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DIMENSIONS OF THE SKULL OF PALAEOSLAVONIC CHILDREN AND JUVENILES

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Abstract: The dependence of the measurements and indices of skull upon age was studied in a group of 640 children's skulls from two palaeoslavonic localities in Czechoslovakia. Conditioned arithmetic means and correlation coefficients were applied, and parallel polynomial regression analyses showed that, in the linear model, the square root of age should be preferred to the non-transformed variable. The comparison of the values of correlation coefficients implied that the measurements are by far more age-dependent than the indices and that the measurements of the frontal bone are more strongly correlated with age than the occipital and parietal region.

Key words: Skull dimensions and indices, Palaeoslavonic children and juveniles, Polynomial regression analysis.

The study of children's skeletons is a natural part of the anthropological research of every burial-place, but they are subjected to a more detailed study almost exclusively from the palaeodemographical point of view. There are only rare occasions to meet a large enough set of well preserved children's skeleton to enable a detailed metric analysis. Large palaeoslavonic burial-places give a good basis for such research. Comparatively satisfying results were brought by the study of long bones of children (STLOUKAL, HANÁKOVÁ 1978). Also the results of the study of children's skulls from Mikulčice (STLOUKAL 1962, HANÁKOVÁ, STLOUKAL 1974) can be considered as interesting. Recently we have studied two large anthropological series from the cemetery in Rajhrad (the 9th century) and Ducové (mostly the 11th to 15th century). Using the t-test of equality of means applied to the two series in the particular age-groups we did not found significant differences which may prevent the merging of children skulls of Ducové and Rajhrad. Then we put them together to form one group of 640 items; regarding to the bad state of preservation no measurements could be established in all the items and so the highest number was taken in the measure 29 (389 cases). We divided the set into 18 age-groups, namely with the step of halfyear until 4 years and with the step 1.5 year between the 5th and 19th year of age; boys and girls could not be distinguished.

During the preliminary stage preceding profounder analysis, we undertook a descriptive analysis of pair statistical dependences of measures and indices of the skull upon the age. For a rough description of these dependences, we made use of conditioned arithmetic means for individual age-groups. Numerical results of this analysis are presented in tables: the number (N) of cases, conditioned arithmetic mean ($\overline{x}$), standard deviation(s), minimum and maximum values. The study was limited only to basic measurements and indices of the vault that are numbered according to MARTIN and SALLER (1957). In the tables, *Table*

Statistics of the particular measurements

Age \ No of MARTIN:	1				8			
	N	x̄	s	min—max	N	x̄	s	min—max
0.5	5	133.0	9.5	120—145	3	104.7	7.6	96—110
1	8	148.3	7.6	134—158	8	124.6	9.7	112—139
1.5	5	142.2	8.8	133—151	3	126.0	10.1	117—137
2	8	153.0	9.8	139—166	8	126.3	7.6	119—139
2.5	15	162.8	10.5	148—182	14	130.6	8.3	120—149
3	17	164.5	7.9	153—178	17	130.6	5.9	120—140
3.5	11	162.5	8.1	152—176	8	131.4	6.2	125—144
4	17	162.0	7.9	147—179	15	130.3	7.8	113—145
5	42	166.8	8.2	150—187	34	132.5	6.3	121—144
6.5	39	168.8	7.3	152—182	40	134.2	6.9	121—150
8	35	171.3	7.4	153—185	34	135.1	6.1	117—146
9.5	30	171.7	8.4	151—187	28	135.5	6.3	126—147
11	25	174.0	7.1	163—190	26	135.7	7.6	121—151
12.5	20	176.0	7.5	165—187	20	137.0	4.8	125—144
14	23	173.7	7.3	162—185	22	139.1	7.4	123—155
15.5	26	178.8	8.2	165—195	22	138.0	6.3	128—156
17	23	178.6	5.4	169—191	21	138.7	6.9	126—155
18.5	6	183.5	11.4	173—205	7	142.4	10.8	127—159
	ΣN = 355		r = 0.635		ΣN = 330		r = 0.464	
	k = 1.1146		r' = 0.681		k = 1.0454		r' = 0.499	

Age \ No of MARTIN:	17				23			
	N	x̄	s	min—max	N	x̄	s	min—max
0.5	2	82.5	4.9	79— 86	3	376.7	15.2	363—393
1	4	105.5	7.6	98—116	4	431.3	20.9	405—455
1.5	1	107.0	—	—	4	435.3	5.5	428—440
2	3	108.3	2.3	107—111	6	445.0	8.7	435—455
2.5	7	113.6	3.4	109—119	7	460.1	10.7	444—475
3	8	113.1	5.5	105—123	9	462.9	14.8	445—485
3.5	5	122.4	5.3	115—129	5	470.8	14.6	450—487
4	7	119.4	6.2	113—130	9	466.2	16.6	445—500
5	24	121.3	7.9	108—140	19	473.3	19.5	430—505
6.5	29	122.7	4.6	108—130	29	479.0	15.7	456—509
8	29	124.6	5.8	114—141	24	483.0	15.1	457—513
9.5	24	127.8	6.4	115—140	19	485.1	13.9	464—507
11	22	127.6	8.1	110—143	14	492.4	15.2	470—522
12.5	18	131.2	5.6	121—145	17	497.6	18.3	465—520
14	18	129.9	4.9	121—142	17	496.9	13.1	475—518
15.5	21	133.1	5.8	124—149	17	502.7	19.1	467—536
17	21	134.1	8.7	120—155	16	504.0	12.6	488—535
18.5	6	134.5	7.2	127—146	6	520.5	24.3	485—556
	ΣN = 249		r = 0.678		ΣN = 225		r = 0.718	
	k = 1.1328		r' = 0.723		k = 1.1673		r' = 0.764	

1

in age-groups and correlation coefficients

9				10			
N	$\bar{x}$	s	min – max	N	$\bar{x}$	s	min – max
11	75.0	8.2	58— 87	11	96.7	12.0	75—116
10	82.4	4.5	77— 91	9	105.0	5.7	99—116
10	81.1	4.7	73— 91	10	105,5	6.9	97—115
12	82.8	4.4	75— 89	9	102.9	6.2	95—111
14	85.5	3.9	77— 91	11	110.5	6.9	98—120
21	86.1	3.2	79— 92	20	108.5	6.3	100—123
13	86.5	3.8	80— 91	13	110.4	7.4	100—126
22	87.5	5.3	78— 99	19	107.9	6.1	99—121
50	88.1	4.3	78— 97	39	110.5	5.3	101—121
38	90.0	4.6	82—100	36	111.5	6.1	96—123
37	91.1	4.0	81— 98	37	114.2	6.4	100—128
29	92.2	3.7	87—100	28	115.3	7.7	102—135
22	93.5	4.0	87—101	23	114.7	6.7	98—128
22	94.0	5.3	86—105	22	115.1	5.8	105—127
22	96.1	4.6	88—106	19	118.9	6.1	106—131
21	94.9	5.6	83—107	21	117.2	6.8	105—129
24	96.3	3.2	90—103	20	117.9	6.5	105—131
7	98.0	6.4	89—105	7	120.9	8.0	112—134
ΣN = 385		r = 0.687		ΣN = 354		r = 0.540	
k = 1.1221		r' = 0.727		k = 1.0568		r' = 0.574	

25				26			
N	$\bar{x}$	s	min – max	N	$\bar{x}$	s	min – max
2	262.0	14.1	252—272	5	86.4	14.4	69—107
4	315.3	23.0	284—333	8	106.6	8.6	90—117
4	317.3	6.9	311—327	10	107.7	5.1	100—115
7	324.9	17.0	290—343	9	107.9	5.9	97—115
14	342.3	9.8	326—363	15	115.5	5.3	105—123
13	338.6	12.7	321—359	22	113.9	4.2	108—123
9	349.7	11.1	332—366	15	117.0	5.1	109—125
11	343.5	14.6	328—381	23	115.9	6.5	103—130
30	348.1	12.7	331—371	49	119.0	6.0	108—131
33	354.2	13.9	313—377	40	119.8	6.7	104—138
28	354.1	11.4	332—376	37	120.1	4.9	109—130
22	358.9	15.5	331—387	28	123.1	7.0	110—142
23	359.1	11.6	337—378	26	123.3	5.5	114—135
17	359.8	13.4	338—384	23	121.1	5.1	114—133
16	356.2	11.7	338—375	25	124.1	4.2	118—133
16	363.4	8.3	346—374	21	124.3	4.4	118—133
18	359.7	18.0	306—383	24	124.7	6.0	117—140
6	367.3	19.3	348—403	8	125.8	5.5	122—138
ΣN = 273		r = 0.509		ΣN = 388		r = 0.549	
k = 1.0987		r' = 0.570		k = 1.1262		r' = 0.616	

Table 1

Age \ No of MARTIN:	27				28			
	N	$\bar{x}$	s	min—max	N	$\bar{x}$	s	min—max
0.5	2	98.5	7.8	93—104	9	88.4	6.9	77— 99
1	7	113.1	6.9	102—121	11	96.5	6.1	90—106
1.5	28	113.4	7.7	100—122	12	95.7	7.0	86—112
2	10	117.3	8.5	100—127	13	100.4	5.9	93—110
2.5	16	119.0	6.2	110—129	17	107.6	5.9	99—118
3	21	118.7	6.1	108—133	22	106.5	8.6	89—123
3.5	13	127.2	7.1	116—139	15	106.5	6.5	91—121
4	19	120.6	6.4	110—131	19	105.2	10.1	83—122
5	42	121.7	7.3	104—136	42	108.3	7.9	89—125
6.5	44	123.5	7.1	107—138	37	109.0	7.3	89—121
8	38	123.9	8.0	110—145	33	109.5	7.5	98—135
9.5	30	125.6	8.3	108—141	25	107.6	7.0	94—120
11	27	122.7	7.3	108—136	28	113.1	7.7	100—132
12.5	20	126.2	9.4	107—143	21	112.7	6.7	99—125
14	22	122.4	6.6	107—132	19	110.1	7.6	100—128
15.5	21	126.9	5.6	117—138	20	111.2	6.2	102—127
17	25	124.9	7.0	110—140	19	113.2	6.4	100—128
18.5	9	122.4	11.8	108—145	7	115.6	4.5	108—121
	$\Sigma N = 374$ $k = 1.025$		$r = 0.258$ $r' = 0.299$		$\Sigma N = 369$ $k = 1.063$		$r = 0.451$ $r' = 0.501$	

Age \ No of MARTIN:	31				I 1 (8 : 1)			
	N	$\bar{x}$	s	min—max	N	$\bar{x}$	s	min—max
0.5	8	74.3	5.6	65— 82	3	81.6	7.7	75.0— 90.0
1	11	81.9	3.4	76— 86	7	85.5	7.2	75.5— 95.7
1.5	12	82.2	4.3	75— 91	3	85.4	9.9	77.5— 96.5
2	14	83.9	4.3	76— 90	8	83.0	9.8	73.5—100.0
2.5	17	88.8	3.7	82— 95	14	80.3	9.8	67.8— 98.0
3	21	87.9	5.9	77— 98	15	79.6	4.9	72.1— 87.6
3.5	15	89.2	5.1	78— 99	7	80.4	6.9	72.7— 92.3
4	20	88.6	7.2	75—101	14	81.6	7.3	70.9— 98.6
5	42	90.2	5.4	78—103	33	79.1	5.8	69.4— 94.7
6.5	36	90.5	5.0	79— 99	37	79.3	5.3	69.9— 91.4
8	32	91.8	5.2	84—110	33	79.0	5.3	66.5— 93.5
9.5	24	90.3	4.4	80— 98	28	78.9	6.3	71.9— 97.4
11	27	95.4	5.1	86—106	24	78.7	5.8	69.1— 90.4
12.5	21	94.3	4.9	84—105	19	77.8	4.0	72.2— 85.0
14	19	91.6	5.2	83— 99	21	80.5	5.8	71.0— 92.8
15.5	20	93.8	4.7	85—103	22	77.0	5.0	70.7— 92.9
17	19	94.7	6.3	81—109	21	77.8	4.7	70.4— 91.7
18.5	6	95.3	3.5	89— 99	6	78.2	7.9	69.3— 89.8
	$\Sigma N = 364$ $k = 1.0790$			$r = 0.509$ $r' = 0.560$	$\Sigma N = 315$ $k = 1.0053$		$r = —0.181$ $r' = —0.195$	

(continued)

29				30			
N	x̄	s	min – max	N	x̄	s	min – max
6	73.8	9.2	62— 84	3	78.7	4.5	74— 83
8	89.6	5.8	78— 97	7	98.6	6.9	87—106
10	89.8	4.3	81— 94	8	97.9	6.7	89—106
10	90.0	3.7	85— 96	11	102.0	6.9	91—113
15	97.5	2.8	91—101	16	104.3	5.7	94—112
21	96.8	3.0	93—104	20	105.6	5.9	97—119
15	97.9	4.8	90—105	13	110.2	4.9	103—119
23	98.0	4.3	91—108	19	107.1	5.5	98—119
51	101.1	4.5	92—110	43	107.6	6.1	95—120
39	102.5	5.2	92—115	41	109.6	5.7	98—120
36	103.3	4.2	94—113	38	109.9	6.8	97—128
28	104.6	4.4	97—115	29	111.0	7.2	96—124
26	106.2	4.0	99—117	26	109.3	6.3	97—120
23	105.2	4.0	99—114	20	112.4	7.8	98—125
25	107.4	3.7	98—116	23	109.1	5.5	97—117
21	107.9	3.9	99—116	21	113.0	4.5	104—121
25	108.4	4.0	100—116	25	110.9	6.3	95—123
7	110.3	4.9	105—120	8	110.6	10.4	98—130
ΣN = 389		r = 0.686		ΣN = 371		r = 0.359	
k = 1.212		r' = 0.751		k = 1.050		r' = 0.413	

I 2 (17 : 1)				I 3 (17 : 8)			
N	x̄	s	min – max	N	x̄	s	min – max
2	66.7	7.1	61.7—71.7	2	81.0	1.9	79.6— 82.3
4	71.0	2.8	67.7—73.4	4	87.3	3.0	83.1— 89.7
1	70.9	—	—	1	91.5	—	—
3	69.2	6.9	64.5—77.1	3	86.2	4.0	81.6— 89.2
7	71.0	6.4	62.7—80.4	6	86.4	5.4	77.2— 92.5
8	70.6	2.7	66.9—76.5	7	88.0	4.3	84.0— 96.9
5	74.0	3.1	71.0—77.7	5	92.5	5.6	83.3— 97.7
7	74.7	5.2	70.6—85.0	7	90.3	8.0	83.7—104.8
22	73.3	5.6	63.5—84.0	21	91.9	7.9	77.1—109.4
27	73.0	3.6	66.9—81.8	28	91.6	3.6	83.1—100.0
28	72.7	4.2	65.7—86.9	28	92.3	5.0	82.9—103.4
24	75.1	4.0	68.0—83.0	23	94.5	6.3	83.3—108.7
21	73.3	3.9	66.3—82.0	22	93.7	8.4	81.0—115.3
18	74.1	2.9	69.1—79.7	18	95.9	4.8	86.4—102.2
17	74.5	3.3	69.9—79.6	17	92.9	5.4	83.9—102.2
21	74.6	4.7	67.9—88.7	19	96.2	4.0	85.5—102.2
20	74.4	3.9	68.2—84.7	18	95.6	5.8	85.7—109.2
6	73.4	3.7	68.3—77.7	6	94.4	7.0	85.5—102.8
ΣN = 241		r = 0.201		ΣN = 235		r = 0.348	
k = 1.0116		r' = 0.227		k = 1.0206		r' = 0.373	

Table 1

Age \ No of MARTIN:	I 13 (9 : 8)				I 22 (29 : 26)			
	N	$\bar{x}$	s	min – max	N	$\bar{x}$	s	min – max
0.5	2	70.7	3.1	68.5—72.9	5	83.6	4.1	78.5—89.9
1	6	65.2	2.2	62.5—67.8	8	84.2	3.3	77.8—88.8
1.5	3	65.3	5.5	59.1—69.2	10	83.4	2.2	80.9—87.6
2	7	65.3	3.7	59.7—69.8	9	83.7	2.4	80.0—87.6
2.5	10	65.2	4.6	59.1—71.7	15	84.5	3.3	78.3—90.5
3	12	66.5	4.0	60.4—72.0	21	84.8	2.7	79.5—91.7
3.5	7	67.7	3.8	61.9—72.0	15	83.7	2.5	78.9—86.8
4	12	66.2	5.0	57.6—76.7	23	84.6	3.0	78.5—92.2
5	28	66.5	3.2	60.7—73.0	49	85.1	1.9	80.2—89.6
6.5	35	67.1	3.4	61.6—74.6	38	85.5	2.1	80.8—89.7
8	29	67.4	3.7	60.8—76.0	36	85.9	1.5	82.1—89.6
9.5	26	68.4	2.9	62.5—75.0	27	85.3	2.1	80.5—88.3
11	18	68.4	3.8	60.9—74.1	25	86.2	2.1	81.5—89.9
12.5	19	68.5	3.2	63.4—75.0	23	86.9	1.4	84.2—90.7
14	19	69.4	3.9	63.2—76.9	25	86.6	3.3	75.4—94.9
15.5	18	68.4	1.9	64.8—72.3	21	86.8	1.9	82.5—89.6
17	21	69.3	3.1	62.7—73.8	24	86.9	2.2	81.8—90.6
18.5	6	69.9	5.3	64.3—76.4	7	87.3	0.9	86.1—88.6

$\Sigma N = 278$ $r = 0.307$
$k = 0.9963$ $r' = 0.302$

$\Sigma N = 381$ $r = 0.385$
$k = 1.0019$ $r' = 0.388$

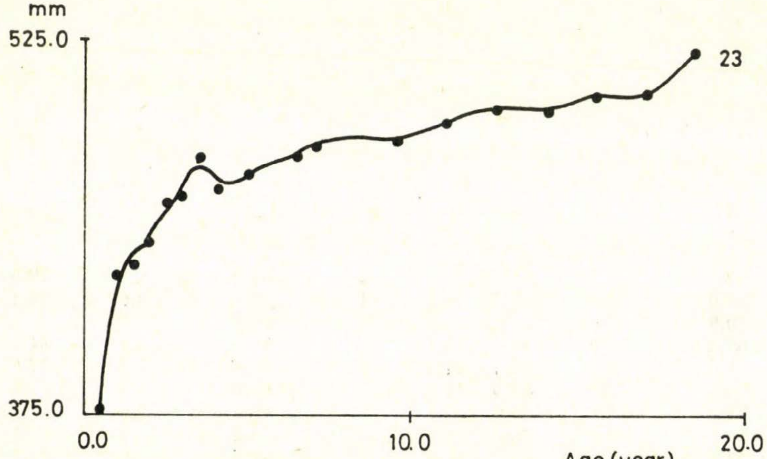

Fig. 1. **Graphic representation of the circumference of the skull (MARTIN No. 23)**

there are the s-values taken from the computer outputs as a part of description of samples; we do not do any further conclusions from it.

A more delicate description of the statistical dependence measures v. age was attempted by using correlation coefficient, denoted *r* in the tables. Owing to parallel polynomial regression analyses, linear model, i.e. whose input variables

(continued)

I 24 (30 : 27)				I 25 (31 : 28)			
N	x̄	s	min—max	N	x̄	s	min—max
2	82.4	3.6	79.8—84.9	8	84.4	1.7	82.4—86.4
7	87.1	2.6	84.7—91.2	11	85.0	3.1	80.2—90.3
8	86.4	2.5	82.6—89.8	12	86.1	4.7	81.3—97.8
10	87.1	2.5	82.5—91.0	13	83.3	2.1	79.6—86.3
16	87.6	2.7	83.6—92.2	17	82.6	2.4	78.8—88.9
20	89.0	1.8	85.5—91.1	21	82.8	3.2	76.6—90.3
13	86.7	2.1	81.3—88.8	15	83.8	1.7	80.0—87.0
19	88.8	2.9	81.7—92.0	19	84.1	3.1	80.0—91.5
42	88.4	2.0	83.3—93.9	42	83.4	2.8	75.0—89.5
41	88.5	1.6	84.1—91.9	35	83.4	2.8	76.7—89.1
37	88.7	1.9	84.0—93.5	32	83.9	2.2	77.0—87.4
29	88.5	2.1	83.3—93.5	24	84.3	2.4	80.0—88.0
26	89.0	2.1	83.7—95.0	27	84.4	3.5	78.0—98.0
20	89.1	1.3	86.9—91.8	21	83.8	2.1	80.2—87.3
22	88.9	1.9	85.7—92.1	19	83.3	3.9	75.8—93.3
21	89.1	1.8	86.0—92.6	20	84.4	2.3	78.8—87.4
25	88.8	1.9	85.2—93.7	19	83.7	2.5	77.1—87.7
8	89.5	1.0	87.8—90.8	6	82.5	2.7	79.2—87.5
$\Sigma N = 366$		r = 0.237		$\Sigma N = 361$		r = —0.006	
k = 1.0140		r' = 0.264		k = 1.0000		r' = —0.016	

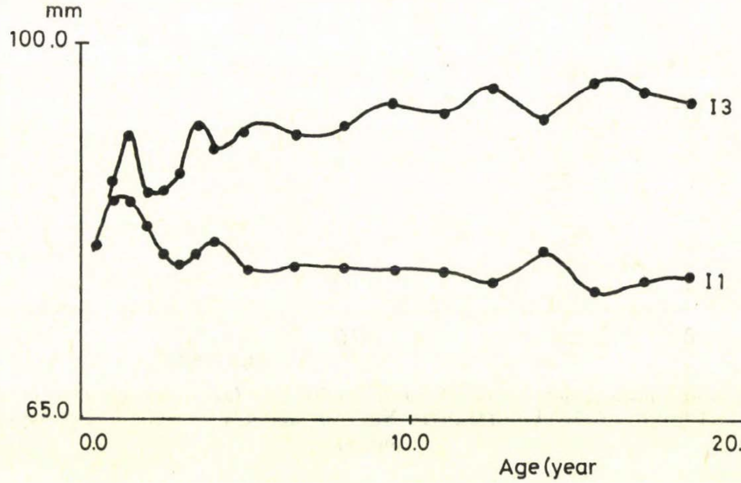

Fig. 2. **Graphic representation of the indices 1 and 3**

are in the same form as measured, was found not to express well enough the statistical dependence, especially concerning the measurements (indices were not the case). An improvement can be reached by transforming the variable "age" into its square root. The correlation coefficients for transformed variable were newly calculated (in the table they are denoted *r*'). In order that we may

judge easily the increase in the descriptive power of the correlation coefficient r', we present also the ratio of the residual sum of squares for the linear regression model with original value of age to that with transformed value of age (this ratio is denoted k in the tables). This ratio, except for a unique case, was always greater than 1, which implied that the statistical dependence of measures on age was better described by the correlation coefficient r'.

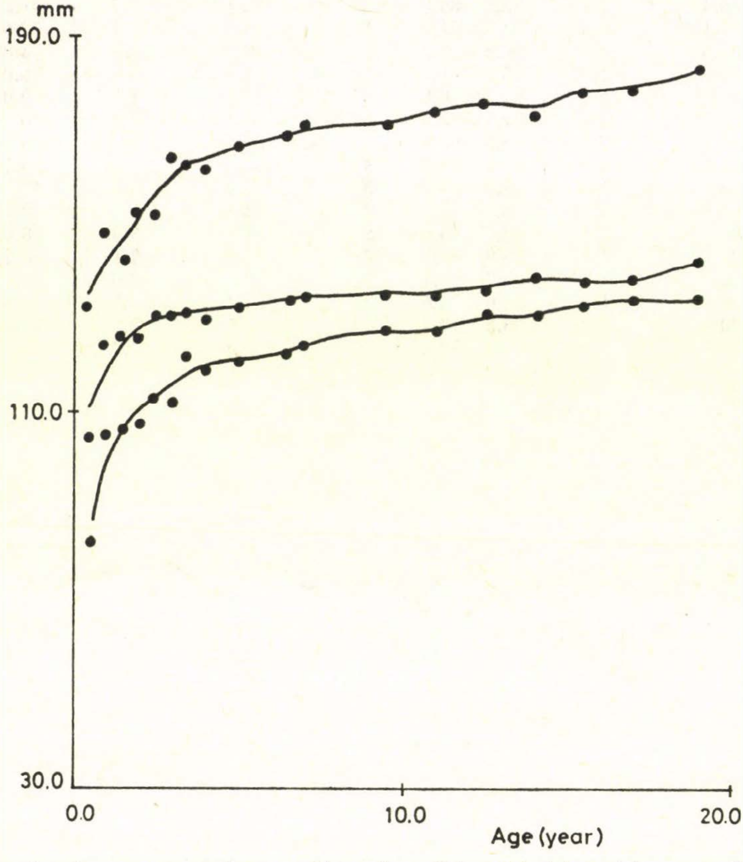

Fig. 3. Graphs of non-parametric smoothing of conditioned (arithmetic) means of the length, breadth and height of the skull (MARTIN Nos 1, 8, and 17) by using cubic polynomials (splines)

The advantage of the transformed value of age was verified also in polynomial regression. The test of significance of regression coefficients practicaly never permitted those terms containing the transformed value to be excluded. These results confirmed that the application of square root of age (transformed value) is preferable whenever the dependence of the measurements upon age is studied. This is not valid for the indices, which is suggested apparently by the values of the ratios k in the table because they differ only slightly from 1.

By comparing the values of correlation coefficients we discovered, above all, that the dependence upon age was much stronger for the measurements than for the indices except for the only measure 27 (parietal sagittal arc) which fell, from this viewpoint, among the indices. It must be noted, however, that individual age-groups were not represented uniformly, especially the four lowest age-groups were very small, which implied that their affect on the magnitude of age dependence is damped by the stronger higher age-groups. The value of correlation coefficient can be biased by the high variability of the variable, or by the above-mentioned small size of some age-groups, or by a great difference in age-dependence in various age-groups. Polynomial regression model for our population only confirmed the well-known fact that the age-dependence of most variables is substantially stronger exactly in lower age-groups.

The numerical results in the tables suggest that the strongest age-correlation holds for the circumference of the skull (Martin-No 23) (Fig. 1), the lowest, and the only two negative ones, holds for cranial index I 1 (8:1) (Fig. 2) and occipital sagittal index I 25 (31:28). A higher age-correlation can be observed for cranium height and length (Fig. 3), and for those measurements that are relative to the forehead (29, 9, 26, 10); middle values can be observed for the anterio-posterior arc 25, the maximum breadth, and both measurements of occipital bone; the lowest correlation is observable for both measurements of parietal bone. Among the indices, the stronger age-correlation holds for frontal bone 22 (29:26), as well, the middle one for parietal index 24 (30:27), the lowest one for Index 25 (31:28). As for the other indices, a high value of correlation coefficient can be observed for the indices 3 (17:8) and 13 (9:8), the correlation of the indices 1 (8:1) and 2 (17:1) cannot be considered proven.

We could refer in this brief paper only some results obtained during the first stage of the study of children's skulls from early medieval localities. Multidimensional analysis of a larger set of measurements of skull and of facial skeleton, and in addition of data from other palaeoslavonic localities may provide the means for gaining additional important information and for attempting at an estimation of the age of a deceased child on the basis of some cranium measurements.

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Ószláv gyermekek és ifjak koponyájának dimenziói

(Összefoglalás)

A koponya méreteinek és indexeinek az életkortól való függését tanulmányozták két csehszlovákiai ószláv lelőhelyről származó 640 gyermek koponyáján. Feltételes számtani középértékeket és korrelációs koefficienseket alkalmaztak, és a párhuzamos polinom regressziós analízis azt mutatta, hogy — a lineáris modell esetében — a nem-transzformált változóhoz az életkor négyzetgyökét kell előnyben részesíteni. A korrelációs koefficiensek értékeinek összehasonlítása azt sejteti, hogy a méretek sokkal inkább életkor-függőek, mint az indexek, és hogy a homlokcsont méretei sokkal szorosabban korrelálnak az életkorral, mint az occipitalis és a parietalis régióié.

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