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KATEŘINA MACKOVÁ, JANA VELEMÍNSKÁ

CRANIOMETRICAL NORMS FOR RECENT CZECH POPULATION INTENDED FOR EVALUATION OF THE CRANIAL SIZE AND SHAPE USING LATERAL X-RAY FILMS

ABSTRACT: The submitted study is based on craniometrical analysis of control lateral X-ray images of the heads of individuals who belong to healthy Czech population and have neither jaw and teeth shape disharmony nor previous orthodontic therapy. We investigated 52 adult men, 36 women, 27-five-year-old boys and 30 girls. For the measurements of 123 metric traits for each individual the special software Craniometrics was used. The main aim of the study was to set up recent Czech craniometrical norms useful as comparative data in historical, osteological and paleoanthropological research. Standards were developed, characterizing cranial size and shape and positional parameters regarding to the intactness of leading structures on the historical material. For this reason, characteristics including the Articulare point, the Orbitale point and the Frankfurt horizontal, were newly involved. Developmental and growth changes in the postnatal period were evaluated, as well as sexual dimorphism. Almost all linear characteristics involved in the study show significant intersexual differences in adulthood, with higher values in the male group. On the contrary, angular values do not show any strong sexual dimorphism. In children, more intersexual differences were proved in angular characteristics than in linear dimensions.

KEY WORDS: Recent osteological craniometrical norms – Lateral X-ray film – Sexual dimorphism – Growth and development

INTRODUCTION

Teleroentgenometry is a commonly used method in medicine and clinical anthropology. Many studies are based on the investigation of patients undergoing any type of orthodontic treatment. The results of other studies are applicable in medical practice, where these can be used for investigation of abnormal development in congenital defects and growth disorders or post-traumatic states. But there are some problems with use in osteology, because some cranial structures are not very well preserved in historical material.

Because taking distant X-ray images of the skull in healthy population is currently not allowed for ethical reasons, studies made on these images are not frequent. The collection of images used in this study is even more exclusive thanks to its extent, which is important in statistical processing.

The submitted study is a follow-up to an earlier one (Šmahel *et al.* 1998). The same material was investigated, but moreover some new characteristics were evaluated to fulfil special osteology requirements.

The presented work is aimed to be used as a comparative set of various cranial characteristics, intended to be applied

in further osteological studies comparing the situation in contemporary population with historical material and also for various anthropological reconstructions and modelling. Although these norms have not been published yet, they were already used as comparative material in facial skeleton analysis of the Upper Paleolithic skulls (Velemínská *et al.* 2005).

This paper includes the basic results of the detailed analysis which is completely presented in Macková (2004). One part of our study is focused on the search for intersexual differences and ontogenetic changes of craniometrical characteristics. The results obtained in male and female groups were compared, girls with boys and also boys with men, and girls with women. We registered changes in shape and size of the skull, which are related to dental situation and age of subjects.

MATERIAL AND METHODS

Lateral distant X-ray images of the heads of individuals belonging to healthy Czech population were used for research. Films were made between 1960 and 1970 for the Stomatological Clinic Královské Vinohrady in Prague.

These images were used like controls in studies of the growth and development of patients with congenital craniofacial defects, for assessment of the subsequent development and effects of the medical treatment.

The complete collection of films includes altogether 145 images of the heads of 52 healthy men, 36 women and 57 children (this group consists of 30 girls and 27 boys) in the age from 4 to 6 years. All the children still had deciduous incisors when the images were taken. All individuals included in the collection were randomly selected from the healthy Czech population. The additional precondition was that all the probands had to be without obvious facial disharmony, reverse occlusion or they never suffered orthodontic therapy.

The children's X-ray films were obtained during orthodontic investigation at several Prague nursery schools. The parent's agreement was the prerequisite. Adult probands were volunteers, hospitalized in the clinic due to non-serious injuries. Different subjects were involved during childhood and adult age.

The lateral X-ray films were taken under standard conditions: centric occlusion and the proband's head fixed in stable position with cephalostat. The focus-film distance was always 400 cm, the object-film distance was 30 cm. Also the enlargement was always constant – it made 8.1 %. One of important advantages of this type of X-ray images is the very small distortion and sharp contours of displayed structures.

Images were first transferred to the computer memory. The digitised films were further processed using Adobe Photoshop 6.0. Contrast and clarity were modified and then 37 co-ordinates of craniometrical points were

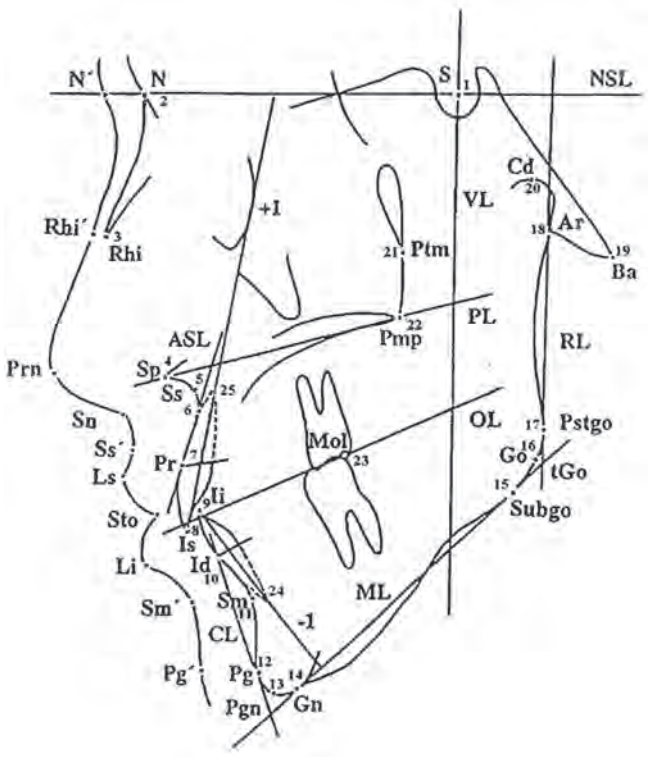

FIGURE 1. Craniometrical points and reference lines marked on the skull and soft profile. These points were recorded and further used for analysis.

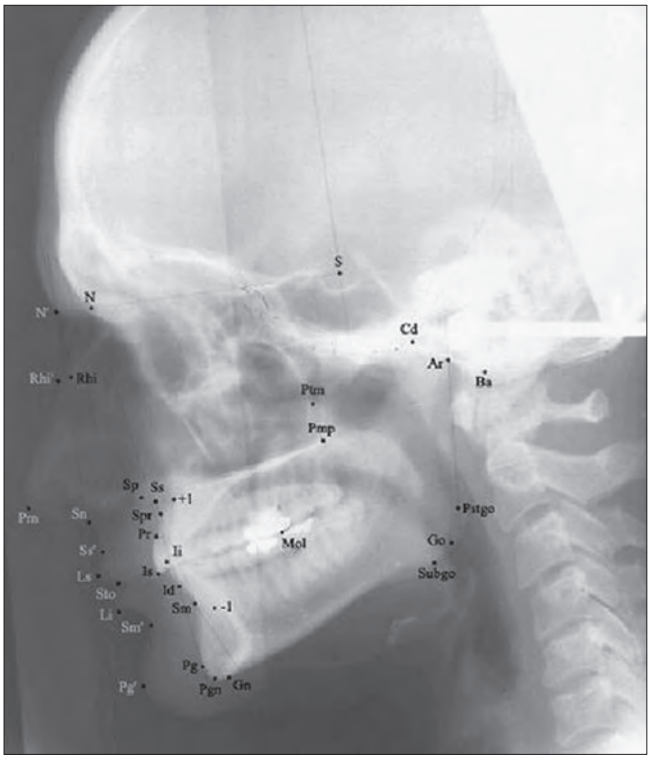

FIGURE 2. Teleroentgenogram of the head made in lateral projection. On the picture, craniometrical points are marked on the skull and soft profile of the face (Velemínská *et al.* 2003).

recorded. The process of point recording was identical for each subject; we proceeded always in the same sequence using the Sigma-Scan Pro 5 software. All craniometrical points and reference lines were localised by the same anthropologist before digitisation, in case of double contours the midpoint between two sides was used. Individual craniometrical points were marked according to conventional abbreviations (for detailed explanation see Šmahel *et al.* 1998).

Figure 1 illustrates craniometrical points and reference lines which were used in this study, *Figure 2* shows craniometrical points marked on the teleroentgenogram of the head.

After the initial process of obtaining craniometrical points by the above described procedure, metric traits of the skulls were measured with the aid of the Craniometrics software. The data output of the software processing was furthermore statistically processed.

The Craniometrics software was developed for detailed craniofacial metric analysis of lateral X-ray films of patients with clefts who are undergoing medical treatment at the Stomatological Clinic Královské Vinohrady, but it has a wide spectrum of applications.

The measured files involve linear (distance between two points, distance between a point and a straight line) and angular (angles determined by three points or by two straight lines) dimensions that can be defined beforehand. The program includes also some special dental and jaw dimensions, applicable in orthodoncy (for more information about used program see Velemínská *et al.* 2003).

For this work we measured altogether 123 metric traits of the skull for each individual (altogether 145 individuals) – 44 linear, 60 angular and 19 dental and special dimensions were included. All processed characteristics are presented in *Tables 1, 2, 3* and *4*.

We divided all 145 data sets into four groups which included 52 men, 36 women, 27 boys and 30 girls. This distribution was essential for further implementation of statistical comparisons. For each group of probands we calculated basic statistic characteristics (mean, median, standard deviation, variance, etc. – see *Tables 1, 2, 3* and *4*) to complement the value of each parameter. For this calculation, we used the program Statistica 5.0. Linear dimensions were corrected with regard to 8.1% enlargement. Thanks to these corrections, all the data presented in this study as norms equate to real values of skull parameters.

The differences between compared groups of images were ascertained with the aid of T-test for independent samples (Two sample t-test). We pursued sexual dimorphism in children skulls and adult skulls and differences between the skull dimensions in childhood and adult age separately for males and females. This part is important for the comparison of our results with those of earlier researches (Šmahel *et al.* 1998), and also for the comparison with authors who worked not only with X-ray films, but also with other types of images and real skulls.

RESULTS

Our goal was to obtain information about character and variability of the skull morphology and offer an information source for subsequent studies.

To accomplish this goal, we measured parameters ordinarily used in medicine together with newly involved characteristics; consequently this study collates 123 metric traits obtained from each of above described head images. Choosing the proper characteristics for historical material, we especially considered the quality of preservation in leading structures. Dimensions processed in our study include craniometrical points unusual in this type of analysis (the Articulare point and the Frankfurt horizontal) together with commonly used dimensions related to the Sella point. The inclusions criteria were oriented to identify normative values which can successfully assist in osteology studies. After finishing the measurements, we adjusted all the obtained values in accordance to 8.1% magnification to obtain the real values of measured parameters.

Selected important characteristics and their real values are presented together with basic statistical indicators in *Tables 1, 2, 3* and *4*. Data were separated in accordance to sex and age to obtain more specific and practically useful cephalometrical standards.

Sexual differences in adults

Not surprisingly, sexual dimorphism was found to be significant especially in linear dimensions. Almost all linear characteristics involved in the study show significant intersexual differences, with higher values in the male group. On the contrary, angular values do not show any strong sexual dimorphism. Intersexual differences in the cranium shape and configuration of its structures are much smaller than size differences. It holds in childhood as well as in adult age.

The palate position related to skull base (Pmp-VL, Pmp-FH, Ptm-VL, Cd-FH, PL/NSL), and also the vertical position of the mandible articulation (Ar-Ba, Cd-FH), is the same in both sexes.

Only slight intersexual differences occur in the length of the alveolar process of the maxilla (Sp-Is) and in the depth of bony nasopharynx (Pmp-Ba).

Male and female skulls show the same size of the angle formed with NSL and FH lines (NSL/FH).

Among the investigated angle characteristics, sexual dimorphism is noticeable in dimensions characterizing the slope of upper alveolar process. Women have larger protrusion of the maxillary alveolar process (ASL/NSL, N-Ar/ASL, ASL/FH, ASL/PL) and larger overjet (Is-Ii). Also the Articulare angle (S-Ar-tGo) reaches significantly higher values in women, which indicates the steeper position of the mandible ramus in females.

Sexual differences in children

In childhood, intersexual differences are as a rule smaller than in adulthood. This rule is found in newly involved as

TABLE 1. Real values of the skull parameters and their basic statistical indicators for adult men (group of 52 adult men).

	Newly involved characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-Go	117.681	116.349	119.014	117.340	104.357	127.271	22.903	4.786	0.664
N-Ar	95.023	93.934	96.111	95.458	86.337	101.795	15.291	3.910	0.542
Ar-Ba	10.514	9.704	11.325	10.675	4.608	18.992	8.480	2.912	0.404
Cd-Ba	21.772	20.977	22.566	21.679	16.753	30.435	8.140	2.853	0.396
Ar-Go	51.616	50.327	52.905	52.054	41.258	60.887	21.446	4.631	0.642
Ar-Pgn	111.041	109.696	112.385	111.184	99.685	120.916	23.319	4.829	0.670
Rhi-Ar	100.770	99.606	101.935	101.813	90.074	107.623	17.497	4.183	0.580
Sp-Ar	89.567	88.441	90.693	90.231	78.381	97.641	16.367	4.046	0.561
Ss-Ar	85.582	84.432	86.731	85.907	76.161	95.199	17.057	4.130	0.573
Pr-Ar	91.517	90.266	92.769	91.707	82.701	99.510	20.216	4.496	0.624
Id-Ar	95.669	94.407	96.932	95.245	85.513	106.216	20.557	4.534	0.629
Sm-Ar	96.741	95.512	97.971	96.512	85.791	106.078	19.514	4.418	0.613
Pmp-FH	24.741	23.911	25.571	24.986	15.587	34.662	8.895	2.982	0.414
Cd-FH	2.832	2.311	3.353	2.623	0.102	7.317	3.506	1.872	0.260
N-Ar/OL	30.163	29.043	31.282	29.395	21.770	40.080	16.183	4.023	0.558
Or-Po/OL	4.892	3.962	5.822	4.825	0.030	12.510	11.159	3.341	0.463
RL/PL	99.746	98.494	100.998	99.745	88.870	108.180	20.223	4.497	0.624
ASL/NSL	100.653	98.622	102.683	99.970	82.830	119.770	53.204	7.294	1.012
N-Ar-Go	102.769	101.538	104.000	102.575	92.466	113.360	19.544	4.421	0.613
N-Ar-Pgn	70.112	68.860	71.365	69.580	60.640	81.142	20.243	4.499	0.624
N-Ar/ASL	97.070	95.083	99.057	98.355	82.100	112.490	50.931	7.137	0.990
S-N-Ar	17.702	17.072	18.332	17.570	11.960	24.870	5.117	2.262	0.314
Ar-N-Rhi	98.148	96.489	99.807	97.750	83.830	108.850	35.500	5.958	0.826
Ar-N-Sp	67.790	66.716	68.863	67.195	57.720	77.350	14.874	3.857	0.535
Ar-N-Ss	62.933	61.968	63.898	62.970	56.240	71.460	12.013	3.466	0.481
Ar-N-Pr	65.386	64.379	66.392	65.650	57.710	72.530	13.061	3.614	0.501
Ar-N-Id	62.599	61.641	63.557	62.720	55.580	70.530	11.834	3.440	0.477
Ar-N-Sm	60.644	59.701	61.586	60.930	51.720	69.620	11.468	3.386	0.470
Ar-N-Pg	62.314	61.343	63.285	62.195	52.560	72.180	12.164	3.488	0.484
Ar-N-Gn	59.138	58.174	60.102	59.000	50.170	68.950	11.987	3.462	0.480
PL/FH	2.514	1.985	3.044	2.145	0.260	7.640	3.622	1.903	0.264
ML/FH	21.655	19.748	23.562	20.630	4.710	39.520	46.901	6.848	0.950
RL/FH	79.894	78.680	81.108	79.735	69.160	91.130	19.014	4.360	0.605
ASL/FH	108.788	106.768	110.807	108.280	93.150	127.530	52.632	7.255	1.006
CL/FH	87.412	85.370	89.455	87.235	71.410	102.830	53.836	7.337	1.017
NSL/FH	8.126	7.289	8.964	8.720	0.320	14.090	9.049	3.008	0.417
N-Pg/FH	88.193	87.149	89.236	88.415	80.340	96.880	14.046	3.748	0.520
N-Rhi/FH	124.026	122.328	125.723	124.040	108.720	135.840	37.170	6.097	0.845
N-Sp/FH	93.668	92.528	94.808	93.835	82.300	102.450	16.771	4.095	0.568
N-Ss/FH	88.810	87.818	89.803	88.935	80.820	96.720	12.699	3.564	0.494
N-Pr/FH	91.264	90.254	92.273	91.440	82.270	98.990	13.150	3.626	0.503
N-Id/FH	88.476	87.464	89.488	88.895	80.920	97.790	13.213	3.635	0.504
N-Sm/FH	86.522	85.527	87.517	86.905	79.250	95.990	12.782	3.575	0.496
Ss-Sm/FH	83.371	81.848	84.894	83.040	71.220	98.010	29.922	5.470	0.759
+1/N-Ar	83.549	81.624	85.475	83.135	67.490	99.320	47.843	6.917	0.959
–1/N-Ar	37.805	35.975	39.635	36.915	24.200	59.510	43.194	6.572	0.911
+1/FH	109.396	107.382	111.410	108.390	91.840	124.640	52.345	7.235	1.003
–1/FH	63.652	61.747	65.556	62.180	52.210	84.040	46.816	6.842	0.949
Ss+Sm(mod)	–1.261	–2.098	–0.424	–1.230	–8.418	6.466	9.041	3.007	0.417
Pr+Id(mod)	1.068	0.485	1.650	0.837	–3.210	6.087	4.373	2.091	0.290

TABLE 1. Continued.

	Basic characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-S	69.481	68.659	70.302	69.103	62.632	75.541	8.704	2.950	0.409
S-Ba	45.484	44.610	46.357	45.056	38.862	50.888	9.843	3.137	0.435
N-Rhi	23.078	22.066	24.090	23.053	12.812	29.537	13.208	3.634	0.504
N-Sp	52.936	51.990	53.881	53.478	45.227	58.760	11.527	3.395	0.471
N-Pr	69.855	68.733	70.977	70.476	58.733	76.226	16.244	4.030	0.559
N-Gn	120.281	118.397	122.166	121.064	103.552	137.206	45.823	6.769	0.939
Sp-Is	28.808	27.924	29.693	28.631	21.637	36.198	10.100	3.178	0.441
Pr-Id	19.485	18.914	20.055	19.704	15.116	23.228	4.197	2.049	0.284
Ii-Gn	42.485	41.570	43.399	42.687	34.598	52.017	10.789	3.285	0.455
Id-Gn	32.193	31.383	33.004	32.160	26.290	39.214	8.475	2.911	0.404
Sp-Pg	62.351	60.675	64.026	62.493	49.473	76.735	36.222	6.018	0.835
Sp-Pmp	53.377	52.488	54.265	53.927	46.004	59.556	10.190	3.192	0.443
Ss-Pmp	48.935	48.112	49.759	49.278	41.582	55.180	8.745	2.957	0.410
Pmp-Ba	44.102	43.288	44.916	43.779	38.268	50.712	8.549	2.924	0.405
S-Pgn	125.826	124.163	127.489	126.226	113.127	140.379	35.683	5.974	0.828
Cd-Go	61.619	60.461	62.776	62.244	52.576	70.842	17.289	4.158	0.577
Pgn-Go	73.311	72.243	74.380	73.765	61.684	83.312	14.741	3.839	0.532
S-Ar	35.819	34.891	36.746	35.888	29.112	43.867	11.104	3.332	0.462
Pmp-VL	12.479	11.690	13.269	12.063	7.317	21.295	8.039	2.835	0.393
Ptm-VL	12.798	12.125	13.471	12.636	7.265	20.268	5.845	2.418	0.335
Pr-PL	16.981	16.173	17.790	16.790	11.314	23.562	8.432	2.904	0.403
Mol-PL	24.583	23.960	25.206	24.514	19.787	29.870	5.006	2.237	0.310
Mol-ML	30.259	29.520	30.999	30.782	23.543	36.485	7.053	2.656	0.368
N-S-Ba	131.627	130.092	133.163	132.120	118.220	142.170	30.430	5.516	0.765
N-S-Cd	128.847	126.507	131.186	129.095	114.360	145.110	70.598	8.402	1.165
N-S-Ar	126.128	124.702	127.554	126.320	113.140	137.230	26.243	5.123	0.710
N-S-Go	101.709	100.540	102.878	102.295	91.240	109.950	17.628	4.199	0.582
S-N-Rhi	115.850	113.938	117.762	116.070	97.740	128.820	47.160	6.867	0.952
S-N-Sp	85.491	84.296	86.686	85.455	72.770	96.070	18.425	4.292	0.595
S-N-Ss	80.634	79.524	81.745	80.360	71.290	90.180	15.915	3.989	0.553
S-N-Pr	83.087	81.924	84.251	83.470	74.300	91.250	17.461	4.179	0.579
S-N-Id	80.301	79.162	81.440	80.305	71.680	89.950	16.741	4.092	0.567
S-N-Sm	78.346	77.254	79.438	78.675	68.670	88.340	15.390	3.923	0.544
Ss-N-Sm	2.353	1.745	2.960	2.225	-2.330	6.510	4.760	2.182	0.303
S-Ar-tGo	141.879	140.305	143.453	141.390	130.210	154.940	31.950	5.652	0.784
OL/NSL	12.460	11.244	13.676	12.325	3.050	21.550	19.070	4.367	0.606
Ar-tGo-N	49.160	48.171	50.149	49.580	39.440	55.780	12.622	3.553	0.493
N-tGo-Gn	72.603	70.974	74.232	72.125	60.210	90.220	34.228	5.850	0.811
PL/NSL	7.990	6.978	9.001	8.125	0.680	15.700	13.202	3.634	0.504
ML/RL	121.772	119.804	123.740	121.015	106.110	139.730	49.971	7.069	0.980
CL/ML	70.943	69.277	72.609	70.495	59.260	86.710	35.812	5.984	0.830
PL/ML	22.015	20.098	23.932	20.930	10.610	38.520	47.396	6.884	0.955
ASL/PL	108.355	106.351	110.358	106.890	91.140	127.640	51.791	7.197	0.998
S-Go%N-Gn	0.683	0.669	0.697	0.681	0.567	0.799	0.002	0.050	0.007
S-tGo%N-Gn	0.704	0.689	0.719	0.700	0.576	0.834	0.003	0.054	0.007
+1/PL	108.964	106.998	110.929	108.415	97.280	124.590	49.851	7.060	0.979
–1/ML	94.705	92.619	96.791	95.605	79.630	108.650	56.120	7.491	1.039
+1/–1	134.213	131.695	136.730	134.005	110.420	149.730	81.764	9.042	1.254
Is-Ii	2.693	2.409	2.976	2.897	0.157	4.727	1.037	1.018	0.141
Is+Ii	2.487	1.997	2.976	2.498	–1.082	7.041	3.088	1.757	0.244

TABLE 2. Real values of the skull parameters and their basic statistical indicators for adult women (group of 36 adult women).

	Newly involved characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-Go	109.590	107.377	111.804	108.845	95.231	125.751	46.269	6.542	1.090
N-Ar	89.646	88.153	91.139	90.001	78.598	99.169	21.041	4.412	0.735
Ar-Ba	9.537	8.791	10.284	8.957	5.115	14.320	5.259	2.206	0.368
Cd-Ba	19.113	18.315	19.912	19.196	14.315	23.201	6.020	2.360	0.393
Ar-Go	45.331	43.754	46.909	45.135	36.551	55.878	23.496	4.662	0.777
Ar-Pgn	101.909	100.260	103.558	102.297	91.727	110.120	25.678	4.874	0.812
Rhi-Ar	95.205	93.611	96.799	95.169	86.742	106.158	23.979	4.710	0.785
Sp-Ar	85.524	84.056	86.992	85.867	75.768	94.275	20.352	4.339	0.723
Ss-Ar	80.554	79.282	81.826	80.419	71.698	88.638	15.276	3.759	0.627
Pr-Ar	86.442	84.946	87.938	86.006	78.485	95.786	21.132	4.421	0.737
Id-Ar	89.224	87.798	90.649	89.338	81.869	96.225	19.190	4.213	0.702
Sm-Ar	89.988	88.537	91.438	89.971	82.463	97.912	19.860	4.286	0.714
Pmp-FH	23.555	22.377	24.732	23.929	17.025	35.919	13.095	3.481	0.580
Cd-FH	2.794	1.880	3.709	1.838	0.004	13.766	7.898	2.703	0.450
N-Ar/OL	30.899	29.402	32.396	31.095	21.580	39.790	19.582	4.425	0.738
Or-Po/OL	5.719	4.306	7.132	5.330	0.220	16.080	17.438	4.176	0.696
RL/PL	97.914	96.369	99.460	97.685	88.700	105.480	20.867	4.568	0.761
ASL/NSL	105.601	103.319	107.882	105.625	91.030	117.680	45.479	6.744	1.124
N-Ar-Go	103.646	102.291	105.002	103.333	96.456	110.307	16.044	4.006	0.668
N-Ar-Pgn	68.599	66.914	70.283	68.208	58.922	79.964	24.784	4.978	0.830
N-Ar/ASL	92.205	89.789	94.621	92.250	79.490	105.610	50.999	7.141	1.190
S-N-Ar	17.952	17.274	18.631	17.777	13.056	21.699	4.023	2.006	0.334
Ar-N-Rhi	97.246	95.496	98.997	96.904	88.990	113.189	26.774	5.174	0.862
Ar-N-Sp	69.242	67.947	70.538	68.855	61.810	77.921	14.661	3.829	0.638
Ar-N-Ss	62.731	61.734	63.728	62.429	56.651	69.335	8.686	2.947	0.491
Ar-N-Pr	65.819	64.720	66.919	65.576	61.021	73.625	10.563	3.250	0.542
Ar-N-Id	62.393	61.386	63.400	61.830	56.759	69.695	8.857	2.976	0.496
Ar-N-Sm	60.625	59.579	61.670	60.633	54.685	68.133	9.550	3.090	0.515
Ar-N-Pg	62.211	61.028	63.394	62.200	55.973	70.035	12.216	3.495	0.583
Ar-N-Gn	58.807	57.663	59.950	58.394	52.147	65.898	11.421	3.379	0.563
PL/FH	2.054	1.429	2.680	1.325	0.030	6.710	3.413	1.848	0.308
ML/FH	21.484	19.109	23.859	20.975	11.150	35.510	49.270	7.019	1.170
RL/FH	81.351	79.929	82.772	81.605	70.520	87.820	17.647	4.201	0.700
ASL/FH	113.001	110.661	115.342	113.740	99.970	123.920	47.860	6.918	1.153
CL/FH	87.194	83.714	90.674	87.255	64.690	110.120	105.771	10.285	1.714
NSL/FH	7.483	6.577	8.388	7.435	2.810	13.120	7.160	2.676	0.446
N-Pg/FH	87.536	86.187	88.885	88.555	79.390	96.570	15.903	3.988	0.665
N-Rhi/FH	122.571	120.921	124.220	123.085	115.040	138.620	23.770	4.875	0.813
N-Sp/FH	94.568	93.372	95.764	94.920	87.380	101.840	12.500	3.535	0.589
N-Ss/FH	88.056	87.066	89.047	87.870	82.220	92.570	8.567	2.927	0.488
N-Pr/FH	91.144	90.109	92.180	91.410	84.620	97.140	9.362	3.060	0.510
N-Id/FH	87.718	86.589	88.847	88.050	80.040	94.950	11.143	3.338	0.556
N-Sm/FH	85.950	84.745	87.155	86.910	77.970	94.420	12.681	3.561	0.593
Ss-Sm/FH	82.921	80.851	84.992	83.300	71.120	98.990	37.449	6.120	1.020
+1/N-Ar	83.929	81.823	86.035	85.325	68.310	96.430	38.731	6.223	1.037
–1/N-Ar	38.653	35.375	41.930	36.105	23.400	60.200	93.829	9.687	1.614
+1/FH	109.275	107.139	111.410	110.715	91.820	120.680	39.828	6.311	1.052
–1/FH	63.998	60.451	67.545	61.555	46.810	88.860	109.898	10.483	1.747
Ss+Sm(mod)	–0.786	–1.856	0.284	–0.450	–8.722	5.751	10.814	3.163	0.527
Pr+Id(mod)	1.962	1.103	2.821	1.910	–3.713	6.054	6.968	2.539	0.423

TABLE 2. Continued.

	Basic characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-S	66.868	65.753	67.984	66.783	61.612	74.930	11.753	3.297	0.550
S-Ba	41.486	40.553	42.419	41.635	36.478	46.842	8.220	2.758	0.460
N-Rhi	23.025	21.627	24.423	22.667	14.778	33.632	18.459	4.132	0.689
N-Sp	49.155	48.045	50.266	49.759	43.203	58.133	11.642	3.282	0.547
N-Pr	64.794	63.190	66.398	65.166	55.283	74.271	24.294	4.741	0.790
N-Gn	109.785	107.168	112.402	109.064	96.152	124.764	64.684	7.735	1.289
Sp-Is	27.067	25.936	28.198	26.846	20.310	34.033	12.079	3.343	0.557
Pr-Id	18.047	17.387	18.707	17.921	14.894	23.690	4.112	1.950	0.325
Ii-Gn	38.167	37.076	39.257	38.354	31.252	45.648	11.235	3.224	0.537
Id-Gn	28.476	27.495	29.458	28.344	23.133	34.796	9.096	2.901	0.483
Sp-Pg	55.233	53.021	57.446	54.963	41.383	66.474	46.212	6.538	1.090
Sp-Pmp	51.025	50.043	52.006	50.996	45.895	57.050	9.096	2.901	0.483
Ss-Pmp	45.473	44.710	46.236	45.112	42.158	52.000	5.500	2.256	0.376
Pmp-Ba	42.629	41.503	43.755	43.128	35.994	51.148	11.971	3.328	0.555
S-Pgn	115.979	114.053	117.905	115.301	105.894	129.309	35.023	5.692	0.949
Cd-Go	55.240	53.597	56.883	55.139	46.252	67.794	25.483	4.855	0.809
Pgn-Go	70.034	68.792	71.276	70.599	60.703	77.570	14.560	3.670	0.612
S-Ar	33.289	32.300	34.277	32.945	27.604	40.505	9.228	2.922	0.487
Pmp-VL	13.727	12.690	14.764	14.173	7.885	19.443	10.159	3.066	0.511
Ptm-VL	13.558	12.668	14.447	14.020	9.145	18.489	7.468	2.628	0.438
Pr-PL	15.723	14.721	16.725	14.938	10.304	21.970	9.485	2.962	0.494
Mol-PL	21.641	20.944	22.339	21.512	17.458	26.354	4.594	2.062	0.344
Mol-ML	27.029	26.128	27.931	27.007	21.261	32.559	7.674	2.664	0.444
N-S-Ba	130.937	129.034	132.840	130.773	120.331	144.299	31.629	5.624	0.937
N-S-Cd	128.483	126.224	130.741	128.511	115.368	144.557	44.574	6.676	1.113
N-S-Ar	123.659	121.772	125.546	123.980	111.420	136.091	31.098	5.577	0.929
N-S-Go	101.655	100.321	102.989	102.230	93.557	110.777	15.549	3.943	0.657
S-N-Rhi	115.199	113.129	117.268	114.683	105.741	133.784	37.407	6.116	1.019
S-N-Sp	87.195	85.623	88.767	86.917	79.688	95.842	21.591	4.647	0.774
S-N-Ss	80.683	79.377	81.989	80.676	74.154	87.004	14.896	3.860	0.643
S-N-Pr	83.772	82.456	85.087	83.692	76.977	91.627	15.118	3.888	0.648
S-N-Id	80.345	79.103	81.588	79.752	73.548	88.094	13.478	3.671	0.612
S-N-Sm	78.577	77.311	79.843	78.009	71.709	87.644	14.002	3.742	0.624
Ss-N-Sm	2.106	1.357	2.855	2.332	–2.770	5.300	4.897	2.213	0.369
Pr-N-Id	3.426	2.827	4.025	3.673	–0.714	6.553	3.134	1.770	0.295
N-Ss-Pg	179.077	177.081	181.074	177.755	167.790	190.620	34.828	5.902	0.984
S-Ar-tGo	145.176	143.292	147.061	143.908	132.198	159.670	31.017	5.569	0.928
OL/NSL	12.946	11.428	14.464	12.455	4.920	21.490	20.135	4.487	0.748
Ar-tGo-N	49.841	48.703	50.978	50.279	44.021	55.910	11.306	3.362	0.560
N-tGo-Gn	70.291	68.200	72.381	69.730	59.623	81.616	38.180	6.179	1.030
PL/NSL	6.676	5.618	7.734	6.135	1.980	13.750	9.779	3.127	0.521
ML/RL	120.134	117.754	122.515	119.950	107.550	134.210	49.513	7.037	1.173
CL/ML	71.238	69.014	73.461	71.890	58.220	83.380	43.179	6.571	1.095
PL/ML	22.344	19.999	24.689	20.980	10.110	36.800	48.028	6.930	1.155
ASL/PL	112.333	109.818	114.847	111.895	94.580	126.960	55.213	7.431	1.238
S-Go%N-Gn	0.679	0.661	0.698	0.676	0.577	0.758	0.003	0.054	0.009
S-tGo%N-Gn	0.697	0.677	0.717	0.696	0.593	0.788	0.003	0.059	0.010
+1/PL	108.606	106.463	110.748	108.220	91.130	120.430	40.096	6.332	1.055
–1/ML	94.433	91.419	97.447	92.525	75.610	117.230	79.347	8.908	1.485
+1/–1	134.558	130.927	138.188	132.705	115.260	165.190	115.125	10.730	1.788
Is-Ii	3.425	3.012	3.837	3.298	1.587	7.338	1.608	1.219	0.203
Is+Ii	2.958	2.430	3.486	3.124	0.107	6.306	2.634	1.561	0.260

TABLE 3. Real values of the skull parameters and their basic statistical indicators for boys (group of 27 five-year-old boys).

Newly involved characteristics									
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-Go	91.647	89.759	93.536	90.569	83.702	101.547	24.636	4.774	0.919
N-Ar	79.275	77.999	80.550	79.581	73.408	86.493	11.242	3.225	0.621
Ar-Ba	10.677	9.871	11.483	11.025	5.844	13.472	4.486	2.037	0.392
Cd-Ba	17.881	16.963	18.800	18.356	12.619	22.792	5.828	2.322	0.447
Ar-Go	36.383	35.280	37.486	36.661	31.662	43.313	8.407	2.789	0.537
Ar-Pgn	83.336	81.577	85.094	83.667	74.712	92.470	21.361	4.445	0.855
Rhi-Ar	79.531	78.525	80.537	79.988	74.860	83.741	6.988	2.543	0.489
Sp-Ar	73.799	72.862	74.737	74.292	68.761	78.625	6.072	2.370	0.456
Ss-Ar	71.022	70.134	71.910	71.077	67.154	75.210	5.448	2.245	0.432
Pr-Ar	73.985	72.772	75.197	73.940	68.483	79.483	10.162	3.066	0.590
Id-Ar	74.983	73.337	76.630	74.899	67.182	83.703	18.729	4.162	0.801
Sm-Ar	76.738	74.959	78.517	76.710	68.546	85.533	21.860	4.497	0.865
Pmp-FH	16.790	15.965	17.615	16.573	12.465	20.876	4.702	2.086	0.401
Cd-FH	2.103	1.518	2.688	1.982	0.155	4.793	2.364	1.479	0.285
N-Ar/OL	36.329	35.294	37.363	36.140	30.250	40.770	6.843	2.616	0.503
Or-Po/OL	10.099	8.859	11.338	9.250	4.460	17.060	9.813	3.133	0.603
RL/PL	102.525	100.803	104.246	101.960	91.290	110.760	18.934	4.351	0.837
ASL/NSL	84.379	80.615	88.143	85.250	59.150	101.660	90.550	9.516	1.831
N-Ar-Go	97.841	96.016	99.666	99.043	90.236	105.875	21.284	4.614	0.888
N-Ar-Pgn	69.535	68.347	70.723	69.935	64.088	75.072	9.022	3.004	0.578
N-Ar/ASL	111.358	107.774	114.942	110.530	92.960	135.560	82.089	9.060	1.744
S-N-Ar	15.872	15.200	16.545	15.932	12.915	19.979	2.893	1.701	0.327
Ar-N-Rhi	84.382	82.612	86.152	83.880	74.465	94.715	20.022	4.475	0.861
Ar-N-Sp	67.334	66.038	68.629	66.850	62.141	75.693	10.727	3.275	0.630
Ar-N-Ss	63.053	61.844	64.262	63.353	57.656	70.149	9.344	3.057	0.588
Ar-N-Pr	63.244	61.964	64.524	63.258	55.300	69.414	10.473	3.236	0.623
Ar-N-Id	60.245	58.985	61.505	60.701	52.149	65.597	10.142	3.185	0.613
Ar-N-Sm	58.859	57.784	59.933	59.000	52.318	63.817	7.376	2.716	0.523
Ar-N-Pg	58.660	57.628	59.693	58.473	53.706	63.658	6.810	2.610	0.502
Ar-N-Gn	54.863	53.896	55.830	54.417	49.885	58.837	5.980	2.445	0.471
PL/FH	4.270	3.214	5.326	3.810	0.360	9.680	7.125	2.669	0.514
ML/FH	24.736	22.951	26.521	24.720	17.450	34.250	20.365	4.513	0.868
RL/FH	73.941	72.197	75.686	75.300	65.220	80.850	19.440	4.409	0.849
ASL/FH	94.816	91.171	98.461	94.800	67.300	114.210	84.904	9.214	1.773
CL/FH	79.472	77.585	81.359	80.140	70.840	88.150	22.755	4.770	0.918
NSL/FH	10.404	9.123	11.686	10.560	3.500	16.160	10.496	3.240	0.624
N-Pg/FH	84.937	83.581	86.292	85.950	76.320	92.120	11.736	3.426	0.659
N-Rhi/FH	110.659	108.754	112.564	110.600	101.170	121.380	23.195	4.816	0.927
N-Sp/FH	93.609	92.142	95.076	93.010	85.820	101.520	13.751	3.708	0.714
N-Ss/FH	89.329	87.971	90.688	89.340	80.670	95.340	11.797	3.435	0.661
N-Pr/FH	89.519	87.997	91.041	89.680	77.910	96.370	14.801	3.847	0.740
N-Id/FH	86.521	84.918	88.124	87.580	74.760	93.270	16.420	4.052	0.780
N-Sm/FH	85.135	83.673	86.597	85.810	74.930	92.380	13.657	3.695	0.711
Ss-Sm/FH	79.671	77.481	81.862	81.130	65.660	88.140	30.664	5.538	1.066
+1/N-Ar	71.703	68.197	75.209	72.540	48.440	88.150	78.556	8.863	1.706
–1/N-Ar	43.867	41.807	45.926	42.940	30.910	53.830	27.099	5.206	1.002
+1/FH	98.005	94.232	101.778	98.020	71.150	115.630	90.957	9.537	1.835
–1/FH	70.168	67.813	72.522	70.870	54.880	82.600	35.421	5.952	1.145
Ss+Sm(mod)	1.191	0.348	2.034	1.457	–2.746	5.658	4.912	2.132	0.410
Pr+Id(mod)	1.951	1.354	2.547	2.159	–1.596	3.835	2.459	1.508	0.290

TABLE 3. Continued.

	Basic characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-S	61.130	60.195	62.066	60.986	57.315	67.578	6.047	2.365	0.455
S-Ba	35.981	34.974	36.988	36.098	31.807	40.460	7.002	2.545	0.490
N-Rhi	17.917	16.990	18.845	17.703	12.011	23.053	5.941	2.344	0.451
N-Sp	40.541	39.466	41.615	40.152	36.467	45.233	7.974	2.716	0.523
N-Pr	57.331	55.875	58.787	57.481	51.750	64.138	14.642	3.680	0.708
N-Gn	93.205	91.029	95.382	93.113	82.196	104.995	32.721	5.502	1.059
Sp-Is	23.465	22.744	24.186	23.636	20.612	26.638	3.591	1.823	0.351
Pr-Id	12.184	11.193	13.174	11.594	7.503	20.008	6.773	2.503	0.482
Ii-Gn	31.769	31.039	32.499	32.253	28.101	35.286	3.678	1.845	0.355
Id-Gn	25.458	24.788	26.128	25.503	22.095	29.049	3.098	1.693	0.326
Sp-Pg	49.476	47.811	51.140	49.567	40.343	56.897	19.134	4.207	0.810
Sp-Pmp	43.723	43.030	44.415	43.923	39.281	46.687	3.314	1.751	0.337
Ss-Pmp	40.585	39.887	41.284	40.445	35.978	43.878	3.369	1.765	0.340
Pmp-Ba	38.835	38.067	39.602	38.843	35.370	44.059	4.073	1.941	0.374
S-Pgn	95.213	93.036	97.390	96.431	81.645	105.397	32.739	5.503	1.059
Cd-Go	43.361	42.328	44.394	43.176	38.244	48.765	7.371	2.611	0.503
Pgn-Go	54.227	52.756	55.698	54.585	48.112	63.238	14.957	3.720	0.716
S-Ar	26.505	25.606	27.403	26.287	21.231	31.412	5.575	2.271	0.437
Pmp-VL	12.919	12.098	13.741	12.826	8.623	16.787	4.663	2.077	0.400
Ptm-VL	12.488	11.823	13.153	12.773	9.375	15.654	3.054	1.681	0.323
Pr-PL	16.638	15.916	17.360	16.524	13.244	20.508	3.599	1.825	0.351
Mol-PL	16.364	15.539	17.189	16.418	12.693	20.755	4.703	2.086	0.401
Mol-ML	24.320	23.530	25.110	24.088	18.594	28.186	4.311	1.997	0.384
N-S-Ba	133.804	131.953	135.655	133.972	124.051	143.062	21.887	4.678	0.900
N-S-Cd	128.197	125.213	131.181	127.892	111.155	139.838	56.895	7.543	1.452
N-S-Ar	124.867	122.817	126.917	125.148	114.900	135.063	26.851	5.182	0.997
N-S-Go	99.924	98.316	101.532	100.119	91.065	105.553	16.531	4.066	0.782
S-N-Rhi	100.255	98.098	102.411	100.392	89.577	113.005	29.721	5.452	1.049
S-N-Sp	83.206	81.643	84.769	83.305	77.717	92.869	15.613	3.951	0.760
S-N-Ss	78.926	77.425	80.426	78.549	72.653	86.598	14.391	3.794	0.730
S-N-Pr	79.116	77.537	80.695	79.014	69.898	86.436	15.926	3.991	0.768
S-N-Id	76.117	74.566	77.669	75.796	66.747	82.851	15.381	3.922	0.755
S-N-Sm	74.731	73.356	76.105	74.422	66.916	81.118	12.072	3.474	0.669
Ss-N-Sm	4.195	3.408	4.981	4.310	0.094	8.241	3.950	1.987	0.382
Pr-N-Id	2.999	2.527	3.471	3.145	0.764	5.510	1.425	1.194	0.230
N-Ss-Pg	171.521	169.900	173.141	171.254	163.510	181.110	16.775	4.096	0.788
S-Ar-tGo	139.474	137.063	141.886	139.841	125.855	150.198	37.164	6.096	1.173
OL/NSL	20.459	19.181	21.736	20.050	13.080	25.680	10.434	3.230	0.622
Ar-tGo-N	56.865	55.190	58.541	55.428	49.257	63.893	17.940	4.236	0.815
N-tGo-Gn	73.934	72.513	75.354	73.947	66.803	81.848	12.890	3.590	0.691
PL/NSL	6.807	5.769	7.845	6.780	0.060	12.160	6.888	2.625	0.505
ML/RL	130.805	128.650	132.961	129.510	121.150	140.730	29.689	5.449	1.049
CL/ML	75.750	74.275	77.226	75.220	70.460	83.670	13.915	3.730	0.718
PL/ML	28.217	26.660	29.775	27.810	21.500	36.510	15.509	3.938	0.758
ASL/PL	91.313	87.866	94.760	91.930	71.530	108.750	75.943	8.715	1.677
S-Go%N-Gn	0.629	0.616	0.642	0.634	0.577	0.713	0.001	0.032	0.006
S-tGo%N-Gn	0.640	0.627	0.652	0.641	0.587	0.728	0.001	0.031	0.006
+1/PL	94.503	91.232	97.775	95.380	75.380	109.350	68.388	8.270	1.592
–1/ML	85.056	83.209	86.902	84.410	75.940	95.040	21.780	4.667	0.898
+1/–1	151.507	147.179	155.835	152.440	132.460	174.610	119.684	10.940	2.105
Is-Ii	2.160	1.646	2.675	2.275	–1.340	4.250	1.829	1.301	0.250
Is+Ii	1.089	0.357	1.822	0.670	–2.270	6.741	3.704	1.851	0.356

TABLE 4. Real values of the skull parameters and their basic statistical indicators for girls (group of 30 five-year-old girls).

	Newly involved characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-Go	86.268	84.940	87.595	86.045	78.656	96.230	12.635	3.555	0.649
N-Ar	74.518	73.104	75.933	74.361	67.298	83.388	14.342	3.787	0.691
Ar-Ba	10.653	9.943	11.363	10.579	6.813	13.768	3.613	1.901	0.347
Cd-Ba	16.942	16.152	17.732	16.891	12.306	20.544	4.476	2.116	0.386
Ar-Go	34.604	33.681	35.526	34.097	30.802	40.578	6.104	2.471	0.451
Ar-Pgn	80.761	79.475	82.046	80.100	73.465	87.787	11.854	3.443	0.629
Rhi-Ar	76.469	75.119	77.819	76.097	71.134	86.264	13.072	3.616	0.660
Sp-Ar	71.446	70.278	72.614	71.170	66.636	78.012	9.783	3.128	0.571
Ss-Ar	68.575	67.503	69.647	68.059	64.392	74.611	8.235	2.870	0.524
Pr-Ar	71.885	70.755	73.015	71.381	66.812	77.960	9.157	3.026	0.552
Id-Ar	72.647	71.446	73.849	71.815	67.068	78.460	10.355	3.218	0.588
Sm-Ar	74.244	72.936	75.553	73.987	68.353	80.401	12.280	3.504	0.640
Pmp-FH	15.295	14.632	15.958	15.137	12.587	18.234	3.154	1.776	0.324
Cd-FH	1.840	1.351	2.330	1.756	0.046	4.813	1.720	1.311	0.239
N-Ar/OL	35.282	33.991	36.573	34.535	28.810	44.070	11.945	3.456	0.631
Or-Po/OL	11.153	9.818	12.488	11.565	4.640	17.100	12.780	3.575	0.653
RL/PL	101.800	100.259	103.341	102.100	95.000	109.260	17.035	4.127	0.754
ASL/NSL	86.874	84.269	89.480	86.365	72.430	103.070	48.692	6.978	1.274
N-Ar-Go	97.806	96.383	99.229	97.683	89.356	106.022	14.527	3.811	0.696
N-Ar-Pgn	68.803	67.410	70.197	68.176	61.315	78.463	13.925	3.732	0.681
N-Ar/ASL	108.956	106.464	111.449	108.865	93.420	124.970	44.557	6.675	1.219
S-N-Ar	15.757	15.214	16.301	15.846	13.381	19.542	2.118	1.455	0.266
Ar-N-Rhi	90.498	88.306	92.691	90.155	78.326	106.742	34.471	5.871	1.072
Ar-N-Sp	70.530	69.240	71.819	70.828	63.680	78.744	11.929	3.454	0.631
Ar-N-Ss	65.642	64.544	66.741	65.446	59.649	71.646	8.660	2.943	0.537
Ar-N-Pr	65.669	64.469	66.868	65.694	59.815	70.918	10.321	3.213	0.587
Ar-N-Id	62.431	61.307	63.554	62.370	54.547	67.480	9.053	3.009	0.549
Ar-N-Sm	61.085	59.960	62.210	60.955	53.392	66.436	9.081	3.014	0.550
Ar-N-Pg	60.475	59.338	61.613	60.108	54.000	65.560	9.277	3.046	0.556
Ar-N-Gn	56.564	55.443	57.685	55.756	50.534	61.872	9.016	3.003	0.548
PL/FH	3.138	2.187	4.088	2.640	0.180	9.370	6.478	2.545	0.465
ML/FH	26.718	24.921	28.515	26.785	17.880	42.760	23.159	4.812	0.879
RL/FH	76.089	74.678	77.500	75.940	64.020	84.480	14.277	3.778	0.690
ASL/FH	95.145	92.674	97.616	93.885	80.680	111.600	43.793	6.618	1.208
CL/FH	78.067	75.439	80.695	79.400	66.250	95.240	49.535	7.038	1.285
NSL/FH	8.407	7.346	9.467	8.070	2.540	16.600	8.063	2.840	0.518
N-Pg/FH	84.521	83.349	85.693	83.890	79.660	91.160	9.856	3.139	0.573
N-Rhi/FH	114.543	112.193	116.893	114.335	105.170	134.320	39.619	6.294	1.149
N-Sp/FH	94.575	93.251	95.899	94.985	88.500	103.390	12.573	3.546	0.647
N-Ss/FH	89.688	88.519	90.857	89.395	84.580	98.140	9.802	3.131	0.572
N-Pr/FH	89.714	88.517	90.911	89.235	84.970	97.180	10.279	3.206	0.585
N-Id/FH	86.477	85.567	87.387	86.200	82.440	92.300	5.937	2.437	0.445
N-Sm/FH	85.130	84.084	86.177	84.955	79.850	91.140	7.852	2.802	0.512
Ss-Sm/FH	79.196	77.619	80.774	78.670	71.100	91.990	17.846	4.225	0.771
+1/N-Ar	72.987	70.728	75.247	72.880	59.900	82.430	36.615	6.051	1.105
–1/N-Ar	44.726	41.985	47.467	43.680	32.100	66.500	53.884	7.341	1.340
+1/FH	97.020	94.719	99.321	96.510	85.200	109.710	37.969	6.162	1.125
–1/FH	68.759	65.734	71.784	66.625	53.770	90.720	65.634	8.102	1.479
Ss+Sm(mod)	0.472	–0.398	1.342	0.840	–6.818	4.180	5.428	2.330	0.425
Pr+Id(mod)	1.868	1.262	2.475	2.249	–2.426	5.621	2.639	1.624	0.297

TABLE 4. Continued.

	Basic characteristics								
Variable	**Mean**	**5th percentil**	**95th percentil**	**Median**	**Minimum**	**Maximum**	**Variance**	**SD**	**Standard error**
N-S	57.825	56.631	59.018	57.865	49.719	63.569	10.213	3.196	0.583
S-Ba	34.125	33.419	34.831	33.811	30.321	38.464	3.571	1.890	0.345
N-Rhi	16.851	16.092	17.610	17.000	12.800	20.804	4.131	2.033	0.371
N-Sp	38.068	37.231	38.906	38.272	32.483	42.113	5.032	2.243	0.410
N-Pr	54.471	53.354	55.589	53.968	49.114	60.077	8.962	2.994	0.547
N-Gn	88.407	86.929	89.885	87.971	82.885	98.623	15.670	3.959	0.723
Sp-Is	22.785	22.219	23.351	22.570	20.307	26.353	2.299	1.516	0.277
Pr-Id	10.927	10.397	11.458	11.110	7.580	12.897	2.017	1.420	0.259
Ii-Gn	30.419	29.801	31.037	30.372	26.946	33.869	2.738	1.655	0.302
Id-Gn	24.960	24.187	25.733	24.678	20.625	29.479	4.287	2.071	0.378
Sp-Pg	47.088	45.919	48.258	46.936	41.302	55.163	9.808	3.132	0.572
Sp-Pmp	42.798	42.132	43.464	43.015	39.760	46.672	3.178	1.783	0.325
Ss-Pmp	39.541	38.996	40.086	39.480	37.003	42.602	2.131	1.460	0.267
Pmp-Ba	37.294	36.412	38.176	37.046	33.896	43.085	5.577	2.362	0.431
S-Pgn	91.534	90.208	92.860	90.883	84.337	98.258	12.610	3.551	0.648
Cd-Go	40.731	39.832	41.629	40.340	36.161	46.042	5.787	2.406	0.439
Pgn-Go	53.273	52.095	54.450	52.667	47.977	59.874	9.942	3.153	0.576
S-Ar	24.582	23.867	25.298	24.187	19.915	28.360	3.673	1.917	0.350
Pmp-VL	12.788	12.005	13.571	12.589	8.206	17.490	4.398	2.097	0.383
Ptm-VL	12.312	11.584	13.040	12.435	7.833	16.258	3.799	1.949	0.356
Pr-PL	16.359	15.817	16.901	16.492	13.309	19.730	2.108	1.452	0.265
Mol-PL	15.750	15.252	16.248	15.905	13.225	18.325	1.777	1.333	0.243
Mol-ML	22.779	22.256	23.303	22.960	20.053	25.144	1.965	1.402	0.256
N-S-Ba	133.546	131.897	135.194	133.002	126.509	145.376	19.484	4.414	0.806
N-S-Cd	128.043	125.004	131.083	127.722	112.502	145.693	66.249	8.139	1.486
N-S-Ar	124.441	122.766	126.116	123.909	111.931	132.644	20.119	4.485	0.819
N-S-Go	99.483	98.381	100.585	98.911	92.324	107.520	8.711	2.951	0.539
S-N-Rhi	106.255	103.823	108.688	106.191	94.075	124.139	42.428	6.514	1.189
S-N-Sp	86.287	84.764	87.809	86.582	79.035	98.286	16.619	4.077	0.744
S-N-Ss	81.400	80.049	82.750	81.158	75.398	90.842	13.074	3.616	0.660
S-N-Pr	81.426	79.988	82.863	80.592	75.564	89.903	14.826	3.850	0.703
S-N-Id	78.188	76.892	79.484	77.928	71.386	85.322	12.040	3.470	0.634
S-N-Sm	76.842	75.512	78.172	76.134	70.231	84.307	12.683	3.561	0.650
Ss-N-Sm	4.558	3.772	5.343	4.922	–1.040	8.003	4.426	2.104	0.384
Pr-N-Id	3.238	2.667	3.809	3.564	–1.145	6.425	2.338	1.529	0.279
N-Ss-Pg	170.057	168.374	171.740	168.901	164.053	180.330	20.315	4.507	0.823
S-Ar-tGo	140.054	137.812	142.296	140.827	128.963	151.205	36.053	6.004	1.096
OL/NSL	19.526	18.120	20.932	19.300	12.170	27.550	14.176	3.765	0.687
Ar-tGo-N	56.613	55.443	57.782	56.143	50.876	63.974	9.808	3.132	0.572
N-tGo-Gn	74.017	72.400	75.634	73.699	66.642	86.481	18.746	4.330	0.790
PL/NSL	6.265	5.292	7.238	6.405	0.930	10.570	6.783	2.604	0.476
ML/RL	130.630	128.750	132.510	130.555	118.590	140.930	25.346	5.034	0.919
CL/ML	75.068	73.005	77.131	74.525	65.300	87.770	30.527	5.525	1.009
PL/ML	28.979	27.186	30.772	28.185	19.930	40.400	23.061	4.802	0.877
ASL/PL	93.045	90.861	95.229	92.185	80.460	106.740	34.214	5.849	1.068
S-Go%N-Gn	0.625	0.613	0.638	0.624	0.536	0.686	0.001	0.034	0.006
S-tGo%N-Gn	0.635	0.622	0.649	0.634	0.529	0.711	0.001	0.037	0.007
+1/PL	94.920	92.908	96.933	92.885	84.810	104.360	29.050	5.390	0.984
–1/ML	84.378	81.716	87.040	85.355	71.120	100.550	50.820	7.129	1.302
+1/–1	152.086	149.152	155.020	150.285	142.380	178.700	61.742	7.858	1.435
Is-Ii	2.086	1.483	2.689	2.058	–1.852	5.719	2.608	1.615	0.295
Is+Ii	0.906	0.442	1.370	0.697	–1.214	4.650	1.542	1.242	0.227

well as in basic parameters. If compared with the situation in adults, more intersexual differences were proved in the children group in angular characteristic, although in most cases the p-value of the T-test reached more than 0.05.

In correspondence with the situation in adults, the position of the mandible articulation (Ar-Ba, Cd-FH) in childhood is the same for both sexes. Dimensions characterizing the upper alveolar process (Sp-Is, Pr-PL) and the maxillar size (Sp-Pg, Sp-Pmp) do not show any significant intersexual differences. Dimensions characterizing the mandibular body length and height (Pgn-Go, Id-Gn) show identical values in girls as in boys. This situation differs when compared with adults.

Parameters characterizing the face length and its growth in anterior-inferior direction (Ar-Pgn, Sm-Ar) reach significantly higher values in boys. Conversely, in girls both alveolar processes (S-N-Pr, S-N-Id) are more protruding. Significant are also differences in subspinal depth of the maxilla (Ss-Pmp) and the anterior dental height (Pr-Id). Sexual dimorphism is shown also in the parameters SP-Ar and Pmp-FH, although in other dimensions characterizing the palatal position towards the skull base we did not detect any sexual differences; this was not proven in adults either. All mentioned linear parameters reach higher average values in boys, although girls have more proclinated nasal bones (S-N-Rhi). This situation originates in generally larger size of linear characteristics of the cranium in boys.

Some of the differences proved in childhood were not proved in adulthood. In children skulls we have determined significant differences in the size of angles describing the mandibular and maxillary protrusion (S-N-Id, S-N-Sm, Ar-N-Sp, S-N-Sp, S-N-Ss).

On the contrary, the differences connected with the unequal protrusion of the upper alveolar process which we proved in adults, are not present in children.

Remarkably higher values of angles including the Ar-N line and craniometrical points of the face profile (like Ar-N-Ss, Ar-N-Pr, Ar-N-Id, Ar-N-Sm, Ar-N-Pg and Ar-N-Gn) were found in the girls' group. The same situation occurs in the values of the angles including the same craniometrical points of the face profile and the S-N line. It demonstrates a greater protrusion of the face in girls. This situation does not have any equivalent in adulthood. Also, the significantly greater proclination of nasal bones (S-N-Rhi, Ar-N-Rhi) and more acute angle NSL/FH in girls do not represent relevantly different traits in adulthood.

Sagittal jaw relations (Ss-N-Sm) and the convexity of the face (N-Ss-Pg) do not seem to prove any differences neither in childhood nor in adulthood. Pr-N-Id angle has almost the same size for both sexes in childhood, while in adulthood it reaches larger size in the female group.

Developmental changes

For both sexes, highly significant enlargement of linear skull parameters from childhood to adulthood is natural.

Highly significant enlargement in the length of the presellar and postsellar parts of the skull base (N-S, S-Ba) during ontogeny occurs in both sexes. The angle of the skull base (N-S-Ba) diminishes its size.

The bony framework for nasopharynx (Pmp-Ba) deepens with age in both sexes; significant is also the enlargement of the nasal bones' length (N-Rhi) and the proclination of nasal bones (S-N-Rhi, Ar-N-Rhi a N-Rhi/FH).

The maxilla (N-Pr) significantly increases its size during ontogeny, also the proclination of upper maxillary process and upper incisors (ASL/PL, ASL/FH, S-N-Pr, ASL/NSL) increases, but total protrusion of the upper jaw (S-N-Ss, N-Ss/FH) stays constant.

During ontogeny, the face growths in antero-inferior direction (the parameter S-Pgn lengthens) and rotates anteriorly (the ratios S-Go%N-Gn, S-tGo%N-Gn enhance). The face structures grow in vertical direction, but the change of the vertical proportions is only minimal.

The size of the angle NSL/FH in females does not change with age, in males this angle gets more acute and in adults it reaches the same size in men as in women. This results in the female group in same relations of other craniometrical points and FH line like relations of the characteristics including the same points and NSL line. We have statistically proved the significance of these relations within the female group. That is why we assume that the FH line could function by the images analysis like the NSL analogy and also the characteristics related to the FH line represent a suitable supplement of the standard set of craniometrical parameters.

The hard palate descends, while the slope of the palatal plane (PL/NSL) stays constant. The palatal line stability predetermines this parameter for use as the reference line of the skull similarly to the FH line.

The shape changes in the mandible are caused by the marked growth of its body (Pgn-Go) and ramus (Cd-Go) and by compensational and adaptation mechanisms that make constant jaw relations possible. One of these adaptation mechanisms is the reduction of the chin angle (CL/ML). The slope of the lower jaw (ML/FH), the vertical jaw relations (PL/ML) and gonial angle (ML/RL) diminish the steepness of the occlusal plane (OL/NSL). The steepness of the mandibular ramus (RL/FH) increases and the Articulare and Condylion points move inferiorly. During ontogeny, the protrusion of the mandible, the protrusion of the chin and of the chin process increases (angles S-N-Id, S-N-Sm, Ar-N-Pg, Ar-N-Gn, CL/FH and N-Pg/FH increase).

Newly involved angle Ss-Sm/FH, characterising sagittal jaw relations, significantly increases its size with age. This situation is confirmed by significant changes in the size of the angle of sagittal jaw relations (Ss-N-Sm). Similarly the face profile (N-Ss-Pg) flattens.

The anterior dental height (Pr-Id) and the proclination of the lower and upper incisors (+1/PL, –1/ML) increase in relation with the simultaneous eruption of the permanent dentition. It causes the changes in size of angles +1/N-Ar, +1/FH and –1/FH, thus the intericisal angle (+1/–1) considerably decreases. The changes in dentition cause also the prolongation of the Mol-ML and Mol-PL distance. Both

alveolar processes substantially procline from childhood to adulthood, but the angle of sagittal intraalveolar relations (Pr-N-Id) changes only very slightly. The maxillary overjet (Is-Ii) and overbite (Is+Ii) extends, larger changes occur in females.

As to special characteristics, any significant ontogenetic changes do not occur in their values with the only one exception in the parameter Ss+Sm(mod), where a significant difference between the groups of boys and adult men was found. The same difference was not observed in the female group, neither in the sexual dimorphism analysis.

DISCUSSION AND CONCLUSIONS

All acquired data (with special emphasis to newly involved characteristics) represent norms for the present and past-century Czech population. Submitted norms are suitable for further use in anthropology, osteology, medicine and other disciplines. Gathered data can be employed as standards for further measurements carried on historical material, also in anthropological reconstructions or by 3D reconstructions based on the use of known dimensions for the estimation of selected cranial characteristics.

As a typical example of application of this type of data collections, the work of Vlček and Šmahel (1997, 1998) can be mentioned. The authors assessed proportions of skulls from bone remains of Czech monarchs and their families by comparing parameters of historical skulls with norms. They also followed cognation of individuals.

All disciplines using metric analysis of teleroentgenographs or photographs are opportunities for using our data sets as norms. Many authors aspire to find methods how to assess the position of missing cranial parts using correlation analysis. The knowledge of the size of other related dimensions is also important for these investigations. In the past, authors of this type of studies used data obtained by direct measurements on images or by recording craniometrical points with digitiser (for example Šmahel, Škvařilová 1988a, b). Another application for constituted norms are various intracranial relations analyses (for example the studies of Škvařilová *et al.* 1997, Marešová 2003, Marešová *et al.* 2004) or the skull size and shape evaluating for various age or ethnic groups (Anton 1989, Cerci *et al.* 1993, Giles, Elliot 1962, Richardson 1980, Swlerenga *et al.* 1994, and others). This type of data represents an important information source for people origin and nations cognation research (Niskanen 2002, Pietrusewsky 1999), secular trends, and phylogenetic and ontogenetic changes monitoring (Bishara *et al.* 1984, El Batouti *et al.* 1994, Kerr 1979, Šabík 1996, Vika, Kamínek 2001). This method can also be used in forensic and historical anthropology, for example for sex assessment (Hsiao *et al.* 1996). Important is also the use in evaluation of skull deviations – deformed, damaged or distinct from the normal state (Velemínská 2000). These applications represent only a brief overview of the wide range of scientific disciplines, where it is possible to take advantage of this programme and newly created norms. More quite similar examples of norms created for different nations can be found in relevant literature.

The need of standards made individually for each population is caused by significant differences in size and shape of the cranium in individuals belonging to various nations. Therefore it is important to develop and use special norms for different ethnic groups. This importance is emphasized for example in the study of Miyajima *et al.* (1996), who found highly significant differences in skull proportions of the Japanese and Euroamericans.

Films used for our purposes were made in the 1970s. It is possible that because of secular trends there could be some differences in parameters between the present population and the sample of the population captured in the images. If there is any disparity caused by the secular trend, it is probably very small, because the time distance is not as long as in comparisons of the groups of North-American children, studied by Warren and Bishara (2001) and Warren *et al.* (2003), or in adult Americans studied by Jantz and Jantz (2000).

All measured data presented in the submitted report correspond to those obtained by measuring the same collection of films but using another method. These samples of comparative data were published by Šabík (1996) and Šmahel *et al.* (1998). Also, obtained evidence of developmental changes of cranial structures corresponds with the findings published in previous studies (for further details see Macková 2004, Šmahel *et al.* 1998).

Intersexual differences are in general smaller in childhood than in adult age. More marked differences in adulthood are the results of typically longer growth period for males in comparison with females subsequently leading to a larger final skull size in males.

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Kateřina Macková
Jana Velemínská
Department of Anthropology
and Human Genetics
Faculty of Natural Science
Charles University
Viničná 7
128 44 Prague 2, Czech Republic
E-mail: katerina.mackova@unicorn.eu
E-mail: velemins@natur.cuni.cz