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A COMPREHENSIVE CASE REPORT OF THE UNIVERSITY OF MONTANA CASE 37

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By

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ABSTRACT

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A Comprehensive Case Report of the University of Montana Case 37

Committee Chair: Dr. Randall R. Skelton

In this professional paper I examine the human skeletal remains of one individual. The remains were analyzed to gain insight into the age, sex, ancestry, stature, weight, pathology, and trauma of the individual. Forensic anthropological methods were applied to UMFC 37. The remains of UMFC 37 represent a male, between the age of 40 and 60. He is likely a Caucasian. UMFC 37 is between 5 feet 6 inches and 5 feet 10 inches tall and weighs between 148 and 167 pounds.

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Introduction

The goal of this project is to conduct a comprehensive case study of unidentified remains in the custody of the University of Montana's Physical Anthropology Laboratory and to offer an opinion on what the skeletal remains may have to indicate. It is the skeleton that helps forensic anthropologists to identify a set of unidentified remains. The work that follows will include information that falls within anthropological procedure: determining biological sex, ancestry, age, stature, weight, pathology, and trauma. Doing so will generate a biological profile which is a critical first step in any assessment of skeletal remains. This will be accomplished in a couple of ways: by visually assessing individual skeletal morphological features, taking physical measurements, and applying those criteria to widely established data sets.

Forensic Anthropology has come a long way in being able to decipher and interpret what can be discovered from the remains. It is the intent with regards to this case, to apply established forensic anthropological methods currently recognized on biological indicators. In a case such as this, a positive outcome would be to demonstrate the ability to create a biological profile for an unidentified set of skeletal remains. If identification cannot be made through a comprehensive effort, then perhaps new methods and questions need to be explored.

Materials and Methods

This case study will be approached as if the remains were just brought to my attention for evaluation. For this case study, I conducted a blind assessment of UMFC 37. Contextual information and taphonomic indicators were included in any assessment. Skeletal inventory were done with morphoscopic analysis and measurements were taken with calipers. Trauma and antemortem pathological conditions will be explored by gross visualization of remains.

As part of this case study, certain individuals were consulted as experts in their field to help me gain new information applicable to this case. This will be done through interview and review of the case.

Relevant Background: UMFC37

On June 24, 1983, the Jefferson County Sherriff's Department received reports that a cranium was found along the interstate north of Boulder, Montana. The postcranial skeletal material was found June 25, 1983 in two 30-gallon plastic garbage bags inside the Basin, Montana cemetery, approximately 10-12 miles from the location of the cranium. This material was sent to Dr. Ron Rivers, the Montana State Medical Examiner, to determine the approximate time since death. On August 15, 1983, the partial human skeleton was delivered to the University of Montana's Physical Anthropology Laboratory from Dr. Ron Rivers. The University of Montana Forensic Case 37 (UMFC 37) report was completed by Peggy McCallum.

Skeletal Inventory of UMFC37

The first step to perform on any case when confronted with decomposed, skeletonized or mummified remains is to gather the “context”, or background information pertaining to a case. This begins the process of documentation and collection of as many bones and fragments as possible because analysis can provide information to identify the individual, trauma, and any pathologies present (Byers, 2011; White and Folkens, 2000). The assumption was made that the cranial and post cranial material was one individual, even though the cranial and post cranial material were found approximately 10 to 12 miles apart. The matching soil staining, as well as the timing and proximity of the finds are what were used to determine this. There is some evidence of cortical delamination on the distal femur and the bones are uniformly stained, likely due to the bones being buried. More evidence of burial comes in the form of roots in the cranium, particularly in the nasal cavity. The time since death for UMFC 37 could not be determined, but since the measurements that were run through Fordisc’s result did not deviate from the norm, it is assumed that UMFC 37 is from a modern population. However, evidence of modern dental work wasn't present. The recovery of the complete skeleton is the best-case scenario and is paramount to the investigative efforts of law enforcement (Maples, 1994; Steadman, 2003; Burns, 2007; Reichs, 1998; Ubelaker, 2003; Stewart, 1951).

<u>Cranial Elements:</u>

Cranium: The skull appears to be 97% intact except for eight maxillary teeth including 1, 7, 9, 10, 11, 12, 15 and 16. Tooth 14 has a charcoal-like substance on the broken distal surface. Teeth 1, 15 and 16 look like they have been resorbed. Teeth 10 and 11 look like they were broken in the sockets postmortem, while 7, 9 and 10 likely came out during decomposition. No auditory ossicles are present. There is no adhering tissue; there is discoloration over the entire cranium likely from soil staining.

<u>Post Cranial Elements:</u>

Vertebrae: (Total 13 out of 24) Normally, there are seven cervical, 12 thoracic, and five lumbar vertebrae. This inventory includes 14 vertebrae, which are disarticulated, skeletonized, and discolored from soil staining. A few are fragmentary with the spinous processes missing, likely from postmortem damage from recovery or handling. Epiphyses are fused. Evidence of Schmorl's nodes has been noted on many of the vertebrae, with osteophytes present on a few of the lumbar as well as the thoracics.

They possibly consist of the following:

<u>Cervicals (2)</u> – Two contiguous cervical vertebrae in the C3-C6 section are present.

<u>Thoracic (7 possibly 8)</u> – Six contiguous thoracic vertebrae are present as well as a seventh vertebrae that could possibly be a thoracic or a lumbar. The vertebrae consist of T4 through T10 and T12 or L1. Bones are complete with some arthritic lipping on the vertebral bodies.

<u>Lumbar (3)</u> – Bones are complete without tissue or gross abnormalities. All epiphyseal plates appear to be closed in these vertebral elements. Elements appear to be L2, L3, and L4.

Sternum (1) – The sternum is present.

Sacrum (1) –The sacrum is complete with no greasiness with some slight erosion on the edges. All sections are fused.

Upper Extremities:

Left Scapula (1) –Left scapula is complete with small postmortem cracks on the inferior angle. All epiphyses are fused.

Right Scapula (1) – Right scapula is complete with small cracks around the edges of the anterior and posterior borders. All epiphyses are fused.

Left Clavicle (1) – Clavicle is intact with the epiphysis fused.

Left Humerus (1) – Bone is complete with some erosion and the epiphyses are fused. Humeral head has damage as well on the distal end, which appears to be postmortem.

Right Humerus (1) – Bone is complete with the epiphyses fused. Humeral head and medial epicondyle appear to have postmortem damage.

Left Radius (1)– Radius is complete with the epiphyses fused.

Left Ulna (1) – Left ulna is complete with no greasiness, bone is discolored and no tissue adhering. Epiphyses are fused.

Right Ulna (1) – The right ulna is complete. The bone is discolored with no tissue adhering. Epiphyses are fused.

Carpals (1) – Right hamate

Metacarpals (5) – Right MC2 and MC3, right MC3-MC5

Phalanges (1) – One proximal phalanx.

Tarsals (5) – Right intermediate cuneiform, talus, calcaneus, cuboid, and navicular

Metatarsals (5) - Left MT1-MT5.

Left Ribs (7) – Seven ribs are present. Ribs on this side are a little more fragmented than the right side.

Right Ribs (9) – Nine ribs are present. The first rib is present as well as a nearly complete set.

Pelvic Girdle:

Right Os Coxae (1) – The pubis, illium, and ischium are fused. The bone is complete with some trauma on the anterior portion of the ilia. The bone is discolored with some trauma along the edges of the iliac spine.

Left Os Coxae (1) – The bone is complete with some trauma on the anterior portion of the ilia. The bone is discolored with a small crack along the iliac fossa.

Lower Extremities:

Right Femur (1) – Largely intact with the epiphyses fused. Discolored with trauma on the femoral head as well as both medial and lateral sides of the distal end.

Additional Inventory:

A few additional bones are included with the case. These bones include a left lateral mandibular incisor, an unfused greater horn of the hyoid bone, and an unidentified piece of ossified cartilage.

Figure 1: UMFC 37 Inventory

Biological Profile UMFC 37

Sex Estimation

Sex Estimation From The Cranium

The determination of sex is an important first step because it eliminates approximately half of the population (France, 1988; Skelton, 2003). Two methods of sex determination currently exist. These methods include morphoscopic analysis of morphological features which have been discussed heavily in many texts (Bass, 2005; Burns, 2007; Phenice, 1967; White and Folkens, 2000) and osteometric measurements that may be used with different formulae and standards (Steadman, et al, 2006; Bass, 2005; France, 1988; Ubelaker and Volk, 2000; Buikstra and Ubelaker, 1994). Evaluation of the cranium using morphoscopic methods revealed that UMFC 37 was most consistent with the characteristics of a male. UMFC 37 has rounded orbital margins (4) and the supra orbital ridge is prominent (5). The mastoid processes are large (3) and the temporal lines extend past the external auditory meatus but isn't very prominent. There are robust nuchal lines on the occipital bone with a large inion hook (5). All of these characteristics are typical of a male (from Skelton 2006:6).

Determining the sex of a skull by discriminant function analysis can be done with a formula from Giles and Elliot (1963) for determining an individual of indeterminate race: 2.164(g-op)+1.000(eu-eu)+6.224(zy-zy)+6.122(po-ms)=[1495.40]70%. The calculated value of 1566.66 is higher than the sectioning point; therefore the individual can be determined to be male.

Sex Estimation From The Postcrania

Using the Cowal and Pastor (2008) method for evaluating sex from the proximal ulna, the results indicated male. This metric method for assessing sex in human remains takes the following five measurements into account: the notch length, the olecranon width, the coronoid height, radial notch height, and radial notch width.

The following function was performed using the variables that were measured: Y= (NLx0.254) + (OWx0.235) + (-14.175) using the dimensions for notch length and olecranon width of an ulna of undetermined sex. According to Cowal and Pastor (2008), for a score that is greater than the sectioning point (0.005), the individual can be classified as male, while for a lower score the individual would be considered female. The calculated score for the left (.95) and the right (1.48) are both greater than the sectioning point of 0.005 (Table 1); therefore it can be concluded that the individual is male. Cowal and Pastor (2008) have stated that this method for sex determination from the ulna can produce moderately high standards of accuracy (82.4%). Still, those authors advise that further studies should be undertaken in the application of medico-legal investigation for more modern samples.

Table 1: Measurements of the proximal ulna for UMFC 37

Measurements of the Proximal Ulna		
Measurement	Left	Right
Notch Length	39.96mm	42.70mm
Olecranon Width	21.18mm	20.07mm
Coronoid Height	37.62mm	37.00mm
Radial Notch Height	16.89mm	16.80mm
Radial Notch Width	23.45mm	23.98mm

Both the left scapula and clavicle of UMFC 37 produced a sex estimation of male. All of the measurements of the scapula height (166.64mm), glenoid fossa length (37.34mm), and clavicle length (164mm) were above the mean for male based on information provided in Bass (2005). See Tables 2 and 3 below.

Table 2: Measurement ranges for sex determination from the scapula

Measurement Ranges for Sex Determination From the Scapula			
Length	Females	Indeterminate	Males
Scapula Length	<129mm	140-159	>160
Glenoid Cavity Length	<34mm	34-36	>37

(From Bass 2005:123)

Table 3: Measurement ranges for sex determination from the clavicle

Measurement Ranges for Sex Determination From the Clavicle						
Measurement	Sex	N	Mean	Standard Deviation	Standard Error of the Mean	Critical Ratio (t)
Clavicle Length	M	98	158.24	10.06	1.158	13.90
	F	100	140.28	7.99	0.800	

(From Bass 2005:131)

Four different measurements were taken to help determine the sex of UMFC 37 from the femur. All of the measurements taken for the right femur fall into the male category with none of the measurements indicating female. The circumference of the femur indicates male, being over 81mm (Bass 2005:230 and DiBennardo and Taylor 1979). See Tables 4 and 5 below.

Table 4: Measurement ranges for sex determination from the femur

Measurement Ranges for Sex Determination From the Femur					
	Female	Probable Female	Indeterminate	Probable Male	Male
Vertical Diameter	<41.5mm	41.5-43.5mm	43.5-44.5mm	44.5-45.5mm	>45.5mm
Popliteal Length	<106mm	106-114.5mm	114.5-132mm	132-145mm	>145mm
Bicondylar Width	<72mm	72-74mm	74-76mm	76-78mm	>78mm
Trochanteric Oblique Length	<390mm	390-405mm	405-430mm	430-450mm	>450mm

(From Bass 2005:230)

Table 5: Measurements for femur from UMFC 37

Measurements for Femur	
Measurement	Right
Vertical Diameter	51.53mm
Popliteal Length	148.34mm
Bicondylar Width	79mm
Trochanteric Oblique Length	459mm
Femoral Circumference	95mm

(From Bass 2005:230)

Sex Estimation from the Pelvis

The pelvis for UMFC 37 also indicates male. The pelvic inlet is narrow and more oval than round. The subpubic angle is less than 90 degrees, the iliac blades have very little flare, the pubis is short with an almost triangle shape to it. The auricular surface is relatively flat and the sciatic notch is narrow. Overall, the pelvic bones for UMFC 37 are more rugged and muscular. See Table 6.

Table 6: Characteristics of the male and female pelvis

Characteristics of the Male and Female Pelvis	
Female	**Male**
Birth canal round	Birth canal heart-shaped
Subpubic angle >90 degrees	Subpubic angle ~90 degrees
Iliac blades flare laterally	Less lateral flare
Pubis long and square	Pubis short and rounded
Auricular surface elevated	Auricular surface flat
Acetabulum relatively small	Acetabulum relatively large
Obturator foramen smaller and triangular	Obturator foramen larger and oval
Coxal smaller and less rugged	Coxal larger and more rugged
Wide sciatic notch	Narrow sciatic notch

(From Skelton 2006:25-26)

The ischium-pubis index is an index used by Washburn (1948) to measure easily and effectively the difference in proportion between male and female pelves. The measurement of the subpubic angle often is made for this same reason. The length of the ischium and pubis is measured from the point at which they meet in the acetabulum (Washburn 1948:200).

$$\text{Ischium-Pubis Index} = \frac{\text{Pubis length (81.98) X 100}}{\text{Ischium length (93.51)}}$$

The ischium-pubis index aids in sex estimation:

Table 7: Ischium-Pubis Index Sex Estimation

Ischium-Publix Index Sex Estimation	
White (N=200)	**Negroes (N=100)**
Below 90 = male	Below 84 = male
90-95 sex indeterminate	84-88 = sex indeterminate
95+ = female	88+ = female

(From Washburn 1948:206)

<u>Sex Estimation Conclusion</u>

The final assessment for UMFC 37 is that the skeletal remains are consistent with those of a male. The cranium and post cranial evidence are conclusive and indicative of an individual who is male.

Ancestry Estimation

Most researchers agree that identifying ancestry requires developing and testing reliable anthropological techniques that are capable of separating one human being from another with a definitive degree of accuracy (Iscan, 1988; Reichs, 1998; Byers, 2011).

It is the belief that human biological races do not exist, and yet the assignment of ancestry to a set of skeletal remains is a routine part of forensic anthropological analysis. To be of value the ancestry categories used by forensic anthropologists must reflect the everyday usage of the society with which they interact (Sauer, 1992). Ancestry is a beneficial tool for forensic anthropologists because in cases like this it is important to provide law enforcement and the general public with visuals of what a person might have looked like.

Ancestry assessments using cranial morphoscopic traits rely on subjective trait lists and observer experience (Hefner et al., 2014a). There are few empirically supported methods for assessing ancestry using morphoscopic traits. Unlike metric methods, morphoscopic traits have not been analyzed using statistics. Due to human variation, traits can only be used probabilistically to estimate ancestry (Hefner et al., 2014a).

At some stage during skeletal analysis, either the medical examiner's office or law enforcement may ask the forensic anthropologist to assess the ancestry of a set of skeletal remains. These assessments are usually accomplished through either a visual assessment of morphoscopic traits and/or the measurements of the cranial and postcranial skeleton (Hefner et al., 2014b).

The only part of the skeleton that population affinity, ancestry, or race may be evaluated with any degree of reliability using visual inspection or morphological variation, is the skull. However, it is important to note that the reliability of this method is still only about 50% to 75% (Skelton 2006:21). When these traits were examined in UMFC 37 the traits indicated a person of European ancestry.

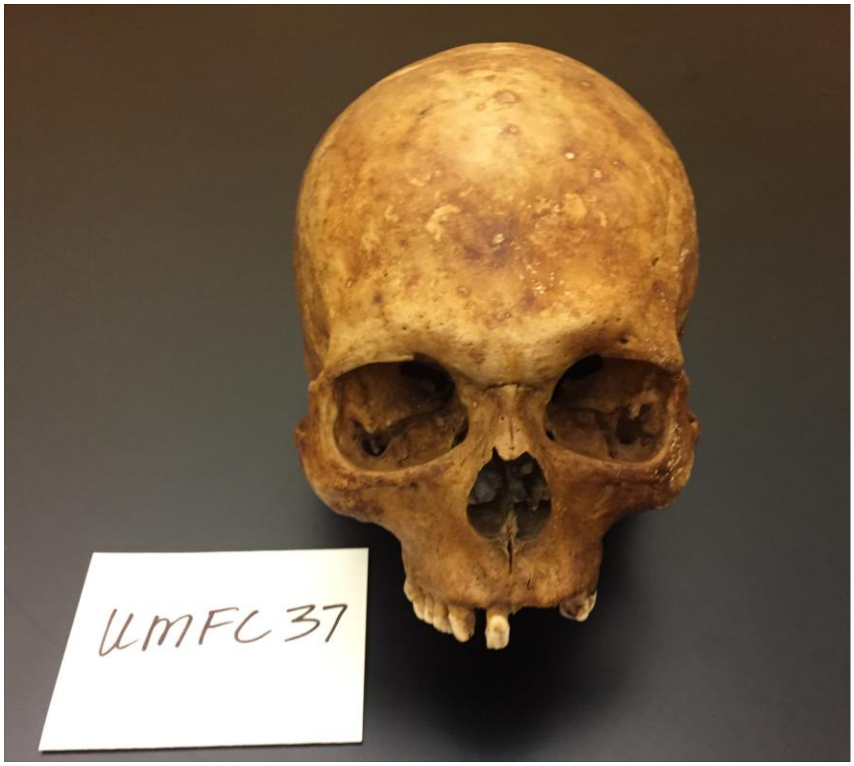


Figure 2: UMFC 37 Skull

Ancestry Estimation from the Cranium

One way of determining the race of the skull is to do a visual assessment. Using a list of characteristics I was able to provide a morphometric estimation of the ancestry of UMFC 37. Using this table UMFC 37 appears to have “Caucasoid” characteristics with a few “Mongoloid” features presenting as well. The traits that UMFC 37 relates to the most are in bold. See Table 8 below.

Table 8: Racial characteristics of the skull as defined by others

Racial Characteristics of the Skull			
Trait	**“Mongoloid”**	**“Caucasoid”**	**“Negroid”**
Skull Length	Long to short	**Long to short**	Mostly long
Skull Breadth	Broad	**Narrow to broad**	Narrow
Skull Height	Medium	**High**	Low
Coronal Contour	**Round**	Long to round	Long
Sagittal Contour	Arched	**Round**	Flat
Face Breadth	Broad	**Narrow**	Narrow
Face Height	High	**High to medium**	Low to medium
Face Projection	Not projecting	**Nose projects**	Jaws project
Zygomatics	Weak back taper	**Strong back taper**	Strong back taper
Interorbital Dist.	**Medium**	Narrow	Wide
Orbit Shape	Rounded	**Angular to round**	Rectangular
Nasal Orifice Width	**Medium**	Narrow (ht=2wd)	Wide (ht=wd)
Nasal Bone Width	Medium	**Narrow**	Wide
Nasal Sill	Sharp edge	**Smooth edge**	Sharp edge
Palate Width	Medium	Narrow to medium	**Wide**
Ruggedness	Medium	Gracile	**Rugged**

(From Skelton 2006)

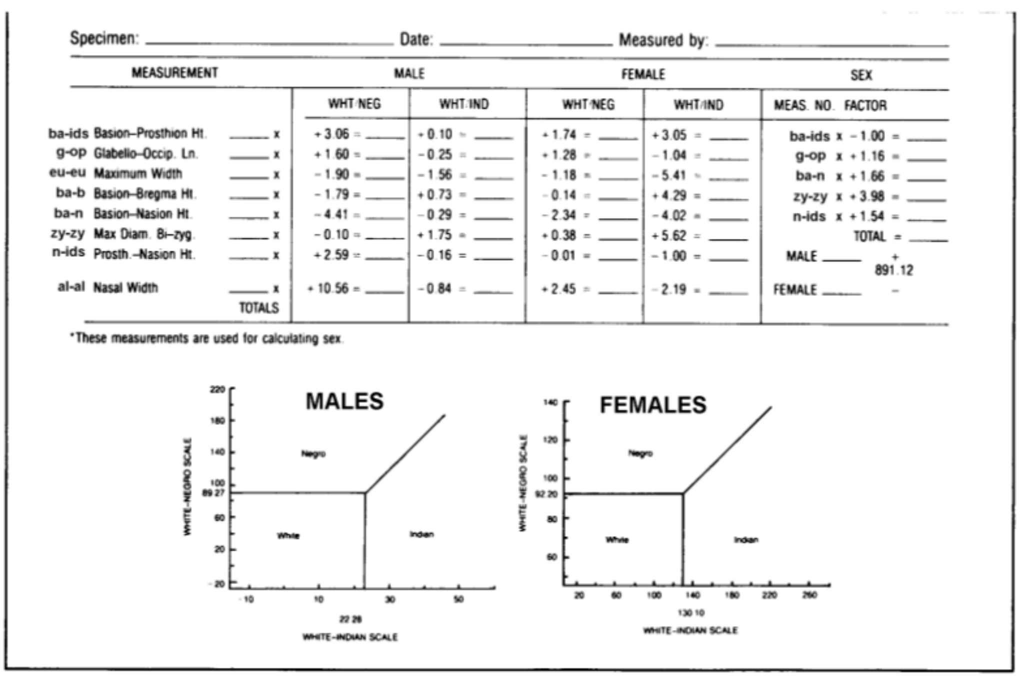
<u>Ancestry Estimation using FORDISC</u>

FORDISC was used to estimate ancestry of UMFC 37. Stephen Ousley and Richard Jantz (2005) designed FORDISC in 1993; this computer program uses discriminant function analysis that was developed from a database of skeletal measurements (Burns 2007:59). The program uses data from two sources, the first is the University of Tennessee’s Forensic Database and the second is data from W.W. Howell’s cranial database. The Tennessee database uses information from modern forensic cases, and Howell’s database uses information from a variety of populations from around the world (Skelton 2006:24). When the dimensions of the cranium were run through FORDISC it was determined that UMFC 37 is closest to an American White Male. See Appendix I for FORDISC results. See Appendix II for FORDISC results for ancestry estimation from the postcranial elements.

Ancestry Estimation using Discriminant Function Analysis

The Giles and Elliot (1963) discriminant function analysis was used to assess ancestry of the skull of UMFC 37. See Figure 3 below. It was assessed using between both the White and Negroid and White and Indian categories. With a sectioning point between White and Negroid 89.27, the resulting score of 24.74 indicates that UMFC 37 was White or Indian. The results on the White and Indian function indicated that Indian was possible with a score of 24.23. The sectioning point between White and Indian is 22.28. It is worth noting that the sample used to develop this discriminant function was the Terry Collection, which dates to the late 1800s to the early 1900s. Therefore, this is a less appropriate reference population for someone like UMFC 37 who died in 1983. It is also worth noting that because of this since the calculated score was very close to the sectioning point that UMFC 37 is not likely to be Indian.

Race Identification from Cranial Measurements



Specimen: ______ Date: ______ Measured by: ______

MEASUREMENT		MALE		FEMALE		SEX
		WHT/NEG	WHT/IND	WHT/NEG	WHT/IND	MEAS. NO. FACTOR
ba-ids Basion–Prosthion Ht.	____ x	+ 3.06 = ____	+ 0.10 = ____	+ 1.74 = ____	+ 3.05 = ____	ba-ids x − 1.00 = ____
g-op Glabello–Occip. Ln.	____ x	+ 1.60 = ____	− 0.25 = ____	+ 1.28 = ____	− 1.04 = ____	g-op x + 1.16 = ____
eu-eu Maximum Width	____ x	− 1.90 = ____	− 1.56 = ____	− 1.18 = ____	− 5.41 = ____	ba-n x + 1.66 = ____
ba-b Basion–Bregma Ht.	____ x	− 1.79 = ____	+ 0.73 = ____	− 0.14 = ____	+ 4.29 = ____	zy-zy x + 3.98 = ____
ba-n Basion–Nasion Ht.	____ x	− 4.41 = ____	− 0.29 = ____	− 2.34 = ____	− 4.02 = ____	n-ids x + 1.54 = ____
zy-zy Max Diam. Bi–zyg.	____ x	− 0.10 = ____	+ 1.75 = ____	+ 0.38 = ____	+ 5.62 = ____	TOTAL = ____
n-ids Prosth.–Nasion Ht.	____ x	+ 2.59 = ____	− 0.16 = ____	− 0.01 = ____	− 1.00 = ____	MALE ____ + 891.12
al-al Nasal Width	____ x	+ 10.56 = ____	− 0.84 = ____	+ 2.45 = ____	− 2.19 = ____	FEMALE ____ −
	TOTALS					

*These measurements are used for calculating sex.

Figure 3: Giles and Elliot worksheet for ancestry identification from cranial measurements (From Skelton 2006:23).

Ancestry Estimation Conclusion

My final assessment for the ancestry of UMFC 37 is the individual has traits typical of a Caucasian.

Age Estimation

There are a couple of ways to determine the biological age of skeletal remains with varying degrees of success. Once a certain age is reached, estimation begins to depend at that point focusing of degenerative changes on the bones (Bass 2005:12). Age for UMFC 37 was determined using the pubic symphyseal face, sternal rib end metamorphosis, with auxiliary input from sutures, dental wear, as well as other minor indicators.

Age Estimation from the Pelvis

One of the most widely used indicators of age-at-death has been the metamorphosis of the symphyseal surface of the pubis of the os coxae. Age-related changes at the pubic symphysis have been recognized for many years, and the first formal system for using these changes to determine age was developed by Todd (1920). The pubic symphysis was used to determine age from the pelvis using Meindl *et al.* (1985), which proposes a simplified scheme with different age ranges. UMFC 37 exhibits a smooth unbillowed surface. The pubic symphysis exhibits a fairly smooth surface with irregularities and some adhering projections, known as fusing ossific nodules. The presence of tiny pores in the surface of the pubic symphysis suggests and advanced age of 40 or older. According to Meindl *et al.* (1985) the symphyseal surface of UMFC 37 was determined to be within the mature stage and the degenerative stage. The mature stage, which is Todd stages VIII, is described as having a smooth surface with no degenerative changes with all ramparts completed: 40 to 44 years. The degenerative stage, Todd XI and X, is marked by degenerative changes. This may include bone loss, ossific nodules, and the formation of an elevated rim around the margins of the symphysis. Age for this stage is suggested as older than 45 years (Meindl et al., 1985).

Using the Suchey-Brooks method for determining the age-at-death of an individual, it was determined that the individual was likely to have been a Stage 5, which has a mean age of 45.6 and a standard deviation of 10.4 with 95% confidence (Bass, 2005).

An analysis of an age-at-death study conducted by Kristen Hartnett (2010), looked at testing the accuracy of age estimation from the pubic bone by looking at a modern sample of known age, race, and sex at the Forensic Science Center in Phoenix, Arizona. This is a revised test the Suchey-Brooks pubic symphysis method by using a modern sample. In this article new descriptions and age ranges were created. This method will be used on UMFC 37 due to the individual being from a modern population.

Based on the revised phase descriptions in the Hartnett (2010) article UMFC 37 was determined to be in phase 5. Phase 5 is characterized by the face of the pubic symphysis becoming more porous and dense, and is depressed but still maintains its oval shape. Ridges and furrows are absent on the face. There is some breakdown of the rim on the ventral border. This phase has a mean of 53.87 with a standard deviation of 8.42. The range for Phase 5 is between 37–72.

The articulation surface of the coxal bones and the sacrum is known as the auricular surface and is known to undergo changes with age. Degenerative changes to the auricular surfaces are looked at to estimate age for an individual based on phases as determined by Lovejoy et al. (1985b). The auricular surface of UMFC 37 was determined to be a phase N with some features from J. N is marked by dense bone replacing the coarse grained surface with no billows or striae. There is slight to moderate degenerative changes to apex, increased irregularity around the margins, and moderate porosity and irregularity of the retroauricular area. J is marked by a surface that is still mostly coarse grained, but with islands of dense bone appears. The apex may show slight degenerative changes, becoming broader and may develop some lipping. (Lovejoy *et al*. 1985a:15). This provided an age range for UMFC 37 for phase J would be 40 to 44 years and phase N has an age range of 45 to 49 years. This gives a composite age range for UMFC 37 of 40 to 49 years. With other methods available that are more accurate for age estimation, the auricular surface was used as a supplement to the others.

Age Estimation from the Sternal Rib Ends

Age can be estimated fairly accurately using the metamorphosis at the sternal end of the ribs. For component I: pit depth, a measurement of 3.29 mm on the right fourth sternal end of the rib was taken which provided a mean age of 30.7 years and a standard deviation of 12.40 years (Iscan, 1984). Component II: pit shape, deals with change in the shape of the pit, initially being a slight amorphous indentation and later developing into a v-shaped structure. Pit shape for the sternal rib end of UMFC 37 can be classified as a stage 4: A wide U-shaped with thinning walls with a mean age of 47.1 years and a standard deviation of 11.61 years (Iscan, 1984). Component III analyses changes in the configurations of the rim and walls of the pit, with the rim starting out smooth and regular and eventually becomes increasingly irregular (Iscan, 1984). On UMFC 37, component III seems to be in stage 4, which includes the rim becoming sharper and increasingly irregular. The walls are thinner and less dense with noticeable deterioration in texture. This stage gives UMFC 37 a mean age of 49.5 years with a standard deviation of 11.21 years. The total component score of 10 gives UMFC 37 a mean age of 47.1 years with a standard deviation of 12.03 years (Iscan, 1984).

Kristen Hartnett (2010) also looked at testing the accuracy of age estimation from the sternal end of the ribs by looking at a modern sample of known age, race, and sex at the Forensic Science Center in Phoenix, Arizona. This is a revised test of the Iscan method by using a modern sample. In this article new descriptions and age ranges were created. This method will be used on UMFC 37 due to the individual being from a modern population. See Table 9 below.

Table 9: Revised Sternal Rib End Method for UMFC 37

Revised Modern Sternal Rib End				
Component I	Stage 2	24.63	2.00	22.63-26.63
Component II	Stage 4	42.43	2.98	39.45-45.41
Component III	Stage 4	42.43	2.98	39.45-45.41

(From Hartnett 2012).

<u>Estimating Adult Age from Dentition</u>

Once a permanent tooth erupts, it starts to wear. These rates and patterns of the wear are governed by multiple factors including tooth morphology and size, angle, chewing habits and diet. One useful way in assigning dental ages to adult specimens is to look at the wear within a population, if the wear tends to be fairly homogeneous; it means that the wear could be a product of age (White and Folkens 2005:365). However, accelerated wear can happen in cases of pathology. The tooth-wear patterns on the right maxillary were determined to fall into category H based on exposed dentine, which provided an age range between 40-50 (Lovejoy 1985).

Estimating Adult Age from Cranial Suture Closure

In the early 1900s suture closure was widely used to determine the age of skeletal remains, but fell out of use in the 1950s with the promise of other more useful and accurate techniques. Meindl and Lovejoy (1985) brought this technique back into use. Meindl and Lovejoy (1985) cranial vault sutural ages calculated by adding scores from 1-7, for UMFC 37 that score added up to 14 which yielded a mean age of 45.2 years with a standard deviation of 12.6 years. For the lateral-anterior sutural age, a composite score of 9 which gives a mean age of 51.9 and a standard deviation of 12.5.

Age Estimation Conclusion

Combining all of the methods of age estimation UMFC 37 gives a broad age range of 18 to 64 years old. I would narrow this age range to 40 to 60 years old. Although the ectocranial sutures provide older ages for the upper end of the scale, most of the other methods indicate a maximum age of around in the upper 50s based on the most accurate methods.

Stature

There are two ways to estimate adult stature using either a regression formula based on the correlation of skeletal elements to living stature or reconstruction of stature by measuring and adding together the lengths of contiguous skeletal elements (Burns, 2007; Trotter and Glesser, 1952; White and Folkens, 2005).

For UMFC 37 I determined that the mathematical approach was best considering large portions of the skeletal remains that would help in the anatomical approach are missing. There was not sufficient amount of material from head to foot, especially with the missing tibiae and fibulae. The most reliable way of estimating stature in the skeleton is from the length of long bones.

<u>Stature Estimation from Long Bones</u>

The procedure for estimating the stature of UMFC 37 from long bone length was calculated using several suitable bones including the humerus, ulna, radius, and femur according to the instructions in Burns (2007). See Table 10 below.

Table 9: Expected Maximum Stature from Long Bone Lengths for American White Males

Expected Maximum Stature from Long Bone Lengths for American White Males		
Long Bone Name	Maximum Length	Expected Maximum Stature
L. Humerus	345mm	177cm= 5’10”
R. Humerus	339mm	175cm=5’9”
L. Radius	245mm	172cm=5’8”
L. Ulna	263mm	171cm=5’7”
R. Ulna	262mm	171cm=5’7”
R. Femur	478mm	175cm=5’9”

(From Trotter and Gleser 1952:496)

Table 10: Stature Estimation Formulas

White Males Right Side
Humerus: 3.08(33.9)+70.45±4.05=174.9= 5 feet 7 inches – 5 feet 10 inches
Ulna: 3.70(26.2)+74.05±4.32=171.0= 5 feet 6 inches – 5 feet 9 inches
Femur: 2.38(47.8)+61.41±3.27=175.2= 5 feet 8 inches – 5 feet 10 inches

White Males Left Side
Humerus: 3.08(34.5)+70.45±4.05=176.7= 5 feet 8 inches – 5 feet 11 inches
Radius: 3.78(24.5)+79.01±4.32=171.6= 5 feet 6 inches – 5 feet 9 inches
Ulna: 3.70(26.3)+74.05±4.32=171.4= 5 feet 6 inches – 5 feet 9 inches

(From White and Folkens 2005:399)

<u>Stature Conclusion</u>

I would conclude that the stature for this individual was between 5 feet 6 inches and 5 feet 10 inches.

Weight

Weight is one of the most difficult characteristics to determine with any reliability. There are charts that can be used to assess possible weight of an individual for a given height. However, the problem with these kinds of charts is they show what people should weigh not what they actually weigh (Skelton 2006). Although a contentious method, it was used to give some idea of where UMFC 37 would have possibly weighed. The height/weight table was used for robust males and was determined that the individual weighed between 148-165 pounds.

Pathology

There are a couple of minor pathologies for UMFC 37. Minor pathologies for UMFC 37 also include osteophytic lipping on the thoracic vertebrae. Osteophytic lipping is usually a normal sign of aging in older individuals. Dental wear pathologies can be an indicator of other health problems and environmental stressors. The teeth of UMFC 37 are worn into the dentin on the right side, while on the left the wear on the second premolar and first molar is only moderate. The left second and third molars are missing and the sockets are almost completely resorbed. The left canine and first premolar are broken in the socket. There is also some ridging on the left tempro mandibular fossa.

Trauma

One such evidence of trauma is known as Schmorl's nodes. Schmorl's nodes can be a circular, linear or combination of the two, depressed lesions, usually with a sclerotic floor in either of the centra endplates. In some cases only a small circular depression or shallow pit will be present in the center of the centrum. Schmorl's depressions result from herniation of the nucleus pulposus, the partially liquid central portion of the intervertebral disc (Mann and Hunt, 2005). According to Dar (2006), in a study of 240 adult spines (T4-L5) found Schmorl's nodes in 48.3 percent (N=116) of the individuals. Surprisingly, in a study by Pfirrmann and Resnick found that: (1) Schmorl's nodes were associated with moderate but not advanced degenerative changes to the vertebrae and (2) Schmorl nodes are probably not a significant factor in the development of spinal disease. Figure 4 shows evidence of both Schmorl's nodes and osteophytic lipping on a thoracic vertebra.

Figure 4: Schmorl's Nodes on UMFC 37 Thoracic Vertebrae

Literature Review

As a result of the inspection of the bones for trauma, evidence of Schmorl's nodes were determined to be present on the centrums of the vertebral column and required further review. Schmorl's nodes are encountered often in skeletal remains in both archaeological contexts and forensic cases. Despite all the research that has been submitted on the subject, researchers have yet to fully understand them. A sort of consensus on how they form seems to have been reached, but why they form is still widely debated. Schmorl's nodes are a result of a hernia in the *nucleus pulposus* between the vertebrae through the cartilaginous endplate and into the centurm (Burke, 2012; Williams, Manek, Sambrook, Spector & McGregor, 2007; Plomp, Vioardsdóttir, Weston, Dobney and Collard, 2015; Peng, Wu, Shang, Wang and Yang, 2003).

Multiple theories have been presented as to what processes might be the cause of Schmorl's nodes such as developmental factors, degenerative changes, pathological process, and trauma (Fahey, Opeskin, Silberstein, Anderson, & Briggs, 1998). However, it has been agreed on that Schmorl's Nodes are the result of any process that weakens the vertebral body or the cartilaginous endplate (Resnick, 1978; Schmorl and Junghanns 1971).

Some studies have suggested that Schmorl's nodes might predispose a person to degenerative disk disease while others have suggested that they might be a result of degenerative disk disease (Resnick, 1978; Ortner 2003; Williams et al., 2007).

A number of studies have been conducted to determine if the presence of Schmorl's nodes is correlated with age of the individual. Hilton et al. (1976) found frequencies of the lesions were similar between groups who were <50 years of age and those individuals who were >50 years of age. However, a study conducted by Pfirrmann and Resnick (2001) on 100 vertebral columns concluded that 58% of the individuals with a mean age of 68.2 had Schmorl's nodes.

Most researchers did not examine C1 through S1. Most of the studies only looked at the lower thoracic vertebrae through the lumbar vertebrae (Plomp et al., 2015; Peng et al., 2003). This is important to note because it has been shown that Schmorl’s nodes are most prevalent in the lower thoracic region (Burke 2012, Williams et al., 2007). It was also noted in the Burke (2012) study that Schmorl’s nodes were seen as high as C6. Since Schmorl’s nodes are defined as a lumbar disease people tend to limit observation to that area and might skew results into showing a lower frequency than is really present.

All of the research leads to the conclusion that the mechanisms by which Schmorl’s nodes are formed is known, but the cause of formation remains unknown. Both repetitive stress and trauma have been noted as possible factors, but age has been shown to be a poor indicator for the formation of Schmorl’s nodes.

Conclusion

In conclusion, UMFC 37 represents a male, between the ages of 40 and 60. He is likely of Caucasian descent. UMFC 37 is between 5 feet 6 inches and 5 feet 10 inches tall and between 148 and 167 pounds. UMFC 37 exhibits signs of Schmorl’s nodes on several of the vertebrae as well as osteophytic lipping.

Appendix I

FORDISC 3.1 Analysis of Current Case
Using cranial data file version 1.21

DFA results using 23 measurements:

AUB	BBH	BNL	BPL	DKB	EKB	FOB	FOL	FRC	GOL
MAB	MAL	NLB	NLH	OBB	OBH	OCC	PAC	UFBR	UFHT
WFB	XCB	ZYB							

From Group	Group Counts	Into Group BM	Into Group WM	Percent Correct
BM	78	72	6	92.3 %
WM	235	21	214	91.1 %

Total Correct: 286 / 313 (91.4 %) *** CROSS-VALIDATED ***

Two Group Discriminant Function Results

Group	Classified into	Distance from	Posterior	Typ F	Typ Chi	Typ R
WM (207/236)	**WM**	33.9	0.994	0.127	0.067	0.127
BM (75/79)		44.3	0.006	**0.018**	**0.005**	0.063

Group Means and Discriminant Function Coefficients

Current Case		Chk	BM 78	WM 235	DF Weights	Relative Weights
AUB	129	++	120.8	123.3	-0.395	10.7 %
BBH	145	+	137.3	141.7	0.004	0.2 %
BNL	110	+	104.4	106.3	-0.485	9.9 %
BPL	96	-	104.2	98.9	0.382	22.0 %
DKB	24	+	23.4	21.3	0.242	5.7 %
EKB	104	+	99.7	97.7	0.072	1.5 %
FOB	35	++	30.0	32.0	-0.186	4.1 %
FOL	40	+	36.7	37.6	0.014	0.1 %
FRC	117	+	112.8	114.8	-0.057	1.3 %
GOL	197	++	186.6	188.1	0.086	1.4 %
MAB	65		65.6	61.5	0.139	6.2 %
MAL	53	-	58.0	54.8	0.008	0.3 %
NLB	26		26.3	23.9	0.425	11.2 %
NLH	50	-	52.7	52.9	0.030	0.1 %
OBB	41		40.8	41.2	-0.289	1.4 %
OBH	32	-	35.3	34.0	0.662	9.6 %
OCC	111	++	98.6	100.9	-0.045	1.1 %
PAC	111	-	117.0	118.5	-0.042	0.7 %
UFBR	106		106.8	105.1	-0.098	1.8 %
UFHT	71	-	72.8	71.8	-0.110	1.2 %
WFB	101	+	95.9	96.8	0.017	0.2 %
XCB	141	+	135.4	140.1	-0.127	6.4 %
ZYB	138	++	130.4	129.7	0.362	3.1 %

```
          Constant                                  6.797
 ------------------------------------------------------------------------------
           Scores        4.155         -4.155      -5.188
                            (Group means)          (Case)

            Mahalanobis Distance = 8.311
 ------------------------------------------------------------------------------
   +/- measurement deviates higher/lower than all group means; ++/-- deviates
one to two STDEVs
   +++/--- deviates two to three STDEVs; ++++/---- at least three STDEVs
 ------------------------------------------------------------------------------
Natural Log of VCVM Determinant =  49.8650
```

Appendix II

```
--------------------------------------------------------------------
FORDISC 3.1 Analysis of Current Case
Using postcranial data file version 1.17

DFA results using 34 measurements:
 CALCBR  CALCXL  CLAAPD  CLAVRD  CLAXLN  FEMBLN  FEMCIR  FEMEBR
 FEMHDD  FEMMAP  FEMMTV  FEMSAP  FEMSTV  FEMXLN  HUMEBR  HUMHDD
 HUMMWD  HUMMXD  HUMXLN  ILIABR  INNOHT  RADAPD  RADTVD  RADXLN
 SACABR  SACAHT  SACS1B  SCAPBR  SCAPHT  ULNCIR  ULNDVD  ULNPHL
 ULNTVD  ULNXLN

 -------------------------------------------------------------------
     From          Group             Into Group          Percent
     Group         Counts         BM          WM         Correct
 -------------------------------------------------------------------
        BM           42            39           3          92.9 %

        WM          267            10         257          96.3 %
 -------------------------------------------------------------------
     Total Correct:      296 / 309 ( 95.8 %) *** CROSS-VALIDATED ***

  Two Group Discriminant Function Results
 ------------------------------------------------------------------------------
    Group          Classified     Distance        Probabilities
                      into          from      Posterior  Typ F   Typ Chi  Typ R
 ------------------------------------------------------------------------------
        WM          **WM**          53.8        0.999    0.074    0.017   0.108
(240/268)
        BM                          68.2        0.001    0.008    0.000   0.047
(42/43)
 ------------------------------------------------------------------------------

   Group Means and Discriminant Function Coefficients
 -----------------------------------------------------------------------------
 Current Case    Chk            BM             WM          DF       Relative
                                42            267        Weights     Weights
 -----------------------------------------------------------------------------
 CALCBR     43     -           43.7           44.0        0.245        0.3 %
 CALCXL     81     -           85.9           87.0       -0.013        0.1 %
 CLAAPD     11    --           13.6           13.1        0.538        1.0 %
 CLAVRD     13     +           11.3           10.9        0.182        0.3 %
 CLAXLN    158                158.1          157.7       -0.053        0.1 %
 FEMBLN    483                485.3          468.7        0.232       15.7 %
 FEMCIR     95     +           93.5           92.9       -0.056        0.1 %
 FEMEBR     83                 82.8           85.7       -0.163        1.9 %
 FEMHDD     52    ++           47.0           48.3       -0.035        0.2 %
 FEMMAP     34     +           31.8           31.1        0.390        1.1 %
 FEMMTV     28     -           28.0           28.4        0.582        0.9 %
 FEMSAP     28     -           28.4           28.4       -0.209        0.0 %
 FEMSTV     33     +           32.2           32.6       -0.153        0.2 %
 FEMXLN    483                488.6          472.2       -0.172       11.4 %
 HUMEBR     59    --           64.2           64.8       -0.069        0.2 %
 HUMHDD     50     +           46.7           49.1       -0.304        2.9 %
 HUMMWD     19                 19.4           18.7        0.325        0.8 %
 HUMMXD     22     -           23.7           23.4        0.473        0.5 %
 HUMXLN    343     +          342.3          334.8       -0.071        2.2 %
 ILIABR    169     +          154.1          162.5       -0.109        3.7 %
 INNOHT    221                211.9          224.6       -0.424       21.7 %
 RADAPD     13     -           13.1           12.9       -0.328        0.3 %
 RADTVD     15     -           15.9           16.4       -0.444        0.8 %
```

RADXLN	250	-	268.8	253.7	0.162	9.8 %
SACABR	114	+	103.6	108.9	-0.050	1.1 %
SACAHT	133	++	104.8	112.3	-0.060	1.8 %
SACS1B	54	+	50.7	51.2	0.163	0.3 %
SCAPBR	113	+	111.0	108.4	0.311	3.3 %
SCAPHT	159	-	161.5	163.2	-0.004	0.0 %
ULNCIR	35	-	36.9	36.5	0.088	0.2 %
ULNDVD	12	--	15.6	14.4	0.213	1.0 %
ULNPHL	243		256.2	240.4	-0.083	5.3 %
ULNTVD	17		16.6	17.5	0.002	0.0 %
ULNXLN	266	-	287.0	271.7	0.173	10.7 %
		Constant			5.589	
		Scores	7.176	-7.176	-7.221	
			(Group means)		(Case)	

Mahalanobis Distance = 14.351

+/- measurement deviates higher/lower than all group means; ++/-- deviates one to two STDEVs
+++/--- deviates two to three STDEVs; ++++/---- at least three STDEVs

---

Natural Log of VCVM Determinant = 68.9849

Appendix III

Cranial Measurements

Maximum Length: 197mm

Maximum Breadth: 141mm

Byzygomatic Breadth: 138mm

Cranial Base Length: 110mm

Basion Bregma: 145mm

Basion-Prosthion Length: 96mm

Maximum Alveolar Breadth: 65mm

Maximum Alveolar Length: 53mm

Biauricular Breadth: 129mm

Upper Facial Height: 71mm

Minimum Frontal Breadth: 101mm

Upper Facial Breadth: 106mm

Nasal Height: 50mm

Nasal Breadth: 26mm

Orbital Breadth: 41mm

Orbital Height: 32mm

Biorbital Breadth: 104mm

Interorbital Breadth: 24mm

Frontal Chord: 117mm

Parietal Chord: 111mm

Occipital Chord: 111mm

Foramen Magnum Length: 40mm

Foramen Magnum Breadth: 35mm

Mastoid Length: 25mm

Mid-Orbital Width: 56mm

Postcranial Measurements

Clavicle Maximum Length: 159mm

Clavicle Ant.-Post. Diameter at Midshaft: 11mm

Clavicle Sup.-Inf. Diameter at Midshaft: 13mm

Scapula Height: 159mm

Scapula Breadth: 113mm

Humerus Maximum Length: 343mm

Humerus Epicondylar Breadth: 59mm

Humerus Vertical Head Diameter: 50mm

Humerus Maximum Diameter at Midshaft: 22mm

Humerus Minimum Diameter at Midshaft:19mm

Radius Maximum Length: 250mm

Radius Ant.-Post. Diameter at Midshaft: 13mm

Radius Med.-Lat. Diameter at Midshaft: 15mm

Ulna Maximum Length: 266mm

Ulna Dorso-Volar Diameter: 12mm

Ulna Transv. Diameter: 17mm

Ulna Physiological Length: 243mm

Ulna Minimum Circumference: 35mm

Sacrum Anterior Height: 133mm

Sacrum Ant.-Sup. Breadth: 114mm

Sacrum Max. Trans. Diameter of Base S1: 54mm

Innominate Height: 221mm

Innominate Illiac Breadth: 169mm

Innominate Pubis Length: 83mm

Innominate Ischium Length: 90mm

Femur Maximum Length: 483mm

Femur Bicondylar Length: 483mm

Femur Epicondylar Breadth: 83mm

Femur Maximum Diameter of Femoral Head: 52mm

Femur Ant.-Post. Subtrchanteric Diameter: 28mm

Femur Med.-Lat. Subtrochanteric Diameter: 33mm

Femur Ant.-Post. Midshaft Diameter: 34mm

Femur Med.-Lat. Midshaft Diameter: 28mm

Femur Midshaft Circumference: 95mm

Calcaneus Maximum Length: 81mm

Calcaneus Middle Breadth: 43mm

References

Bass, W.M. 2005. Human Osteology: A Laboratory and Field Manual. Fifth Edition. Missouri Archaeological Society.

Buikstra J, Ubelaker D. 1994. Standards for Data Collection from Human Skeletal Remains. Fayetteville: Arkansas Archaeological Survey.

Burke, Kelly L. "Schmorl's Nodes in an American Military Population: Frequency, Formation, and Etiology." *Journal of Forensic Sciences* 57(3): 571-77. American Academy of Forensic Sciences, 2012.

Burns, K.R. 2007. Forensic Anthropology Training Manual. Second Edition. New Jersey. Pearson Prentice Hall.

Byers, S. 2011. Introduction to Forensic Anthropology (4^{th} ed.). Boston: Pearson Education, Inc.

Burris, B.G. et al. 1998. "Identification of Race and Sex from Palate Dimensions." *Journal of Forensic Science* 43(5):959-963.

Cowal, L.S. and R.F. Pastor. 2008. "Dimensional Variation in the Proximal Ulna: Evaluation of A Metric Method for Sex Assessment." *American Journal of Physical Anthropology* 135:469-478.

Dar G, Hershkovitz I. 2006. Sacroiliac Joint Bridging: Simple and Reliable Criteria for Sexing the Skeleton. J Forensic Science 51: 480-483.

DiBennardo, R. and J.V. Taylor. 1979. "Sex Assessment of the Femur: A Test of a New Method." *American Journal of Physical Anthropology* 50:635-638.

Dunn, Tyler E. 2014. "Estimation of Body Mass Index from the Metrics of the First Metatarsal." Master's Thesis, Boston University.

Fahey, V., Opeskin, K., Silberstein, M., Anderson, R., Briggs, C. 1998. "The Pathogenesis of Schmorl's Nodes in Relation to Acute Trauma. An Autopsy Study." *Spine* 23(21):2272-5

Falys, C.G. et al. 2006. "Auricular Surface Aging: Worse Than Expected? A Test of the Revised Method on a Documented Historic Skeletal Assemblage." *American Journal of Physical Anthropology* 130:508-513.

France D. 1998 Observational and Metric Analysis of Sex in the Skeleton. In K. Reichs (ed.): Human Osteology – Advances in the Identification of Human Remains. Springfield: Charles Thomas, pp.163-186.

Giles, E. and O. Elliot. 1963. "Sex Determination by Discriminant Function Analysis of Crania." *American Journal of Physical Anthropology* 21:53-68.

Hartnett, Kristen M. 2010. "Analysis of Age-at-Death Estimation Using Data from a New Modern Autopsy Sample- Part I: Pubic Bone." *Journal of Forensic Sciences* 55:114-1151.

Hartnett, Kristen M. 2010. "Analysis of Age-at-Death Estimation Using Data from a new, Modern Autopsy Sample- Part II: Sternal End of the Fourth Rib." *Journal of Forensic Sciences* 55:1152-1156.

Hefner, Joseph T. 2003. "Assessing Nonmetric Cranial Traits Currently Used in Forensic Determination of Ancestry." MA thesis, University of Florida, Gainesville.

Hefner, J., Ousley, S. 2014a. *Statistical Classification Methods for Estimating Ancestry Using Morphoscopic Traits*. Journal of Forensic Sciences 59(4): 883–890.

Hefner, J., Spradley K., Anderson B. 2014b. *Ancestry Assessment Using Random Forest Modeling*. Journal of Forensic Sciences 59(3):583–589.

Hilton, F.C., Ball, J., Benn, R.T. 1976. "Vertebral Endplate Lesions (Schmorl's Nodes) in the Dorsolumbar Spine" *Ann Rheum Dis* 35:127-32.

Holland, T.D. 1995. "Brief Communication: Estimation of Adult Stature from the Calcaneus and Talus." *American Journal of Physical Anthropology* 96:315-320.

Iscan, M.Y. et al. 1984. "Age estimation from the ribs by phase analysis: White males." *Journal of Forensic Science*. 29:1094-1104.

Íşcan M.Y. 1988. Rise of Forensic Anthropology. Yearbook of Physical Anthropology. 31:230.

Lovejoy, C.O. et al. 1985. "Multifactorial Determination of Skeletal Age at Death: A Method and Blind Test of Its Accuracy." *American Journal of Physical Anthropology* 68:1-14

Lovejoy, C.O. et al. 1985a. "Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for the Determination of Adult Skeletal Age at Death." *American Journal of Physical Anthropology* 68:15-28.

Mann, R.W., Hunt, D.R. 2005. Photographic Regional Atlas of Bone Disease. Springfield, IL: Charles C. Thomas.

Maples W. 1994. Dead Men Do Tell Tales. New York: Doubleday.

Meindl, R.S. et al. 1985. “A Revised Method of Age Determination Using The Os Pubis, With a Review and Tests of Accuracy of Other Current Methods of Pubic Symphyseal Aging.” *American Journal of Physical Anthropology* 68:29-45.

Meindl, R.S. and C.O. Lovejoy. 1985. “Ectocranial Suture Closure: A Revised Method for the Determination of Skeletal Age at Death Based on the Lateral-Anterior Sutures.” *American Journal of Physical Anthropology* 68:57-66.

Molnar, P. 2008. “Dental Wear and Oral Pathology: Possible Evidence and Consequences of Habitual Use of Teeth in a Swedish Neolithic Sample.” *American Journal of Physical Anthropology* 136:423-431.

Ortner, D.J. 2003. “Osteoarthritis and diffuse idiopathic skeletal hyperstosis.” In: Ortner, D.J., editor. Identification of Pathological Conditions in Human Skeletal Remains. San Diego, CA: Academic Press, 545-60.

Ousley *et al*. 2009. “Understanding Race and Human Variation: Why Forensic Anthropologists are Good at Identifying Race.” *American Journal of Physical Anthropology* 139:68-76.

Ousley, S.D. and R.L. Jantz. (2005). Personal Computer Forensic Discriminant Functions. The University of Tennessee, Knoxville.

Peng, B., Wu, W., Hou, S., Shang, W., Wang, X., Yang, Y. 2003. “The Pathogenesis of Schmorl’s Nodes. *The Journal of Bone and Joint Surgery* 85(6):879-882.

Pfirrmann, C.W.A., Resnick, D. 2001. “Schmorl Nodes of the Thoracic and Lumbar Spine: Radiographic-Pathologic Study of Prevalence, Characterization, and Correlation with Degenerative Changes of 1650 Spinal Levels in 100 Cadavers. *Radiology* 219:368-74.

Phenice, TW. 1967. Newly Developed Visual Method of Sexing the OS Pubis. Am J. Physical Anthropology 30:297-302.

Plomp, Kimberly A., Una Strand Vioarsdóttir, Darlene A. Weston, Keith Dobney, and Mark Collard. 2015. "The Ancestral Shape Hypothesis: An Evolutionary Explanation for the Occurrence of Intervertebral Disc Herniation in Humans." *BMC Evolutionary Biology* 15(1)

Raxter, M.H. et al. 2006. “Revision of the Fully Technique for Estimating Stature.” *American Journal of Physical Anthropology* 130:374-384.

Reichs K. 1998. Forensic Anthropology: A Decade of Progress. In K Reichs (ed.) Forensic Osteology-Advances in the Identification of Human Remains. Springfield: Charles C. Thomas, pp.13-33.

Resnick, D., Niwayama, G. 1978. "Intervertebral Disk Herniations: Cartilaginous (Schmorl's) Nodes. *Radiology* 126(1):57-65.

Sauer, N.J. 1992. *Forensic anthropology and the concept of race: If races don't exist, why are forensic anthropologists so good at identifying them?* Social Science & Medicine 34(2):107–111.

Schmorl, G., Junghanns, H. 1971. "The Human Spine in Health and Disease." New York, NY: Grune & Stratton.

Skelton, R.R. 2006. Anthropology 512 Advanced Forensic Anthropology. Unpublished laboratory manual available from the author: randall.skelton@umontana.edu

Slaus, M. 2008. "Osteological and Dental Markers of Health in the Transition From the Late Antique to the Early Medieval Period in Croatia." *American Journal of Physical Anthropology.* 136:455-469.

Steadman D. 2003. Introducing Forensic Anthropology. In D Steadman (ed.): Hard Evidence: Case Studies in Forensic Anthropology. Upper Saddle River: Prentice, 1-22.

Steadman D, Adams B, Konigsberg L. 2006. Statistical Basis for Positive Identification in Forensic Anthropology 131:15-26.

Stewart TD. 1951. Scientific Responsibility. Am J Physical Anthropology. 9:1-5.

Ubelaker D, Volk C. 2001. A Test of the Phenice Method for the Estimation of Sex. J Forensic Science 47:19-24.

Ubelaker D, Smialek J. 2003. The Interface of Forensic Anthropology and Forensic Pathology in Trauma Interpretation. In D. Steadman (ed.): Hard Evidence – Case Studies in Forensic Anthropology. Upper Saddle River: Pearson Ed, pp.155-159.

Trotter M, Gleser G. 1952. Estimation of Stature from Long Bones of American whites and Negroes. Am J. Physical Anthropology 10:463-514.

Washburn, S.L. 1948. "Sex Differences in the Pubic Bone." *American Journal of Physical Anthropology* 6:199-208.

Williams, F. M. K., N. J. Manek, P. N. Sambrook, T. D. Spector, and A. J. Macgregor. 2007. "Schmorl's Nodes: Common, Highly Heritable, and Related to Lumbar Disc Disease." *Arthritis & Rheumatism* 57(5):855-60.

White T, Folkens P. 2000. Human Osteology (2nd ed.). San Diego: Elesevir Science

White, T.D. and P.A. Folkens. 2005. The Human Bone Manual. Massachusetts. Elsevier Academic Press.