# IDENTIFICATION OF SKELETAL REMAINS

November 5, 2010

Now that we have reviewed the fundamentals of human anatomy, as well as the various measurements and indices applied to skeletal remains we can apply this knowledge to the identification of skeletal remains.

In the identification of skeletal remains the following needs to be determined:

1. **Sex**

The best bones for the determination of sex are those of the pelvis, which has an accuracy of 98% when properly examined. The pelvic bone (innominate) is composed of three bones, the pubic, ischial and iliac. Of these three bones it is the pubic that is best utilized for the determination of sex.
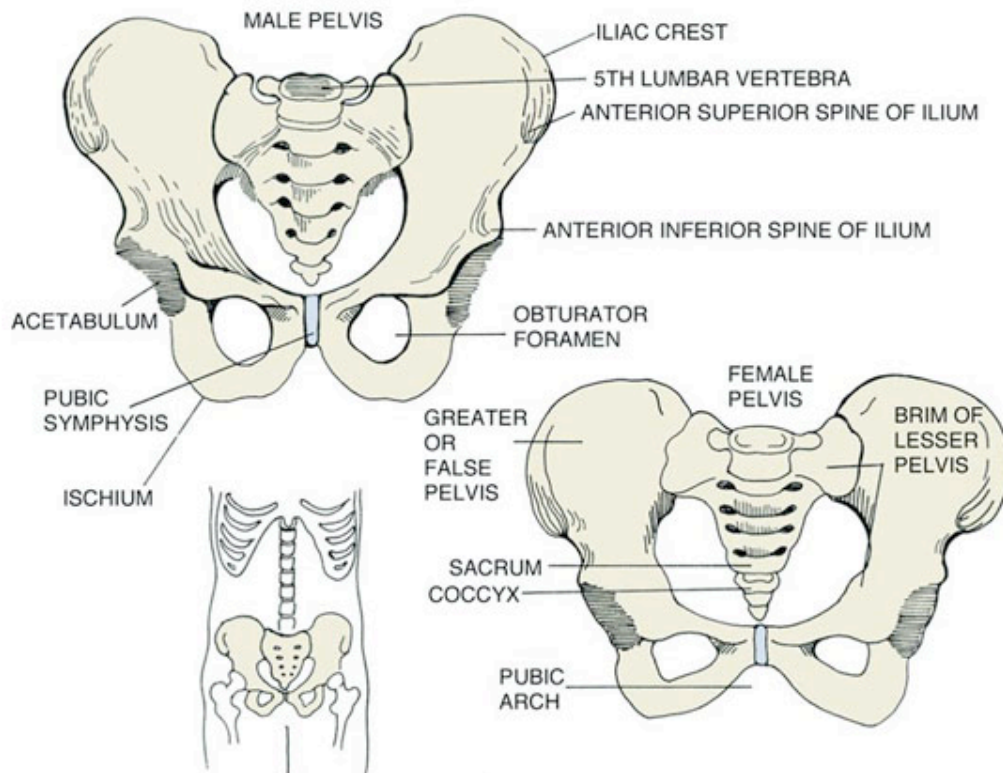
The pelvis as a whole in the male is more massive and has prominent muscle ridges. In the female the pelvis is more slender, smaller and relatively smooth. The subpubic angle in the male is V-shaped with an angle less than 90 degrees, usually about 70
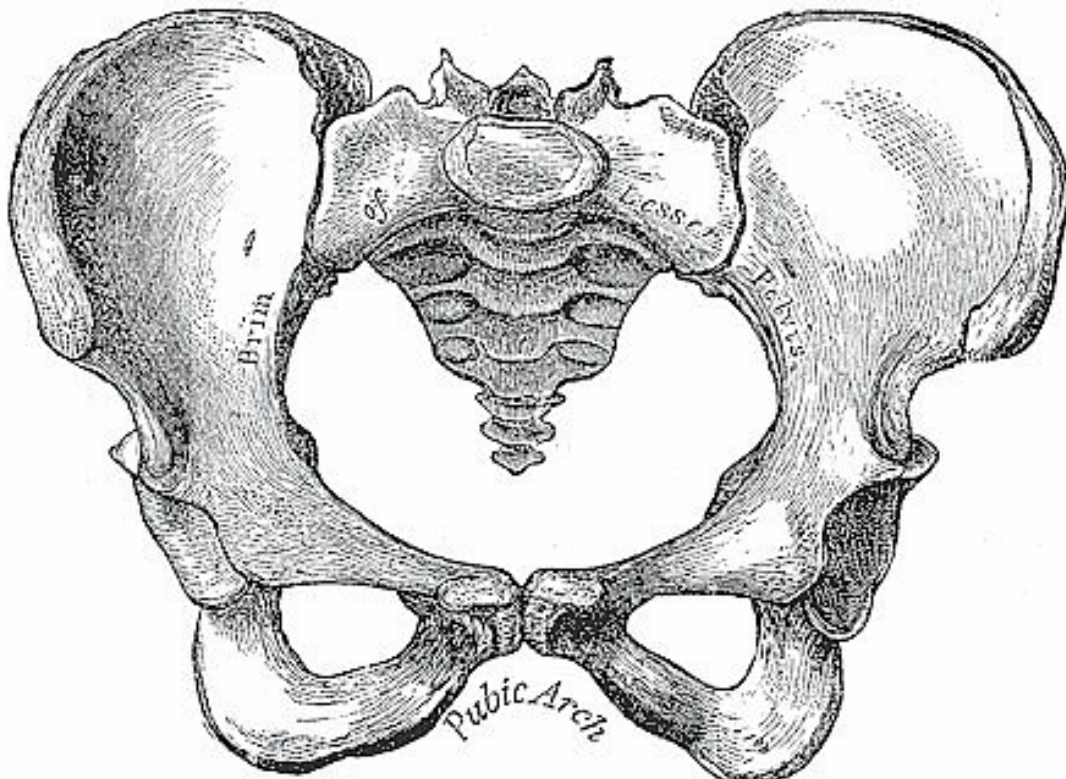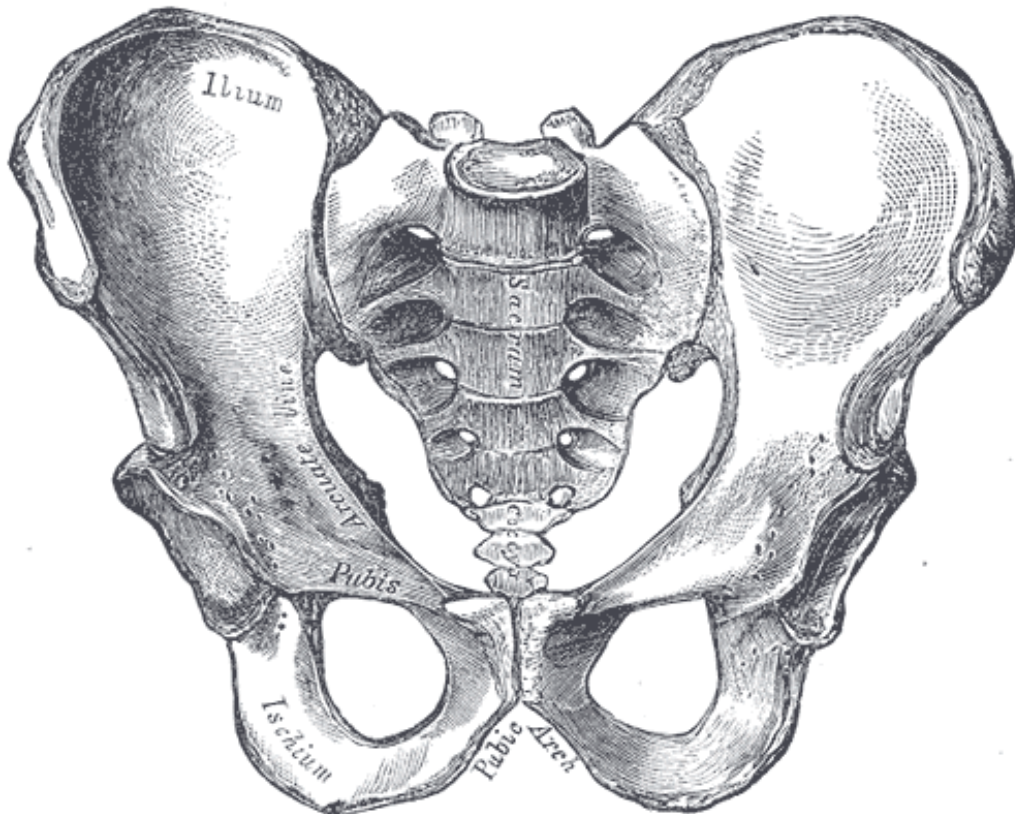
degrees (upper image), whereas the supubic angle in the female is U-shaped, rounded, broader, divergent with an angle of 90 degrees or higher (lower image).

To determine the subpubic angle, line up the pubic face with a straight line and trace the lower angle. Measure the angle subtended with a protractor and double the result. The body of the pubic bone, which is lateral to the symphysis, tends to be triangular in males, whereas in females it is more rectangular; in females there is a bony ridge running down the ventral surface from the pubic crest; in females there is a concavity of the lower margin of the inferior pubic ramus immediately lateral to the lower border of the symphysis; in females there is a ridge of elevated bone on the medial aspect of the ischiopubic ramus, immediately lateral to the symphysis, whereas in males this area is broad and flat; the ischiopubic index (pubic length x 100 divided by the ischial length is less than 90 in adult white males, in adult females it is over 95).

The greater sciatic notch in the male is smaller, deeper and narrow typically at an angle of less than 68 degrees, whereas in the female it is larger and more open, divergent, typically at an angle of 68 degrees or greater. Harrison and Hrdlicka believe that the greater sciatic notch in of itself has a 75% success rate for the determination of sex.
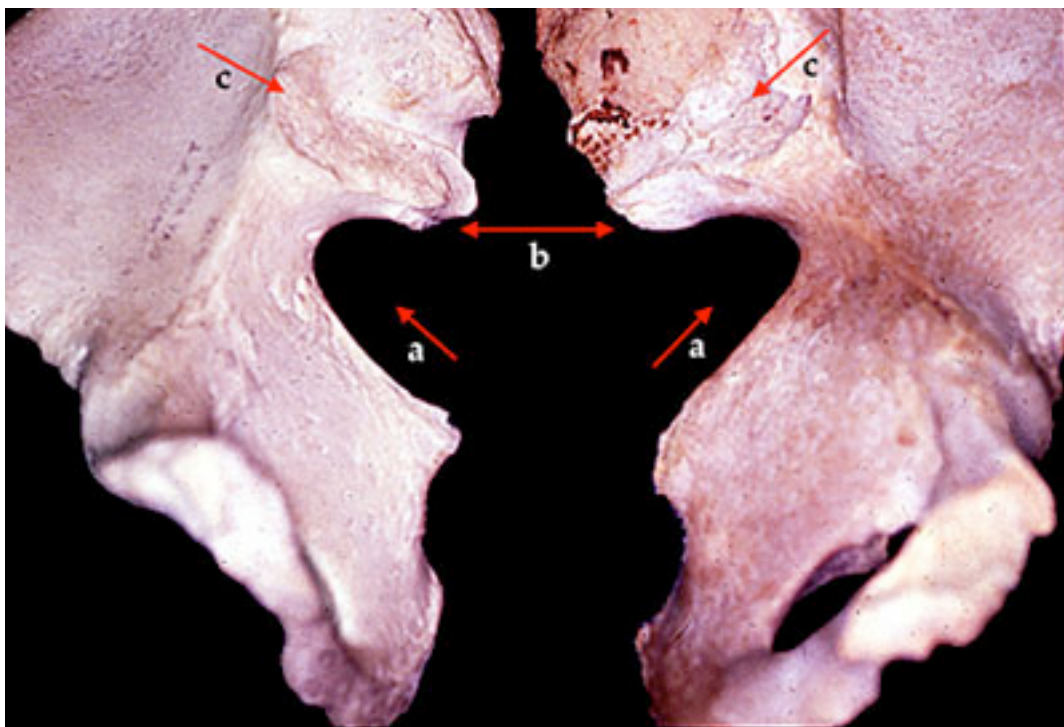
The sciatic notch on the left is female

The acetabulum (hip socket) in the male is larger (averaging 52 mm in diameter, whereas in females it averages 46 mm) and is more lateral in its location, whereas in the female it is smaller and located more anterior (antero-lateral).
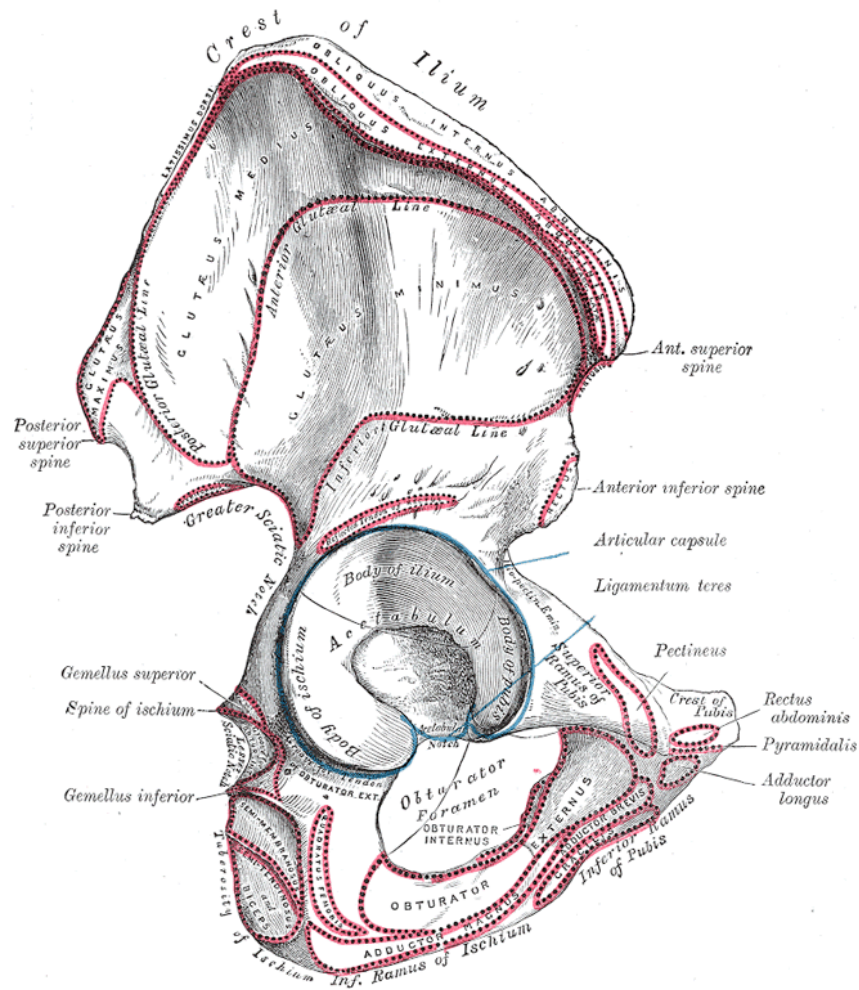
The acetabulum in a male

The obturator foramen is more ovoid in the male, but triangular in the female; the pre-auricular sulcus, which serves for the attachment of the anterior sacroiliac ligament, lies just lateral to the sacroiliac joint and is well defined in females, but virtually absent in males.

In the male the pelvic inlet is small with a long antero-posterior axis, appearing heart-shaped due to the protrusion of the sacrum into the posterior brim. In the female it is relatively large with a long transverse axis appearing more circular.
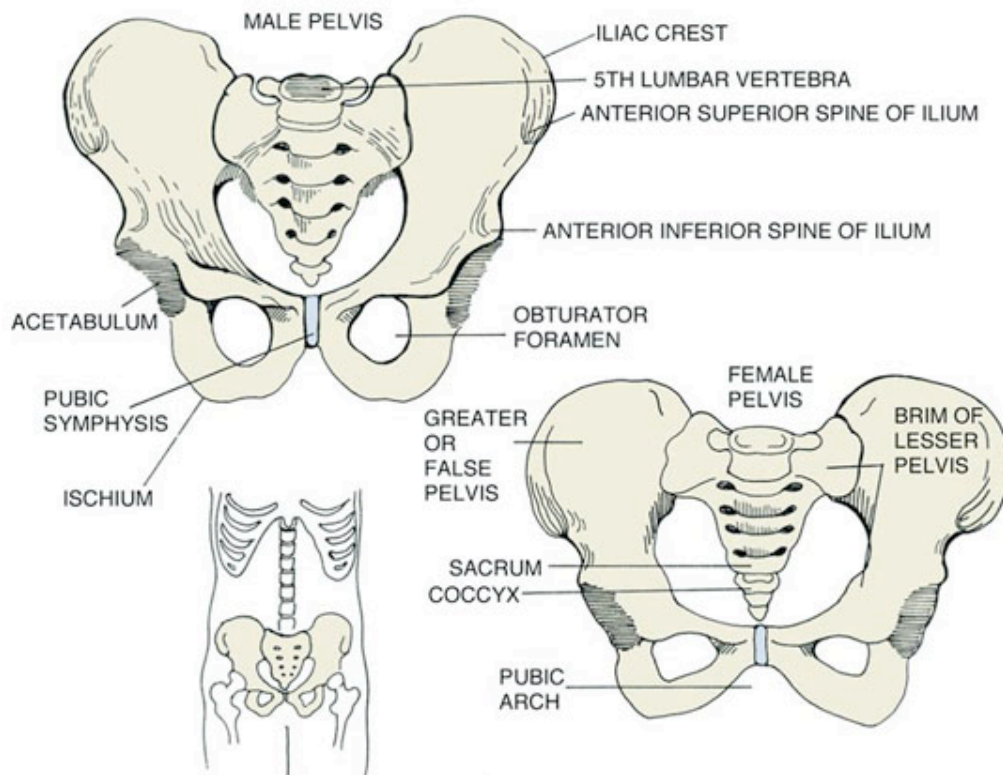
The sacrum in the male is typically longer, narrower and has a more evenly distributed continuous curve down the whole bone, sometimes with a slight forward projection of the coccyx as compared to the female. In females the sacrum is shorter, broader with a prominent curve between S1-2 and S3-5. Also, the superior articular surface in males is larger than that of females. The male sacrum may have more than five segments, which is rare in the female. Comparing the transverse diameter of the first sacral vertebra (CW) with that of the base of the sacrum (BW) by utilizing the formula CW x 100/BW shows he male to have an average of 45 and the female 40.

The above pictures are of a male sacrum. The left is the dorsal or posterior view and the right is the ventral or anterior view.

The above pictures are of a female sacrum. The left is the dorsal or posterior view and the right is the ventral or anterior view.

The pelvic cavity in males is relatively narrow and deep, whereas in females it is wide and shallow. The length of the ilium is greater than its height making it to appear more vertical in the male, whereas in the female the ilium appears to be lower and to flare outward. The pubic symphysis is higher in the males as compared to the female.
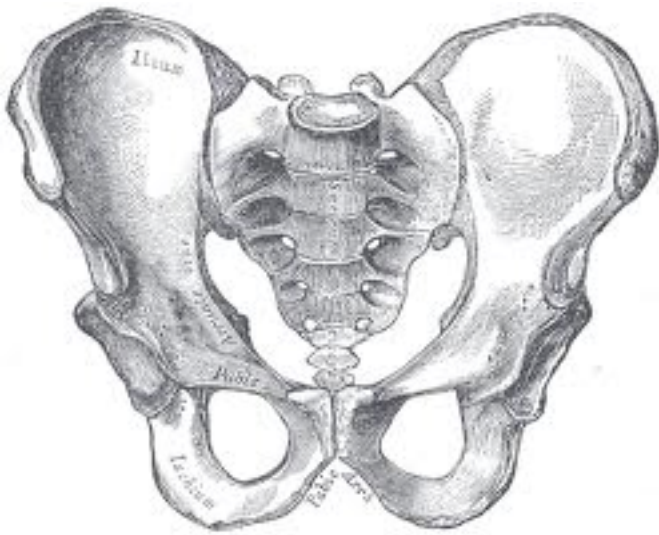
The above left picture is from a male pelvis showing the substantive length as compared to its height. The above right is from a female pelvis showing the lowered and flared appearance.

Sex can also be determined by using the bones of the skull, which have an accuracy of 85%. There are some general features of the skull, which are very helpful in determining the sex of the skeletal remains: a large skull is typically male, and a small skull is generally female; the cranial capacity in the male skull is generally 200 cc greater than the female; the female skull is usually rounder than the male.
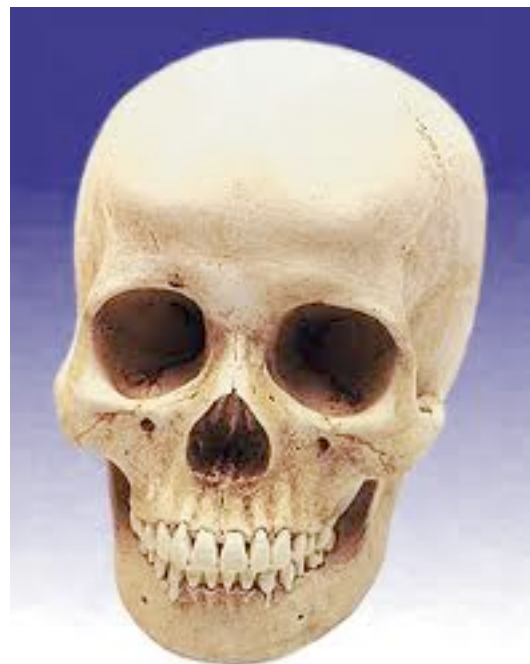
The skull on the left is that of an adult male, whereas that on the right is an adult female. In the male the frontal bones forming the forehead (squamosal portion of the frontal bones) is more slanted, whereas in the female it is more rounded or globular and smoother. The frontal and parietal eminences are in general more prominent in the female skulls; examination of the zygomatic process will show that the posterior ridge projects back beyond the external auditory meatus in the male skull, also the zygomatic arches bow outward more than the female, where they remain more medial. The supraorbital ridges are more pronounced and strongly developed in males, whereas in females they are far less developed often appearing only as a trace. The orbits are higher, more rounded and relatively larger with sharp orbital margins in the females. The male has rounded orbital margins. The glabella (the somewhat rounded swelling above the root of the nose) in males are more massive in the males.

Craniometric Points, Frontal View

bregma

glabella

nasion

frontale

euryon

ectoconchion

orbitale

zygion

alare

nasospinale

gonion

pogonion
gnathion

Craniometric Points, Lateral View
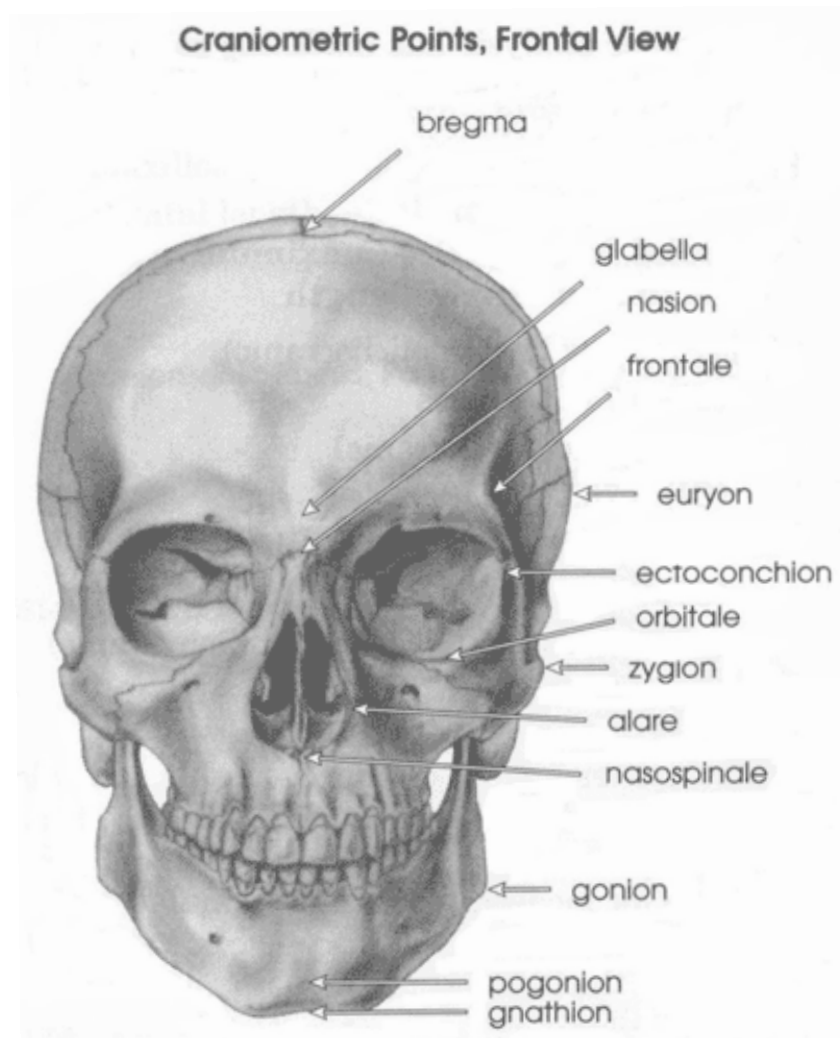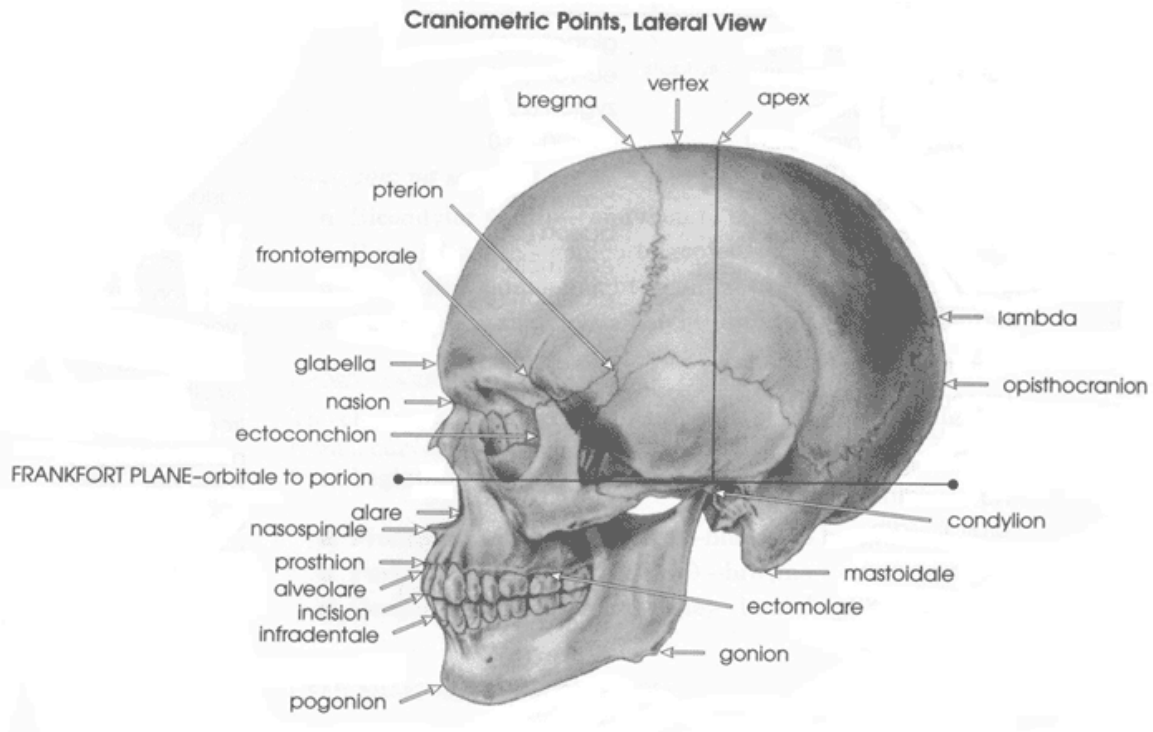
The maxillary bones (check bones) in males are more massive whereas in females they are slender. The nasal aperture in the male is higher and narrower and its margins are sharp rather then rounded. Also, the nasal bones are larger and meet in the midline at a sharper angle. The mastoid process (located behind each ear lobe or opening of the external ear canal are larger in the male. In the back of the head (occipital region) is typically smooth in the female. Also, in the midline of the occipital region is a bony prominence, external occipital protuberance, which is far more prominent in males. The mandible in the male is larger and thicker, with greater body height, especially at the symphysis, and a broader ascending ramus. The angle formed by the body and ramus is less obtuse, i.e. under 125 degrees. The condyles are larger and the chin is square.

The upper image is a female mandible and the lower a male mandible.

The palate is typically larger and broader in the male.

condylar process

coronoid process

submandibular fossa

mandibular foramen

sublingual fossa

alveolar process

mental foramen

mental protuberance (chin)

ramus

body

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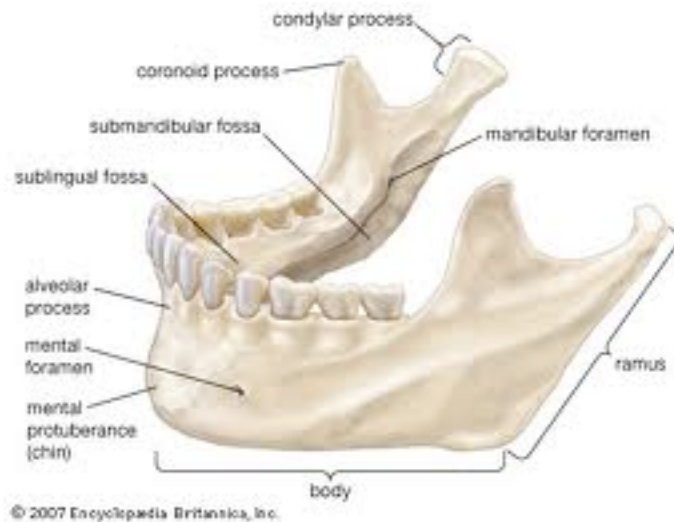
The shape of the male arch is more of a U, whereas the female is more parabolic.

Mouth (Oral Cavity)

Gingiva (gums)

Hard palate

Uvula

Papillae of tongue

Premolar

Canine

Incisor

Lips

Soft palate

Palatine tonsil

Molars

Tongue
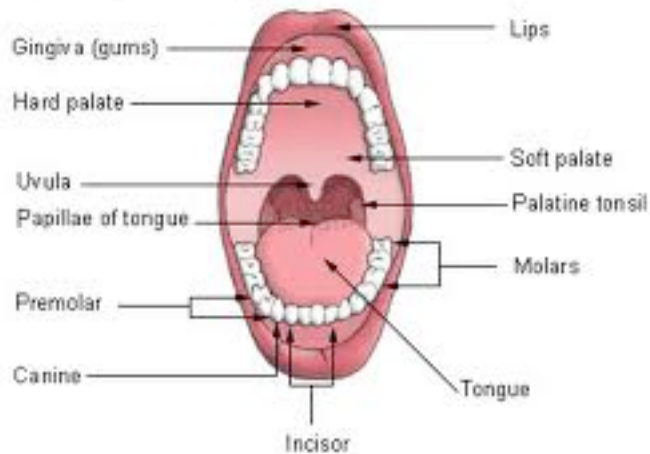
The base of the skull has larger occipital condyles, a larger foramen magnum and typically larger foramina in males. Also, the basilar portion of the occiput and the body of the sphenoid are longer in the male.

Other bones that can be used to determine sex are the sternum, scapula and femur.
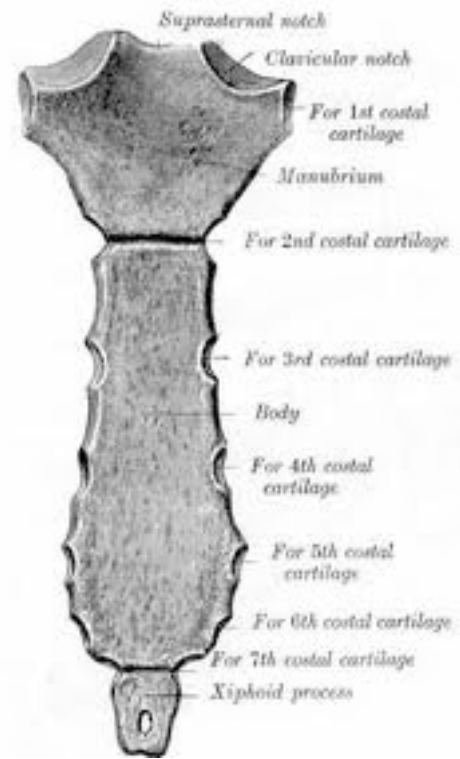
As has already been pointed out the sternum is divided into two major parts, the upper half, the manubrium and the lower, the body, which comprises much of the sternum. The body in males is at least twice the length of the manubrium. It is less than this in females.
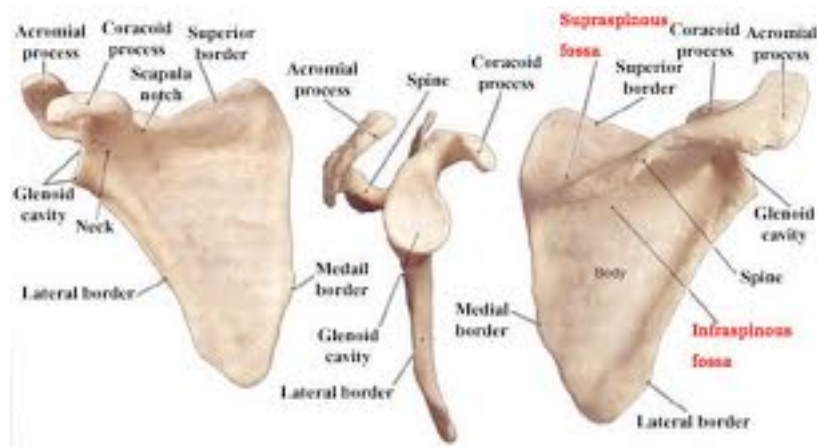
These illustrations are from a male.

Stewart and McCormick using a radiographic technique determined that if the sternum is less than 122 mm it is female, when over 173 mm it is male.

The scapula in males will generally have a deep supra-scapular notch. That of the female is more shallow. The vertical diameter of the glenoid cavity in females is less

than 36 mm, in males it is greater according to Dwight. In males the height of the scapula is typically greater than 157 mm, whereas in females it is less than 144 mm.

Of the long bones it is the femur, which is most commonly used for sex determination. The femur in males is larger and heavier than in females. The angle of the neck to the shaft is greater in females. Lastly, if the head diameter is less than 46 mm it is generally female. Pearson and Bell using the vertical diameter of the femoral head have indicated the male is typically greater than 45 mm and the female is less than 41 mm. The angle formed by the neck of the femur with its shaft (the collodiaphyseal angle) is less than 40 degrees in the male and greater than 50 degrees in the female. The maximum oblique length of the femur in males according to Brash is approximately 459 mm, whereas in females it is 426 mm. However, Pearson and Bell give values for men of 447 mm and 409 mm for females.
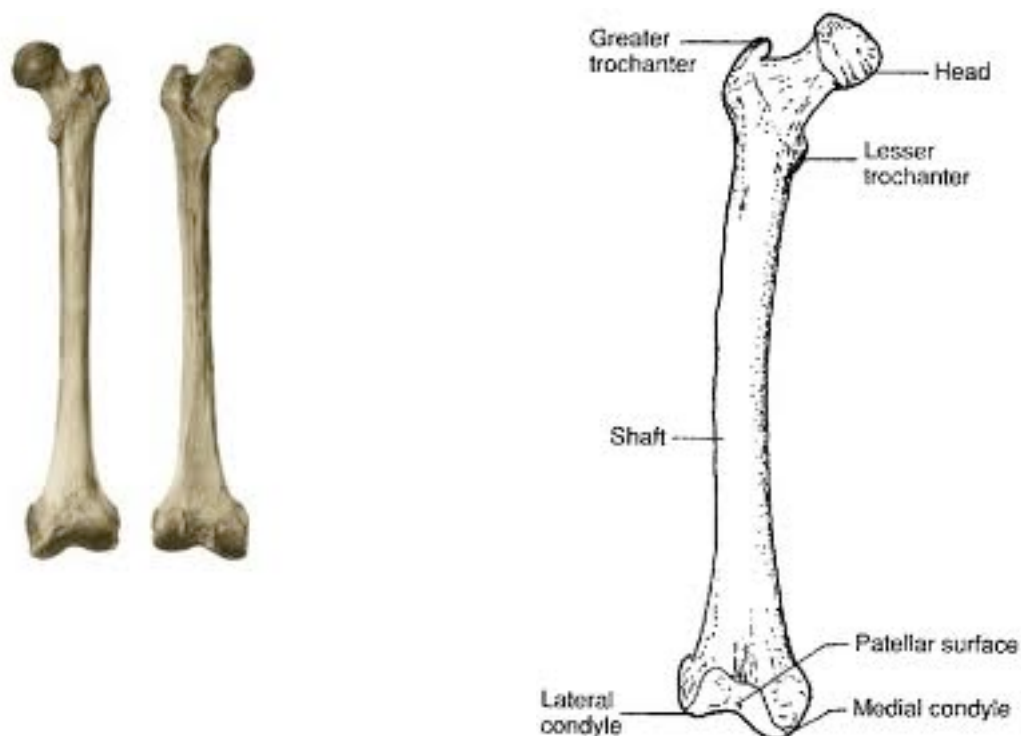
The femur on the left is that from a female, whereas that on the right is from a male.

The humerus, radium and ulna typically are not used for sex determination. However, on occasion you may find perforations of the olecranon fossa of the distal end of the humerus, which occurs more commonly in females than males and usually on the left side.

2. Race

There are three major biologic divisions of humans: Caucasoid (white, anglo, etc.), Negroid (Black, etc.), and Mongoloid. Racial differences in the skeleton are best determined from examination of the skull. The long bones of the extremities can also be helpful. However, it should be borne in mind that although in the last 10,000 years there has been increasingly stable large populations, i.e. caucasoid, negroid and mongoloid there has also been considerable interbreeding such that individual variations can reach a point in which it is virtually impossible to determine the race of the skeletal remains.

The wide zygomatic arches which give the high bone features of the mongoloid race may also produce a transverse facial width, which is greater than the width of any other part of the head.

There is a feature of the skull of blacks that is not always present, but when it is it strongly suggest black race, and that is the presence of deep grooves on the nasal floor (sill) on either side of the nasal septum

The femur in blacks is generally straighter, the anteroposterior bowing being less than those of caucasoids or mongoloids. Blacks long bones in general are longer than those of caucasians or mongloids.

The following are the major differences in the races seen in the respective skulls. You will also note the caucasoid (white) is further subdivided into Nordic (north european), Alpine (central european) and mediterranean (south european).

Character	nordic	alpine	mediterranean	mongoloid	black
	caucasoid			mongoloid	black
Skull length	long	short	long	short	long
Skull breadth	narrow	broad	narrow	broad	narrow
Skull height	high	high	moderate h	middle	low
Sagittal contour	rounded	arched	rounded	arched	flat
Face breadth	narrow	wide	narrow	very wide	narrow
Face height	high	high	moderate h	high	low
Orbital opening	angular	round	angular	rounded	rectangular
Nasal opening	narrow	moderately wide	narrow	narrow	wide
Lower nasal margin	sharp	sharp	sharp	sharp	troughed or guttered
Nasal profile		straight		slanted down	straight
Molar bone		curved		curved	at right angles
Upper incisors		smooth		smooth	shovel-shaped
Bony browridges		well developed		faint	faint
Prognathism		rare		present	low frequency
Facial profile	straight	straight	straight	straight	downward slant
Palate shape	narrow	moderately w	narrow	moderately w	wide

Although, not a skeletal feature, head hair is often found with skeletonized remains, which can serve as an indicator of race.

The hair of the blacks is very tightly coiled and black. The diameter of the individual hair is the lowest of the three races, usually about 50 microns.

The hair of the mongoloids is black and straight and is the widest of the three races, typically 100 microns and greater.

The hair of caucasoids has a wide range of color and form. Its diameter is between the blacks and mongoloids, ranging from 70 to 90 microns.

3. Age at the Time of death

For the fetus and the young infant, Forensic dentists, through the utilization of x-rays can reasonably estimate age from 13 to 16 weeks in utero through 14 years of age, when calcification of the permanent second molar usually occurs. Kraus and Jordan published a textbook, "The Human Dentition Before Birth," in 1965. One of the tables listed in this book is entitled, "The Calcification of the Deciduous Dentition," which is as follows:

Deciduous Tooth	Hard Tissue Formation Begins (Fertilization Age in Utero, Weeks)	Amount of Enamel Formed at Birth	Enamel Completed (Months After BIrth)	Root Completed (Year)
Maxillary				
central incisor	14 (13-16)	Five-sixths	1½	1½
lateral incisor	16 (14⅔-16½)	Two-thirds	2½	2
canine	17 (15-18)	One-third	9	3¼
first molar	15 (14½-17)	Cusps united; occlusal complete calcification plus ½ to ¾ crown height	6	2½
second molar	19 (16-23½)	Cusps united; occlusal incompletely calcified; calcified tissue covers one-fifth to ¼ crown height	11	3
Mandibular				
central incisor	14 (13-16)	Three-fifths	2½	1½
lateral incisor	16 (14⅔-?)	Three-fifths	3	1½
canine	17 (16-?)	One-third	9	3¼
first molar	15 (14½-17)	Cusps united; occlusal completely calcified	5½	2¼
second molar	18 (17-19)	Cusps united; occlusal incompletely calcified	10	3

Typically, fetal and neonatal age are accomplished through examination of the body rather than skeletal remains. This is primarily due to the fact that skeletal remains of the fetus, neonate, and infant are usually difficult to find or are destroyed early.

In infants and young children the primary dating indices are the appearance of ossification centers in developing cartilage. However, these are rarely identifiable due to the fact they are rarely found in dried skeletal remains since cartilage disintegrates within weeks or months and the ossification centers in the diaphyses and epiphyses seldom remain. As always radiologic examination is your best bet to develop whatever information is still available.

The methodology for determination of the age of skeletal remains in the older child and young adult is no different than for the fetus, infant and young child.

In 1969 Olivier published the following tables on permanent tooth eruption.

Males

Maxillary teeth	French Authors	Anglo-Saxon Authors
central incisors	7 yr. 2 m. 13 d. ± 11 m. (4¾ - 9¼)	7.45 ± 0.755
lateral incisors	8 yr. 4 m. 12 d. ± 1 yr. (6¼ - 11)	8.67 ± 0.817
canine	11 yr. 1 m. 23 d. ± 1 yr. 2 m. (8¼ - 13¾)	11.68 ± 1.178
first premolar	10 yr. 7 m. 6 d. ± 1 yr. 6 m. (7½ - 13¾)	10.50 ± 1.426
second premolar	11 yr. 4 m. 12 d. ± 1 yr. 4 m. (8¼ - 14)	11.40 ± 1.473
first molar	6 yr. 4 m. 1 d. ± 0 yr. 10 m. (4¾ - 8¾)	6.51 ± 0.657
second molar	12 yr. 6 m. 1 d. ± 1 yr. 3 m. (9¼ - 15)	12.58 ± 1.141

Mandibular teeth		
central incisors	6 yr. 3 m. 23 d. ± 0 yr. (4¾ - 8¼)	6.51 ± 0.629
lateral incisors	7 yr. 4 m. 20 d. ± 0 yr. (5½ - 9¼)	7.83 ± 0.738
canine	10 yr. 8 m 28 d. ± 1 yr. 2 m. (7¾ -13¼)	10.76 ± 1.183
first premolar	10 yr. 9 m. 29 d. ± 1 yr. 5m. (7½ - 13½)	11.11 ± 1377
second premolar	11 yr. 6 m. 8 d. ± 1 yr. 3 m. (8¼ - 14)	11.52 ± 1.515
first molar	6 yr. 3 m. 26 d. ± 0 yr. 9 m. (4¼ - 8½)	6.40 ± 0.705
second molar	12 yr. 0 m. 7 d. ± 1 yr. 3 m. 7 d (9-14½)	11.99 ± 1.133

Females

Maxillary teeth	French Authors	Anglo-Saxon Authors
central incisors	7 yr. 0 m. 0 d. ± 0 yr. 9 m. (5¼ - 8¾)	7.14 ± 0.729
lateral incisors	7 yr. 11 m. 14 d. ± 0 yr. 11 m. (6 - 10¼)	8.25 ± 0.912
canine	10 yr. 6 m. 1 d. ± 1 yr. 1 m. (8 -13¼)	11.03 ± 1.153
first premolar	10 yr. 1 m. 8 d. ± 1 yr. 3 m. (7½ - 13¼)	10.12 ± 1.234
second premolar	10 yr. 8 m. 7 d. ± 1 yr. 5 m. (7¾ - 14)	11.10 ± 1.484
first molar	6 yr. 3 m. 15 d. ± 0 yr. 10 m. (4¼ - 8½)	6.38 ± 0.760
second molar	11yr. 11 m. 26 d. ± 1 yr. 2 m. (9½ -15)	12.13 ± 1.142

Mandibular teeth		
central incisors	6 yr. 2 m. 23 d. ± 0 yr. 8 m. (4½ - 8)	6.20 ± 0.555
lateral incisors	7 yr. 1 m. 8 d. ± 0 yr. 9 m. (5 -8¾)	7.44 ± 0.786
canine	9 yr. 8 m. 10 d. ± 1 yr. 2 m. (7 -12½)	9.84 ± 1,010
first premolar	10 yr. 0 m. 3 d. ± 1 yr. 4 m. (6¾ - 13½)	10.44 ± 1.306
second premolar	10 yr. 11 m. 27 d. ± 1 yr. 4 m. (7¾ - 14½)	11.375 ± 1.535
first molar	6 yr. 2 m. 22 d. ± 0 yr. 11 m. (4¼ - 8¾)	6.08 ± 0.669
second molar	11 yr. 6 m. 10 d. ± 1 yr. 4 m. (8¾ - 14¾)	11.57 ± 1.120

An understanding of the time of appearance of major ossification centers is very helpful in the determination of skeletal age in the child and young adult. The appearance of ossification centers is typically completed around 5 years of age. From the period of 5 years of age up to approximately 25 years of age the fusion of the epiphyses is utilized for age determination. Bernard Knight and Pekka Saukko pointed out there are some general points that need to be kept in mind when determining the age of skeletal remains:

1. The age of skeletal remains are affected by sex, race and nutrition of the deceased. Also, maturity of the deceased is not synonymous with the calendar age.

2. Female skeletal remains are almost always in advance of males of the same age, race, nutrition level and geographic location. Maturity tends to be more advanced in those who live in the hotter climates.

3. There are substantive variations in epiphyseal closure dates. Epiphyseal union occurs over a period of time and not all at once. As an example, epiphyseal union of the medial end of the clavicle occurs typically over a period of time ranging from 18 to 30 years.

McKern and Stewart developed a table on the appearance of major ossification centers.

Those for caucasian boys are as follows:

Birth	12 months	20 months	3 years, 1 month
Calcaneus	Second finger-1st phalanx	First toe-first phalanx	Femur, great trochanter
Talus	Fourth finger-first phalanx	Middle cuneiform	Patella
Femur, distal	First finger-second phalanx		
Tibia, proximal		21 months	3 years, 3 months
		Third finger-3rd. ph.	Fourth metatarsal
Cuboid	13 months	Fourth finger-3rd. ph.	
Humerus,	Third toe-first phalanx	Navicular of foot	3 years, 4 months
head	second metacarpal	Fifth toe-first phalanx	Fifth toe-third phalanx
	medial cuneform		
2 months			3 years, 7 months
Capitate			Third toe-third phalanx
Hamate	14 months	22 months	Fourth toe-third phalanx
Lateral	Fourth toe-first phalanx	First metacarpal	
cuneiform	Second toe-first phalanx	First metatarsal	3 years, 8 months
	Firth toe-second phalanx		Fifth metatarsal
3 months		23 months	Second finger-3rd. ph.
Femur, head		First finger-1st. ph.	
Capitulum			
Tibia, distal	15 months		3 years, 10 months
	Third metacarpal	2 years	Radius, proximal
	Second toe-2nd. phalanx	Fifth finger-2nd. ph.	
6 months	Fifth finger-first phalanx	Lunate	4 years, 2 months
Fibula, distal			Multangulate majus
7 months	16 months	2 years, 2 months	4 years, 4 months
Humerus,	Fourth toe-2nd. phalanx	Second metatarsal	Navicular, hand
greater tuber.	Fourth metacarpal		
Radius, distal		2 years, 5 months	4 years, 8 months
		Second finger-3rd. ph.	Multangulate minus
10 months	18 months	Fifth finger-third ph.	
Triquetrum	Second finger-2nd. ph.		5 years+
	Third finger-second ph.	2 years, 11 months	Humerus, medial epicon
11 months	Fourth finger-2nd. ph.	Third metatarsal	Ulna, distal
3rd. fin.-1st p	Firth metacarpal	Fibula, proximal	Fifth toe-second phalan
First toe-2nd			
phalanx			

Those for caucasian girls are as follows:

Birth	8 months	14 months	2 years
Calcaneus	Second finger-1st. ph	First metacarpal	Lunate
Talus	First finger-2nd phalanx	First toe-first phalanx	Third toe-3rd ph.
Femur, distal	Third toe-first phalanx	Fifth finger-1st. ph.	Fourth toe-3rd ph.
Tibia, proximal		Third finger-3rd. ph.	Fibula, proximal
Cuboid	9 months	Fourth finger-3rd. ph.	Femur, greater troch
Humerus,	Third toe-2nd-phalanx	Navicular of foot	
head	Fourth toe-1st-phalanx	Middle cuneform	2 years, 2 months
	Medial cuneiform	First metatarsal	Second toe-3rd ph.
2 months			Fourth metatarsal
Capitate			
Hamate	10 months	15 months	2 years, 5 months
Lateral	Second metacarpal	First finger-1st ph.	Fifth metatarsal
cuneiform	Second toe-2nd ph.	Fifth finger-2nd ph.	
	Fourth toe-2nd ph.		2 years, 8 mons.
3 months	Third metacarpal	17 months	Multangulate maj
Femur, head	Second toe-1st. ph.	Second finger-3rd ph.	
Capitulum	Triquetrum	Fifth finger-third ph.	2 years, 9 mons.
Tibia, distal			Humerus, medial
			epicondyle
4 months	11 months	19 months	3 years
Humerus,	Fourth metacarpal	Second metarsal	Radius, proximal
greater tub.	Fifth finger-1st. ph.		Multangulate
			minus
6 months	12 months	21 months	3 years, 2 months
Fibula, distal	Fourth finger-2nd. ph.	Fifth toe-3rd ph.	Navicular, hand
Radius, dist.	Third finger-2nd. ph.		
		22 months	4 years, 6 months
7 months	13 months		
1st toe-2nd p	Fifth metacarpal	23 months	5 years
3rd fin-1st p	Second finger-2nd. ph	Patella	Fifth toe-second ph.
4th finger-			
first phalanx			

Some advocate that the best indicator of age determination of skeletal remains from birth to the early teen is through radiological examination of the wrist. As has already been indicated, there are eight small bones in the wrist called the carpals. None of these are present at birth. The sequence of their appearance is also quite regular. A

radiologist can be most helpful in this regard. In actuality, age determination through examination of the carpal bones is more accurate than examination of tooth eruption sequence.

Examination of epiphyseal closure of long bones is used for the determination of the age of skeletal remains extending from the mid-teens to the early twenties. As previously indicated the beginning epiphyseal closure to its completion takes several years. The following table is from Bernard Knight and Pekka Saukko and depicts the age of epiphyseal closure in years, in male subjects, in non-tropical climates. For the female one must deduct one to two years as females mature earlier than males. There are two dates given, the former represents the beginning of closure, which begins in the middle of the epiphyseal plate, and the latter represents the completion of the closure.

Head of femur	16-19	Acromion	17-19
Greater trochanter	16-19	Distal femur	17-20
Lesser trochanter	16-19	Proximal tibia	17-19
Head of humerus	16-23	Proximal fibula	16-21
Distal humerus	13-16	Distal tibia	16-19
Medial epicondyle	16-17	Distal fibula	16-19
Proximal radius	14-17	Metatarsals	15-17
Proximal ulna	14-17	Iliac crest	18-22
Distal radius	18-21	Primary elements pelvis	14-16
Distal ulna	18-21	Sternal clavicle	23-28
Metacarpals	14-17	Acromial clavicle	18-21

Skeletal aging in the later years is not nearly as finite as skeletal aging in the child and the young adult. From approximately 25 years until old age, there are no dramatic events such as tooth eruption or the appearance of ossification centers. There are three anatomical structures which are used in this period of life for aging, the pubic symphysis, sternal ribs and skull sutures.

The right and left hip-bones (innominate bones) meet in the midline in front to form the pubic symphysis. It should be understood the right and left pubic bones do not actually articulate: they are separated throughout life by the symphyseal cartilage. Each pubic bone presents a symphyseal surface or face, which Todd described in 1920 as a

"modified diaphyso-epiphyseal plane and, as such, may be expected to show a meta-morphosis, if not actual growth, as an age feature."

There were three major contributors in evaluating the role of the pubic symphysis as an age indicator: Todd (Studies I-VIII, '20-'30); Brooks ('55); McKern and Stewart ('57). The methodology primarily used today is that of McKern and Stewart, who after studying the methodology of Todd and Brooks, divided the face of the symphysis to be analysed into three components. Component I is the dorsal half of the face, component II is the ventral half and component III is represented by the whole surface as it is in relation to the dorsal and ventral components. Each of these components is then divided into five developmental stages as follows:

I. Dorsal Plateau

  0. Dorsal margin absent.

  1. A slight margin formation first appears in the middle third of the dorsal border.

  2. The dorsal margin extends along entire dorsal border.

  3. Filling in of grooves and resorption of ridges to form a beginning plateau in the middle third of the dorsal demi-face.

  4. The plateau still exhibiting vestiges of billowing extends over most of the dorsal demi-face.

  5. Billowing disappears completely and the surface of the entire demi-face becomes flat and slightly granulated.

II. Ventral Rampart

  0. Ventral beveling is absent.

  1. Ventral beveling is present only at superior extremity of ventral border.

  2. Beveling extends inferiorly along ventral border.

  3. The ventral rampart begins by means of bony extensions from either or both extremities.

  4. The rampart is extensive but gaps are still evident along the earlier ventral border, most evident in the upper two-thirds.

  5. The rampart is complete.

III. Symphyseal Rim

0. The symphysial rim is absent.

1. A partial dorsal rim is present, usually at the superior end of the dorsal margin, it is round and smooth in texture and elevated above the symphysial surface.

2. The dorsal rim is complete and the ventral rim is beginning to form. There is no particular beginning site.

3. The symphysial rim is complete. The enclosed symphysial surface is finely grained in texture and irregular or undulating in appearance.

4. The rim begins to break down. The face becomes smooth and flat and the rim is no longer round but sharply defined. There is some evidence of lipping on the ventral edge.

5. Further breakdown of the rim (especially along superior, ventral edge) and rarefaction of the symphysial face. There is also disintegration and erratic ossification along the ventral rim.22

COMPONENT II

II-1 II-2 II-3 II-4 II-5
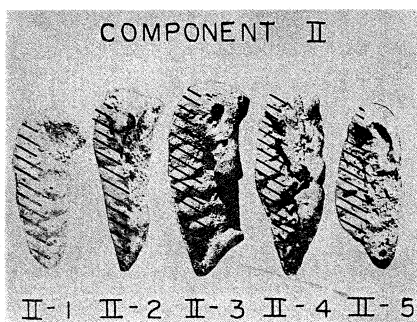
The above image represents the five active stages of Component II

Pragmatically, a three figure score is made from an evaluation of each Component. Another way of expressing this is the components and their stages are used to give a total score, which could range from 0 to 15. If all three Components are stage 0, the score is 0; if Component I is in stage 2, Component II in stage 2, and Component III in stage III, the score is 7; and so on. Going to the appropriate table the age is between 20-24

With the basic work of Todd and the refinements introduced by Brooks and by McKern and Stewart, the pubic symphysis takes its place as the most reliable indicator of age in this age group. However, even utilizing this methodology, the assessment of age within this age group is at best within the nearest half-decade even when applied by an experienced anthropologist. It also must be understood that this methodology applies only to males and not females. This is due to the fact that there is a risk of overestimation of age in females due to the physical trauma during parturition, which could deform the dorsal border of the symphysis thus mimicking age changes.

There is another limitation to this method, and that it extends through the fifth decade only.

By itself the pubic symphysis registers age in five year intervals. In correlation with other parts of the skeleton, it should facilitate aging in five year intervals, especially in the third and fourth decades of life. In these decades, using the pubic symphysis and other parts of the skeleton you may be able to determine the age of the skeletal remains plus or minus two years.

There have been many attempts to utilize suture closure of the skull to determine age. If you remember the bones of the skull are separated by sutures, which in a sense, are analogous to epiphyseo-diaphyseal planes in that both are loci of growth, and that both have a sequence and timing of union. Just as epiphyseo-diaphyseal union most frequently begins centrally and proceeds peripherally, so does suture closure begin endocranially and proceed ectocranially, i.e., it begins inside the skull and and progresses to the outside. There is a difference, however, epiphyseal union is always complete in normal cases (with the possible exception of the ramal epiphysis of the

ischium), whereas suture closure may be incomplete (so-called "lapsed union,") in perfectly normal, healthy individuals.

"Lapsed union is characteristic of all ectocranial sutures, As a consequence, ectocranial sutures tend to remain in a state of incomplete union, some in a very high degree." What is "lapsed union?" As the term implies it is incomplete union in the sense that a process once begun has not gone on to completion. The cranial vault bones have a very unique structure: they have two layers, an inner table and an outer table, separated by a vascular spongy-bone space (the diploë). The impetus to closure is from the inner table to the outer, i.e., endocranial to ectocranial.

There is an important aspect of this closure that must be remembered and that is ectocranial suture closure is so variable that it should not be used as the final determinate of whether the suture is closed or not. If you are going to attempt to use suture closure as part of your determination of age, always use endocranial closure. It should be understood that the progress of suture closure "has only a very general relationship with age. So erratic is the onset and progress of closure that an adequate series will provide just about any pattern at any age level. Thus, as a guide for age determination, such a trend is of little use. In other words, suture closure, as either a direct or supportive evidence for skeletal age identification, is generally unreliable." In the last analysis, "if other aging areas of the skeleton are absent, then crude estimates can be made in terms of decades only." To give you an example of the danger of relying upon a single aging criteria utilizing closure of a skull suture, in 1960 Genovese and Moss examined a prehistoric skull (about 8,000 to 10,000 years old) excavated at Tepexpan, Mexico. The anthropologist who initially analyzed the skull assigned an age at the time of death of 55 to 65 years based mainly on determination of a skull suture closure. When the skull was restudied on a comparative basis, and when radiographic studies of the teeth were added, an age no greater than 25 to 30 years was determined. There is another issue that needs to be mentioned and that is the premature closure of one or more sutures. There are two terms you need to be cognizant of: precocious closure, which is closure before age of seven (the age at which cranial growth is about 95% complete); premature closure, which is closure after the age of seven, but considerably before the usual or "normal" age of closure.

In summary, due to the phenomenon of "lapsed union" ectocranially, the state of endocranial closure must take precedence in any evaluation of suture-age. Estimation of age of the skull via suture closure is not reliable. Many anthropologist believe it is best to place a skull in a decade, for example in the 20's or 30's, or at a decade mid-point, as 25-35, 35-45, and so on. If the skull is the only part present then this sort of age evaluation is the best you can do. If other bones are present, then suture age may become, at best, partially corroborative.

4. **Stature**

In the estimation of stature it is not uncommon for the non-anthropologist to either over-estimate or underestimate stature. The first published formal tables was in 1888 by Rollet. He utilized the humerus, radius, ulna, femur, tibia, and fibula of 50 male and 50 female French cadavers. The bones were first measured in the "fresh state," and 10 months later in the "dry state; in this time they had lost two mm. in over-all length. In 1892-93, Manouvrier re-assessed Rollet's data, but he excluded all subjects (26 male, 25 female) over 60 years of age, believing that some 3 cm. of calculated stature had been lost. In 1899, Pearson, using Rollet's data, developed another set of regression formulas, based on the bones of the right side only.

During this period the anthropologists held an international meeting at Geneva, Switzerland. From this meeting emerged the "Geneva Agreement": "For the reconstruction of the stature with the aid of the long bones, the maximum length shall be measured in alls case, save in those of the femur, which is to be measured in the oblique position, and the tibia, which is also to be measured in an oblique position, the spine being excluded." This has not always been followed in the many different tables that have been developed.

In 1958, Trotter and Gleser re-evaluated the entire problem of skeletal reconstruction from long bones. The skeletal material was from casualties of the Korean War. Here, larger series of whites and Blacks were available, plus a small series of Mongoloids, Mexicans, and Puerto Ricans. The regression formulae for American white, American Negro, males and females and Mongoloid, and Mexican males are as follows:

Male Caucasoids

stature = 63.05 + 1.31 (femur + fibula)   ± 3.63 cm.
    = 67.09 + 1.26 (femur + tibia)   ± 3.74 cm.
    = 75.50 + 2.60 (fibula)   ± 3.86 cm.
    = 65.53 + 2.32 (femur)   ± 3.94 cm.
    = 81.93 + 2.42 (tibia)   ± 4.00 cm.
    = 67.97 + 1.82 (humerus + radius) ± 4.31 cm.
    = 66.98 + 1.78 (humerus + ulna) ± 4.37 cm.
    = 78.10 + 2.89 (humerus)   ± 4.57 cm.
    = 79.42 + 3.79 (radius)   ± 4.66 cm.
    = 75.55 + 3.76 (ulna)   ± 4.72 cm.

Female Caucasoids

stature = 50.12 + 0.68 (humerus) + 1.17 (femur) + 1.15 (tibia) ± 3.51 cm.
    = 53.20 + 1.39 (femur + tibia)   ± 3.55 cm.
    = 53.07 + 1.48 (femur) + 1.28 (tibia)   ± 3.55 cm.
    = 59.61 + 2.93 (fibula)   ± 3.57 cm.
    = 61.53 + 2.90 (tibia)   ± 3.66 cm.
    = 52.77 + 1.35 (humerus) + 1.95 (tibia)   ± 3.67 cm.
    = 54.10 + 2.47 (femur)   ± 3.72 cm.
    = 54.93 + 4.74 (radius)   ± 4.24 cm.
    = 57.76 + 4.27 (ulna)   ± 4.30 cm.
    = 57.97 + 3.36 (humerus)   ± 4.45 cm.

Male Blacks

stature = 67.77 + 1.20 (femur + fibula)   ± 3.63 cm.
    = 71.75 + 1.15 (femur + tibia)   ± 3.68 cm.
    = 72.22 + 2.10 (femur)   ± 3.91 cm.
    = 85.36 + 2.19 (tibia)   ± 3.96 cm.
    = 80.07 + 2.34 (fibula)   ± 4.02 cm.
    = 73.08 + 1.66 (humerus + radius)   ± 4.18 cm.
    = 70.67 + 1.65 (humerus + ulna)   ± 4.23 cm.
    = 75.48 + 2.88 (humerus)   ± 4.23 cm.
    = 85.43 + 3.32 (radius)   ± 4,57 cm.
    = 82.77 + 3.20 (ulna)   ± 4.74 cm.

Female Blacks

stature = 56,33 + 0.44 (humerus) - 0.20 (radius) + 1.46 (femur) + 0.86 (tibia) ± 3.22
= 58.54 + 1.53 (femur) + 0.96 (tibia)   ± 3.23 cm.
= 59.72 + 1.26 (femur + tibia)   ± 3.28 cm.
= 59.76 + 2.28 (femur)   ± 3.41 cm.
= 62.80 + 1.08 (humerus) + 1.79 (tibia)   ± 3.58 cm.
= 72.65 + 2.45 (tibia)   ± 3.70 cm.
= 70.90 + 2.49 (fibula)   ± 3.80 cm.
= 64.67 + 3.08 (humerus)   ± 4.25 cm.
= 75.38 + 3.31 (ulna)   ± 4.83 cm.
= 94.51 + 2.75 (radius)   ± 5.05 cm.

Male Mongoloids

stature = 70.24 + 1.22 (femur + fibula)   ± 3.18 cm.
= 70.37 + 1.22 (femur + tibia)   ± 3.24 cm.
= 80.56 + 2.40 (fibula)   ± 3.24 cm.
= 81.45 + 2.39 (tibia)   ± 3.27 cm.
= 72.57 + 2.15 (femur)   ± 3.80 cm.
= 71.18 + 1.68 (humerus + ulna)   ± 4.14 cm.
= 74.83 + 1.67 (humerus + radius)   ± 4.16 cm.
= 83.19 + 2.68 (humerus)   ± 4.25 cm.
= 82.00 + 3.54 (radius)   ± 4.60 cm.
= 77.45 + 3.48 (ulna)   ± 4.66 cm.

Male Mexicans

stature = 58.67 + 2.44 (femur)   ± 2.99 cm.
= 75.44 + 2.50 (fibula)   ± 3.52 cm.
= 80.62 + 2.36 (tibia)   ± 3.73 cm.
= 80.71 + 3.55 (radius)   ± 4.04 cm.
= 74.56 + 3.56 (ulna)   ± 4.05 cm.
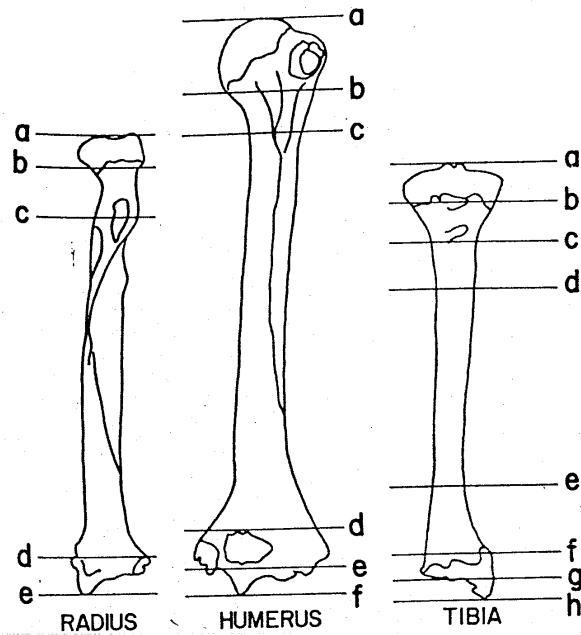= 73.94 + 2.92 (humerus)   ± 4.25 cm.

To convert to English equivalents of feet and inches simply divide the answer by 2.54.

The answer will come out in inches. For example: You have only the femur of a female

black - it measures 38.5 cm. The fourth formula reads: 59.76 + 2.28 (femur) ± 3.41 cm

2.28 × 38.5 = 87.78
87.78 + 59.76 = 147.54 cm ± 3.41 cm.
147.54 ÷ 2.54 = 58.09 inches = 4 feet 10 inches ± 1.3 inches.

RADIUS   HUMERUS   TIBIA

What can be done with fragmentary bones? First, to estimate their total length, second, to then employ them in statural formulae. Here reference is made to the studies of Muller ('35), who made available useful data on 50 radii, 100 humeri, and 100 tibiae. In the humerus **a** is at the most proximal point in the head; **b** is at the most distal point of the circumference of the head; **c** is at the convergence of two areas of muscle attachment just below the major tubercle; **d** is at the upper margin of the olecranon fossa; **e** is at the lower margin of the olecranon fossa; **f** is at the most distal point on the trochlea. These dimensions are proportionately related to total humeral length as follows:

a-f = 100%
a-b = 11.44% ± 1.71%
b-c = 7.60% ± 1.67%
c-d = 69.62% ± 1.74%
d-e = 6.26% ± 0.90%
e-f = 5.47% ± 0.86%

In the radius **a** is at the most proximal point of the head; **b** is at the distal margin of the head; **c** is through the mid-point of the radial tuberosity; **d** is at the distal epiphyseal line; and **e** is at the tip of the styloid process. These dimensions are proportionately related to total radial length as follows:

$$a\text{-}c = 100\%$$
$$a\text{-}b = 5.35\% \quad \pm 1.31\%$$
$$b\text{-}c = 8.96\% \quad \pm 1.95\%$$
$$c\text{-}d = 78.72\% \pm 0.25\%$$
$$d\text{-}e = 7.46\% \quad \pm 1.10\%$$

In the tibia **a** is at the most proximal point of the intercondyloid eminences; **b** is at the proximal epiphyseal line, near the proximal end of the tibial tuberosity; **c** is through the most elevated point of the tuberosity; **d** is at the proximal end of the anterior tibial crest; **e** is at the level of minimum circumference; **f** is at the distal epiphyseal line; **g** is at the level of the distal articular surface; **h** is at the most distal point on the medial malleolus. These dimensions are proportionately related to total tibial length as follows:

$$a\text{-}h = 100\%$$
$$a\text{-}b = 7.88\% \quad \pm 1.31\%$$
$$b\text{-}c = 4.84\% \quad \pm 1.31\%$$
$$c\text{-}d = 8.86\% \quad \pm 0.93\%$$
$$d\text{-}e = 48.54\% \pm 4.27\%$$
$$e\text{-}f = 22.09\% \pm 3.35\%$$
$$f\text{-}g = 3.29\% \quad \pm 0.74\%$$
$$g\text{-}h = 5.03\% \quad \pm 0.92\%$$

The above information cannot cover all fragmentation, nor are all long bones included. However, for the three bones specified, the associated data is extremely worth-while in the hands of an anthropologist.

In summary, the estimation of stature from the measurement of long bones, careful attention should be taken as to how the long bones were measured in the formulae that is used. The bone, or bones, in an individual case should be measured in exactly the same way as by the author (s) of a given formula. It is advisable in the calculation of stature to use more than one long bone, wherever this is possible; also leg bone lengths (tibia and femur) give better estimates than arm bone lengths (radius and humerus). In using comparative tabulations care should be taken to consider: temporal changes (use the most recent data); sex differences; race differences; age differences (correct for

stature loss in old age). In over-all stature reconstruction problem it is suggested to use the data of Trotter and Gleser on American male and female whites and Blacks presented above. In addition it is also suggested you check the "general formulae" of Dupertuis and Hadden. Immature and fragmentary bones may be used to estimate the total length of a given bone. The immature lengths may be referred to tables of length-for-age to give an idea of chronological age; this, in turn, may fit into a height-for-age category. The use of formulae must recognize that a mean stature calculation refers only to a central tendency. The error (standard error) must be used to estimate the chance that the true stature is within certain limits. Lastly, the rate and amount of drying in long bones is not enough of a factor to play any significant role in the reconstruction of stature.

Given a fragment from any of the three bones above, one can estimate the approximate total length of that bone and go on to calculate the stature from the appropriate regression formula. For example: If you have a fragment of the humerus that includes the areas "a" to "d", examining the linear proportions of the humerus shows a-b to be 11.44, b-c to be 7.60, c-d to be 69.62, for a total of 88.66%. The actual measurement of the fragment is 30.2 cm. To obtain the total length divide 30.2 by 0-8866, which equals 34.1 cm. The General Formula is:

length of fragment x 100 ÷ percentage length

5. Weight

Once you know the age and stature you can consult the appropriate medical text or chart, insurance company handouts, on just what the average weight should be. It is then suggested you examine the bones in those areas where muscles arise and insert. The degree of roughness of these areas will tell you something about the muscular development of the individual, whether at the normal level of development or heavier or lighter.

6. Anomalies and Pathologies

It is best that such determinations be left to the Forensic Anthropologist and or the Forensic Pathologist.

It is hoped that the above information is of assistance in helping you to determine the sex, age at the time of death, race, stature, weight and anomalies and pathologies

involving skeletal remains. It is suggested that following your determination of the identification of the skeletal remains that you consult with a Forensic Anthropologist for their learned opinion.