173	126	10
11,7	m	~38	155	83	64	19	28	14	12,0	219	200	68	84	168	118	8
11,8	m	39	150	80	69	21	30	15	13,0	202	190	72	86	166	125	9

Fig. 1 - Living and physiological age; anthropometric data and characteristic geometrical pelvis data of the documented children

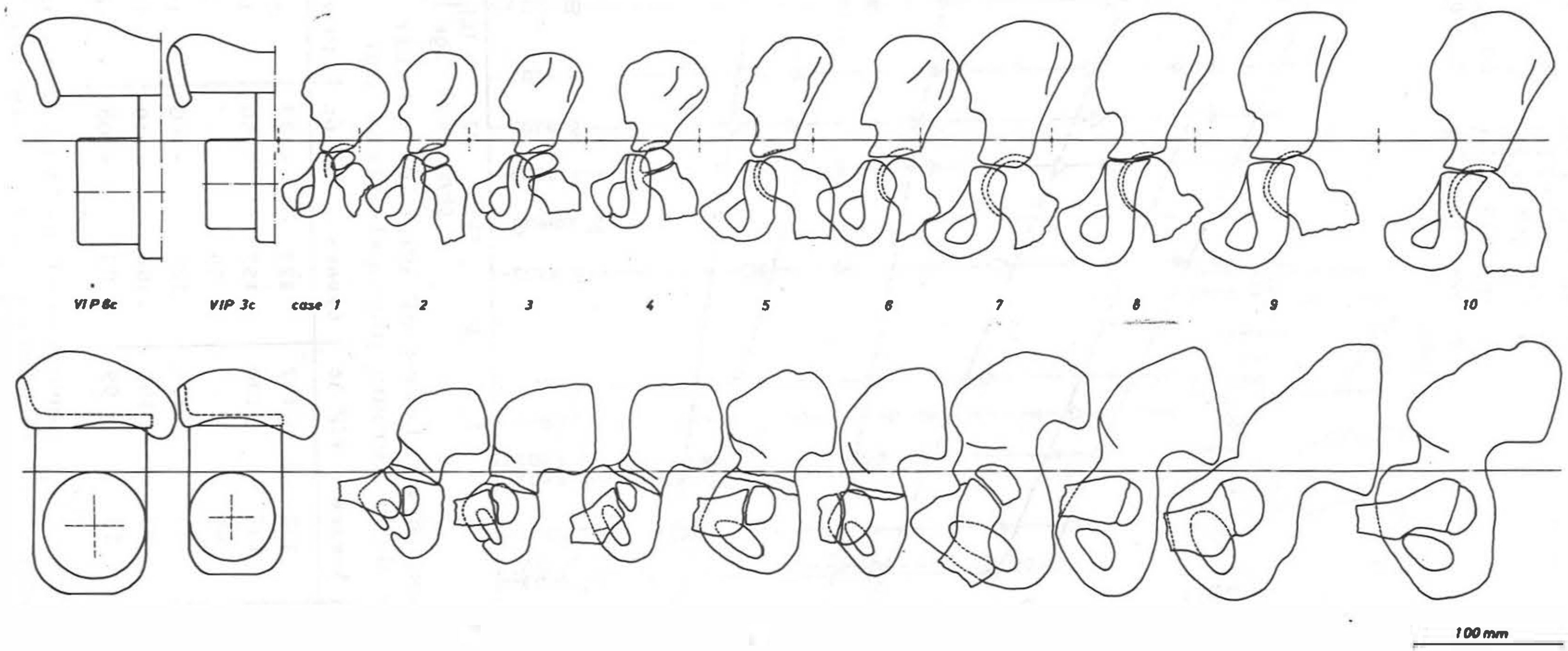

Fig. 2 - Frontal and lateral shape of the pelvis with children

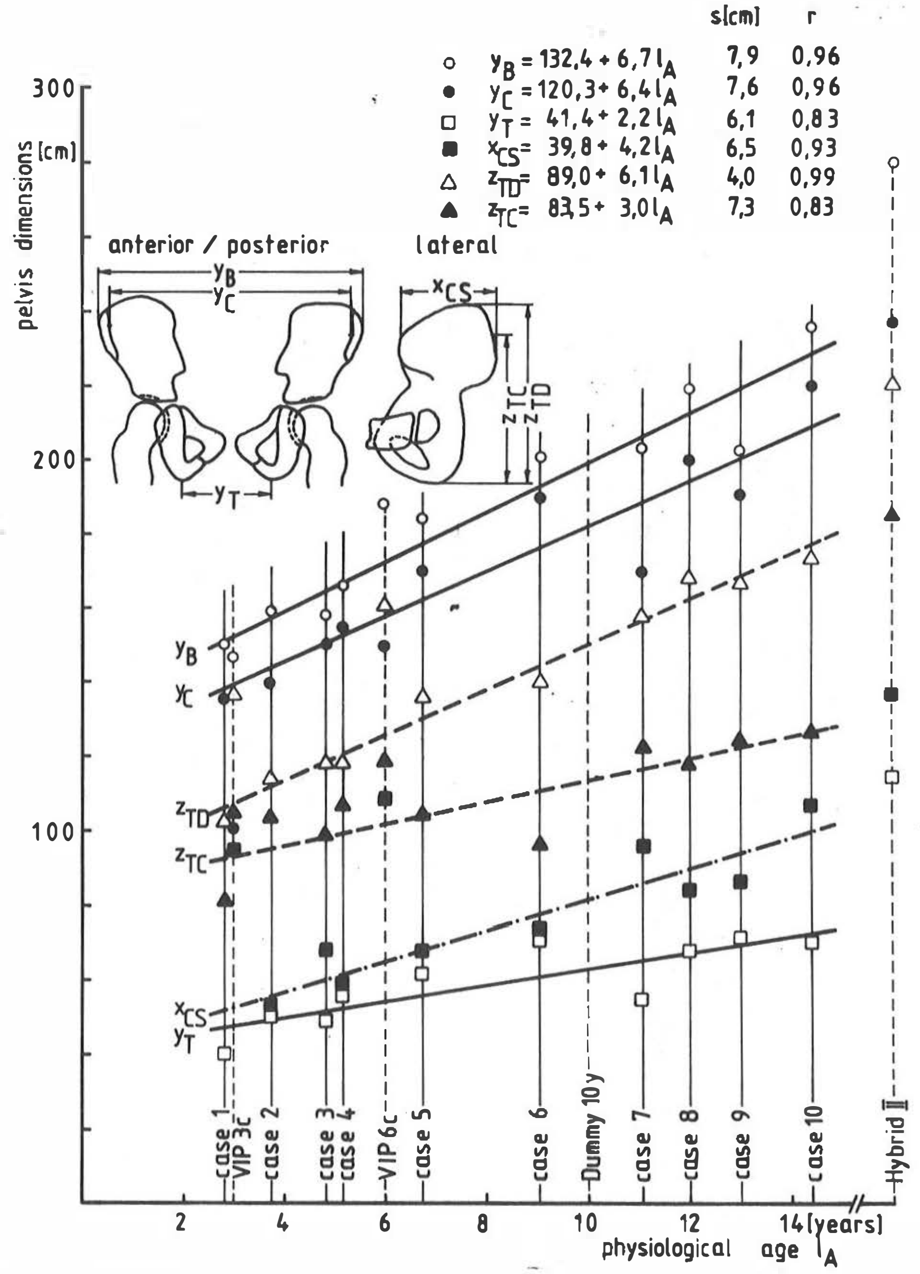

Fig. 3 - Regression analyses of characteristic geometrical pelvis data versus physiological age

Children	3years	VIP 3c	6years	VIP 6c	10 years
y_B	152	~ 147	173	~ 188	199
y_C	139	~ 100	157	~ 150	182
y_T	48	-	55	-	63
x_{CS}	107	~ 137	126	~ 160	150
z_{TD}	93	~ 105	102	~ 119	113
z_{TC}	53	~ 95	65	~ 108	81

Fig. 4 - Characteristic geometrical pelvis data of the 3-, 6- and 10-year-old children as well as the respective data of anthropometric dummies