

Appendix A Osteometric Measurements for Skulls

<i>Maximum length</i>	Measured from the glabella to the opisthocranium
<i>Maximum breadth</i>	Measured from the euryon to euryon
<i>Basion-Bregma Height</i>	Measured from the basion to bregma
<i>Total facial height</i>	Measured from the nasion to gnathion
<i>Upper facial height</i>	Measured from the nasion to alveolare
<i>Bizygomatic breadth</i>	Measured from the zygion to zygion
<i>Nasal height</i>	Measured from the nasion to nasopinale
<i>Nasal Breadth</i>	Measured from the alare to alare
<i>Orbital height</i>	Measured from the upper to lower orbital borders
<i>Orbital breadth</i>	Measured from the maxillofrontale to ectoconchion
<i>Bicondylar breadth</i>	Measured from the condylion laterale to condylion laterale
<i>Bigonial breadth</i>	Measured from the gonion to gonion
<i>Upper facial depth</i>	Measured from the basion to nasion
<i>Upper facial breadth</i>	Measured from the frontomolare temporalis to the frontomolare temporalis
<i>Minimum facial breadth</i>	Measured from the frontotemporale to the frontotemporale
<i>Lower facial depth</i>	Measured from the basion to alveolare

Appendix B: Osteometric Indices for Skulls

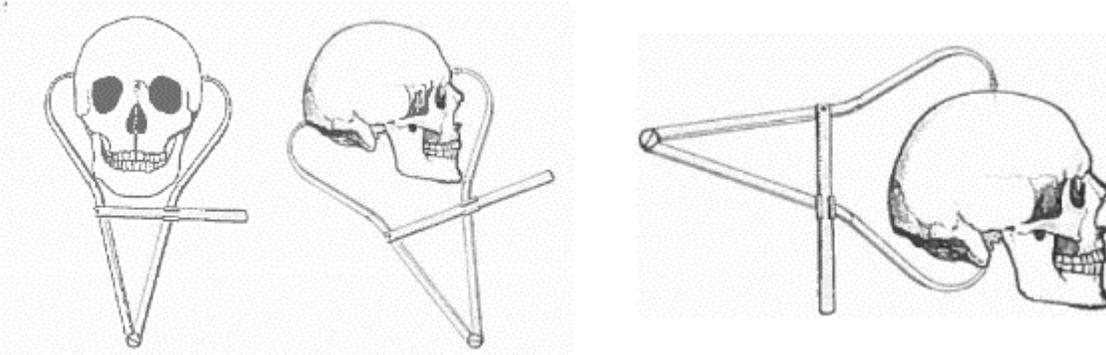
An index is a ratio between one measurement and another which is expressed as a percent. Indices are a useful means of demonstrating in one numerical expression the relationship between two measurements. Indices, also, therefore, tell something of the form of the structures under study. The number of indices invented by biological anthropologists is almost countless. These indices below are among the most commonly used.

<i>Cranial Index</i>	$(\text{Maximum Cranial Breadth} \times 100) / (\text{Maximum Cranial Length})$
<i>Cranial Length-Height Index</i>	$(\text{Basion-Bregma Height} \times 100) / \text{Maximum Length}$
<i>Total Facial Index</i>	$(\text{Total Facial Height} \times 100) / (\text{Bizygomatic Breadth})$
<i>Upper Facial Index</i>	$(\text{Upper Facial Height} \times 100) / (\text{Bizygomatic Breadth})$
<i>Nasal Index</i>	$(\text{Nasal Breadth} \times 100) / \text{Nasal Height}$

Appendix C: Set of Skull Tutorials

<i>Skull Module</i>	http://www.csuchico.edu/anth/Module/skull.html
<i>Data Face</i>	http://face-and-emotion.com/dataface/anatomy/landmarks.jsp
<i>Virtual Skulls</i>	http://australianmuseum.net.au/interactive/Virtual-Skull-Homo-sapiens/

Appendix D: Cranial Capacity Formulae



Formulae #1 (Human skull, modern, sex unknown) -- Measure in mm

Males (Formula 1A): $(0.000266 \times \text{maximum length} \times \text{maximum breadth} \times \text{basion-bregma height}) + 524.6 \text{ cm}^3$

Males (Formula 1B): $(0.000156 \times \text{maximum length} \times \text{maximum breadth} \times \text{basion-bregma height}) + 524.6 \text{ cm}^3$

Females (Formula 1C): $(0.000156 \times \text{maximum cranial length} \times \text{maximum cranial breadth} \times \text{basion-bregma height}) + 812.0 \text{ cm}^3$

Formulae #2 (Human skull, modern, sex unknown) -- Measure in mm (After Hwang, et al., 1995)

Males (Formula 2A): $(0.000307 \times \text{maximum length} \times \text{maximum breadth} \times \text{basion-bregma height}) + 307.5 \text{ cm}^3$

Females (Formula 2B): $(0.000435 \times \text{maximum length} \times \text{maximum breadth} \times \text{basion-bregma height}) - 12.0 \text{ cm}^3$

Males (Formula 2C): $(0.000429 \times \text{maximum length} \times \text{maximum breadth} \times \text{auriculo-bregma height}) + 214.6 \text{ cm}^3$

Females (Formula 2D): $(0.000461 \times \text{maximum length} \times \text{maximum breadth} \times \text{auriculo-bregma height}) + 131.6 \text{ cm}^3$

Formula #3 (chimpanzees skull) -- Measure in mm:

Use the Protsch, et al. formula to determine cranial capacity for male and female:

Males/Females: $(0.0003245 \times \text{length} \times \text{breadth} \times \text{height}) + 95.0 \text{ cm}^3$

Formula #4 (*Homo habilis* and *Australopithecus africanus*)

[Wolpoff](#) (1981) formulae use a series of arcs and breadths. Compare these:

Formula # 4A: Males/Females: $3.2(\text{Biparietal Breadth}) + 9.3(\text{Bregma-Lambda arc}) + 4.6(\text{Lambda-Asterion arc}) - 921.9 \text{ mm}$

Formula # 4B: Males/Females: $3.5(\text{Biparietal Breadth}) + 12.3(\text{Bregma-Lambda arc}) + 4.9(\text{Lambda-Asterion arc}) - 2.8(\text{Bregma-Parietal Mastoid Angle arc}) - 949.3 \text{ mm}$

<i>Maximum Head Length</i>	Measured from the Glabella to inion (measure the distance between the center, most prominent point between the eyebrows and the most backward projection of the head.)
<i>Maximum Head Breadth</i>	Measured between parietal eminences (measure the greatest transverse diameter of the head).
<i>Ear-Head (Auricular) Height</i>	Measured from the acoustic meatus to the highest point of the vertex (measure the distance between the top of the external auditory meatus (opening of the ear) and the apex (or head).

For the next two formulae: L = maximum head length; W = maximum head width, and H = auricular height

Formula #5A (Living modern human head)--Measure in mm

Use the [Lee-Pearson](#) formula as follows:

Males: $0.000337(L-11)(W-11)(H-11) + 406.01 \text{ cm}^3$

Females: $0.000400(L-11)(W-11)(H-11) + 206.60 \text{ cm}^3$

Formula #5B (Living modern human head) Lee's --Measure in cm

Males: $0.365 (L \times B \times H) + 359.34$

Females: $0.375 (L \times B \times H) + 296.40$

Formula #6: Living modern human head) --Measure in cm

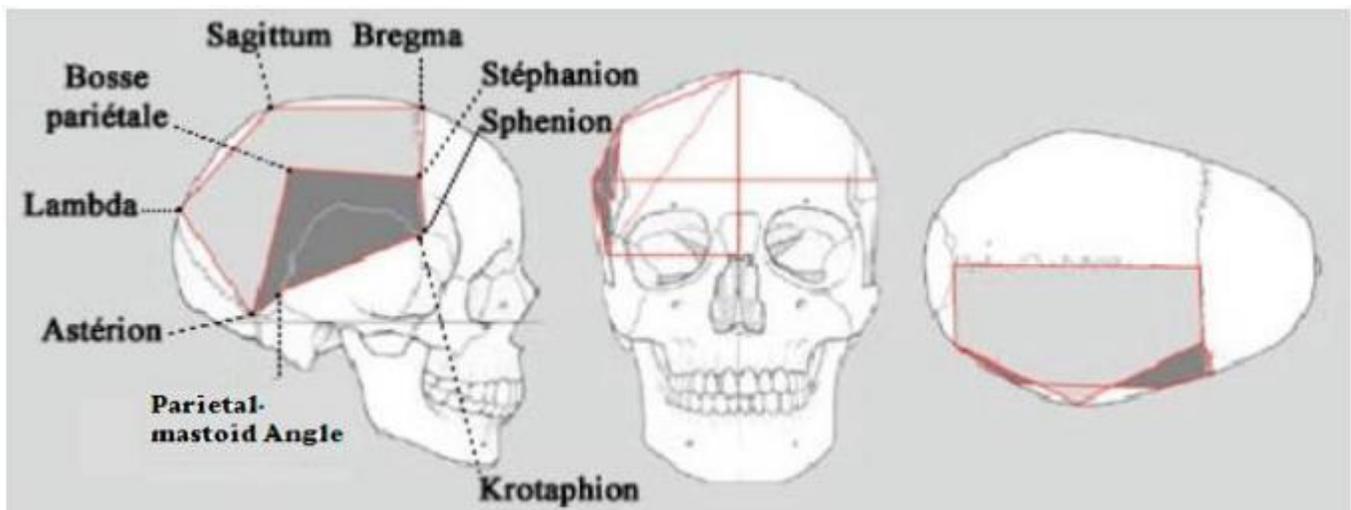
[Spheroid](#) formula: $\pi/6 (L \times B \times H)$

Table I. Showing various parameters on 366 healthy 17-26 years old both sexes, Mugla University students, Turkey.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	366	17	26	19.83	1.96
Body Weight (kg)	366	47	90	65.34	8.88
Body Height (cm)	366	155	193	174.21	8.18
BMI (kg/m ²)	366	18.42	24.82	21.43	1.61
Head length (mm)	366	152	205	182.79	8.02
Head width (mm)	366	136	170	154.62	6.50
Auricular height (mm)	366	107	168	127.94	9.74
WxHxL (cm)	366	2533.35	5275.2	3626.39	451.87
Cranial capacity (cm ³)	366	991.59	1939.50	1371.60	146.37

Source: Niyazi, Usanmaz, Tugay & Tolga Erteki'n, (2017).

Appendix E: Landmarks for Fossil Measurements



Source: [Analyse morphométrique](#)

Appendix F: Human Skull Landmarks (Key to Figures)

A	<i>Gnathion</i>	On the mandible, the middle point on the lower border.
B	<i>Pogonion</i>	On the chin, the most anterior point.
C	<i>Alveolare</i>	Between the upper central incisors and the apex of the septum.
D	<i>Prosthion</i>	On the maxilla, the most anterior point between the upper central incisors. (Do not confuse with the alveolare).
E	<i>Nasospinale</i>	This point is where a line drawn between the lower margins of the right and left nasal apertures is intersected by the mid-sagittal plane.
F	<i>Nasion</i>	The point where the frontal bones and the two nasal bones join.
G	<i>Glabella</i>	Between the supraorbital ridges and above nasion, it is the most forward projecting point of the frontal bone.
H	<i>Bregma</i>	The intersection point between the coronal sagittal sutures.
I	<i>Lambda</i>	The intersection of the sagittal and lambdoidal sutures.
J	<i>Opisthocranion</i>	The posterior end of the maximum length of the skull from the gabella in the middle of the sagittal plane.
K	<i>Inion</i>	A point at the base of the external occipital protuberance.
L	<i>Opisthion</i>	Midpoint of the posterior margin of the foramen magnum.
M	<i>Basion</i>	Midpoint of the anterior margin of the foramen magnum.
N	<i>Euryon</i>	These points are determined with the spreading calipers. The two points are the most widely separated points on the two sides of the skull.
O	<i>Porion</i>	Uppermost point of the external auditory meatus.
P	<i>Maxillofrontale</i>	The point of intersection between the anterior lacrimal crest and the fronto-maxillary suture.
Q	<i>Alare</i>	Most lateral point on the nasal aperture.
R	<i>Orbitale</i>	The lowest point in the margin of the eye orbit.
S	<i>Ectoconchion</i>	Maximum breadth on the lateral wall of the eye orbit.
T	<i>Condylion laterale</i>	On the mandible, the most lateral point of the condyle.
U	<i>Gonion</i>	Most lateral part of the angle of the mandible.
V	<i>Zygion</i>	The most lateral point of the zygomatic arch. A point determined by measurement.
W	<i>Frontomalare temporalis</i>	Outer lateral orbital point, most lateral point of zygomaticofrontal suture.
X	<i>Frontotemporale</i>	Most medial point of superior temporal line or temporal crest on frontal bone

