# Chapter V

# Anthropological Analysis of the Human Remains from Khirbet Qumran: The French Collection*

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There has long been a call in the literature for a detailed osteological analysis of the human remains from the cemetery at Qumran.[1] Prior to 1999, published information was scant, with an *ad hoc* demographic survey[2] and questionable interpretation of one specimen.[3] Although the Qumran collection is small, its possible relation to the Dead Sea Scrolls provides a basis for considerable interest in the results. Rife with political intrigue since their discovery, the Scrolls and related finds are the stuff of Sunday School stories and serious academic scholarship, of conspiracy theories and the history of cultural transition, of unbridled speculation and earnest symbolic reflection.

While a definitive link has not been established between the site and Scrolls, an obvious interest in understanding the people who potentially wrote these documents is not surprising.[4] The added intrigue associated with the 40 year disappearance of the remains only furthers the mystique of the collection.

This chapter will describe the French collection of Qumran human remains,[5] providing a summary of their reemergence, rationale for study, survey of the methods used to date the material, and description of the demographic, anthropometric, and genetic analyses conducted to date.[6] This work contains detailed cranial, skeletal, and dental metric data for the French collection, to facilitate on-going analysis of the remains by osteologists who do not have direct access to the skeletal remains.[7]

## Theoretical Approach

Skeletal remains offer a unique perspective on ancient life because they provide a composite record of humans as biological entities within a cultural and environmental setting, demonstrating the degree to which an individual has adapted to his or her environment. Physical anthropologists thus "look for life in patterns of death,"[8] synthesizing biology and culture into a framework for viewing the past.

The biocultural model emerges from the interaction of data culled from a variety of sources (figure 1). Each constituent provides evidence for the larger biocultural interpretation, both drawing from and contributing to the theory and interpretation of the others. This holistic approach to antiquity recognizes culture as an important mechanism available to humans for adapting to their environment. And as importantly, recognizes the biological constraints on the human animal reflected in cultural practices, both symbolic and material.

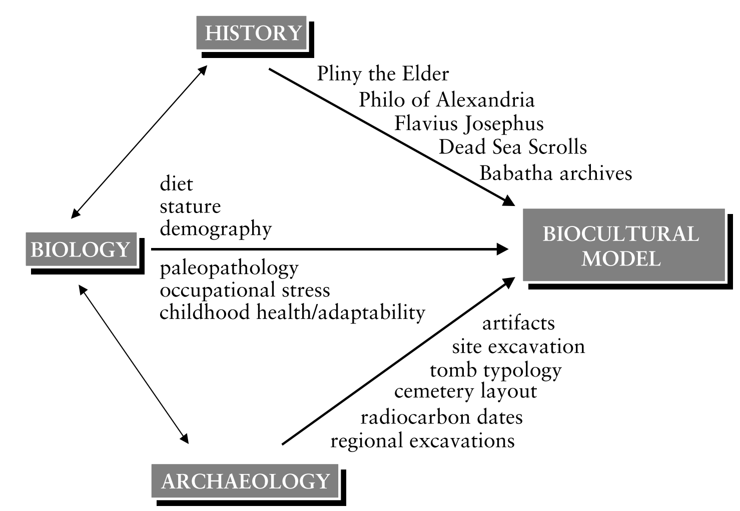


**Fig. 1** – *A biocultural model for the human remains from Khirbet Qumran.*

In antiquity, biological information is 'captured' in the bones of the ancient inhabitants. Bone is a dynamic tissue which affords the body support, leverage, protection, and storage, and therein provides a composite record of lifetime metabolic interactions. In this manner, "the same features that make [bone] resistant to degradation…make it an excellent repository of past biological activity."[9] Yet, specific interpretation is often difficult given the limited ways bone can respond to physiological stressors. When 'insulted,' bone is either deposited or resorbed – a limited repertoire of responses that are often formidable to diagnose differentially. Thus, the historical and archaeological records provide an aid in assessment. In this manner, the cultural account facilitates interpretation of questions biological, and conversely, the skeletal 'catalogue' provides evidence to spark inquiry previously undeveloped in the textual and material archives.[10]

T1

a

T2

b

**Fig. 2** – *Individuals missing from the Qumran collection: (a) Tomb 1 [9849]; (b) Tomb 2 [9845]; (c) Tomb 9 [13]; (d) Tomb 14 [11831]; (e) Tomb 17 [11797]. Inserts display graves or coverings for each tomb.* Bracketed numbers refer to the École Biblique photo archive designation.



T9

c

T14

d

T17

e

If ever there was a collection for such an approach, it is at Qumran. The detailed historical record for the period, region and site, combined with the abundant archaeological record now amassed, provides a rich cultural lens for studying the biological archive frozen in the bones of the Qumran inhabitants. However, the bones do not cooperate with this model. The current collection is too small and incomplete for the reconstruction of community diet, demography and disease profiles.[11] Nevertheless, the data collected for the current study were gathered with an eye towards such a biocultural synthesis in the hopes that later comparison to regional correlates and perhaps future excavations at the site will permit the formation of a more holistic perspective.

### *Justification*

A very real question must be asked of this collection – is it worth the effort? As de Vaux pointed out in the 70s,[12] and Puech[13] and Schuller[14] recently reiterated, the sample size of exhumed remains is insignificant for detailing aspects of community adaptation, reconstructing daily life, group health, longevity, or demographics. Forthcoming analysis by Eshel *et al.* indicates that there may be as many as 1200 inhumations in the cemeteries of Qumran,[15] for which published documentation exists on 53 exhumations.[16] Only 39 have undergone modern anthropological analysis, representing approximately 3.2% of the total interred collection.[17]

A cemetery represents a sampling of the living population from which it drew, often skewing demographic data towards those individuals less adapted. And, not all members of a given population are interred in their representative graveyard. When biased excavation methods and incomplete exhumation are added to the normal taphonomic processes that can disrupt preservation (scavenging, human activity, moisture, etc.), the representative nature of the Qumran collection leaves much to the imagination when attempting to chronicle the life of this desert community.[18]

Were these remains not from Qumran, they would have likely stayed in storage. But the great interest in Qumran has amplified the importance of this sparse collection, especially in light of the numerous and varied hypotheses generated from the remains.[19] These have ranged from a barefoot man, to Roman soldiers, to horsemen. Tales of torture and dismemberment have been reconstructed from the bones. Social structure and sexual behavior have been postulated, with some finding evidence for nuclear families, while others see evidence of celibacy in the skeletal assemblages. Davies warned that "preconceptions lead to over-interpretation"[20] – a truism evidenced by many previous, and at times truly fanciful, reconstructions of the Qumran material.

Due to the quantity and range of speculation based upon these remains, combined with the continuing call in the literature for their analysis, the study of the human bones from Qumran is not only justified but necessary. However, it is important to remember we are describing a subset of poorly preserved individuals, whose information can not be extrapolated to patterns for the community at large.[21] When cognizant of this distinction, such study does indeed add to the present state of knowledge about Khirbet Qumran.

## The Study Collection

The first published reference to the excavation of a tomb at Qumran appears in the letters of Clermont-Ganneau (1874) who reported removing "…a bit of a jawbone, with teeth adhering"[22] which he hoped to submit for anthropological analysis. If such study eventually occurred, the data were not published.

Systematic excavation of Khirbet Qumran began in 1949 by archaeologists from the École Biblique et Archéologique Française in Jerusalem, under the direction of Professor Roland de Vaux, OP. From 1949-1955, 43 graves in the site cemetery were exhumed,[23] but the remains disappeared shortly thereafter, not to be rediscovered for over 40 years.

Solomon Steckoll excavated another 9 skeletons from 10 tombs in 1966.[24] Steckoll engages in wild speculation about these remains in a little known Italian work, with some highly inventive reconstructions based on minimal supporting evidence.[25] In truth, until 1999, only one skeleton had been published in detail, with cursory descriptions of age and sex for 8 other individuals (all from Steckoll's excavations).[26]

In 1999, a German team of scholars published their analysis of a collection of 22 skeletons (or portions thereof) from Qumran.[27] These remains were transported to Germany in the 1950s and remained in storage until their curation in the early 90s. Comparable study of the contents of 18 tombs under French jurisdiction began in the late summer of 1999.[28]

## The French Collection

In mid-July 1999, Sir Jean-Baptiste Humbert, OP[29] invited the authors to analyze the articulated remains of the man from Tomb 18. The skeleton had been on display for decades at the Rockefeller Museum in East Jerusalem. One very long piece of coffin wood,[30] hundreds of smaller wood fragments, and approximately 30 metal nails accompanied the skeleton. The remains were housed in a wood and glass case designed for display purposes. The bones were 'glued' to a cardboard and plaster base, and covered with a thick layer of paraffin preservative. Initial curation began by removing the waxy matrix and reassembling the skeleton in proper anatomical order (several bones were out of place).

Renovation of the École Biblique et Archéologique Française library began in August 1999, which required the movement of all materials in the archaeological laboratories adjacent to the library holdings. In the process of reorganizing the archaeology museum in the Fall 1999, additional Qumran remains were uncovered. The bones were stored in small clearly marked boxes, inside a large unmarked box, which may explain how they went unnoticed in the École's extensive archaeological collection. In December 1999, the remains of 8 more Qumran graves were presented to the first author for analysis.



| Tomb | de Vaux Catalogue | Current Location | Year Exhumed | Original Investigator |
|---|---|---|---|---|
| 3 | Q 3 | Paris | 1951 | Vallois |
| 4 | Q 4 | Paris | 1951 | Vallois |
| 5 | Q 5 | Paris | 1951 | Vallois |
| 6 | Q 6 | Paris | 1951 | Vallois |
| 7 | Q 7 | Paris | 1951 | Vallois |
| 8 | Q 8 | Paris | 1951 | Vallois |
| 10 | Q 10 | Paris | 1951 | Vallois |
| 11 | Q 11 | Paris | 1951 | Vallois |
| 12 | Q 12 | Jerusalem | 1953 | Kurth |
| 13 | Q1 3 | Jerusalem | 1953 | Kurth |
| 15 | Q 15 | Jerusalem | 1953 | Kurth |
| 16a | Q 16-I | Jerusalem | 1953 | Kurth |
| 16b | Q 16-II | Jerusalem | 1953 | Kurth |
| 17 | Q 17 | Jerusalem | 1953 | Kurth |
| 18 | Q 18 | Jerusalem | 1953 | Kurth |
| 19 | Q 19 | Jerusalem | 1953 | Kurth |
| A | QN 01 | Jerusalem | 1955 | Kurth |
| B | QN 02 | Jerusalem | 1955 | Kurth |

**Table 1**
*Individuals in the French Collection of Human Remains from Qumran*

The Jerusalem segment includes material from Tombs 12, 13, 15, 16a, 16b, 17,[31] 19, and Tombs A and B; the Paris collection holds Tombs 3, 4, 5, 6, 7, 8, 10, and 11 (table 1).[32] Bones from Tombs 1, 2, 9, 14, and 17 have not resurfaced for analysis,[33] although photos of the skeletons from these tombs exist in de Vaux's photograph archive at the École Biblique (figure 2).[34]

### Provenience

The current collection has been missing for over 40 years, thus a discussion of provenience is warranted. Several lines of evidence were used to corroborate the authenticity of the collection under study.

For the remains in Jerusalem, each of the individuals (except Tomb 18) was presented in a series of small cardboard boxes, labeled with a tomb designation. Pieces of wood from Tombs 17 through 19 were packaged in plastic bags, skeletal material was wrapped in toilet paper, and metal nails were stored in small Jordanian cigarette boxes. Notes with the site name and dates were often enclosed and many of the bones were labeled with masking tape, found underneath the paraffin preservative that covered most of the remains.[35]

Permission was granted in August 2000 to analyze the 8 individuals housed at the Musée de l'Homme in Paris.[36] These individuals were stored in small open cardboard storage trays, with information related to provenience written either directly on the bones, or on the paraffin covering the remains. Many of the large pieces of bone were labeled with India ink indicating the site ("Kh. Qumran"), location ("Palestine"), a date of exhumation, a tomb number, and a catalogue number specific to the Musée de l'Homme.

Figure 3 illustrates the multiple lines of evidence used to establish provenience for this collection. For Tomb 18, there was a clear match between the materials presented for analysis and de Vaux's original photographic record [3a & b]. Enclosed packing materials (such as the Jordanian cigarette box in [3c]) and hand-written notes [3d] provided another layer of evidence. Writing on pieces of masking tape (apparently in the same hand as the enclosed notes) found under the paraffin preservative [3e] or directly on the bones [3f] likewise hint at their origin and date of exhumation. And, consistency with the field notes of de Vaux and the original osteologists help build a strong circumstantial case of provenience for this collection.

In the Musée de l'Homme collection, the possible remains of Tomb 3 were mixed with the remains of Tombs 4, 5, and 8. Written on several bones directly, and located under the paraffin covering, were rather large "3"s written in what appears to be crayon or grease pencil. All such pieces represent redundancies of body parts for a given individual, as illustrated by the 2 sacra found in the "T8 box." The sacrum pictured in Figure [4a] with a large "3" under the paraffin does not match the corre-


**Fig. 3** – *Provenience of the French Qumran skeletal collection: (a) Tomb 18 remains upon exhumation by de Vaux; (b) Tomb 18 remains as presented to the authors in July 1999; (c) Jordanian cigarette box containing small cranial fragments; (d) notes associated with Tomb A; (e) masking tape on bone under paraffin; and (f) India ink label on bones.*

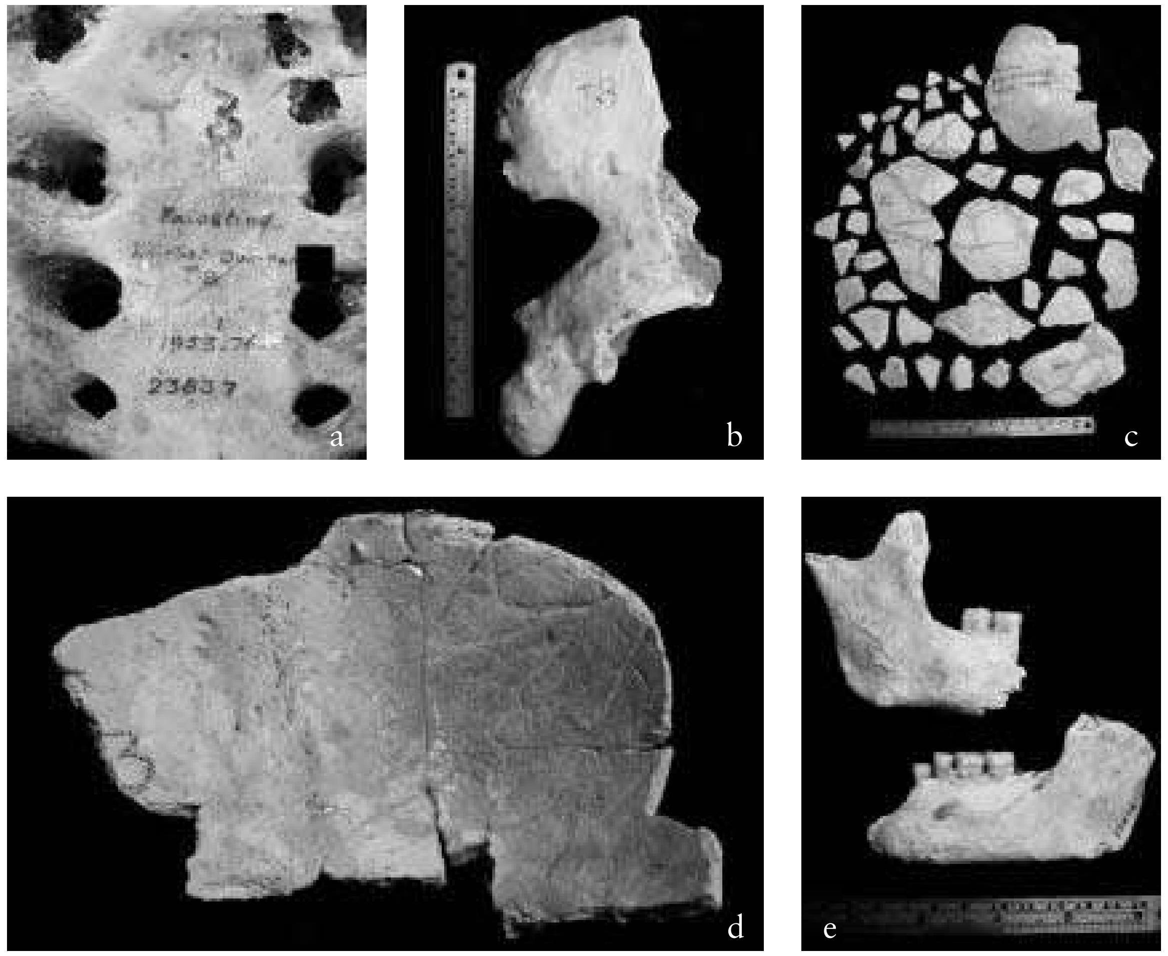


**Fig. 4** – *Bones comprising the individual from Tomb 3. The two pelvic portions–(a) sacrum and (b) innominate–were labeled with a graphite #3 under the paraffin preservative. The cranial portions in images (c) and (d) were placed in a box labeled "Tomb 8," but in a separate box from the remaining duplicate bones likewise labeled with an "8." The largest piece of calvarium seen in image (d) was labeled with a partial blue "3" under the paraffin. Finally, the mandible fragments in (e) were found in the Tomb 5 box, but far more robust than the remaining Tomb 5 bones, including a duplicate (gracile and older) mandible.*

sponding innominates for that tomb in size or robusticity (while its duplicate does match). The sacrum, innominate, cranial fragments, and mandible shown in Figure 4 are of comparable robusticity, were labeled with a "3", and/or represent duplicate parts to other tombs. These were treated as representative of Tomb 3 in the current study.

### Conservation

All of the bones were covered with varying degrees of wax preservative. Initial conservation plans included removing the paraffin with toluene or xylene and later preservation with either polyvinyl acetate (PVA) or acroloyid B-72. However, when samples were tested in both solvents, the bone crumbled. Thus, the paraffin matrix was left in place until a suitable alternative can be found.[37]

Paraffin was cleaned only from those areas of contact needed for reassembly, or when the layer was covering a feature of interest. In most cases, the wax was melted or carefully removed with a dental pick. All bones were photographed extensively to create a digital archive.

## The Cemetery

Most of the individuals in the French collection were from what de Vaux called the main cemetery ("Cimetière Principal").[38] One was from the central extension ("Extension Médiane"), and one from the northern cemetery ("Cimetière Nord"). Figure 5 illustrates the location of the skeletons in the current study, as they appear on the original cemetery map of de Vaux.[39] All were buried in a south/north orientation, except Tomb 4. All were single interments, save Tomb 16 (a and b). There were three individuals in the French collection buried with coffins (Tombs 17, 18, and 19) as evidenced by the preserved wood and nails, and one individual (Tomb 11) was a clear re-interment.

### New Cemetery Survey

Prompted by a generalized request in the literature and increasing concerns about looting at the site, as well as a means to determine the location of some of the questionable burials and to assess the actual number of graves at Qumran, a new survey of the cemetery was



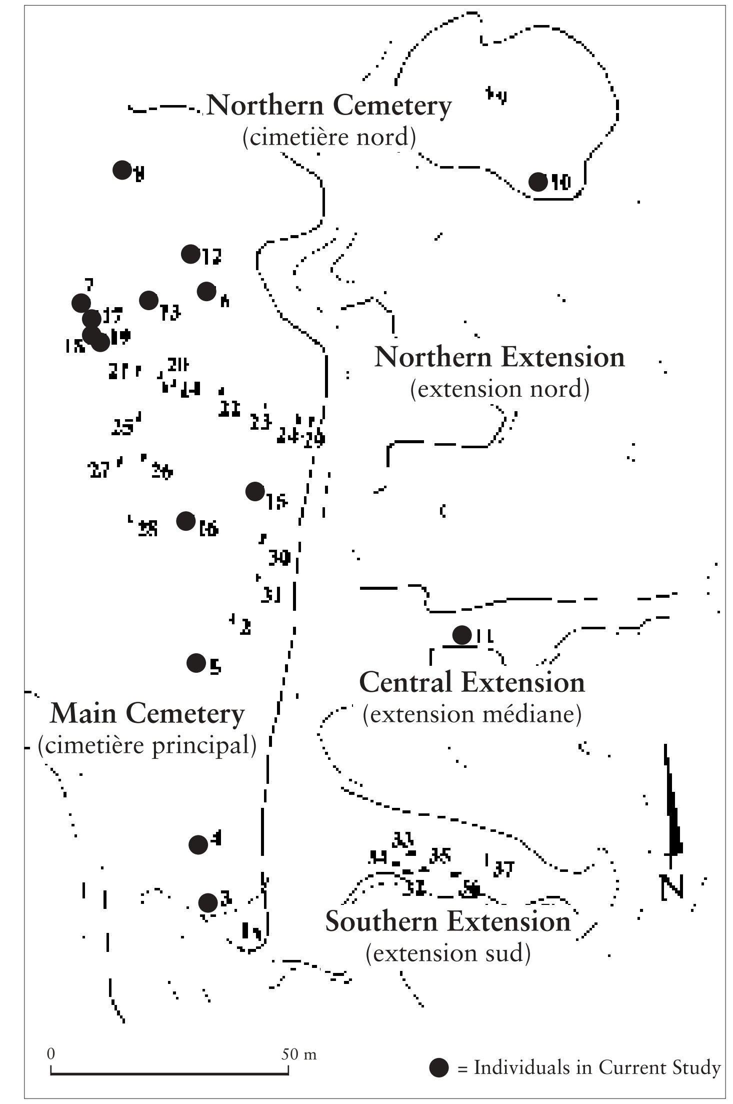


**Fig. 5** – *The Cemetery at Qumran. Adapted from* Humbert and Chambon, 1994, p. 214.

conducted in the Spring 2001.[40] Figure 6 illustrates the placement of all open tombs, overlayed on the de Vaux map. Those no longer visible are not included, with explanations listed below.

Several additional pits now appear on the map, some perhaps due to the excavations of Steckoll in 1966, some to looting.[41] There is a possibility that one of the exhumations reflects the work of Clermont-Ganneau,[42] however this is rather unlikely given the time elapsed since his visit to the site. A summary of the tombs in question follows:

*Tomb 1* – The location of Tomb 1 on the southern edge of the main cemetery ("Cimetière Principal") has been called into question in the new mapping. Two pits now appear in that region, but neither is quite as far south as indicated by de Vaux. Tomb 1 is either slightly farther north than indicated by de Vaux, or has been destroyed and the pit labeled as "1?" is thus a new addition. The skeletal remains for this tomb have not been located to date.

*Tombs 7 and 8* – These two tombs are no longer evident, presumably due to the construction of the Visitor's Center at Qumran. Given the controversy surrounding the remains from tomb 7 and the apparent "misalignment" of the grave compared to those around it (according to de Vaux's notes), the loss of the surface features associated with Tomb 7 is indeed regrettable.

*Tombs 9 and 10* – An additional discrepancy includes the location of Tomb 10 in the northern cemetery ("Cimetière Nord"). This tomb is either now missing (and the current pit represents more recent 'activity') or it was misplaced in the original mapping. De Vaux's diagram shows the grave in the southeast corner of the northern cemetery; however, today a pit appears in-line with "Tomb 9" and much more centrally located. Taylor questioned the location of Tombs 9 and 10, and placed them in the northern corner of the "main cemetery."[43] Another possibility is that Tombs 9 and 10 belong in the "northern extension" (there are indeed several excavated pits in this area, as shown in the new survey map), and Tombs A and B (also missing) are located in the "northern cemetery."

*Tomb 14* – Apparent foot traffic from tourists in the graveyard seems to have destroyed evidence of Tomb 14. In de Vaux's original mapping, two pits are indicated near the designation for Tomb 14, with no corresponding number for the second open grave. This duplication does not appear in the re-survey, and Tomb 14 is no longer visible.

*Tombs A and B* – Two notes tucked in with the bones from Tomb A make reference to its location in the "Cimetière Nord" (see figure 3d). Neither Figures 5 or 6 illustrate this "forgotten northern cemetery"[44] (if indeed it is not "Cimetière Nord"). Professor Emile Puech of the

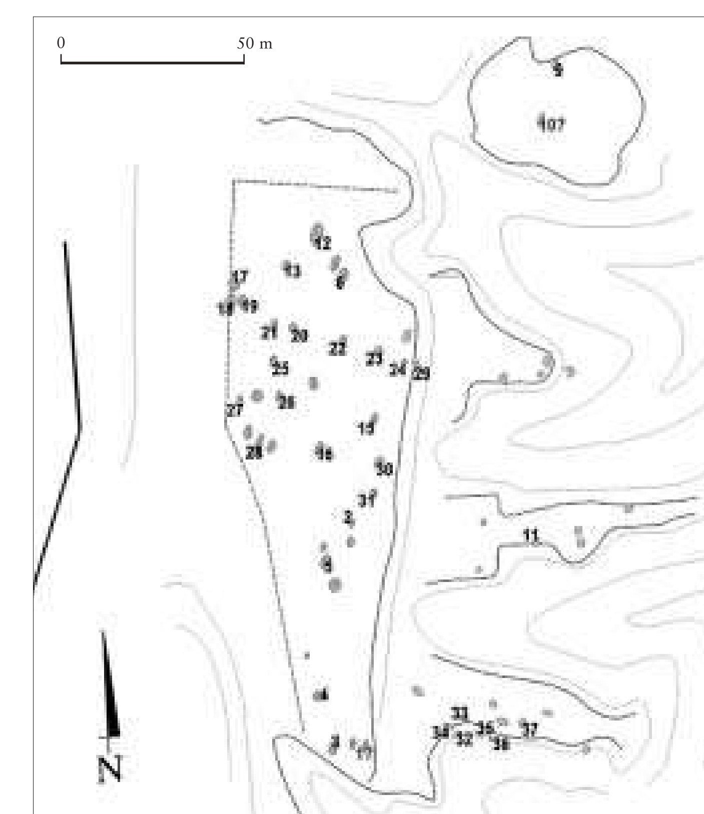


**Fig. 6** – *Re-survey of the Cemetery at Qumran [April 2001].* J. Rosenberg and Elaine Meyers.

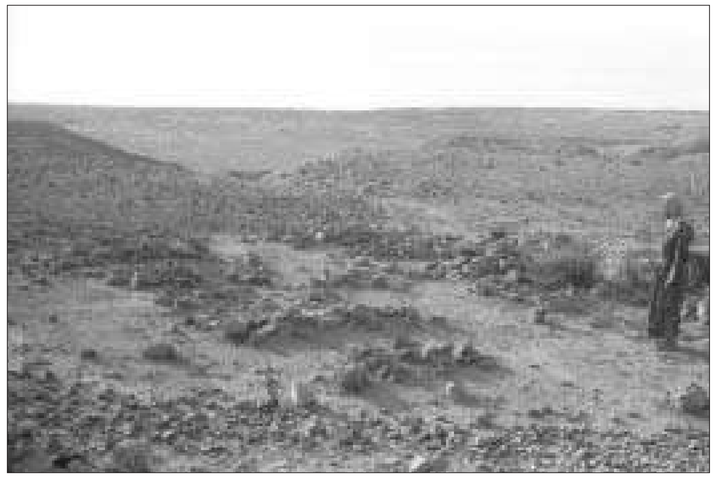

**Fig. 7** – *Photograph of the small northern cemetery prior to the exhumation of Tombs A and B (from* Humbert and Chambon, *1994, p. 216)*

École Biblique et Archéologique Française published a possible location for this small cemetery, and Dr. Röher-Ertl and colleagues subsequently postulated a slightly different location in their *Revue de Qumran* article.[45] The only specific information available beyond de Vaux's cryptic reference in his field notes is a photograph of the graveyard (figure 7).[46]

Excavated pits for each of these appear in aerial photographs of the site taken in the later 1950s by the Royal Jordanian Air Force (figure 8). Tombs 1, 7, 8, and 14 are visible. Most of the pits coincide with those on de Vaux's map (see figure 5), though there are clear anomalies present.

### Preservation vs. Exhumation

The cranium and innominates were the skeletal elements of choice for exhumation by de Vaux's team. Figure 9 compares the remains *in situ* as photographed by de Vaux,[47] with a schematic of those bones currently available for study. Presumably the majority of each skeleton was left in the grave.[48]

In the schematics, the dark gray regions indicate bones available for the current analysis, the light gray illustrates those visible in the photographs, and the white areas represent missing or obstructed bones. As is clearly illustrated in this figure, even when we have evidence that the entire skeleton was preserved, the pelvis and cranium were usually the only bones removed for analysis.

The selection of these skeletal elements provides a history lesson in physical anthropology – at the time of the exhumations, age, sex and "race" were the topics of interest and those elements believed capable of addressing these issues were the only ones conserved. Also, Zias suggested that those individuals for whom we have more

*Fig. 8 – Aerial view of the cemetery taken by the Royal Jordanian Airforce at the time of de Vaux's excavations. Open pits are visible as dark dots. This image was first published in a different orientation by* Humbert and Chambon, 1994, p. 213, #442.



skeletal material available provide evidence of differential preservation – *e.g.*, later burials, possibly Bedouin intrusions.[49] The French collection clearly does not attest to this pattern; the remains may indeed prove to be of later origin, but not based upon the percentage of skeleton remaining in the grave.

### Dating Methods

Several methods have been utilized to try to date the remains in the Qumran cemetery. A lamp from Tomb 4, a small piece of textile in Tomb 1, scattered jewelry, wood, nails and broken pottery[50] represent the limited grave goods discovered to date. Taylor reported a date of Period Ib for the material remains in Tomb 4 and Period II for the lamp in Tomb 26. Steckoll placed charcoal found in his grave 9 at 120 CE±210 years, and Zias believed the beads from graves in the southern extension were of recent Bedouin origin.[51]

Several attempts have been made to date the bones directly; all have been unsuccessful due to a lack of the remnant protein needed for radiocarbon dating. Stekoll stated that he sent a sample for carbon dating but found no collagen in the bone.[52] The German team likewise attempted carbon-14 dating to no avail. Comparable frustration was reported in dating associated wood samples, due to contamination by the paraffin preservative.[53]

For the current study, bone samples from all of the individuals in the Jerusalem portion of the French collection were submitted for radiocarbon dating. In addition, wood from Tomb 18 was likewise analyzed. Given recent advances in the instrumentation and contamination control procedures utilized for radiocarbon dating, we hoped to overcome past disappointments.[54] Sadly, samples were run at 2 independent laboratories,[55] with the same negative results as all previous attempts.

To determine the level of carbon in the bones, samples from all individuals were tested using stable isotope analysis.[56] Fresh bone contains ~15 % carbon and 5 % nitrogen (the latter being the most diagnostic of protein), and the carbon/nitrogen ratio is between 3.0 and 3.2. The major constituent of protein in human bone is nitrogen. Therefore, when values for carbon approach the expected percentage (15 %) but no nitrogen is found in the sample, the carbon is most likely a contaminant.

As seen in Table 2, none of the individuals in the French collection approach these values. This indicates a significant loss of proteinacous carbon, thus explaining the negative results from the radiocarbon dating. There was not enough carbon in the bone samples to permit even accelerator mass spectroscopy (AMS) analysis. Using significantly less sophisticated technology, Steckoll reported the same results.[57]

For the coffin wood, the material was so impregnated with wax that the carbon in the cellulose was indistinguishable from the carbon in the paraffin. Additional samples of wood from Tombs 16, 17, and 18 will continue to be tested as funds become available.

The bone samples of the French collection are denatured beyond current radiometric capabilities. Heat, salinity, pH, and other environmental factors have conspired to mask the organic signals of interest. Conservation methods employed in the field likewise contaminated the coffin-wood samples.

| Tomb | Mass (mg) | AMS Date | C WT % | N WT % | Ratio C/N |
|---|---|---|---|---|---|
| 4 | 1.3 | - | 7.9 | 0 | N/A |
| 5 | 1.0 | - | 4.9 | 0.3 | 14.8 |
| 7 | 1.1 | - | 9.1 | 0 | N/A |
| 8 | 1.2 | - | 18.5 | 0 | N/A |
| 10 | 1.2 | - | 8.4 | 0 | N/A |
| 11 | 1.0 | - | 3.3 | 0 | N/A |
| 12 | 1.1 | N/A | 6.3 | 0 | N/A |
| 15 | 1.0 | N/A | 1.4 | 0.2 | 7.9 |
| 16a | 1.0 | N/A | 13.2 | 0 | N/A |
| 16b | 0.9 | N/A | 9.8 | 0 | N/A |
| 18 | 0.9 | N/A | 2.9 | 0.3 | 9.8 |
| 19 | 0.7 | N/A | 27.2 | 0.2 | N/A |
| A | 1.1 | N/A | 1.5 | 0.2 | 8.1 |
| B | 1.5 | N/A | 1.9 | 0 | N/A |
| Fresh Bone Values | | | 15% | 5% | 3.0-3.2 |

**Table 2** – *Stable Isotope and Radiocarbon Results for the French Collection of Human Remains from Qumran*

Study of the metal nails associated with burials in Tombs 17 (figure 10), 18, and 19 may yield information for temporal placement of the remains.[58] Although a systematic nail typology does not seem to exist for Hellenistic or Roman Palestine,[59] there is enough distinction in morphology to determine whether the nails are of early or recent manufacture. Gross morphological analysis indicates Roman-period construction, given the square-shape of the shaft.[60] Chemical analysis of the metal may likewise provide insights on construction.[61]

### Demographic Reconstruction

#### *Age Determination*

The analysis of biocultural adaptation proceeds from a demographic perspective. For ancient populations, inferences are made about survival from patterns of morbidity and mortality.

During the period of growth and development, age estimation is usually quite precise. With the cessation of growth and the completed eruption of the permanent dentition, assessment of age becomes more difficult, relying on evidence of degenerative processes such as wear and arthritic response.

When multiple bones are available for a single individual, determination of age using intersecting lines of evidence can be highly accurate, even for older adults. However, when based on a few skeletal elements, definitive appraisal becomes more difficult. For the Qumran collection, while only a few bones were exhumed for each individual, they were fortunately those skeletal elements most diagnostic for age and sex reconstruction.

Since the 1950s when Kurth[62] and Vallois[63] made their original estimations for the individuals in the French collection, many refinements in aging techniques have been made. Also a plethora of new methods have been intro-

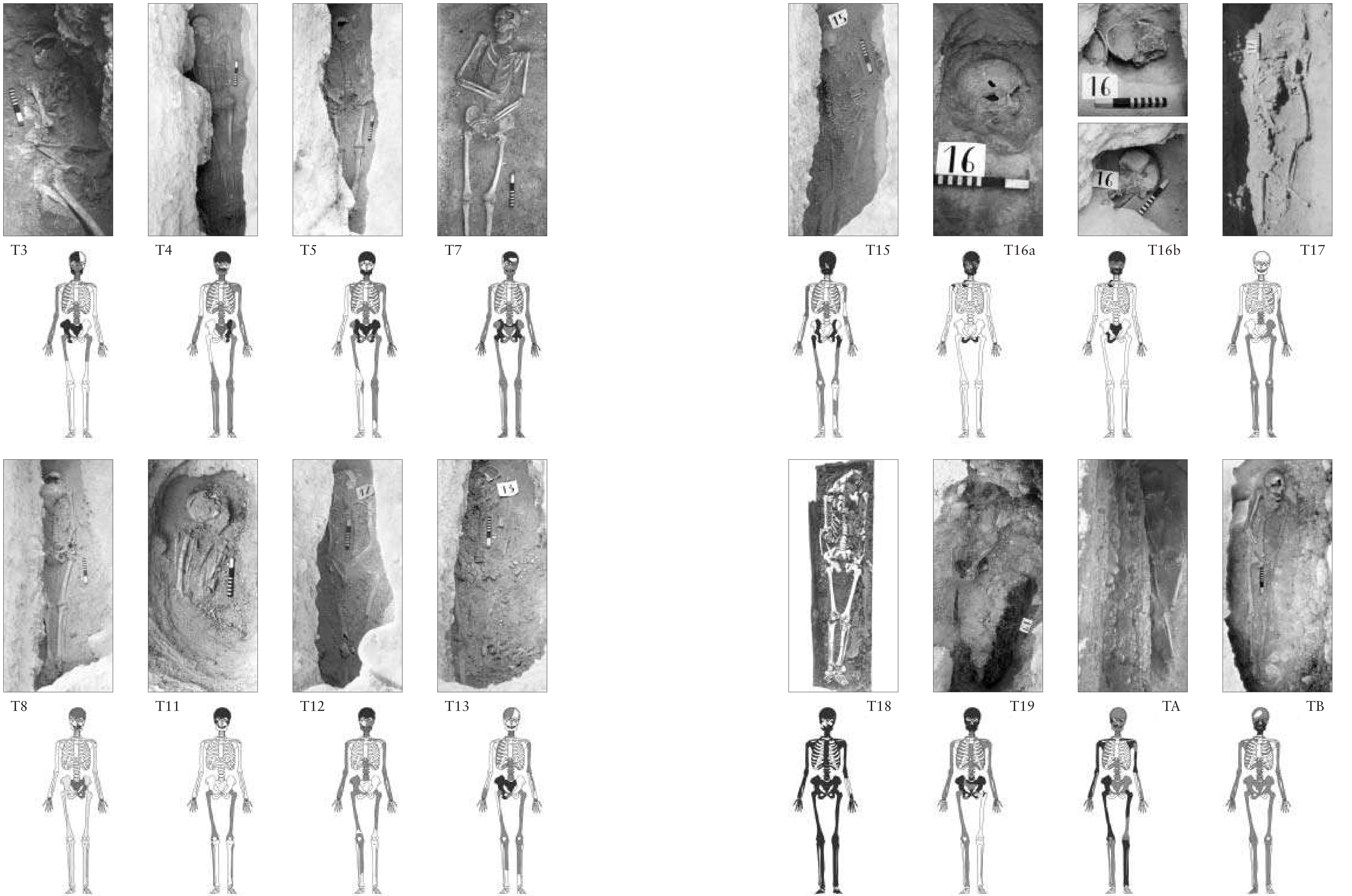


**Fig. 9 –** *A comparison of preservation versus conservation. The photographs illustrate the skeletons as seen upon exhumation. The schematics below demonstrate those portions of the skeleton available for current analysis.*

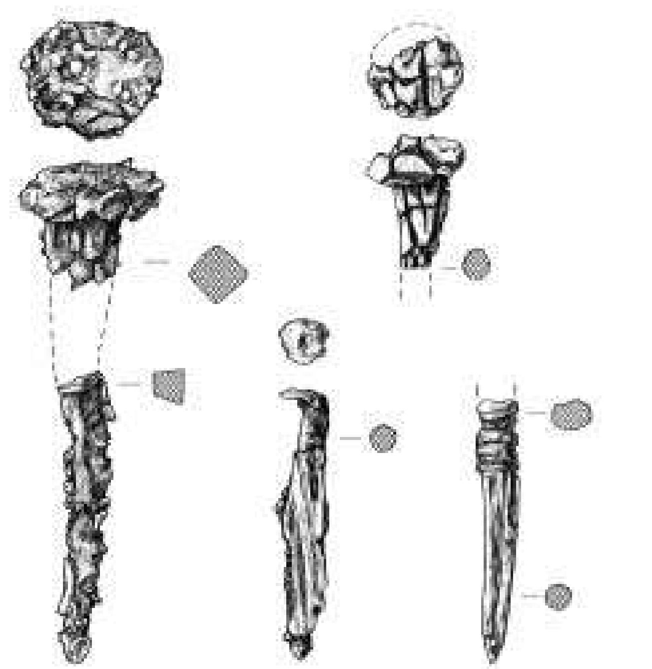

**Fig. 10** – *Assorted nails from Tomb 17 (scale 1:2).* Drawings by Marina Zeltzer.

duced from which the current analysis could draw.[64] No doubt, comparable improvements will likewise be available for future investigators, from which to reassess the ages presented herein.[65] The current analysis drew upon as many techniques as possible (figure 11):

*Epiphyseal Union* – Degree of epiphyseal fusion provides a useful measure of age in growing subadults. The articular ends of bones ossify separately from the mid-section, allowing continued growth during maturation. Skeletal maturity is reached when the epiphysis is joined (fused) to the metaphysis (shaft), which occurs at different times along a single bone and throughout the skeleton (see Figure 9). Physiological stressors such as nutrition and disease can impede the rate of growth, however fusion appears relatively consistent within populations. Therefore, subadult age estimates based on epiphyseal fusion provide a useful method for forensic analysis of age at death.

*Dental Eruption* – In subadults, one of the most useful indicators of age is dental development. Calcification and eruption patterns of the teeth are highly accurate through age 12 years, and continue to be an excellent monitor of chronological age until approximately 21 years.[66]

*Pubic Symphysis* – In adults, scoring the morphology of the face of the pubic symphysis - the point of articulation between the two innominates (hip bones) - is considered quite reliable.[67] Todd outlined a 10-stage method for assessing this surface, based on a large sample of male innominates. Changes in the symphyseal surface over time proceed in a predictable pattern from a heavily contoured face, to one delimited by a rim in the mid 30s, to a surface marked by increasing porosity after 40 years. Analysis by Meindl and coworkers has shown the Todd method to be the most accurate of the pubic symphyseal methods available.[68] The Todd method was available to Kurth and Vallois in the 1950s and may explain the accuracy of their estimates. Changes in the morphology of this feature, as illustrated by Suchey and Katz, were likewise utilized for the current study.[69]

*Auricular Surface Morphology* – The site of articulation of the innominate with the sacrum, known as the auricular surface, was the second pelvic age indicator employed. The method was developed by Lovejoy and coworkers,[70] using a portion of the innominate often better-preserved in the depositional context than the pubic symphysis. This was certainly true for the French Qumran collection where 16 auricular surfaces versus 4 pubic symphyses were available. In a system reminiscent of Todd's pubic symphysis method, the auricular surface technique compares changes in billowing, granulation, porosity, and transverse organization on the face of the innominate's articulation with the sacrum. It also permits a bit more

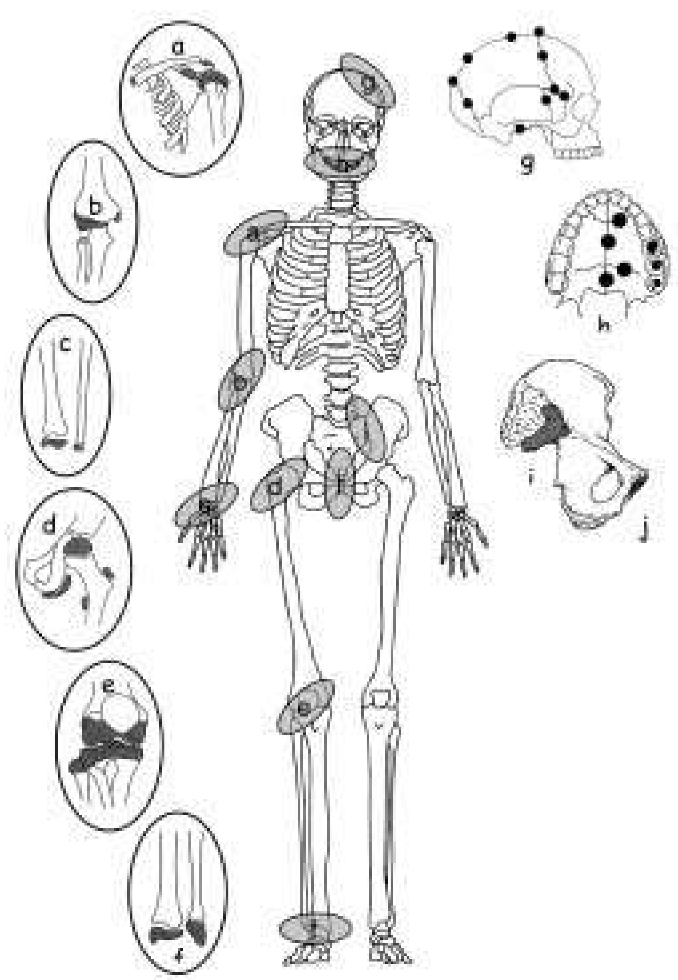


**Fig. 11** – *Age determination features including epiphyseal fusion of the (a) proximal humerus [16-23 yrs], scapula [14-22 yrs], and clavicle [18-30 yrs]; (b) distal humerus [9-16 yrs], proximal ulna [16-23 yrs], and radius [16-23 yrs]; (c) distal radius [16-19 yrs] and ulna [21-25 yrs]; (d) proximal femur [16-20 yrs] and innominate [14-21 yrs]; e) distal femur [14-21 yrs], proximal tibia [16-22 yrs] and fibula [14-21 yrs]; and (f) distal tibia [14-19 yrs] and fibula [14-19 yrs]. Points for (g) scoring degree of suture closure in the cranium and (h) palate are shown, as is degree of dental wear (h). Age changes in (i) auricular surface and (j) pubic symphsis morphology of the innominate are likewise illustrated.* Adapted from Buikstra and Ulbelaker [1994], White [2000], and Schwartz [1995].



| Method Tomb | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 15 | 16a | 16b | 18 | 19 | A | Br |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cranium** | | | | | | | | | | | | | | | | | |
| Cranial Suture Closure | - | - | 35-45 | 30-45 | 35-45 | - | 30-40 | - | 30-35 | - | - | 30-40 | - | - | 35-45 | 35-49 | - |
| Smith Attrition | IV | - | V | VIII | - | VII | - | - | IV | - | III | VII | IV | IV | IV | V | e |
| Brothwell Attrition | IIB | - | IIIB | IIIA | - | - | IIIA | - | - | - | IA | IA | IIB | IB | IIB | - | e |
| Scott Attrition | V | - | VIII | - | - | - | VII | - | - | - | III | IV | VI | IV | VI | - | e |
| Molnar Attrition | - | - | - | - | - | - | - | - | IV | - | III | V | IV | IV | IV | VI | e |
| Palate Suture Closure | - | - | - | - | - | - | - | - | A | - | 14-15 | - | - | A | - | 50 | 50+ |
| Dental Eruption | A | A | A | A | - | A | A | - | A | A | 15 | A | - | A | - | A | - |
| **Postcranium** | | | | | | | | | | | | | | | | | |
| Epiphyseal Fusion | - | A | - | - | A | - | - | - | - | A | 15-16 | A | - | A | - | A | - |
| Sacrum Fusion | A | A | A | - | - | A | - | - | - | A | <18 | A | A | A | - | - | - |
| Innominate Fusion | A | A | A | - | A | A | A | - | - | A | 15 | A | A | A | - | A | - |
| Clavicle Fusion | - | - | - | - | - | - | - | - | - | A | S | - | - | A | - | A | - |
| Todd Pubic Symphysis | - | - | - | - | - | 35-45 | - | - | - | - | - | - | - | 27-35 | 35-39 | - | - |
| Suchey-Brooks Pubic Symphysis | - | - | - | - | - | 40-45 | - | - | - | - | - | - | - | 23-39 | 35-45 | - | - |
| Auricular Surface Method | - | 30-35 | 45-59 | - | 40-44 | 50 | 40-49 | - | - | 40-45 | - | - | 40-45 | 30-35 | - | 45-60 | - |
| **Cumulative Age Determination** | A | 30-35 | 45-50 | 35-45 | 40-45 | 40-45 | 40-45 | A | 30-35 | 40-45 | 15-6 | 30-40 | 30-40 | 30-33 | 40-42 | 45-50 | 60+ |

**Table 3** – *Aging Methods used for Demographic Analysis of the French Qumran Human Remains*

finesse at aging older individuals, with 50-60 year and 60+ year age categories.

*Cranial Suture Closure* – Fusion of the cranial sutures is highly variable between individuals, however, this method has been utilized with success, especially when multiple sutures on the skull are available. A technique refined by Meindl and Lovejoy,[71] this method evaluates 17 points on the cranium for a composite score of degree of suture fusion and/or obliteration. It is important to note that some old individuals never undergo this fusion. Thus, this method is best used as part of a multifaceted aging methodology.

*Dental Attrition* – As a by-product of mastication, the tooth crown begins to wear with time. It has been argued that such wear is actually needed for the teeth to function properly.[72] The stage of tooth wear reached by time of death can often be used in an assessment of chronological age. Individual variation such as age of eruption of the teeth, types of food eaten, and consistency of intake, can affect the functional age estimate; however, when combined in a multifactorial demographic analysis, these methods have demonstrated a high success rate (70%).[73] To achieve the most accurate measure, it is important to have a subadult collection to form a baseline of wear.[74] This was not possible for the Qumran collection, however four methods were employed to assess rate of dental wear,[75] demonstrating considerable consistency between the scales.

For the French Qumran collection, multiple methods of age assessment were employed for each individual. Table 3 illustrates the results of these measures. Not all aging techniques were created equal, thus more weight is given to some methods over others. For example, techniques controlled largely by genetic influences such as dental eruption or fusion of the epiphyses are weighted most heavily. Changes in articular morphology of the innominate are good for adult remains, and cranial suture closure and dental attrition provide further complementary data from which to build an age profile. As in any good circumstantial case, the more information available, the stronger the resultant determination.

By employing aspects of bone growth, dental development, dental attrition, and changes in the morphology of the pelvis, we were able to add to the original estimates. Table 4 illustrates that the average age for this sub-sample of Qumran inhabitants was 30-40 years, with the individual from Tomb B reaching old age by Qumran standards.

| Tomb | Original | Current |
|---|---|---|
| 3 | - | adult |
| 4 | - | 30-35 |
| 5 | - | 45-50 |
| 6 | - | 35-45 |
| 7 | - | 40-45 |
| 8 | - | 40-45 |
| 10 | - | 40-45 |
| 11 | - | adult |
| 12 | 30 | 30-35 |
| 13 | - | 40-45 |
| 15 | 16 | 15-16 |
| 16a | 30 | 30-40 |
| 16b | 30-40 | 30-40 |
| 17 | - | adult |
| 18 | 30 | 30-33 |
| 19 | 30-40 | 40-42 |
| A | 30-35 | 45-50 |
| B | <50 | 60+ |

**Table 4** – *Original and Current Age Estimations for the French Qumran Collection [ages in years]*

| Method | Bone Tomb | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 15 | 16a | 16b | 18 | 19 | A | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cranium** | | | | | | | | | | | | | | | | | | |
| Browridge | Frontal | M | M | M | M | - | M | M | M | M | - | M | M | - | M | M | - | - |
| Supraorbital Ridge | Frontal | - | - | M | - | - | I | M | M | M | - | I | I | - | M | M | - | - |
| Temporal Line | Parietal | - | - | M | - | M | M | - | M | M | - | * | M | - | M | M | - | - |
| Mastoid Process | Temporal | - | M | I | I | M | M | M | - | M | - | * | M | M | M | M | - | - |
| Zygomatics | Zygomatic | - | - | - | - | - | M | - | M | - | - | * | M | - | M | M | F | - |
| Nuchal Crest | Occipital | - | M | M | - | M | M | M | - | M | - | * | M | M | M | M | - | - |
| Mental Eminence | Mandible | M | - | M | M | - | I | M | - | M | - | M | M | M | M | M | - | M |
| Gonial Eversion | Mandible | M | - | I | - | - | - | M | - | M | - | * | - | M | M | M | - | M |
| Mandibular Breadth | Mandible | M | - | I | M | - | - | M | - | M | - | * | M | M | M | M | - | - |
| Genial Tubercles | Mandible | - | - | I | M | - | M | M | M | M | - | I | M | M | M | M | - | M |
| **Postcranium** | | | | | | | | | | | | | | | | | | |
| Hyoid | Hyoid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | M |
| Ossified Thyroid cartiledge | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | M |
| Clavicle Length | Clavicle | - | - | - | - | - | - | - | - | - | - | - | - | - | I | - | F | - |
| Glenoid Cavity Length | Scapula | - | - | - | - | - | - | - | - | - | - | - | - | - | M | - | F | - |
| Scapula Length | Scapula | - | - | - | - | - | - | - | - | - | - | - | - | - | M | - | M | - |
| Scapular Index | Scapula | - | - | - | - | - | - | - | - | - | - | - | - | - | I | - | M | - |
| Midshaft Circumference | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Vertical Head Diamter | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | I | - | F | - |
| Transverse Head Diameter | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | I | - | F | - |
| Humerus Length | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | I | - | F | - |
| Articular Width of Epicondyle | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Epicondylar Breadth | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Medial Epicondylar Angle | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | M | - |
| Deltoid Tuberosity | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Olecrenon Shape | Humerus | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | M | - |
| Vertical Head Diameter | Femur | - | - | - | - | M | - | - | - | - | - | * | - | - | M | - | F | - |
| Linea Aspera Robusticity | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Bicondylar Width | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Femur Midshaft Circumference | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Femur Length | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Physiological Length | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| A/P Diameter | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Trochanteric Oblique Length | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Trochanteric Angle | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | - | - |
| Popliteal Length | Femur | - | - | - | - | - | - | - | - | - | - | * | - | - | F | - | F | - |
| Proximal Breadth | Tibia | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Distal Breadth | Tibia | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| Tibia Midshaft Circumference | Tibia | - | - | - | - | - | - | - | - | - | - | * | - | - | M | - | F | - |
| **Pelvis** | | | | | | | | | | | | | | | | | | |
| Sciatic Notch | Innominate | M | M | M | - | M | M | - | - | - | M | * | - | - | I | - | I | - |
| Acetabular-Pelvic Index | Innominate | - | - | - | - | - | - | - | - | - | - | - | - | - | M | - | - | - |
| Ischiopubic Index | Innominate | - | - | - | - | - | - | - | - | - | - | - | - | - | M | - | - | - |
| Preauricular Sulcus | Innominate | M | M | M | - | M | I | - | - | - | M | * | - | - | M | - | F | - |
| Auricular Surface Elevation | Innominate | M | M | M | - | M | M | M | - | - | M | M | - | - | M | - | I | - |
| Ventral Arc | Innominate | - | - | - | - | - | M | - | - | - | - | - | - | - | M | M | - | - |
| Subpubic Concavity | Innominate | - | - | - | - | - | F | - | - | - | - | - | - | - | M | - | - | - |
| Ischiopubic Ramus Ridge | Innominate | - | - | - | - | - | I | - | - | - | - | - | - | - | M | - | - | - |
| Arcuate Line | Innominate | - | I | - | - | M | M | - | - | - | M | * | - | - | M | - | F | - |
| Ala vs. Promotory Width | Sacrum | M | M | M | - | M | I | - | - | - | M | * | - | M | M | - | - | - |
| Sacrum Curvature | Sacrum | I | M | I | - | - | F | - | - | - | M | * | - | - | M | - | - | - |
| Sacral Index | Sacrum | F | - | F | - | - | - | - | - | - | M | - | - | - | M | - | - | - |
| **Cumulative Sex Determination** | | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | F | M |

**Table 5 –** *Sex Determination Methods used for Demographic Analysis of the French Collection of Qumran Human Remains*



Several new additions have been made to the list of original age estimates, and the ages for two individuals (Tombs 19 and A) have been adjusted. Specific ages could not be calculated for the individuals in Tombs 3, 11, and 17 based on inadequate preservation/exhumation of needed skeletal indicators.[76] They are thus listed only as "adult."

### *Sex Determination*

It has been demonstrated that different areas of the skeleton grow at different rates, depending on the functional demands of the associated soft tissues. Thus, "the development of sexual dimorphism has to be regarded as the result of a complex pattern of interacting factors."[77] While *Homo sapiens* do not demonstrate significant sexual dimorphism when compared to most of our primate relatives, there is generally enough difference to permit accurate delineation between males and females.[78] In short, men tend to be more robust than women. Care should be taken in comparing across human populations however, due to differential nutrition, disease, and climatic influences on morphology.

Although determination of age is relatively clear-cut in subadults and increases in difficulty among adults, the opposite trend is true when determining sex. Establishing the sex of subadult remains below the age of 10 years is highly problematic because most distinguishing features do not begin to appear until the onset of puberty. Fortunately, this is only problematic for one individual in the study collection.

For the French collection of Qumran remains, sex determination was made on the basis of standard osteological features of the cranium, appendicular skeleton, and pelvis, including:

*Cranium* – Robusticity of the browridge, mastoid process, nuchal crest, temporal lines, zygomatics, and mandible were non-metric techniques employed for determining sex of the cranial remains. While the female skull retains gracile attributes seen in the pre-pubescent skull, the male cranium becomes markedly rougher in adulthood at the sites of muscle attachment.

*Appendicular Skeleton* – When long bones were present, metric and non-metric robusticity features such as differences in humeral head diameter, size of the deltoid tuberosity (humerus attachment site of the large deltoid muscle of the shoulder), and epicondylar breadth ("elbow") were used. For the femur, size of the femoral head, robusticity of the linea aspera (site of attachment for the hamstring muscles of the leg), and size of the condyles were used.

*Pelvis* – The bones of the pelvic girdle (innominates and sacrum) are the most diagnostic for sex determination. Factors contributing to the overall size and shape of the pelvis are constrained by both the demands of bipedal locomotion, as well as those particular to perpetuating the species. This region of the skeleton accordingly shows considerable sexual dimorphism, principally in relation to the requirements of childbirth. Morphology of the pelvis is thus an especially diagnostic tool for sex determination, since female pelvic geometry permits a greater outlet for passage of the neonate head and shoulders.

Given its role in childbirth, features of the innominate such as the morphology of the pubic arch, width of the sciatic notch, presence of a preauricular sulcus, shape of the symphyseal block, robusticity of the pubic ramus, size of the acetabulum, and elevation of the auricular surface are particularly useful diagnostic tools. Sacral morphology (curvature and diameter) was also used for the few sacra available.

As was true for aging methods, many techniques have been refined and/or introduced since the 1950s.[79] Some measures are again more reliable than others, though a lengthy list of supplemental measures are provided for completeness. Krogman ranked accuracy in sex determination using the pelvis at 95%, followed by the skull at 92%, the mandible alone at 90%, and long bone measures at 80%.[80] Stewart indicated slightly lower yields, however the order of accuracy was the same.[81]

Metric and non-metric methods of sex determination provided comparable results for this collection, an expected outcome "so long as care and skill are employed."[82] Table 5 provides a list of methods and cumulative results for both metric and non-metric methods.[83]

Information was scant for some individuals (Tombs 6, 11, 13, and B), while plentiful for others (Tombs 18 and A). The youth in Tomb 15 had not reached maturity and was thus more difficult to sex; however, those features that had developed were distinctively male.

Remains for Tomb B were the most incomplete, however the size and shape of the hyoid bone, robusticity of the edentulous mandible, and presence of ossified thyroid cartilage were indicative of a male.[84] In addition, photographic evidence for the Tomb B skeleton *in situ* illustrates a distinctively male pubis (though photographic evidence of this sort should never preclude actual osteological analysis).

In the original estimations of the Qumran remains by Kurth and Vallois, two females were reported, several individuals for whom sex was not determined, and the

| Tomb | Original | Current |
|---|---|---|
| 3 | - | M |
| 4 | - | M |
| 5 | - | M |
| 6 | - | M |
| 7 | F? | M? |
| 8 | - | M |
| 10 | - | M |
| 11 | - | M |
| 12 | M | M |
| 13 | M | M |
| 15 | M | M |
| 16a | M | M |
| 16b | M | M |
| 17 | - | - |
| 18 | M | M |
| 19 | M | M |
| A | F | F |
| B | M | M |

**Table 6 –** *Original and Current Sex Estimations for the French Qumran Collection*

| Measurement | | Tomb 3 | | Tomb 4 | | Tomb 5 | | Tomb 6 | | Tomb 7 | | Tomb 8 | | Tomb 10 | | Tomb 11 | | Tomb 12 | | Tomb 13 | | Tomb 15 | | Tomb 16a | | Tomb 16b | | Tomb 18 | | Tomb 19 | | Tomb A | | Tomb B | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L |
| Upper Body | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Clavicle** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| max length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 148.0 | - | - | - | 132.5 | - | - | - |
| AP midshaft diam | (APd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8.3 | - | - | - | 9.4 | 9.2 | - | - |
| SI midshaft diam | (SId) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.0 | - | - | - | 10.2 | 10.4 | - | - |
| midshaft circumference | (mdc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 36.0 | - | - | - | 32.5 | 34.5 | - | - |
| max breadth of sternal end | (seb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.3 | - | - | - | 19.6 | - | - | - |
| **Scapula** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| scapula height | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 190.0 | - | - | - | 167.0 | - | - | - |
| scapula breadth | (mxw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 106.8 | - | - | - | 87.8 | 93.4 | - | - |
| length of spine | (spl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 129.0 | - | - | - | 130.3 | 124.4 | - | - |
| length of supraspinous line | (ssl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| length of infraspinous line | (isl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 122.0 | - | - | - | 93.7 | - | - | - |
| glenoid cavity length | (gcl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 42.2 | 40.5 | - | - | - | 32.5 | - | - |
| glenoid cavity breadth | (gcb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 26.6 | 26.7 | - | - | 33.3 | - | - | - |
| **Sternum** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| manubrium length | (mbl) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 53.0 | | - | | - | | - | |
| manubrium width | (mbw) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 57.1 | | - | | - | | - | |
| maximum sternal length | (mls) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 89.6 | | - | | - | | - | |
| sternal notch 1 width | (S1) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 38.0 | | - | | - | | - | |
| sternal notch 3 width | (S3) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 33.3 | | - | | - | | - | |
| max length of sternal body | (msl) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | 151.0 | | - | | - | | - | |
| **Humerus** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maxiumum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 246.0 | - | - | - | - | - | 316.5 | 315.5 | - | - | 281.6 | - | - | - |
| epicondylar breadth | (bew) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 46.9 | - | - | - | - | - | 62.7 | 61.3 | - | - | 55.5 | - | - | - |
| vertical diam. of head | (vdh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.4 | - | - | - | - | - | 46.2 | 46.5 | - | - | 38.7 | - | - | - |
| transverse diam. of head | (tdh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.0 | - | - | - | - | - | 43.0 | 43.4 | - | - | 33.3 | - | - | - |
| max diam. at midshaft | (mxm) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18.0 | - | - | - | - | - | 20.5 | 22.8 | - | - | 17.6 | 17.4 | - | - |
| min diam. at midshaft | (mnm) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.9 | - | - | - | - | - | 18.1 | 18.3 | - | - | 13.4 | 13.7 | - | - |
| max diam. of capitulum | (mdc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.9 | 16.9 | - | - | 15.7 | - | - | - |
| least circumference | (lcf) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 50.5 | - | - | - | - | - | 67.0 | 64.0 | - | - | 51.8 | 51.0 | - | - |
| articular width | (atw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 39.4 | - | - | - | - | - | 48.5 | 45.5 | - | - | 37.6 | - | - | - |
| midshaft circumference | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 54.0 | - | - | - | - | - | 70.0 | 67.0 | - | - | 52.0 | 52.0 | - | - |
| **Radius** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 259.0 | - | - | - | 212.0 | - | - | - |
| AP midshaft diam. | (Apd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.1 | - | - | - | 10.0 | - | - | - |
| ML midshaft diam. | (MLd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.9 | - | - | - | 12.3 | - | - | - |
| minimum circumference | (mnc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 44.5 | - | - | - | 36.5 | - | - | - |
| midshaft circumference | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 47.0 | - | - | - | 37.0 | - | - | - |
| head circumference | (hdc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 81.0 | 80.9 | - | - | 55.0 | - | - | - |
| max ML distal breadth | (mdb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.5 | - | - | - | 25.8 | - | - | - |
| head diam. | (hdd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.1 | 25.4 | - | - | 17.3 | - | - | - |
| **Ulna** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 282.0 | - | - | - | - | - | - | - |
| AP diam. | (Apd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.7 | - | - | - | - | - | - | - |
| ML diam. | (MLd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.9 | - | - | - | - | - | - | - |
| physiological length | (psl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 211.5 | - | - | - | - | - | - | - |
| minimum circumference | (mnc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 43.0 | - | - | - | - | - | - | - |
| midshaft circumference | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 50.5 | - | - | - | - | - | - | - |
| transverse diam. of shaft | (tds) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.1 | - | - | - | - | - | - | - |
| Lower Limb | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sacrum** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| max transverse dia of base | (mtb) | 18.3 | | 17.5 | | 20.3 | | - | | - | | - | | - | | - | | - | | 15.7 | | - | | - | | - | | 20.8 | | 20.3 | | - | | - | |
| max anterior height | (mah) | 109.2 | | 102.5 | | 110.1 | | - | | - | | - | | - | | - | | - | | 111.0 | | - | | - | | - | | 120.0 | | - | | - | | - | |
| max anterior breadth | (mab) | 117.5 | | - | | 115.1 | | - | | - | | 107.8 | | - | | - | | - | | 106.5 | | - | | - | | - | | 118.5 | | - | | - | | - | |
| midventral curve length | (mvl) | 117.0 | | 114.0 | | 115.0 | | - | | - | | - | | - | | - | | - | | 108.0 | | - | | - | | - | | 129.0 | | - | | - | | - | |
| length of ala | (la) | 38.4 | - | - | - | 31.6 | 32.6 | - | - | - | - | 34.0 | 31.8 | - | - | - | - | - | - | 25.2 | 31.6 | - | - | - | - | - | - | 37.3 | 38.8 | - | 27.8 | - | 56.2 | - | - |
| anterior/posterior diam. | (APd) | 32.7 | | 31.6 | | 31.1 | | - | | 33.5 | | 30.6 | | - | | - | | - | | 31.9 | | 33.1 | | - | | - | | 34.2 | | 32.0 | | - | | - | |
| medial/lateral diam. | (MLd) | 61.4 | | 41.2 | | 54.9 | | - | | 56.6 | | 47.6 | | - | | - | | - | | 44.7 | | 22.2 | | - | | - | | 50.6 | | 50.1 | | - | | - | |
| articular surface length | (aul) | 68.0 | - | - | - | 60.2 | 59.4 | - | - | - | - | 61.5 | 59.3 | - | - | - | - | - | - | 50.7 | 54.7 | - | - | - | - | - | - | 66.4 | 66.7 | - | - | - | - | - | - |

| Measurement | | Tomb 3 | | Tomb 4 | | Tomb 5 | | Tomb 6 | | Tomb 7 | | Tomb 8 | | Tomb 10 | | Tomb 11 | | Tomb 12 | | Tomb 13 | | Tomb 15 | | Tomb 16a | | Tomb 16b | | Tomb 18 | | Tomb 19 | | Tomb A | | Tomb B | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L |
| **Innominate** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum height | (mxh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 204.5 | - | - | - | - | - | - | - | 210.5 | - | - | - | 189.0 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 153.0 | - | - | - | - | - | - | - | - | - | - | - | 132.5 | - | - | - |
| pubis length | (pbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 66.5 | - | - | - | - | - | - | - |
| ischium length | (isl) | - | - | 88.1 | 84.7 | - | - | - | - | - | - | - | 74.2 | - | 68.1 | - | - | - | - | 85.9 | - | 67.8 | 61.8 | - | - | - | - | 89.3 | 89.8 | - | - | 78.1 | - | - | - |
| acetabulum diam. | (ad) | - | - | 57.8 | 55.3 | 55.2 | 50.5 | - | - | 59.4 | 55.1 | 52.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.7 | - | - | - | - | - | - | - |
| maximum iliac height | (ilh) | - | - | 123.5 | 127.6 | 135.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 124.8 | - | - | - | 118.8 | - | - | - |
| pubic symphysis length | (psl) | - | - | - | - | - | - | - | - | - | - | - | 33.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| pubic symphysis width | (psw) | - | - | - | - | - | - | - | - | - | - | - | 13.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Patella** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 43.9 | 42.7 | - | - | - | - | - | - |
| total breadth | (tb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 46.0 | - | - | - | - | - | - | - |
| body height | (bh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.5 | 21.6 | - | - | - | - | - | - |
| **Femur** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 462.5 | 464.5 | - | - | 381.0 | - | - | - |
| bicondylar length | (bcl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 457.5 | 461.0 | - | - | 378.0 | - | - | - |
| anterior-posterior diam. | (APd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.5 | 30.1 | - | - | 23.2 | 22.7 | - | - |
| medial-lateral diam. | (MLd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 25.6 | 25.9 | - | - | 22.8 | 23.2 | - | - |
| maximum diam.r of head | (mdh) | - | - | - | - | - | - | - | - | 44.4 | 43.7 | - | - | - | - | - | - | - | - | - | - | 32.5 | 34.1 | - | - | - | - | 46.2 | 47.6 | - | - | 34.1 | 34.7 | - | - |
| circumference of midshaft | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 92.5 | 89.0 | - | - | 71.0 | 75.0 | - | - |
| subtrochanteric AP diam. | (sAP) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.6 | 23.9 | - | - | - | - | 28.5 | 27.8 | - | - | 23.2 | 27.0 | - | - |
| subtrochanteric ML diam. | (sML) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.9 | 28.2 | - | - | - | - | 33.6 | 31.6 | - | - | 24.0 | 23.0 | - | - |
| bicondylar width | (bcw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 83.4 | 83.1 | - | - | 68.0 | - | - | - |
| popliteal length | (ppl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 128.8 | - | - | - | 127.9 | - | - | - |
| trochanteric oblique line | (tol) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 443.5 | 444.0 | - | - | 377.0 | - | - | - |
| **Tibia** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 391.0 | - | - | - | - | 343.5 | - | - |
| anterior/posterior diam. | (APd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 36.7 | 36.0 | - | - | - | 20.1 | - | - |
| medial/lateral diam. | (MLd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.1 | 23.2 | - | - | - | 17.8 | - | - |
| midshaft circumference | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 88.5 | - | - | - | - | 69.0 | - | - |
| max prox bicondylar width | (bw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 78.1 | - | - | - | - | 60.6 | - | - |
| circ at nutrient foramen | (circ) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 95.0 | 95.0 | - | - | - | 79.0 | - | - |
| distal breadth | (db) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 48.0 | 48.3 | - | - | - | 45.7 | - | - |
| **Fibula** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 377.5 | 380.5 | - | - | - | - | - | - |
| midshaft circumference | (msc) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 47.0 | 45.0 | - | - | - | - | - | - |
| anterior/posterior diam. | (APd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.5 | 15.5 | - | - | - | - | - | - |
| transverse diam. | (tvd) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12.8 | 12.8 | - | - | - | 12.1 | - | - |
| max distal breadth | (eb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 25.2 | 24.5 | - | - | - | 20.4 | - | - |
| max proximal breadth | (pb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 25.6 | 25.8 | - | - | - | 24.4 | - | - |
| **Calcaneus** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 80.5 | 80.1 | - | - | - | - | - | - |
| minimum width | (mnw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 32.7 | 32.4 | - | - | - | - | - | - |
| load arm width | (law) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 48.3 | 45.0 | - | - | - | - | - | - |
| load arm length | (lal) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 50.2 | 48.5 | - | - | - | - | - | - |
| height of cuboidal facet | (cbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.4 | 27.2 | - | - | - | - | - | - |
| body height | (bh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.0 | 51.5 | - | - | - | - | - | - |
| length post-to-post facet | (lpf) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.9 | - | - | - | - | - | - | - |
| **Talus** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| maximum length | (mxl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 51.2 | 55.0 | - | - | - | - | - | - |
| maximum width | (mxw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 46.5 | 47.5 | - | - | - | - | - | - |
| body height | (bh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 38.5 | 34.5 | - | - | - | - | - | - |
| max length of trochlea | (mlt) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 32.1 | 29.8 | - | - | - | - | - | - |
| max width of trochlea | (mwt) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 37.3 | 35.4 | - | - | - | - | - | - |
| Cervical Vertebra | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Cervical 1** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| posterior body height | (pbh) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| maximum breadth | (mxb) | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |

| Measurement | | Tomb 3 | Tomb 4 | Tomb 5 | Tomb 6 | Tomb 7 | Tomb 8 | Tomb 10 | Tomb 11 | Tomb 12 | Tomb 13 | Tomb 15 | Tomb 16a | Tomb 16b | Tomb 18 | Tomb 19 | Tomb A | Tomb B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 2** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 3** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 4** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 5** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 6** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Cervical 7** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

| Measurement | | Tomb 3 | Tomb 4 | Tomb 5 | Tomb 6 | Tomb 7 | Tomb 8 | Tomb 10 | Tomb 11 | Tomb 12 | Tomb 13 | Tomb 15 | Tomb 16a | Tomb 16b | Tomb 18 | Tomb 19 | Tomb A | Tomb B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L | R L |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Thoracic Vertebra | | | | | | | | | | | | | | | | | | |
| **Thoracic 1** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.88 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.29 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.64 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 19.70 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.67 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.95 | - | - | - |
| **Thoracic 2** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.08 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.21 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.27 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 19.13 | - | - | - |
| **Thoracic 3** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.93 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 65.35 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 26.52 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.31 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.17 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 12.98 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 35.04 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.77 | - | - | - |
| **Thoracic 4** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.52 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.00 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.63 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.86 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 66.00 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 12.41 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.40 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 23.27 | - | - | - |
| **Thoracic 5** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 19.20 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.00 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 62.55 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.89 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.04 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.46 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.04 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.37 | - | - | - |
| **Thoracic 6** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 19.88 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

| Measurement | | Tomb 3 R L | Tomb 4 R L | Tomb 5 R L | Tomb 6 R L | Tomb 7 R L | Tomb 8 R L | Tomb 10 R L | Tomb 11 R L | Tomb 12 R L | Tomb 13 R L | Tomb 15 R L | Tomb 16a R L | Tomb 16b R L | Tomb 18 R L | Tomb 19 R L | Tomb A R L | Tomb B R L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.94 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 12.50 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 25.22 | - | - | - |
| **Thoracic 7** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 19.73 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 26.64 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.94 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 12.59 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.09 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.54 | - | - | - |
| **Thoracic 8** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.04 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 32.35 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.16 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.72 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.47 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.21 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.60 | - | - | - |
| **Thoracic 9** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.10 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 57.63 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 34.50 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.29 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 15.78 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 13.56 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 34.63 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.93 | - | - | - |
| **Thoracic 10** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.70 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 54.81 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 34.08 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.93 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.76 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.06 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 37.60 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.30 | - | - | - |
| **Thoracic 11** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.82 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 45.71 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 37.07 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.00 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.96 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.90 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 42.08 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 29.09 | - | - | - |
| **Thoracic 12** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 23.07 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 26.00 | - | - | - |

| Measurement | | Tomb 3 R L | Tomb 4 R L | Tomb 5 R L | Tomb 6 R L | Tomb 7 R L | Tomb 8 R L | Tomb 10 R L | Tomb 11 R L | Tomb 12 R L | Tomb 13 R L | Tomb 15 R L | Tomb 16a R L | Tomb 16b R L | Tomb 18 R L | Tomb 19 R L | Tomb A R L | Tomb B R L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 41.92 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.32 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.11 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.86 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 45.73 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.67 | - | - | - |
| Lumbar Vertebra | | | | | | | | | | | | | | | | | | |
| **Lumbar 1** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 24.71 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.00 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 44.56 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.92 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.46 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 17.86 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.29 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.82 | - | - | - |
| **Lumbar 2** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 25.41 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 87.71 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 47.54 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 32.28 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 21.88 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.50 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.91 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.66 | - | - | - |
| **Lumbar 3** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 27.52 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 23.00 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 106.31 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.06 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.09 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 20.94 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.67 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 51.08 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.85 | - | - | - |
| **Lumbar 4** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 28.38 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 23.50 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 50.30 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 33.68 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.24 | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 16.10 | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 52.06 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 35.26 | - | - | - |
| **Lumbar 5** | | | | | | | | | | | | | | | | | | |
| anterior body height | (abh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 29.04 | - | - | - |
| posterior body height | (pbh) | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.03 | - | - | - |
| maximum breadth | (mxb) | - | - | - | - | - | - | - | - | - | - | - | - | - | 94.79 | - | - | - |
| sup body width | (sbdw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.29 | - | - | - |
| sup body length | (sbdl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 35.33 | - | - | - |
| sup vert foramen width | (svfw) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| sup vert foramen length | (svfl) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| inf vert body width | (ivbw) | - | - | - | - | - | - | - | - | - | - | - | - | - | 49.75 | - | - | - |
| inf vert body length | (ivbl) | - | - | - | - | - | - | - | - | - | - | - | - | - | 35.92 | - | - | - |

**Table 7** – *Postcranial Metrics for the French Collection of Human Remains from Qumran*

| Measurement | | Tomb 3 R L | Tomb 4 R L | Tomb 5 R L | Tomb 6 R L | Tomb 7 R L | Tomb 8 R L | Tomb 10 R L | Tomb 11 R L | Tomb 12 R L | Tomb 13 R L | Tomb 15 R L | Tomb 16a R L | Tomb 16b R L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cranial Vault** | | | | | | | | | | | | | | |
| maximum cranial length | g-op | - | 174.0 | - | - | - | - | 175.0 | - | - | - | 163.0 | 187.0 | - |
| maximum cranial breadth | eu-eu | 146.0 | 150.0 | - | - | - | 135.0 | 143.0 | 136.0 | - | - | 144.0 | 144.0 | - |
| basion-bregma height | ba-b | - | - | - | - | - | - | - | - | - | - | 138.0 | 135.0 | - |
| cranial base length | ba-n | - | - | - | - | - | - | - | - | - | - | 96.0 | - | - |
| basion-prosthion length | ba-pr | - | - | - | - | - | - | - | - | - | - | 86.1 | - | - |
| porion-bregma height | po-b | - | 132.0 | - | - | 132.0 | - | 126.5 | - | - | - | 131.0 | - | - |
| basion-porion height | ba-po | - | - | - | - | - | - | - | - | - | - | 58.4 | - | - |
| auricular height | po-ap | - | 134.0 | - | - | 114.0 | - | 131.0 | - | - | - | 128.0 | - | - |
| minimum frontal breadth | ft-ft | - | - | - | - | - | - | 95.9 | - | 101.1 | - | 91.7 | 99.6 | - |
| Biasterionic breadth | as-as | - | - | - | - | - | - | - | - | - | - | - | - | - |
| foramen magnum length | ba-o | - | - | - | - | - | - | - | - | - | - | 32.5 | 37.6 | - |
| foramen magnum breadth | | - | - | - | - | - | - | - | - | - | - | 28.2 | 35.1 | - |
| fronal chord | n-b | - | - | - | - | - | - | 113.0 | - | 121.0 | - | 104.8 | 107.4 | - |
| parietal chord | b-l | 103.6 | 108.1 | - | 98.3 | 107.7 | 108.0 | 113.2 | - | 110.0 | - | 102.3 | 116.9 | - |
| occipital chord | l-o | - | - | - | - | - | - | - | - | - | - | 96.6 | 149.0 | - |
| Lambda-inion chord | l-I | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Inion-opisthion chord | I-o | - | - | - | - | - | - | - | - | - | - | - | - | - |
| frontal arc (tape) | n-b | - | - | - | - | - | - | 136.0 | - | 139.0 | - | 120.0 | 120.0 | - |
| parietal arc | b-l | 135.0 | 125.0 | - | - | 122.0 | 115.0 | 130.0 | - | 125.0 | - | 115.0 | 144.0 | - |
| occipital arc | l-o | - | - | - | - | - | - | - | - | - | - | 111.0 | 114.0 | - |
| transverse biporial arc | po-po | - | 349.0 | - | - | - | - | - | - | - | - | 255.0 | - | - |
| mastoid length | | 29.6 31.7 | - 25.9 | - | - | - | - | 25.5 - | - | 28.9 29.1 | - | 17.7 21.7 | 27.8 26.6 | - - |
| **Facial Metrics** | | | | | | | | | | | | | | |
| basion-nasion length | ba-n | - | - | - | - | - | - | - | - | - | - | 96.0 | - | - |
| basion-alveolar length | ba-ids | - | - | - | - | - | - | - | - | - | - | - | - | - |
| total facial height | n-gn | - | - | - | - | - | - | - | - | - | - | - | - | - |
| upper facial height | n-ids | - | - | - | - | - | - | - | - | - | - | - | - | - |
| bizygomatic diameter | zy-zy | - | - | - | - | - | - | - | - | - | - | 107.9 | - | - |
| biauricular breadth | au-au | - | 116.0 | - | - | - | - | - | - | - | - | 118.1 | 119.0 | - |
| upper facial breadth | fmt-fmt | - | - | - | - | - | - | - | - | 107.2 | - | 94.8 | 103.0 | - |
| bimaxillary breadth | zm-zm | - | - | - | - | - | - | - | - | - | - | - | - | - |
| nasal height | n-ns | - | - | - | - | - | - | - | - | - | - | 46.1 | - | - |
| nasal breadth | al-al | - | - | - | - | - | - | - | - | - | - | 19.7 | - | - |
| simotic chord | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| orbital height | | - | - | - | - | - | - | - | - | - 19.2 | - | 36.1 36.1 | - | - |
| orbital breadth | d-ed | - | - | - | - | - | - | - | - | 35.7 - | - | 33.7 32.6 | - | - |
| biorbital breadth | ec-ec | - | - | - | - | - | - | - | - | 95.3 | - | 92.5 | 93.3 | - |
| interorbital breadth | d-d | - | - | - | - | - | - | - | - | 25.3 | - | 21.6 | - | - |
| midorbital breadth | zo-zo | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bidacryonic arc | d-d | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxilloalveolar length | pr-alv | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxilloalveolar breadth | ecm-ecm | 62.4 | - | - | - | - | - | - | - | - | - | 61.2 | - | - |
| palatal length | ol-sta | 36.8 | - | - | - | - | - | - | - | - | - | - | - | - |
| palatal breadth | enm-enm | 38.5 | - | - | - | - | - | - | - | - | - | 35.3 | - | - |
| **Mandibular Metrics** | | | | | | | | | | | | | | |
| bicondylar breadth | cdl-cdl | - | - | - | - | - | - | - | - | 31.7 | - | 124.0 | - | - |
| bigonial width | go-go | - | - | - | - | - | - | - | - | - | - | 101.1 | - | - |
| foramen mentalia breadth | z-z | 45.3 | - | - | - | - | - | 47.1 | - | 49.6 | - | 44.8 | - | - |
| maxiumum ramus height | | - - | - - | - - | - - | - - | - - | - - | - - | 57.9 - | - - | 48.1 49.3 | - - | - - |
| coronoid process height | crH | - - | - - | - - | - - | - - | - - | - - | - - | 73.9 - | - - | 47.9 50.1 | - - | - - |
| maxiumum ramus breadth | | - - | 48.1 - | - - | - - | - - | - - | 37.7 - | - - | 42.7 - | - - | 39.5 39.0 | - - | - - |
| minimum ramus breadth | | - - | 37.6 - | - 32.4 | - - | - - | - - | - - | - - | - - | - - | 28.2 28.4 | - - | - - |
| height of mandibular body | | - - | - 31.2 | - 26.4 | 33.0 - | - - | - - | 31.1 29.9 | - - | 30.5 30.1 | - - | 26.3 26.2 | - 31.4 | - - |
| breadth of mandibular body | | - - | - 15.6 | - 12.3 | 10.5 - | - - | - - | 11.3 11.7 | - - | 10.3 11.2 | - - | 10.3 11.0 | - 14.3 | - - |
| Maximum projective length | | - - | - | - | - | - | - | - | - | - | - | - | | - |
| mandible length | | - - | - | - 68.0 | - - | - - | - - | - - | - - | 72.9 - | - - | 74.7 75.6 | - - | - - |
| chin height | id-gn | - | - | - | 33.7 | - | - | 29.2 | - | 33.1 | - | 26.8 | - | - |
| mandibular angle | | - | - | 116.0 | - | - | - | - | - | - | - | - | - | - |

| Measurement | Tomb 18 R L | Tomb 19 R L | Tomb A R L | Tomb B R L | 20 | 21 | 24I | 26 | 18 | 31 | 2 | 03-I | 4 | 22 | 32 | 33 | 36 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cranial Vault** | | | | | | | | | | | | | | | | | | |
| maximum cranial length | - | 169.0 | - | - | 187.0 | 179.0 | 181.0 | 183.0 | 182.0 | - | 186.0 | 178.0 | 178.0 | 183.0 | 174.0 | 178.0 | 167.0 | 190.0 |
| maximum cranial breadth | - | 151.5 | - | - | 141.0 | 148.0 | 143.0 | 148.0 | 146.0 | - | 145.0 | 138.0 | 139.0 | 143.0 | 133.0 | 148.0 | 126.0 | 143.0 |
| basion-bregma height | - | - | - | - | 139.0 | 126.0 | 126.0 | 132.0 | - | - | 133.0 | 128.0 | 131.0 | 137.0 | - | 138.0 | 112.0 | 144.0 |
| cranial base length | - | - | - | - | 114.0 | - | 94.0 | - | - | - | 90.0 | 94.0 | 94.0 | 99.0 | - | 93.0 | 77.0 | - |
| basion-prosthion length | - | - | - | - | - | - | 93.5 | - | - | - | 82.0 | 86.0 | 84.4 | - | - | 77.0 | 69.0 | - |
| porion-bregma height | - | 128.0 | - | - | 107.0 | 108.0 | 118.0 | 111.0 | 112.0 | - | 123.0 | 113.0 | 117.0 | 124.0 | 111.0 | 117.0 | 109.0 | 124.0 |
| basion-porion height | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| auricular height | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| minimum frontal breadth | 98.4 | 92.3 | - | - | 91.0 | - | 97.0 | 103.0 | 102.0 | - | 85.0 | 94.0 | 98.0 | 103.0 | 88.0 | 102.0 | | 100.0 |
| Biasterionic breadth | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| foramen magnum length | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| foramen magnum breadth | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| fronal chord | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| parietal chord | - | 111.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| occipital chord | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lambda-inion chord | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Inion-opisthion chord | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| frontal arc (tape) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| parietal arc | - | 129.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| occipital arc | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| transverse biporial arc | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| mastoid length | 16.5 24.2 | 28.0 24.2 | - 21.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Facial Metrics** | | | | | | | | | | | | | | | | | | |
| basion-nasion length | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| basion-alveolar length | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| total facial height | - | - | - | - | - | - | - | - | - | - | 90.3 | 98.5 | 95.6 | - | 112.0 | 106.5 | 94.0 | - |
| upper facial height | - | - | - | - | - | - | 68.0 | - | - | - | 53.3 | 60.0 | 52.5 | - | 65.0 | 61.2 | 56.0 | - |
| bizygomatic diameter | - | 111.2 | - | - | - | - | 128.0 | - | - | - | 99.5 | 117.0 | 114.4 | - | 119.0 | 126.0 | - | - |
| biauricular breadth | 132.8 | 127.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| upper facial breadth | 105.1 | 94.4 | - | - | 98.5 | - | 99.0 | 110.0 | 106.0 | - | 85.4 | 97.0 | 98.9 | 109.0 | 95.5 | 104.0 | - | - |
| bimaxillary breadth | - | - | - | - | - | - | 89.0 | 95.5 | - | - | 72.0 | 86.0 | 86.4 | - | 97.0 | 90.0 | - | - |
| nasal height | - | - | - | - | - | - | 46.0 | - | - | - | 40.3 | 45.5 | 41.2 | - | 51.0 | 47.5 | 42.0 | - |
| nasal breadth | - | 21.9 | - | - | - | 24.5 | 24.0 | - | - | - | 22.0 | 22.5 | 22.5 | 25.0 | 25.0 | 26.4 | 18.0 | - |
| simotic chord | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| orbital height | 32.2 - | - | - | - | 32.8 | 35.5 | 32.0 | - | - | - | 29.5 | 31.8 | 30.5 | - | 35.0 | 32.5 | 30.0 | - |
| orbital breadth | 41.5 - | - | - | - | 38.0 | - | 36.0 | - | - | - | 33.0 | 36.0 | 36.2 | - | 36.0 | 36.0 | 32.0 | - |
| biorbital breadth | - | 89.5 | - | - | - | - | 91.0 | 102.0 | 94.0 | - | 79.0 | 86.0 | 91.2 | - | 91.0 | 96.5 | - | - |
| interorbital breadth | 21.9 | - | - | - | 22.0 | - | 25.0 | - | - | - | 17.3 | 21.0 | 23.2 | - | 22.8 | - | 19.7 | - |
| midorbital breadth | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bidacryonic arc | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxilloalveolar length | - | 65.9 | - | 42.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxilloalveolar breadth | - | - | - | - | - | - | 41.0 | - | - | - | 38.0 | 36.0 | 41.0 | - | - | - | - | - |
| palatal length | - | 49.2 | - | - | - | 32.0 | 35.0 | - | - | - | 28.5 | 35.0 | 33.0 | 33.2 | 33.0 | 40.5 | 29.8 | - |
| palatal breadth | | | | | | | | | | | | | | | | | | |
| **Mandibular Metrics** | | | | | | | | | | | | | | | | | | |
| bicondylar breadth | - | 136.4 | - | 122.7 | - | - | - | 128.0 | - | - | 91.0 | 103.0 | 104.0 | - | - | 118.0 | 97.0 | - |
| bigonial width | 119.5 | - | - | 101.5 | - | - | - | 99.0 | 87.0 | - | 71.3 | 85.0 | 81.5 | 101.0 | 84.0 | 86.5 | 73.5 | - |
| foramen mentalia breadth | 45.8 | 44.5 | - | 38.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxiumum ramus height | - - | - - | - - | 55.7 61.8 | - | 60.0 | 32.0 | - | - | - | 66.0 | 42.0 | 51.0 | 43.0 | - | 53.0 | 57.0 | 45.0 |
| coronoid process height | - - | - 70.4 | - - | - - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| maxiumum ramus breadth | - - | 43.0 42.0 | - - | 34.9 35.0 | 31.0 | 32.3 | 33 | - | 34 | 32 | 29.8 | 28.6 | - | 26.5 | 32.5 | 24.5 | 26.4 | - |
| minimum ramus breadth | - 32.8 | - 31.2 | - - | 25.0 25.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| height of mandibular body | 30.1 31.0 | 31.2 30.9 | - - | 11.9 11.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| breadth of mandibular body | 11.5 10.7 | 11.9 12.2 | - - | 9.6 9.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Maximum projective length | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| mandible length | - 93.9 | - 98.3 | - - | 82.5 82.3 | - | - | 80.0 | - | - | 81.0 | 84.0 | 58.0 | 62.5 | 68.0 | 71.0 | 74.0 | 63.0 | 60 |
| chin height | 31.6 | 31.9 | - | 16.3 | - | 29.6 | - | - | - | 28.0 | 34.0 | 23.0 | 26.0 | - | 30.0 | 27.0 | 27.5 | 23.6 |
| mandibular angle | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Table 8** – *Cranial Metrics for the French Collection of Human Remains from Qumran*

remainder were classified as males (Table 6). The current reassessment identifies the originally indeterminate individuals and changes (with caution) one classification.

The individual from Tomb 7 was originally listed as a "Female ?" by Professor Vallois and now appears in our re-classification as a "Male ?" Please note that the question mark remains – this is not a trivial designation. The narrowness of the sciatic notch, lack of elevation of the auricular surface, and robusticity of the partial mandible and the brow ridge were all decidedly male in aspect. However, caution is advised because one of the femoral head diameters is indeterminate (the other is male), and Vallois may have had the entire skeleton from which to make his determination. It is not clear whether Vallois conducted his sex estimation at graveside with the entire skeleton to draw upon, from photographs, or was limited to examining the exhumed remains at a later time.[85]

Based on those features currently available, we would classify this individual rather definitively as male. However, given that important parts of the puzzle are missing and may have been available to the original investigator, not to mention the credentials of the original investigator,[86] the question mark remains in place.

### *Skeletal Metrics*

For use in sex determination, as well as reconstruction of general robusticity and stature, a suite of measurements of the skull and postcranial skeleton were made.[87] All measurements were completed independently by each of the authors. Results of the blind measures were statistically compared to ensure inter-observer consistency. No significant difference was found between the three sets of measures, thus the numbers listed in each table are an average of the triplicate values.

All postcranial metrics are found in table 7. The reader is directed to schematics in several publications for specific landmarks of postcranial measures utilized in the current study.[88] Cranial metrics can be found in table 8, and figure 12 provides a schematic of landmarks used in these measurements. A legend appears at the end of each table defining the abbreviations found in the table.

### Robusticity

Robusticity has been variously used for sex determination, estimation of social status, and racial classification schemes of the past. These can include width/circumference compared to length, size of muscular attachments, bone thickness, weight, or some combination of the above.[89] As a measure of overall body size, postcranial and cranial robusticity were calculated for the Qumran collection (Table 9).

Mean indices tend to be higher in males than females for measures comparing shaft and/or articular widths to length. However, "normal variability with modifications reflecting health…or other considerations, may mask the sex factor."[90] Thus, the data presented herein are included largely for completeness in reporting of the skeletal metrics.

*Postcranium*

Given the dearth of long bones collected for the French Qumran collection at exhumation, this was a rather cursory analysis. A full range of robusticity measures were calculated for the man in Tomb 18, and several indices were likewise possible for the older woman from Tomb A. Otherwise, the results are rather sporadic. Table 10 lists the postcranial indices by skeleton for the individuals in the French collection. Postcranial measurements were not published for the German material, and thus a comparison between collections was not possible at this time.[91]

As outlined in the preceding "Sex Determination" section, several indices are of some use in creating a demographic profile.[92] While the scapular index provided an "indeterminate" designation for the male in Tomb 18 and a "male" designation for the female in Tomb A (see table 5), the acetabular-pelvic, ischio-pubic, and sacral indices were in agreement with the variety of other sexually dimorphic features.

Other indices may prove useful in future reconstructions of activity patterns, should the sample size be increased.[93] And, when combined with a complete survey of non-metric traits and possible DNA analysis, some measures may likewise help illustrate the degree of genetic relatedness (or lack thereof) between this group and surrounding communities. In isolation however, with only scant long bone information available in the published literature for related collections, the utility of these calculations is minimal.[94]

*Cranial Robusticity*

As with postcranial indices, dimensions of the cranium likewise contribute somewhat to our understanding of this collection across a variety of venues. Table 11 lists the values for the French collection (divided into its component Paris and Jerusalem portions), and the German crania. Most of the indices for the German collection were published by Röher-Ertl and colleagues.[95] Numbers in italics indicate indices calculated for this paper from their published raw data.

The ability to adequately reconstruct the crania in the Paris collection was minimal, and indices for this segment of the collection are thus lacking. While more measures were possible for the Jerusalem portion, again the fragmentary nature of important dimensions precluded thorough measurement for index calculation. The young male from Tomb 15 provided the most complete cranium for the French collection, but must be viewed with some caution as he was not fully grown (15-16 years old).

**Fig. 12** – *Cranial metric points, including:*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *al* | = *alare* | *enm* | = *endomolare* | *l* | = *lambda* | *p* | = *porion* |
| *alv* | = *alveolon* | *eu* | = *euryon* | *la* | = *lacryromion* | *pg* | = *pogonion* |
| *ap* | = *apex* | *fmt* | = *frontomalare temporale* | *mf* | = *maxillofrontale* | *pr* | = *prosthion* |
| *au* | = *auriculare* | *ft* | = *frontotemporale* | *ms* | = *mastoidale* | *pt* | = *pterion* |
| *b* | = *bregma* | *g* | = *glabella* | *n* | = *nasion* | *sta* | = *staphylion* |
| *ba* | = *basion* | *gn* | = *gnathion* | *ns* | = *nasospinale* | *v* | = *vertex* |
| *cdl* | = *condylion laterale* | *go* | = *gonion* | *o* | = *opisthion* | *zy* | = *zygion* |
| *d* | = *dacryon* | *i* | = *inion* | *ol* | = *orale* | | |
| *ec* | = *ectocohnchion* | *id* | = *infradentale* | *op* | = *optisthocranion* | | |
| *ecm* | = *ectomolare* | *inc* | = *incision* | *or* | = *orbitale* | | |

Adapted from Bass [1995]; Buikstra and Ubelaker [1994]; Schwartz [1995].
Please see these sources for complete definitions of the above landmarks.



| Index | Formula |
|---|---|
| **Postcranium** | |
| Scapular Index | maximum breadth x 100/maximium length |
| Claviculohumeral Index | maximum clavicular length x 100/maxiumum humeral length |
| Clavicular Robusticity Index | miclavicular circumference x 100/maximum clavicular length |
| Humerus Robusticity Index | minimum shaft circumference x 100/maximum length |
| Humerus Diaphyseal Index | minimum shaft diameter x 100/maximum length |
| Brachial Index | maximum radius length x 100/maxium humeral length |
| Caliber Index | minimum shaft circumference x 100/physiological length |
| Platymeric Index | subtrochanteric sagittal diameter x 100/subtrochanteric transverse diameter |
| Femoral Robusticity Index | mediolateral + anteroposterior diameters x 100/bicondylar length |
| Pilastric Index | anteroposterior diameter x 100/mediolateral diameter |
| Intermembral Index | (max. humeral + max. radial lengths) x 100/(max. femoral + max. tibial lengths) |
| Crural Index | maximum tibial length x 100/maxiumum femoral length |
| Humerofemoral Index | maximum humeral length x100/maximum femoral length |
| Platycnemic Index | mediolateral diameter x 100/anteroposterior diameter |
| Vertebral Index | posterior body height x 100/anterior body height |
| Sacrum Index | sacral breadth x 100/sacral length |
| Ischiopubic Index | pubic length x 100/ischial length |
| Acetabular-Pubic Index | acetabular diameter x 100/pubic length |
| Calcaneus Index | load arm width x 100/load arm length |
| Calcaneus Length Index | load arm length x 100/maximum length |
| **Skull** | |
| Cranial index | max. cranial breadth x 100/max cranial length |
| Cranial module | max. cranial length + max breadth + max. height/3 |
| Cranial length-height index | height (to ba or po) x 100/max cranial length |
| Cranial breadth-height index | max cranial height x 100/max cranial breadth |
| Mean height index | max. cranial height x 100/[max cranial length + max cranial breadth/2] |
| Mean porion height index | porion-bregma height x 100/[max. cranial length + max. cranial breadth/2] |
| Fronto-parietal index | min. frontal breadth x 100/max. cranial breadth |
| Craniofacial transverse index | bizygomatic breadth x 100/max. cranila breadth |
| Prognathic index | basion-prosthion length x 100/basion-nasion length |
| Total facial index | total facial height x 100/bizygomatic breadth |
| Upper facial index | upper facial height x 100/bizygomatic breadth |
| Jugofrontal index | min. frontal breadth x 100/bizygomatic breadth |
| Orbital Index | max. orbital height x 100/max. orbital breadth |
| Nasal Index | nasal breadth x 100/nasal height |
| Maxilloalveolar index | maxilloalveolar breadth x 100/maxilloalveolar length |
| Palatal index | palatal breadth x 100/palatal length |
| Cranial base flatness index | basion-porion height x 100/ basion -bregma height |
| Foramen magnum Index | max. foramen breadth x 100/max. foramen length |
| Mandibular index | max. projective mandibular length x 100/bicondylar breadth |
| Mandibular body breadth index | mandibular body breadth x 100/mandibular body height |

**Table 9** – *Formulae Used to Compute Cranial and Postcranial Robusticity Indices*

When combined with the more complete cranial data for the German remains, variation about the mean was minimal in all measurements as seen in the coefficients of variation in the last column of Table 12. The largest variations occur in measures associated with the mandible and maxilla, and are the result of inclusion of the edentulous man from Tomb B. With the loss of the teeth and associated alveolar bone, the morphology of both the mandible and maxilla change considerably. When this individual is excluded from the computations, variation for both the palatal index and the mandibular body breadth index drops below 10 (considered an acceptable level of variation for biological samples).[96]

An average index was computed for males and females for each measure and compared for significance.[97] As seen in table 13, there is a significant difference by sex in the cranial module, mean height index, mean porion index and the prognathic index for this collection.

The cranial module indicates the general size of the skull. It is interesting that the female value is higher, as the trend in *Homo sapiens* is for a larger male cranium. Both sexes have a low cranial vault using the mean height index and mean porion-height index measures.[98] The seeming significance of the prognathic index is likely an artifact of

| | Scapular Index | Claviculohumeral Index | Clavicular Robusticity Index | Humerus Robusticity Index | Humerus Diaphyseal Index | Brachial Index | Caliber Index [ulna] | Platymeric Index [femur] | Femoral Robusticity Index | Pilastric Index [femur] | Intermembral Index | Crural Index | Humerofemoral Index | Platycnemic Index [tibia] | Sacrum Index | Ischio-pubic Index | Acetabular-pubic Index | Calcaneus Index | Calcaneus Length Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T3** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 107.6 | - | - | - | - |
| **T4** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T5** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 100.1 | - | - | - | - |
| **T6** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T7** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T8** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T10** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T11** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T12** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T13** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 98.6 | - | - | - | - |
| **T15** | - | - | - | 20.5 | 5.7 | - | - | 90.8 | - | - | - | - | - | - | - | - | - | - | - |
| **T16a** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T16b** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **T18** | 56.2 | 46.8 | 24.3 | 22.1 | 5.7 | 81.8 | 20.3 | 84.8 | 12.5 | 123.0 | 67.4 | 84.5 | 68.4 | 65.7 | 91.9 | 74.5 | 74.7 | 96.2 | 62.4 |
| **T19** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **TA** | 52.6 | 47.1 | 24.5 | 18.4 | 4.8 | 75.3 | - | 96.7 | 12.2 | 101.8 | 68.1 | 90.2 | 73.9 | 88.6 | - | - | - | - | - |
| **TB** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **n** | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 1 | 1 | 1 | 1 |
| **mean** | 54.5±2.6 | 46.9±0.5 | 24.4±0.1 | 20.3±1.9 | 5.4±0.5 | 78.6±4.6 | 20.3 | 90.8±5.9 | 12.3±0.2 | 112.4±15.1 | 67.8±0.5 | 87.4±4.0 | 71.2±3.9 | 77.1±16.2 | 99.5±6.5 | 74.5 | 74.7 | 96.2 | 62.4 |

**Table 10** – *Postcranial Indices for the French Collection of Human Remains from Qumran*

the small female sample size (n=1). In general, both males and females have rather low, broad, rounded cranial vaults, with a medium-sized flat face, average-sized nose, and tall narrow orbits.[99]

### Stature Estimation

The attainment of adult stature results from a combination of genetic and environmental influences. The high correlation between parental and offspring height, and the comparable heights attained by identical twins provide evidence for a genetic component to stature.[100]

However, twin studies and comparisons of immigrant parents and their 'transplanted' children likewise demonstrate that while the genotype (genetic makeup) of the individual sets the limits of terminal height, the environment plays a crucial role in the achievement of genetic potential. Numerous studies have repeatedly shown the importance of the environment on stature, including the role of nutrition, work intensity, and disease stress on the growing subadult.[101] Adult height is thereby influenced by the subadult environmental context of growth.[102]

The study of stature can be useful for understanding changes in adaptive success in the past,[103] as well as in modern forensic settings (individual identification)[104] and public policy decisions.[105] Although stature may vary with age, illness, and even fluctuate slightly throughout the course of a given day, it has proven a useful measure in both forensic and archaeological contexts.[106]

Interest in reconstructing ancient human stature began in the early 1800s.[107] The introduction of regression formulae in the 1950s, developed using modern populations, subsequently enhanced the accuracy of stature estimation, especially when using multiple long bones for the same individual.[108]

For the French Qumran collection, stature was reconstructed using the regression formulae of Trotter and Gleser for the long bones.[109] Unfortunately, the use of multiple criteria was possible for only two individuals in this collection, one male and one female (Tomb 18 and Tomb A). The overall stature for each individual in the current study is listed in Table 14 and compared to the results of previous investigations as reported by Röher-Ertl and colleagues.[110]

Formicola states, "…the absence of records of the actual stature of skeletal samples makes it impossible to check directly the accuracy of estimates provided by the different formulae."[111] However, an internal check on accuracy exists



| | Cranial index | Cranial module | Cranial length-height index | Cranial breadth-height index | Mean height index | Mean porion height index | Fronto-parietal index | Craniofacial transverse index | Prognathic index | Total facial index | Upper facial index | Jugofrontal index | Orbital Index | Nasal Index | Maxilloalveolar index | Palatal index | Cranial base flatness index | Foramen magnum Index | Mandibular index | Mandibular body breadth index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Paris** | | | | | | | | | | | | | | | | | | | | |
| T3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 104.6 | - | - | - | - |
| T4 | 86.2 | - | - | - | - | 53.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | 50.0 |
| T5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 46.6 |
| T6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 31.8 |
| T7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| T8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| T10 | 81.7 | - | - | - | - | 51.1 | 67.1 | - | - | - | - | - | - | - | - | - | - | - | - | 36.3 |
| T11 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Jerusalem** | | | | | | | | | | | | | | | | | | | | |
| T12 | - | - | - | - | - | - | - | - | - | - | - | - | 53.8 | - | - | - | - | - | - | 33.8 |
| T13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| T15 | 88.3 | 148.3 | 84.7 | 95.8 | 58.7 | 55.7 | 63.7 | 74.9 | 89.7 | - | - | 85.0 | 93.4 | 42.7 | - | - | 42.3 | 86.8 | - | 39.2 |
| T16a | | | | | | | | | | | | | | | | | | | | |
| T16b | | | | | | | | | | | | | | | | | | | | |
| T18 | - | - | - | - | - | - | - | - | - | - | - | - | 78.2 | - | - | - | - | - | - | 38.2 |
| T19 | 89.6 | - | - | - | - | 52.3 | 60.9 | 73.4 | - | - | - | 83.0 | - | - | - | - | - | - | - | 38.1 |
| TA | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TB | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 80.7 |
| **German** | | | | | | | | | | | | | | | | | | | | |
| Q20 | 75.0 | 155.7 | 74.0 | 99.0 | 54.0 | 57.0 | 65.0 | - | - | - | - | 81.0 | 86.0 | - | - | - | - | - | - | - |
| Q21 | 83.0 | 151.0 | 70.0 | 85.0 | 49.8 | 60.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Q22 | 78.0 | 154.3 | 75.0 | 96.0 | 58.4 | 68.0 | 72.0 | - | - | - | - | 86.0 | - | - | - | - | - | - | - | - |
| Q24-I | 79.0 | 150.0 | 70.0 | 88.0 | 54.0 | 65.0 | 68.0 | 90.0 | 99.5 | - | 54.0 | 80.0 | 89.0 | 52.0 | - | 85.0 | - | - | - | - |
| Q26 | 81.0 | 154.3 | 72.0 | 89.0 | 55.1 | 61.0 | 70.0 | - | - | - | - | 87.0 | - | - | - | - | - | - | - | - |
| Q28 | 80.0 | - | - | - | - | 62.0 | 70.0 | - | - | - | - | 83.0 | - | - | - | - | - | - | - | - |
| Q31 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Q32 | 76.0 | - | - | - | - | 64.0 | 66.0 | 90.0 | - | 94.1 | 55.0 | 73.0 | 97.0 | 49.0 | - | - | - | - | - | - |
| Q33 | 83.0 | 154.7 | 78.0 | 93.0 | 58.2 | 66.0 | 69.0 | 85.0 | 82.8 | 84.5 | 49.0 | 79.0 | 90.0 | 49.0 | - | - | - | - | - | - |
| Q36 | 76.0 | 135.0 | 68.0 | 89.0 | 53.5 | 65.0 | - | - | 89.6 | - | - | - | 94.0 | 43.0 | - | - | - | - | - | - |
| QSo1 | 75.0 | 159.0 | 76.0 | 101.0 | 60.5 | 65.0 | 70.0 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| QSo2 | 78.0 | 154.7 | 71.0 | 92.0 | 55.9 | 66.0 | 59.0 | 69.0 | 91.1 | 90.8 | 54.0 | 80.0 | 98.0 | 55.0 | - | 75.0 | - | - | - | - |
| QSo3 | 78.0 | 148.0 | 72.0 | 108.0 | 56.4 | 64.0 | 68.0 | 85.0 | 91.5 | 84.2 | 51.0 | - | 88.0 | 50.0 | - | 97.0 | - | - | - | - |
| QSo4 | 78.0 | 149.3 | 73.0 | 94.0 | 57.5 | 66.0 | 71.0 | 82.0 | 89.4 | 83.6 | 46.0 | 87.0 | 84.0 | 55.0 | - | 81.0 | - | - | - | - |

**Table 11** – *Cranial Indices for the French and German Qumran Collections*

by comparing the estimates obtained via 4 different investigators. Although the sample sizes are quite small, estimated statures for the French collection fall within the range for the Kurth, Vallois, and the German collection ($p \leq 0.05$).

Figure 13 illustrates a) male and b) female stature for the combined collection. The estimate for each individual is graphically displayed, illustrating the high degree of consistency of height within each sex. The stature of the Qumran males in this collection ranges from 159-177 cm, and from 152-163 cm for females. Variation within each group is low for both males (CV=3.6; n=11) and females (CV=2.1; n=10).

Figure 14 provides a comparison of the average male and female heights for the collection. The mean male stature in the combined de Vaux collection is 165.7±5.9 cm (n=11) and 158.3±3.3 cm (n=10) for the females.[112] While within sex differences are not significant, as shown in the low coefficients of variation listed above, differentiation in average stature *between* males and females is indeed highly significant ($p=0.001$; $t=3.5$; $df=19$).

| Index | French | | | German | | | Combined | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | mean | CV | n | mean | CV | n | mean | range | CV |
| Cranial index | 4 | 86.5 ± 3.5 | 4.0 | 12 | 78.7 ± 2.7 | 3.4 | 16 | 80.6 ± 4.5 | 75.0-89.6 | 5.5 |
| Cranial module | 1 | 148.3 | - | 10 | 153.1 ± 3.4 | 2.2 | 11 | 152.7 ± 3.5 | 148.0-159.0 | 2.3 |
| Cranial length-height index | 1 | 84.7 | - | 10 | 73.1 ± 2.6 | 3.6 | 11 | 74.2 ± 4.3 | 70.0-84.7 | 5.8 |
| Cranial breadth-height index | 1 | 95.8 | - | 10 | 94.5 ± 6.8 | 7.2 | 11 | 94.6 ± 6.5 | 85.0-108.0 | 6.8 |
| Mean height index | 1 | 58.7 | - | 10 | 56.0 ± 3.0 | 5.3 | 11 | 56.2 ± 3.0 | 49.8-60.5 | 5.3 |
| Mean porion height index | 4 | 53.0 ± 2.0 | 3.7 | 12 | 63.7 ± 3.1 | 4.9 | 16 | 61.0 ± 5.5 | 51.1-68.0 | 9.1 |
| Fronto-parietal index | 3 | 63.9 ± 3.1 | 4.9 | 11 | 68.0 ± 3.6 | 5.3 | 14 | 67.1 ± 3.8 | 59.0-72.0 | 5.7 |
| Craniofacial transverse index | 2 | 74.2 ± 1.1 | 1.4 | 6 | 83.5 ± 7.8 | 9.3 | 8 | 81.2 ± 7.9 | 69.0-90.0 | 9.7 |
| Prognathic index | 1 | 89.7 | - | 5 | 90.9 ± 6.0 | 6.6 | 6 | 90.7 ± 5.4 | 82.8-99.5 | 5.9 |
| Total facial index | | - | | 5 | 87.4 ± 4.7 | 5.4 | 5 | 87.4 ± 4.7 | 83.6-94.1 | 5.4 |
| Upper facial index | | - | | 6 | 51.5 ± 3.5 | 6.8 | 6 | 51.5 ± 3.5 | 46.0-55.0 | 6.8 |
| Jugofrontal index | 2 | 84.0 ± 1.4 | 1.7 | 9 | 81.8 ± 4.5 | 5.6 | 11 | 82.2 ± 4.2 | 73.0-87.0 | 5.1 |
| Orbital Index | 3 | 75.1 ± 20.0 | 26.6 | 7 | 90.3 ± 5.3 | 5.9 | 10 | 85.7 ± 12.7 | 53.8-98.0 | 14.8 |
| Nasal Index | 1 | 42.7 | - | 6 | 51.7 ± 2.8 | 5.4 | 7 | 50.4 ± 4.2 | 42.7-55.0 | 8.4 |
| Maxilloalveolar index | | - | | | - | | | - | | |
| Palatal index | 1 | 104.6 | - | 4 | 84.5 ± 9.3 | 11.0 | 5 | 88.5 ± 12.1 | 75.0-104.6 | 13.6 |
| Cranial base flatness index | 1 | 42.3 | - | | - | | 1 | 42.3 | - | - |
| Foramen magnum Index | 1 | 86.8 | - | | - | | 1 | 86.8 | - | - |
| Mandibular index | | - | | | - | | | | - | |
| Mandibular body breadth index | 9 | 43.9 ± 15.0 | 15.7 | | - | | 8 | 39.2 ± 6.2 | 31.8-50.0 | 15.7 |
| Mandibular ramus index | | - | | | - | | | | - | |

* values for the German and Combined groupings do not include Tomb 36 (subadult).

**Table 12 –** *Cranial Indices for the Combined de Vaux Qumran Collection*

| Index | Male | | Female | | Students' t-Test | | |
|---|---|---|---|---|---|---|---|
| | n | mean | n | mean | df | t | p |
| Cranial index | 12/ | 81.5 ± 4.5 | 4 | 78.0 ± 3.6 | 14 | 1.4 | 0.09 |
| Cranial module | 8 | 151.4 ± 3.1 | 3 | 156.0 ± 2.6 | 9 | -2.3 | 0.02 |
| Cranial length-height index | 8 | 73.3 ± 4.5 | 3 | 76.3 ± 1.5 | 9 | -1.0 | 0.16 |
| Cranial breadth-height index | 8 | 93.8 ± 7.3 | 3 | 96.7 ± 4.0 | 9 | -0.6 | 0.27 |
| Mean height index | 8 | 55.2 ± 2.7 | 3 | 59.0 ± 1.3 | 9 | -2.3 | 0.02 |
| Mean porion height index | 12 | 59.4 ± 5.5 | 4 | 65.8 ± 1.7 | 14 | -2.2 | 0.02 |
| Fronto-parietal index | 10 | 66.3 ± 4.0 | 4 | 69.2 ± 2.5 | 12 | -1.4 | 0.10 |
| Craniofacial transverse index | 6 | 79.0 ± 7.9 | 2 | 87.5 ± 3.5 | 6 | -1.4 | 0.10 |
| Prognathic index | 5 | 92.2 ± 4.2 | 1 | 82.8 | 4 | 2.1 | 0.05 |
| Total facial index | 3 | 86.2 ± 4.0 | 2 | 89.3 ± 6.8 | 3 | -0.7 | 0.28 |
| Upper facial index | 4 | 51.2 ± 3.8 | 2 | 52.0 ± 4.2 | 4 | -0.2 | 0.42 |
| Jugofrontal index | 8 | 83.2 ± 2.9 | 3 | 79.3 ± 6.5 | 9 | 1.5 | 0.09 |
| Orbital Index | 8 | 83.8 ± 13.5 | 2 | 93.5 ± 4.9 | 8 | -1.0 | 0.18 |
| Nasal Index | 5 | 50.9 ± 5.1 | 2 | 49.0 ± 0.0 | 5 | 0.5 | 0.32 |
| Maxilloalveolar index | - | | | - | | - | |
| Palatal index | - | | | - | | - | |
| Cranial base flatness index | - | | | - | | - | |
| Foramen magnum Index | - | | | - | | - | |
| Mandibular index | - | | | - | | - | |
| Mandibular body breadth index | 8 | 39.2 ± 6.2 | | - | | - | |
| Mandibular ramus index | - | | | - | | - | |

**Table 13 –** *Male and Female Cranial Indices for the Combined de Vaux Qumran Collection*

To gauge the relative stature of this small sub-sample of the Qumran community, the combined de Vaux collection was compared to several regional/temporal counterparts. Table 15 lists published stature estimates for Late Hellenistic and Roman period collections from sites relatively near Qumran, in the Dead Sea/Jericho/Jerusalem corridor. These sites include Ein Gedi[113] (n=24), Jericho,[114] Nahal Hever[115] (n=9), Givat Ha'Mivtar[116] (n=17), City of



| Collection | Males | | Females | |
|---|---|---|---|---|
| | mean | n | mean | n |
| Qumran (Vallois) | 160.0* | 1 | - | |
| Qumran (Kurth) | - | | 159.0 | 1 |
| Qumran (German Collection) | 165.7 | 9 | 158.3 | 9 |
| Qumran (French Collection) | 174.4 | 1 | 154.3 | 1 |

* Vallois reported this individual as a "female (?)"

**Table 14 –** *Stature Estimates for Individuals from Qumran*

| Site | Period | Males | | | Females | | | Method | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | x std | range | n | x std | range | n | | |
| **Dead Sea/Jericho/ Judean Hills (Jerusalem)** | | | | | | | | | |
| Ein Gedi | H | 165.9 ± 5.1 | 157-174 | 12 | 151.0 ± 4.9 | 141-165 | 12 | - | Arensburg *et al.* (1980:178) |
| Jericho | H/R | 160.0 | - | - | - | - | - | - | Arensburg & Smith (1983:134 |
| Givat Ha' Mivtar | H/R | 165.0 | 149-181 | 10 | 160.5 | 151-170 | 7 | - | Haas (1970:40-49) |
| City of David | R | 178.0 ± 4.0 | - | - | 151.0 ± 4.5 | - | - | Trotter & Glesser | Smith *et al.* (1992:61) |
| Mount Scopus | R | 166.0 | 155-174 | 5 | 149.0 | 144-153 | 7 | Trotter & Glesser | Zias (1992:100) |
| Nahal Hever | R | 162.4 ± 3.3 | 158-167 | 5 | 154.2 ± 4.0 | 150-159 | 4 | Trotter & Glesser | Nathan (1961:171) |
| Shmuel Ha-Navi St. | R | 168.0 | - | 1 | - | - | - | - | Rahmani (1960:148) |
| **Galilee/Moab/ Ammon/Aravah** | | | | | | | | | |
| Meiron | R | 164.2 | 162-169 | 6 | 148.0 | 143-152 | 7 | Trotter & Glesser | Smith *et al.* (1981:114) |
| Hesbon (Area D) | R | - | - | - | 160.0 | - | - | - | Little (1969:237) |
| Queen Alia Airport | R | 166.2 ± 6.1 1 | 54-176 | 22 | 152.9 ± 5.2 | 146-166 | 12 | Trotter & Glesser | Frohlich (1987:52,54-56) |
| Wadi Faynan | R/B | 169.6 | 178-157 | - | 160.7 | 170-155 | - | Trotter & Glesser | El-Najjar & Al-Shiyab (1998:15) |
| Qumran (Combined) | H/R | 165.7 ± 5.9 | 159-177 | 11 | 158.3 ± 3.3 | 152-163 | 10 | Trotter & Glesser | |

H = Late Hellenistic, R = Roman, B = Early Byzantine

**Table 15 –** *Stature Estimates for the Combined Qumran Collection Compared to Regional Counterparts*

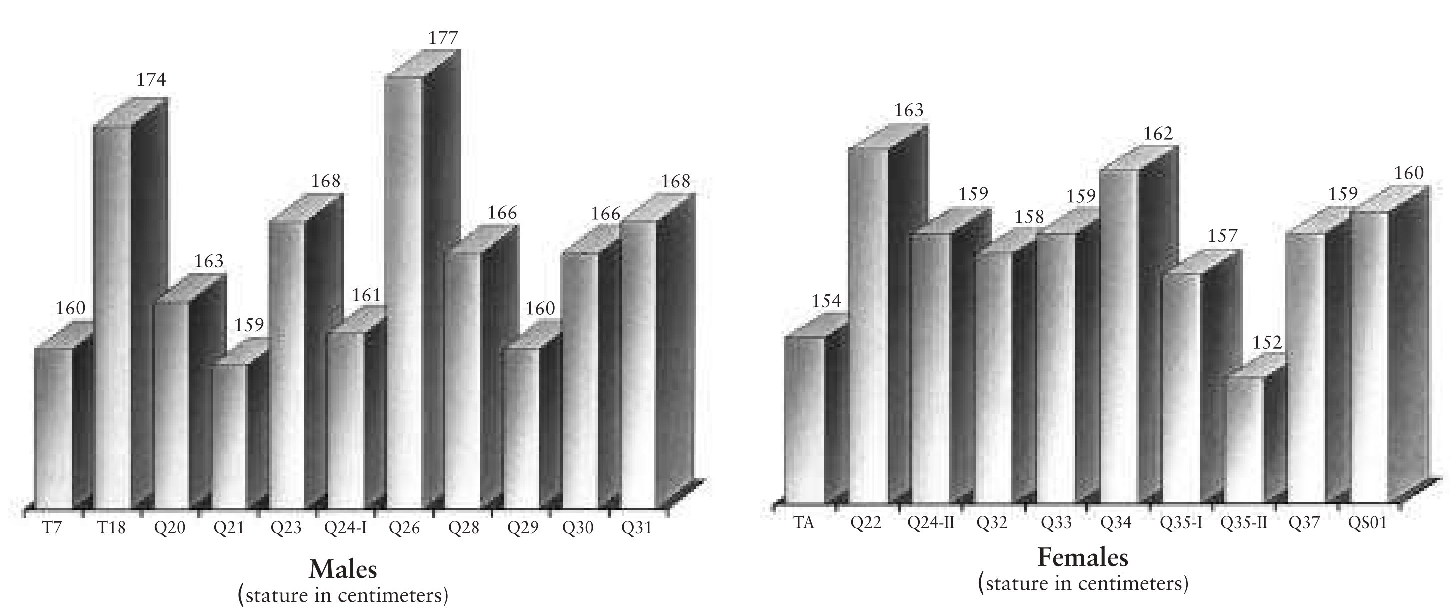


**Fig. 13 –** *Stature estimates for males and females in the Combined de Vaux Qumran collection.*

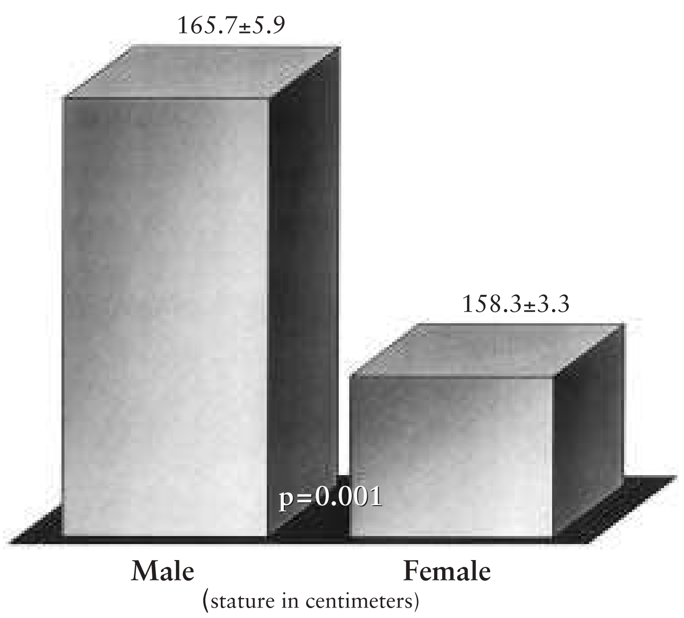


**Fig. 14** – *Comparison of Male and Female average stature for the combined deVaux Qumran collection.*

David,[117] Mount Scopus[118] (n=12), and Shmuel Ha-Navi Street[119] (n=1).

They are likewise compared to a wider distribution of Roman period contemporaries, moving from the Upper Galilee, through Ammon, Moab, and the Aravah. These sites include Meiron[120] (n=13), Queen Alia Airport in Amman[121] (n=34), Hesbon Area D,[122] and Wadi Faynan.[123]

Figure 15 graphically demonstrates this relationship, illustrating comparable peaks in height by location. The difference in stature between males and females for all regions combined is again highly significant (p=0.0001; df=19; t=5.8).

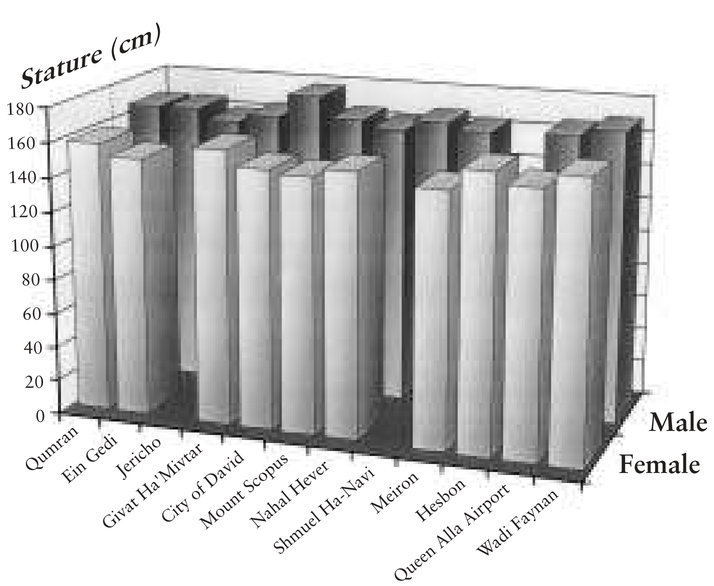


**Fig. 15** – *Variation in stature by site*

## Dental metrics

As a final addition to the overall metric survey of the French collection, several standard measures of dental morphology were collected for the teeth, including length, breadth, height, and diagonal dimensions.[124] Unlike many other elements of the cranium, the rounded and asymmetrical nature of a tooth makes delineation of landmarks problematic. Attrition can likewise cause wear facets that further confuse the definition of measurement points. Figure 16 illustrates the measurements taken. Most followed the recommendations of Moorrees.[125]

As with the cranial and postcranial metrics,[126] all measures were completed independently by the three authors

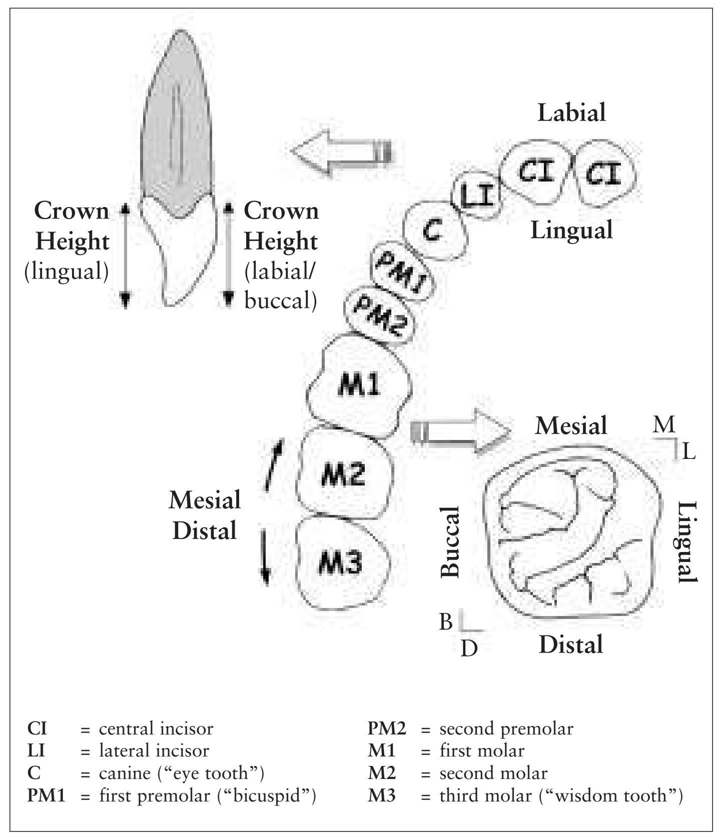


**Fig. 16** – *The human dental arcade showing tooth type, orientation, and measurement surfaces.* Adapted from Hilson [1996].

and values compared for deviation. While greater in this set of measurements than either the cranial or postcranial dimensions, differences were not statistically significant at $p \leq 0.5$. Thus, the values reported in Table 16 are again composites, averaged from the three independent measures.

Scott and Turner reported that dental traits demonstrate a high degree of bilateral symmetry.[127] This proved true for the metric analysis of the French Qumran dentition. No significant difference by side was found for antimeres (mirror images) by any measure employed, for any tooth in either the mandible or maxilla (Table 17).

As a cursory test of sexual dimorphism, a one sample Students' t-test was run comparing the woman in Tomb A to the remaining members of the French collection. There was no statistical difference in any dimension measured at the 0.01 level of significance. Unfortunately dental metrics



were not published for the German collection which would have increased the female sample size beyond a mere test of possible population affinity.

Brace and others have demonstrated significant variation in tooth dimensions across human populations around the world.[128] While comparison of metric values to regional correlates awaits collection of equivalent databases,[129] non-metric comparison of dental morphology (traits scored by presence, absence, or degree of development) was possible, as outlined below.

## Genetic Affinity

Non-metric traits embody a large and diverse group of skeletal and dental features that are scored for presence/absence or degree of expression. Most traits go unnoticed during the lifetime of the individual, ranging in expression from abnormalities of bone fusion, to variations in tooth form, to bony exostoses, to extra facets for articulation. A high correlation of these traits has been reported among related individuals, thus they are often used to assess the genetic composition of archaeological collections.[130] This segment of the analysis focused on dental non-metric traits.[131]

Dental morphology of the individuals from Qumran was scored according to the Arizona State University Dental Anthropology System (ASU DAS).[132] This system classifies features of the dentition, such as cusp number or degree of shoveling on the incisors (presence of mesial/distal ridges on lingual surface), which can then be used to compare groups. Such features are assumed to accurately represent underlying genetic composition and are relatively free of sex, age, or environmental bias.

Antemortem loss, postmortem loss, and attrition however, affect the number of teeth that can be used in morphological studies. In total, eleven individuals from the French collection were suitable for this portion of the analysis (represented by eight maxillae, eight mandibles, and several loose teeth). The following traits were not present in any of the teeth examined:[133]

| | |
|---|---|
| Shoveling | (upper central incisor) |
| Tuberculum dentale | (upper lateral incisor) |
| Mesial ridge | (upper canine) |
| Distal accessory ridge | (upper canine) |
| Cusp 5 | (upper first molar) |
| Carabelli's trait | (upper first molar) |
| Enamel extensions | (upper first molar) |
| >1 Lingual cusp | (lower second premolar) |
| Cusp 6 | (lower first molar) |
| Cusp 7 | (lower first molar) |

There was an interruption groove present on one of three upper lateral incisors and a tendency toward the reduction of the hypocone (in 2 of 3 individuals) on the upper second molars. One of three individuals had buccal pits on the lower first and second molars. Two of the three observable lower second molars expressed a Y groove pattern. All three of the lower second molars for which cusp number could be determined were four-cusped. There was also a four-cusped lower first molar (four-cusped lower first molars are considered rare in most populations, usually not exceeding 10 %).[134]

### *Population Comparison*

In general, the collection exhibited a simplified pattern of dentition found in populations of the Near East, South Asia, and Europe. This pattern differs strongly from that seen in East Asia, the Americas, and Sub-Saharan Africa. Comparison of select traits to regional correlates was therefore conducted. The Qumran features were compared to a collection from Ein Gedi,[135] a Natufian sample,[136] an Early Near East group,[137] and a Native American sample.[138]

The Ein Gedi collection dated from the Late Hellenistic through the Byzantine periods (200 BCE – 640 CE).[139] This material was the most regionally and temporally equivalent to the Qumran collection. The Natufian sample was taken from multiple sites dating to the Late Epipaleolithic (20,000-12,800 years ago).[140] The Early Near East group was a composite collection representing a number of sites from Jordan, Israel, Palestine, Turkey, Syria, Lebanon and Iraq, ranging from the Neolithic to the Early Bronze Age.[141] The North American group was largely collected from the American Southwest, dating to both the historic and prehistoric periods.

Frequencies of the traits were analyzed using Smith's Mean Measure of Divergence (MMD) statistic.[142] The limited number of unworn teeth was problematic. It was therefore decided to remove several traits such as the odontome and the Uto-Aztecan premolar in order to tease out relationships within more closely related groups. By removing these traits, the relationship between the sites within the Near East could be more easily understood, as these traits are almost never present in the Near East.[143]

The results of the analysis are presented in Table 18, with significant differences listed in bold type. A larger MMD indicates a greater amount of biological distance between groups. The North America sample is present as an outlier to illustrate such distance.

A score of <0.100 indicates two closely related groups. The relatively low MMD between the Ein Gedi and Natufian groups suggests they are closely related. Therefore, the results of the Qumran and Near East comparison and the Qumran and Ein Gedi comparison suggest that either the samples are indeed from the same biologically coherent population, or larger samples are needed.

Most of the results indicate relatively close relationships between the samples from the Near East. The only anomalous statistic is the rather divergent result between Qumran and the Natufian sample (0.561±0.150). It should be cautioned that they may not be as highly as divergent as suggested due to the small number of traits compared and small sample size.

| Tooth (Tomb 3) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | - | - | | |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | 10.3 | 9.4 | 11.3 | 11.0 | 5.6 | 4.3 |
| RM2 | 9.9 | 8.7 | 10.9 | 10.7 | 6.7 | 4.6 |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | 6.1 | 6.7 | | | 5.9 | 4.6 |
| LPM2 | 6.6 | 7.7 | | | 5.8 | 3.3 |
| LM1 | 10.3 | 9.8 | 11.2 | 10.5 | 5.3 | 4.3 |
| LM2 | 10.0 | 9.2 | 11.2 | 10.9 | 5.5 | 4.4 |
| LM3 | 11.0 | 9.5 | 11.1 | 10.7 | 5.0 | 5.7 |

| Tooth (Tomb 5) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | 7.7 | 9.2 | | | 8.4 | 10.6 |
| RLI | 6.6 | 6.4 | | | 8.8 | 9.8 |
| RC | 8.7 | 7.7 | | | 10.0 | 10.8 |
| RPM1 | 6.3 | 9.0 | | | 6.9 | 5.5 |
| RPM2 | 7.4 | 8.8 | | | 6.5 | 4.9 |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | 9.0 | 7.9 | | | 9.6 | 10.0 |
| LLI | - | - | | | - | - |
| LC | 6.8 | 6.9 | | | 8.7 | 10.2 |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | 10.3 | 11.5 | 12.3 | 12.5 | 6.0 | 3.8 |
| LM2 | 8.9 | 11.5 | 10.6 | 11.7 | 6.0 | 3.3 |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 6) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | 6.8 | 8.8 | | | 4.3 | 2.1 |
| RM1 | 10.2 | 10.7 | 11.9 | 10.7 | 5.4 | 3.6 |
| RM2 | - | - | - | - | - | - |
| RM3 | 8.9 | 10.6 | 9.9 | 10.6 | 2.2 | 6.0 |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 15) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | 6.9 | - | | | 9.7 | 9.9 |
| RC | 7.9 | - | | | 11.1 | 10.7 |
| RPM1 | 6.7 | 9.2 | | | 9.8 | 7.6 |
| RPM2 | 8.1 | 10.2 | | | 8.4 | 7.0 |
| RM1 | 10.9 | 12.2 | 12.8 | 11.8 | 6.8 | 7.4 |
| RM2 | 10.2 | 13.3 | 13.5 | 12.5 | 6.8 | 8.1 |
| RM3 | - | - | - | - | - | - |
| LCI | 8.4 | - | | | 11.7 | 11.5 |
| LLI | - | - | | | - | - |
| LC | 7.8 | - | | | 12.9 | 11.6 |
| LPM1 | 7.2 | 9.7 | | | 9.8 | 7.1 |
| LPM2 | 7.5 | 10.3 | | | 8.3 | 6.8 |
| LM1 | 10.9 | 11.5 | 12.8 | 11.9 | 6.6 | 6.9 |
| LM2 | 9.5 | 12.6 | 13.7 | 11.3 | 6.9 | 6.9 |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI5.2 | - | | | | 9.5 | 6.8 |
| RLI | 6.5 | - | | | 7.3 | 9.8 |
| RC | 6.9 | - | | | 12.3 | 10.3 |
| RPM1 | 6.9 | 8.0 | | | 9.2 | 5.6 |
| RPM2 | 7.4 | 9.2 | | | 8.1 | 5.6 |
| RM1 | 11.1 | 11.0 | 12.2 | 11.8 | 5.6 | 7.7 |
| RM2 | 11.8 | 10.5 | 11.9 | 12.0 | 4.7 | 7.3 |
| RM3 | - | - | - | - | - | - |
| LCI | 5.2 | - | | | 9.0 | 9.3 |
| LLI | 6.2 | - | | | 10.1 | 10.0 |
| LC | 7.2 | - | | | 12.0 | 10.8 |
| LPM1 | 7.1 | 7.7 | | | 8.9 | 4.9 |
| LPM2 | 8.6 | 9.4 | | | 7.8 | 6.0 |
| LM1 | 11.3 | 10.8 | 12.5 | 11.8 | 7.9 | 5.9 |
| LM2 | 11.4 | 10.6 | 12.6 | 12.2 | 6.9 | 5.3 |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 16a) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | 8.2 | 7.5 | | | 6.5 | 2.5 |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | 9.2 | 6.8 | | | 6.1 | 1.0 |
| RPM2 | - | - | | | - | - |
| RM1 | 11.1 | 11.4 | 11.6 | 13.4 | 7.9 | 6.9 |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | 7.7 | 7.9 | | | 7.2 | 4.4 |
| LLI | 6.3 | 4.8 | | | 4.0 | 4.3 |
| LC | 6.2 | | Worn flat | | | |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | 10.4 | 11.9 | 13.2 | 11.3 | 7.7 | 6.8 |
| LM2 | - | - | - | - | - | - |
| LM3 | 11.1 | 9.6 | 10.3 | 10.8 | 6.1 | 6.0 |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | | - |
| LPM2 | | | Worn to CEJ | | | |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 16b) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | 8.8 | 8.5 | | | 10.2 | 9.3 |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | 9.5 | 9.7 | | | 6.0 | 2.1 |
| RPM2 | 9.4 | 7.3 | | | 8.4 | 3.9 |
| RM1 | 10.2 | 11.7 | 13.5 | 11.6 | 8.9 | 4.0 |
| RM2 | 10.3 | 11.6 | 13.7 | 11.5 | 4.0 | 7.2 |
| RM3 | - | - | - | - | - | - |
| LCI | 8.9 | 8.5 | | | 10.4 | 9.1 |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | 7.0 | 9.5 | | | 6.9 | 3.7 |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | 10.0 | 10.6 | 11.3 | 10.7 | - | 4.3 |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | 11.5 | 11.2 | 11.7 | 12.9 | 6.4 | 5.9 |
| RM2 | 11.5 | 10.8 | 12.4 | 12.5 | 5.9 | 5.6 |
| RM3 | - | - | | | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | 9.0 | 7.2 | | | 4.3 | 4.4 |
| LPM2 | - | - | | | - | - |
| LM1 | 11.7 | 11.1 | 12.5 | 13.1 | 5.6 | 5.5 |
| LM2 | 11.6 | 10.1 | 12.2 | 11.8 | 5.7 | 5.6 |
| LM3 | 8.8 | 9.9 | 10.1 | 9.4 | 5.8 | 6.3 |

| Tooth (Tomb 8) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | 6.3 | 8.9 | | | 6.7 | 5.3 |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | 9.7 | 12.0 | 13.3 | 12.1 | 7.4 | 6.0 |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | | Too broken to measure | | | | |
| LPM1 | 4.6 | 8.3 | | | Broken | |
| LPM2 | - | - | | | - | - |
| LM1 | 9.7 | 11.1 | 10.9 | 12.6 | 6.1 | 4.2 |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | 5.2 | 6.8 | | | 5.4 | 8.3 |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | 4.5 | 6.7 | | | 5.3 | 4.7 |
| LLI | - | - | | | - | - |
| LC | 6.9 | 7.6 | | | 13.2 | 11.5 |
| LPM1 | 7.4 | 8.1 | | | 6.2 | 4.4 |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 10) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | 7.5 | calc | | | 10.7 | 10.2 |
| RPM1 | - | - | | | - | - |
| RPM2 | 7.0 | 8.0 | | | 4.8 | 5.1 |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | 10.5 | 11.0 | 12.0 | 11.1 | 5.2 | 5.9 |
| LM2 | 10.4 | 8.5 | 10.0 | 9.8 | 5.2 | 2.9 |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 12) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | Can't measure due to calculus | | | | | |
| RLI | 6.1 | - | | | - | 9.7 |
| RC | 6.8 | - | | | 11.0 | 10.1 |
| RPM1 | 6.7 | 8.3 | | | 7.9 | 4.4 |
| RPM2 | 7.7 | 8.9 | | | 5.0 | 4.2 |
| RM1 | 11.6 | 11.1 | 12.7 | 12.6 | 4.9 | 4.9 |
| RM2 | 11.7 | 11.3 | 12.8 | 11.9 | 4.7 | 4.8 |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | 7.1 | 8.5 | | | 7.7 | 5.3 |
| LPM2 | | | Roots | | | |
| LM1 | | | Roots | | | |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

| Tooth (Tomb 18) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | 8.8 | - | | | 10.1 | 9.7 |
| RLI | - | - | | | - | - |
| RC | 7.6 | - | | | 9.7 | 11.8 |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | 10.1 | 11.7 | 12.3 | 11.2 | 6.4 | 5.9 |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | 5.9 | - | | | 8.9 | 9.6 |
| LC | | | Socket | | | |
| LPM1 | 9.4 | 9.1 | | | 7.6 | 6.7 |
| LPM2 | 6.0 | 8.4 | | | 6.6 | 5.2 |
| LM1 | 10.3 | 11.9 | 12.4 | 11.3 | 6.5 | 5.1 |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | 5.2 | - | | | 8.4 | 8.5 |
| RLI | - | - | | | - | - |
| RC | 6.2 | 7.5 | | | 10.7 | 11.1 |
| RPM1 | 6.8 | 7.7 | | | 8.1 | 6.9 |
| RPM2 | 6.9 | 8.5 | | | 7.5 | 5.7 |
| RM1 | | | Socket | | | |
| RM2 | | | Resorbing socket | | | |
| RM3 | | | Resorbing socket | | | |
| LCI | 5.3 | - | | | 9.0 | 8.1 |
| LLI | 5.6 | - | | | 8.9 | 8.7 |
| LC | 6.8 | 7.6 | | | 10.8 | 10.0 |
| LPM1 | - | - | | | - | - |
| LPM2 | 7.3 | 8.4 | | | 7.3 | 5.4 |
| LM1 | 10.9 | 10.0 | 12.0 | 11.5 | 6.0 | 5.7 |
| LM2 | | | Socket | | | |
| LM3 | | | Socket | | | |

| Tooth (Tomb 19) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | 7.9 | - | | | 9.5 | 8.3 |
| RLI | | | Root | | | |
| RC | | | Root | | | |
| RPM1 | 6.0 | 8.4 | | | 7.1 | 3.6 |
| RPM2 | 5.8 | 8.7 | | | 6.9 | 3.4 |
| RM1 | 8.8 | 9.7 | 10.3 | 10.9 | 5.8 | 3.6 |
| RM2 | 8.7 | 9.8 | 8.7 | 10.8 | 5.6 | 4.7 |
| RM3 | 8.0 | 10.3 | 9.8 | 10.2 | 6.8 | 5.5 |
| LCI | 8.6 | - | | | 8.9 | 8.6 |
| LLI | 6.8 | - | | | 7.9 | 6.6 |
| LC | 6.9 | - | | | 8.8 | 10.4 |
| LPM1 | 6.2 | 8.4 | | | 6.5 | 4.4 |
| LPM2 | 6.2 | 8.5 | | | 6.7 | 3.4 |
| LM1 | 9.3 | 10.0 | 10.1 | 11.7 | 5.9 | 3.6 |
| LM2 | 10.6 | 7.6 | 8.3 | 10.7 | 5.8 | 3.9 |
| LM3 | 10.1 | 7.6 | 9.2 | 9.9 | 6.0 | 4.5 |
| **Mandible** | | | | | | |
| RCI | 5.6 | - | | | 7.8 | 9.4 |
| RLI | 5.6 | - | | | 8.4 | 7.4 |
| RC | 7.0 | - | | | 9.8 | 9.6 |
| RPM1 | 6.3 | 7.0 | | | 8.0 | 6.0 |
| RPM2 | 6.7 | 7.0 | | | 7.7 | 5.4 |
| RM1 | 9.9 | 9.6 | 10.4 | 11.2 | 5.2 | 4.1 |
| RM2 | 8.3 | 9.4 | 10.5 | 10.8 | 6.2 | 5.3 |
| RM3 | 10.1 | 9.5 | 10.5 | 10.3 | 6.0 | 5.0 |
| LCI | 5.5 | - | | | 7.9 | 7.5 |
| LLI | 5.9 | - | | | 7.7 | 7.8 |
| LC | 6.5 | - | | | 10.3 | 7.8 |
| LPM1 | 6.1 | 6.9 | | | 7.0 | 5.2 |
| LPM2 | 6.1 | 7.4 | | | 6.4 | 5.3 |
| LM1 | 9.9 | 9.6 | 10.4 | 11.1 | 6.0 | 5.2 |
| LM2 | 9.6 | 9.0 | 10.4 | 11.1 | 6.2 | 5.8 |
| LM3 | 8.8 | 9.9 | 10.1 | 9.4 | 5.8 | 6.3 |

| Tooth (Tomb A) | Mesiodistal diameter | Buccolingual diameter | BM-LD distance | BD-ML distance | Crown height (lab/buc) | Crown height (ling) |
|---|---|---|---|---|---|---|
| **Maxilla** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | 6.0 | 6.1 | | | 4.2 | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |
| **Mandible** | | | | | | |
| RCI | - | - | | | - | - |
| RLI | - | - | | | - | - |
| RC | - | - | | | - | - |
| RPM1 | - | - | | | - | - |
| RPM2 | - | - | | | - | - |
| RM1 | - | - | - | - | - | - |
| RM2 | - | - | - | - | - | - |
| RM3 | - | - | - | - | - | - |
| LCI | - | - | | | - | - |
| LLI | - | - | | | - | - |
| LC | - | - | | | - | - |
| LPM1 | - | - | | | - | - |
| LPM2 | - | - | | | - | - |
| LM1 | - | - | - | - | - | - |
| LM2 | - | - | - | - | - | - |
| LM3 | - | - | - | - | - | - |

**Table 16** – *Dental Metrics for the French Qumran Collection*

| Dimension | CI | | | | LI | | | | C | | | | PM1 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | l | r | df | p | l | r | df | p | l | r | df | p | l | r | df | p |
| **Maxilla** | | | | | | | | | | | | | | | | |
| Mesiodistal Diameter | 8.2 ± 0.6 | 8.5 ± 0.5 | 6 | 0.25 | 6.2 ± 0.4 | 6.9 ± 1.1 | 8 | 0.09 | 6.9 ± 0.7 | 7.8 ± 0.8 | 6 | 0.06 | 6.9 ± 1.6 | 7.4 ± 1.5 | 10 | 0.30 |
| Buccolingual Diameter | 8.4 ± 0.9 | 8.1 ± 0.3 | 4 | 0.30 | 5.7 ± 0.8 | 7.6 ± 1.8 | 3 | 0.08 | - | - | - | - | 8.9 ± 0.6 | 8.6 ± 1.0 | 10 | 0.24 |
| Crown height (labial) | 8.4 ± 1.9 | 9.6 ± 1.7 | 6 | 0.19 | 5.8 ± 2.4 | 8.8 ± 1.5 | 7 | 0.06 | 10.1 ± 2.4 | 10.4 ± 0.8 | 5 | 0.42 | 7.7 ± 1.3 | 7.3 ± 1.4 | 9 | 0.32 |
| Crown height (lingual) | 7.5 ± 4.4 | 8.7 ± 2.7 | 6 | 0.31 | 6.8 ± 2.7 | 8.9 ± 2.0 | 6 | 0.13 | 10.7 ± 0.8 | 10.0 ± 1.2 | 5 | 0.19 | 5.4 ± 1.5 | 4.0 ± 2.4 | 9 | 0.14 |
| BM-LD Distance | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| BD-ML distance | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Mandible** | | | | | | | | | | | | | | | | |
| Mesiodistal Diameter | 5.1 ± 0.4 | 5.3 ± 0.2 | 6 | 0.25 | 5.9 ±0.3 | 6.1± 0.6 | 3 | 0.37 | 6.9 ± 0.3 | 6.9 ± 0.5 | 6 | 0.44 | 6.7 ± 0.7 | 6.7 ± 0.3 | 5 | 0.49 |
| Buccolingual Diameter | - | - | - | - | - | - | - | - | 7.2 ± 0.6 | 7.5 | 2 | 0.38 | 7.4 ± 0.7 | 7.6 ± 0.5 | 5 | 0.33 |
| Crown height (labial) | 7.8 ± 1.7 | 7.8 ± 1.7 | 6 | 0.49 | 8.9 ± 1.1 | 7.8 ± 0.8 | 3 | 0.18 | 11.6 ± 1.3 | 10.9 ± 01 | 6 | 0.22 | 7.0 ± 1.3 | 8.4 ± 0.7 | 5 | 0.08 |
| Crown height (lingual) | 7.4 ± 1.9 | 8.2 ± 1.1 | 6 | 0.23 | 8.8 ± 1.1 | 8.6 ± 1.7 | 3 | 0.43 | 10.0 ± 1.6 | 10.3 ±0 .6 | 6 | 0.38 | 5.8 ± 0.4 | 6.2 ± 0.7 | 5 | 0.08 |
| BM-LD Distance | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| BD-ML distance | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

| Dimension | PM2 | | | | M1 | | | | M2 | | | | M3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | l | r | df | p | l | r | df | p | l | r | df | p | l | r | df | p |
| **Maxilla** | | | | | | | | | | | | | | | | |
| Mesiodistal Diameter | 6.6 ± 0.8 | 7.5 ± 1.2 | 7 | 0.13 | 10.1 ± 0.6 | 10.6 ± 1.0 | 11 | 0.16 | 9.7 ± 0.9 | 10.4 ± 1.3 | 6 | 0.21 | 10.4 ± 0.6 | 8.4 ± 0.6 | 3 | 0.06 |
| Buccolingual Diameter | 9.1 ± 1.1 | 8.8 ± 0.9 | 7 | 0.34 | 11.3 ± 0.7 | 11.5 ± 1.2 | 11 | 0.39 | 10.6 ± 2.6 | 12.0 ± 1.6 | 6 | 0.18 | 9.3 ± 1.5 | 10.5 ± 0.2 | 3 | 0.19 |
| Crown height (labial) | 7.2 ± 1.0 | 5.8 ± 1.7 | 7 | 0.13 | 6.5 ± 0.7 | 5.9 ± 1.3 | 11 | 0.17 | 6.2 ± 0.6 | 6.3 ± 1.2 | 6 | 0.44 | 6.1 ± 0.1 | 4.5 ± 3.3 | 2 | 0.28 |
| Crown height (lingual) | 5.1 ± 1.7 | 5.3 ± 2.9 | 7 | 0.47 | 5.1 ± 1.5 | 6.1 ± 2.4 | 11 | 0.19 | 4.7 ± 1.9 | 5.9 ± 1.6 | 5 | 0.20 | 4.9 ± 0.9 | 5.8 ± 0.4 | 3 | 0.17 |
| BM-LD Distance | - | - | - | - | 11.9 ± 1.2 | 11.9 ± 0.9 | 11 | 0.46 | 10.9 ± 2.7 | 12.0 ± 2.0 | 6 | 0.26 | 10.3 ± 1.1 | 9.9 ± 0.1 | 3 | 0.32 |
| BD-ML distance | - | - | - | - | 11.9 ± 0.6 | 11.4 ± 1.5 | 11 | 0.21 | 11.2 ± 0.5 | 10.3 ± 3.6 | 6 | 0.33 | 10.5 ± 0.5 | 10.4 ± 0.3 | 3 | 0.44 |
| **Mandible** | | | | | | | | | | | | | | | | |
| Mesiodistal Diameter | 7.5 ± 1.3 | 7.0 ± 0.3 | 7 | 0.22 | 10.8 ± 0.7 | 10.7 ± 0.7 | 8 | 0.44 | 10.6 ± 0.9 | 10.4 ± 1.6 | 7 | 0.39 | 9.8 ± 1.3 | 10.1 | 2 | 0.21 |
| Buccolingual Diameter | 8.0 ± 0.9 | 8.2 ± 0.9 | 7 | 0.7 | 10.4 ± 0.7 | 10.3 ± 0.9 | 8 | 0.44 | 9.5 ± 0.9 | 9.8 ± 1.0 | 7 | 0.28 | 9.8 ± 0.2 | 9.5 | 2 | 0.21 |
| Crown height (labial) | 6.3 ± 1.4 | 7.0 ± 1.5 | 7 | 0.24 | 6.0 ± 0.10 | 5.7 ± 0.5 | 8 | 0.30 | 5.9 ± 0.7 | 5.9 ± 0.9 | 7 | 0.48 | 5.5 ± 0.5 | 6.0 | 2 | 0.24 |
| Crown height (lingual) | 4.9 ± 1.1 | 5.5 ± 0.3 | 7 | 0.17 | 5.4 ± 0.6 | 5.5 ± 1.7 | 8 | 0.46 | 4.8 ± 1.2 | 5.7 ± 1.1 | 7 | 0.15 | 6.1 ± 0.3 | 5.0 | 2 | 0.07 |
| BM-LD Distance | - | - | - | - | 11.8 ± 0.8 | 11.4 ± 0.8 | 8 | 0.25 | 11.3 ± 1.1 | 11.4 ± 0.9 | 7 | 0.42 | 10.4 ± 0.6 | 10.5 | 2 | 0.46 |
| BD-ML distance | - | - | - | - | 11.5 ± 0.9 | 11.7 ± 0.9 | 8 | 0.36 | 11.2 ± 0.9 | 11.5 ± 0.9 | 7 | 0.30 | 9.8 ± 0.8 | 10.3 | 2 | 0.32 |

**Table 17** – *Comparison of Left/Right Antimeres for the Maxilla and Mandible*

| | QUM | ENE | EGD | NAT | NAM |
|---|---|---|---|---|---|
| QUM | 0 | | | | |
| ENE | 0.170 | 0 | | | |
| EGD | 0.281 | 0.219 | 0 | | |
| NAT | 0.561 | 0.388 | 0.073 | 0 | |
| NAM | 0.690 | 0.709 | 0.637 | 0.967 | 0 |

QUM = Qumran ENE = Early Near East
EGD = Ein Gedi NAT = Natufian
NAM = Native North American

**Table 18** – *MMD Values for the French Collection teeth*



## Conclusions

Although severe limitations on sample size, preservation, and representative skeletal elements hampered our ability to create a detailed biocultural model at this time, considerable information could still be gleaned from the French collection of Qumran remains. Listed below are the results of the current study, with potential avenues for future investigation:

### *Study Collection*

Multiple lines of evidence indicate that the bones of the French collection are indeed those exhumed by de Vaux at Qumran. The collection is composed of individuals from Tombs 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16a, 16b, 18, 19, A, and B. The remains from Tomb 3 appear to have been commingled with remains from Tombs 4, 5, and 8 after excavation and initial labeling.

Bones from Tombs 1, 2, 9, 14, and 17 are still missing. A reference in Taylor may hint at the location of two missing individuals: "Joe Zias has now discovered partial remains of two further skeletons in the Rockefeller's Qumran storage area but these are unlabelled and is therefore unsure where they come from."[144] These two skeletons could not be found on a recent search of the collections by Sheridan or Humbert. Continued investigation will hopefully reveal these and other missing remains from the Qumran collection. If found and provenience verified, this will fill in some of the missing pieces and provide vitally needed additions to the overall sample size.

### *The Cemetery*

A recent re-survey of the Qumran cemetery has demonstrated the on-going degradation of the site since the work of de Vaux. Several excavated tombs have been obliterated (presumably with the remaining bones still housed in these graves), and it is clear from the abundance of open pits that considerable looting of the site is of on-going concern.

The new survey has likewise pointed out some discrepancies in the original mapping of the graveyard, which can hopefully be rectified through photographic evidence (such as the Royal Jordanian Air Force pictures taken shortly after de Vaux's work), re-evaluation of de Vaux's original maps and field notes, and

possible synthesis with the writings of Steckoll. A more detailed survey by Eshel and colleagues will map all the tombs visible above ground and a magnetometer survey should provide further information of importance to understanding the cemetery and the number of individuals interred therein.[145]

### *Preservation vs. Conservation*

Evidence for significant differential preservation was not found in the French collection. Rather, variation in skeletal elements represented in the current study collection seem to have resulted from the discretion of the original excavators.

In a fashion comparable to the French collection, a comparison of de Vaux's photographic record to the preserved remains in the German collection will be conducted. To date, photographs for most of these tombs have been found in the École Biblique et Archéologique Française's archive.

### *Dating Methods*

Bone samples are denatured beyond current radiometric capabilities due to the effects of heat, salinity, pH, and other factors which have conspired to mask the organic signals of interest. Stable carbon and nitrogen isotope analysis conclusively demonstrated the lack of protein remaining in any of the samples from the French collection. In addition, separation of the organic carbon in the wood from the carbon in the waxy preservative awaits further tests.

Future chemical and morphological analysis of the nails associated with two of the tombs (17 and 18) may provide added information for dating the graves. Also, fluoride dating of the bones may help determine the relative temporal relation of the skeletons to one another.

### *Demographic Analysis*

The individuals from Tombs 3, 4, 5, 6, 7, 8, 10, 11, and 13 have now been ascribed an age, and those from Tombs 3, 4, 5, 6, 8, 10, and 11 a sex. The person from Tomb 7 has been re-classified as male (with reservation). Based on the current demographic findings, for the French Qumran collection there is one woman (over 50 years of age), one teenage male (15-16 years old), one elderly man by Qumran standards (over 60 years old), and numerous 30-50 year old males.

Although the sample size in no way permits extrapolating these trends to the entire community, one intriguing pattern will be investigated in more detail. The remains from Tombs A and B are notably older than the rest of the collection. Is there some significance to their separate burial location? Where is that location? Do the historical texts for the region and period provide any insights on the role and/or status of the "elderly"? Their presence in the collection, buried near each other and apparently separate from the other remains, is interesting to contemplate.

### *Robusticity and Stature*

Cranial and postcranial metrics and indices were presented for the French Qumran collection, from which stature and robusticity estimates were computed. The average male height at Qumran (based on the limited sample size) is 165.7±5.9 cm and the average female height is 158.3±3.3 cm. These measures fit well with previous estimates, showing no significant difference in height within each sex, yet a highly significant difference between the sexes. In addition, these estimates fall well within the statistical bounds of neighboring groups.

Collection of comparable data (especially postcranial) from the German collection is anticipated. This will enhance the overall reconstruction of body size for the de Vaux collection, permit additional tests for sex determination, and facilitate future comparisons to regional and temporal comparative collections.

### *Genetic Affinity*

The analysis of non-metric traits in the French Qumran collection hints at genetic relatedness to regional and temporal contemporaries. However, in truth the sample size is too small to draw any definitive conclusions at this point. It is hoped that comparable data can be collected from the German segment of the collection to enhance the sample size of this analysis.

This study is but the first part of a multi-faceted genetic reconstruction of the Qumran skeletal remains. The dental non-metric traits will be combined in a larger survey of non-metric cranial and post-cranial traits to assess degree of genetic relatedness. The metric data outlined above will likewise be analyzed from a biological distance perspective, and comparisons to regional collections completed. DNA analysis is currently being conducted by Prof. Scott Woodward at Brigham Young University in Utah, and the results are hopefully soon forthcoming.

In addition to the studies outlined above, cursory analysis of diet and disease for the collection is possible. While diagenesis (post-mortem alteration) is clearly evident in the bones and thus precludes stable isotope or trace element analysis of diet, the teeth may provide clues to food intake. Examination of dental microwear may convey broad categories of consumption, and examination of dental calculus (hardened tartar) could provide information about plant resources.[146]

Examination of pathological conditions related to iron-deficiency anemia or calcium deficiency (osteopenia/osteoporosis), and evaluation of dental caries (cavities) will further enhance our understanding of the nutrition of these individuals. A survey of pathological conditions such as neoplastic lesions (cancers), congenital abnormalities (birth defects), degenerative lesions, and trauma will likewise allow a glimpse into the adaptational success of these Qumranites.[147]

While anthropological evaluation of community trends are not possible given the scant sample size, interesting life histories (albeit incomplete) can be constructed for some of the individuals in the de Vaux collection.[148] Continued analysis of the current collection (both the French and German components), comparison to regional and temporal contemporaries, and perhaps eventual expansion of the sample size, may one day permit the construction of a biocultural framework to enhance our understanding of this desert community located on the shores of the Dead Sea.

## Notes

* Sincere thanks to Prof. Jean-Baptiste Humbert, OP for making the Qumran skeletal collection available for study and to the following people for their help with this project: Magen Broshi, Mario Chech, Jean-Michel de Tarragon, OP, Hanan Eshel, Weston Fields, Therese Fitzpatrick, John Kampen, Diane Hawkey, Jodi Magness, Edward Maher, Elaine Myers, Sarianna Metso, Robert Mullins, Jerome Murphy-O'Connor, OP, James Phillips, Emile Puech, David Reese, Ferdinand Rohrhirsch, Olav Röhrer-Ertl, J. Rosenberg, Juhana Saukkonen, Eileen Schuller, Marcel Sigrist, Danille Steen, Christy Turner II, Eugene Ulrich, James VanderKam, Sterling VanWagenen, and Jürgen Zangenberg. Please see n. 6 for a list of funding agencies who made this project possible.

1 "Of all the skeletons found, only one was studied in detail and reports of all the others have been published only in cursory form" [Broshi, 1992:112]; "Publish all anthropological materials still in existence …" [Kapera, 1994:110]; "The opening of more of the tombs should provide greater clarity about the marriage/celibacy dispute" [VanderKam, 1994:91]; "Detailed anthropological examination of these skeletal remains have, unfortunately, never been published" [Steckoll, 1974:230].

2 De Vaux [1954:103; 1956:569-72]; Steckoll [1968:335-6]; See Vanderkam [1994:1-15] for a discussion of the early cave and site excavations.

3 Haas and Nathan [1968].

4 Several authors have discussed in detail the possible connection between the site of Qumran, the cemetery, and the Dead Sea Scrolls. Please see the following works for details of this controversy: de Vaux [1973]; Magness [2000]; Donceel and Doncell-Voûte [1994]; Humbert [1994]; Golb [1980]; VanderKam [1994]; Zangenberg [1999]; Hirschfeld [2000].

5 The "French Collection" refers to the Qumran skeletons housed in Jerusalem and Paris, as both are under curation by French research institutes. The remains from 18 graves comprise the French collection. Another 22 skeletons are housed in Germany (please see Röhrer-Ertl, 1999 for more information on this collection).

6 Many thanks to the École Biblique et Archéologique Française and the Couvent St-Étienne in Jerusalem for providing access to the collection and laboratory space in their museum to conduct the research. Additional thanks to the Dorot Foundation, Scandinature Films, the Dead Sea Scrolls Foundation, the WF Albright Institute of Archaeological Research in Jerusalem, the Orion Center for the Study of the Dead Sea Scrolls and Associated Literature at the Hebrew University-Jerusalem, and the University of Notre Dame's Institute for Scholarship in the Liberal Arts, the Graduate School, the Department of Theology, and the Department of Anthropology for generously funding this research. Particular thanks to Professors James VanderKam, Eugene Ulrich, Julia Douthwaite, Chris Fox, and John Cavadini (University of Notre Dame), Weston Fields (Dead Sea Scrolls Foundation), Sterling Van Wagenen (Florida State University), John Spencer (AIAR/ASOR), and Esther Chazon (Orion Center) for their help in securing the necessary funds for this analysis.

7 The German team set a precedent by publishing their data and freely sharing their findings, we are simply following their lead. Upon completion of this research, we plan to make all the information available on the web.

8 Martin *et al.* [1991:27].

9 Armelagos *et al.* [1989:232].

10 For examples of biocultural reconstructions, see: Iscan and Kennedy [1989]; Martin *et al.* [1991]; Van Gerven and Sheridan [1994]; Larsen [1997]; Van Gerven *et al.* [1995]; Goodman and Leatherman [1998]; Sheridan [1999].

11 In the majority of cases only the cranium and pelves were collected for analysis.

12 "… the small number of tombs excavated does not permit us to draw any statistics from them which can validly be applied to the cemetery as a whole." [de Vaux, 1973:47].

13 "Certainly statistics or generalizations would be untimely based on only 43 tombs excavated by de Vaux among the about 1200 numbered burials…" [Puech, 1998:25].

14 "Given the present state of our knowledge, it is far from certain whether any conclusions can be drawn from the cemetery. The proportion of the graves excavated is statistically so small…" Schuller [1999:141].

15 Broshi (personal communication).

16 43 de Vaux, 9 Steckoll, 1 Clermont-Ganneau

17 This percentage assumes an estimate of 1200 graves.

18 Morris [1992].

19 Haas and Nathan [1968]; Steckoll [1974]; Golb [1993]; Broshi [1998]; Röhrer-Ertl *et al.* [1999, 2000]; Zias [2000].

20 Davies [1988:206].

21 Röhrer-Ertl et. al. [1999:6].

22 Clearmont-Ganneau [1874:83].

23 DeVaux [1953; 1954; 1956; 1973].

24 Steckoll [1968; 1969; 1974], Steckoll *et al.* [1971].

25 For example he talks of torture and dismemberment [Steckoll, 1974:228-231] making reference to the work of Haas and Nathan [1968]. However, they never make such suppositions in print.

26 Haas and Nathan [1968]; Steckoll [1968].

27 Röhrer-Ertl *et al.* [1999]; followed by Röhrer-Ertl *et al.* [2000].

28 Special thanks to the University of Notre Dame's Institute for Scholarship in the Liberal Arts, Department of Theology, and Graduate School for providing immediate funding to begin the research when the remains became available.



29 Professor of Archaeology, École Biblique et Archéologique.

30 The largest piece of coffin wood from Tomb 18 measures 152x12x2 cm (LxHxW). Donceel and Donceel-Voûte [1994:14] report the wood as cypress (*Cypressus semper vierns*).

31 Only pieces of wood and approximately 15 nails were found in the box for Tomb 17. No bones were present.

32 Much of the information in Table 1 was gleaned from the catalogue in Röhrer-Ertl *et al.* [1999], on the insert following page 46. Any mistakes in translation are the first author's.

33 Recently Zias [2000:250] published his interpretation of the Qumran skeletal collection, including results for "Tomb 9". Originally the remains from Tombs A and B were designated "T9(A)" and "T10(B)" based on a cryptic reference in de Vaux's notes. After our analysis of the remains at the Musée de l'Homme and the discovery of "Tomb 10" in that collection, a re-survey of de Vaux's notebooks and site diagrams by Drs. Susan Guise Sheridan, Jean-Baptiste Humbert, and Alain Chambon indicated a misinterpretation of his notes. Unfortunately, by this time (September 2000), the aforementioned article was already published.

34 These photographs from the de Vaux archive are presented for the first time through the generosity of the École Biblique et Archéologique Française, Professors Jean-Baptiste Humbert, OP and Jean-Michel de Tarragon, OP. Only the photograph of the skeleton from Tomb 17 has been previously published, in Humbert and Chambon [1994:222].

35 Preserving skeletal material with paraffin was not an uncommon method, as discussed in Risdon [1939:102] and Frohlich [1987:50].

36 Special thanks to Dr. Mario Chech of the Musée de l'Homme for access to the remains and his hospitality during our stay in Paris, and to Professors James Phillips (University of Illinois-Chicago) and Jean-Baptiste Humbert (École Biblique et Archéologique Française-Jerusalem) for their help in securing permission from the Museum.

37 Many thanks to Drs. Mark Schurr (Univ. of Notre Dame) and David Reese (Yale University) for their helpful insights on conservation techniques.

38 For detailed discussions of the cemetery, please see: Taylor [1998]; Kapera [1994]; Puech [1998]; Zangenberg [1999]; Hachlili [2000].

39 Humbert and Chambon [1994:214].

40 This re-survey was in part prompted by Kapera's challenge to prepare a "map of the Qumran cemetery with the exact location of already opened tombs" [1994:110]. Special thanks to J. Rosenberg (WF Albright Institute of Archaeological Research in Jerusalem) and Elaine Myers (University of Toronto) for the new survey of the cemetery. Addition thanks to the Dorot Foundation for funding this aspect of the project, and Prof. Hanan Eshel (Bar Ilan University) for acquiring the proper permission and topographical maps for the survey.

41 Shanks [2001:19]. Taylor [1998:285] likewise makes reference to "clandestine diggers" following Clermont-Ganneau.

42 Clermont-Ganneau [1874].

43 Taylor [1998:287].

44 Ibid.

45 Puech [1998:22]; Röhrer-Ertl *et al.* [1999:35].

46 de Vaux states that the northern cemetery was "a quelque minutes au nord de Khirbet Qumrân" [1956:569]. Detailed survey work planned by Prof. Hanan Eshel (Bar Ilan University) to hopefully find this cemetery.

47 Previously published photographs appeared in Humbert and Chambon [1994], including: Tomb B (#451, p. 217), Tomb 5 (#456, p219), Tomb 7 (#458, p. 220), Tomb 8 (#461, p 221), Tomb 17 (#463, p. 222), Tomb 18 (#466, p. 223), and Tomb 19 (#469, p. 224). Currently, no photos of the interred skeletons for Tombs 6 and 10 can be found in the de Vaux archive.

48 This is most likely, as many of the descriptions in de Vaux's notes are specific about which bones were collected for analysis.

49 Zias states: "Methodologically, it would appear that the material that was complete and in an exceptional state of preservation or deemed important had been selected out by de Vaux for further study and sent to Europe, whereas much of the material that was fragmentary and thereby necessitating extensive laboratory reconstruction was reburied at the site….This in and of itself is telling and arouses suspicion as to the chronology of the material…To the experienced anthropologist this means that the chronological coherence …is highly suspect" [2000:235-6]. The clear photographic evidence from de Vaux's excavations (several of which have been published since 1994, see n. 47) does not bear this out.

50 Taylor presents a useful table of grave goods [1998:307]. A piece of fabric associated with Tomb 1 was recently found by Mireille Bélis (researcher at the École Biblique et Archéologique Française de Jérusalem) and has been submitted for radiocarbon dating.

51 Taylor [1998:297]; Steckoll [1974:211]; Zias [2000:226-7] referring to beads from T32 and TS 1.

52 Steckoll [1969:34-5 and 1974:210]. Taylor's follow-up to these references yielded conflicting information [1998:296].

53 Steckoll [1974:210]; Taylor [1998:296, n. 33], following up on an test by Donceel and Donceel-Voûte.

54 For general reading about C14 methodology, please see: Taylor [2000], and Burleigh [1974].

55 Beta Analytic (Miami, FL) and the University of Arizona (Tucson, AZ).

56 Special thanks to Dr. Mark Schurr (University of Notre Dame) for conducting the stable isotope analysis. Samples were tested at the Laboratory for Biocultural Studies in the Department of Anthropology at Notre Dame.

57 Steckoll [1974:210].

58 As stated by Raymond Nagy, "While nails by themselves have little to say about social processes…archaeological nail assemblages can be used to infer temporal parameters for historic period sties and structures." [p. 177]. Also see Nelson [1968].

59 Personal communication with Hanan Eshel (Bar Ilan University), Robert Mullins (The Hebrew University of Jerusalem), Jodi Magness (University of North Carolina), Samuel Wolff (Israel Antiquities Authority), Jürgen Zangenburg (Bergishe Universität/Gesamthochschule Wuppertal), and Ann Killebrew (Penn State University). While reference to nails appears in several works, a specific typology has not been developed for the period or region. For a discussion of wooden coffins and the possible use of nails in a burial context, see: Hachlili [1999]. For a discussion of nails found at contemporaneous sites, see: Muhly and Muhly [1989:275-280]; Yadin [1963:89-90].

60 Prof. Hanan Eshel (Bar Ilan University), personal communication.

61 Lupu [1989:296-313]; Cohen and Roman [1990:77-80].

62 Prof. Dr. Gottfried Kurth (Professor, Technical University of Braunschweig) curated the German collection of human remains from Qumran, until his death.

63 Prof. Dr. Henri-V. Vallois (Director, Musée de L'Homme, Paris) originally curated the Qumran collection still housed at the museum.

64 Lovejoy *et al.* [1985a & b]; Lovejoy [1985]; Meindl and Lovejoy [1985]; Webb and Suchey [1985]; Lucy *et al.* [1995]; Brothwell [1981]; Brooks and Suchey [1990]; Ubelaker [1979]; Smith [1984]; Scott [1979]; Ubelaker [1987]; Molnar [1971]; Kerley [1965]; Kerley and Ubelaker [1978]; Ubelaker [1987].

65 Discussion of anticipated future advances can be found in Hoppa [2000] and Lovejoy *et al.* [1997].

66 Ubelaker [1978].

67 Several methods have been developed, and we used two in the current study: Todd [1920; 1923] , Brooks and Suchey [1990].

68 Meindl *et al.* [1985].

69 Suchey and Katz [1998].

70 Lovejoy *et al.* [1985b].

71 Meindl and Lovejoy [1985].

72 Hillson [1986].

73 Lovejoy *et al.* [1985a].

74 Miles [1963]. Also see Mays [1998:57-66] for an overview of the utility of dental wear and aging.

75 Smith [1984]; Scott [1979]; Brothwell [1981]; Molnar [1971]. Also see Hilson [1996:231-253] for a review of tooth wear and modification.

76 Tomb 17 "adult" age estimation is based on photographic evidence.

77 Humphrey [1998:72].

78 It is important to clarify that this discussion deals with sex determination, not gender. The two terms are not interchangable, as gender is a cultural application, "a socially imposed division of the sexes" [Rubin, 1975:179]. For a discussion of the biological ramifications of the distinction between sex and gender, see Walker and Cook [1998]. For an overview of the debate within archaeology, see Pearson [1999:95-123].

79 Anderson [1962]; Phenice [1969]; Acsadi and Nemeskeri [1970]; Black [1978]; Stewart [1979]; Meindl, *et al.* [1985]; ; Holland [1991]; Mittler and Sheridan [1992]; Milner [1992]; Lovejoy [1993]; Rogers and Saunders [1994]; Buikstra and Ubelaker [1994]; Maat *et al.* [1997]; France [1998]; Muriail et. al. [1999]; Safont *et al.* [2000].

80 Krogman [1962:112].

81 Stewart [1948:315-21].

82 Meindl *et al.* [1985].

83 For specific measurements, the reader is directed to the appropriate tables in this paper (postcranium - Table 7; cranium - Table 8; postcranial indices - Table 10; and cranial indices - Table 11).

84 Reesinek *et al.* [1999].

85 DeVaux's notes, as published by Humbert and A. Chambon [1994], indicate that on November 28, 1951, only the very large pelvis and skull were removed: "Nous avons enlevé le pelvis qui est très large! et le crâne" [p. 347].

86 For a brief biographical sketch of Professor Vallois' accomplishments, please see the insert to his 1965 *Current Anthropology* article [Vallois, 1965:127].

87 Porter [1999].

88 Bass [1995]; Schwartz [1995:326-334]; Buikstra *et al.* [1994:78-84].

89 St. Hoyme and Ìscan [1989:66].

90 St. Hoyme and Ìscan [1989:69]. Consideration of race is beyond the scope of this paper as outlined previously.

91 Röhrer-Ertl *et al.* [1999:33]. Only stature estimates are given, presumably calculated from femoral length measurements.

92 Including the clavicular robusticity (poor), humerus robusticity, diaphyseal index, femoral robusticity, pilastric index (development of the linea aspera), sacral breadth, ischiopubic index, and the acetabular-pubic index.

93 Dimensions such as the platymeric index (reflects the compression of the femoral shaft), the pilastric index, the platycnemic index (shape of the tibia shaft), vertebral index (compression of the vertebral bodies) and the calcaneal length index (useful in locomotor reconstructions) illustrate morphology of the bones useful in biomechanical reconstructions of activity patterns. See Peterson [1997].

94 Maximum length measurements are available for the humerus, radius, ulna, femur, tibia and fibula of several individuals from Nahal Hever, however no additional measures are provided to permit robusticity calculations [Nathan,

1961:171-172]. Zias [1992a:100] likewise provides length measurements for long bones, but the scant breadth measures are incomplete for index calculations. To date, only the report on remains from Meiron [Smith *et al.*, 1981:113-114] supplies some of the measurements needed to calculate comparative indices for robusticity. Regional comparisons will be published in a forthcoming article in *Dead Sea Discoveries* [Sheridan, n.d.].

95 Many of the cranial indices are published in the *Revue de Qumran* article by Röhrer-Ertl *et al.* [1999:30-31]. Numbers in italics indicate the values computed for this paper using data published in the same table.

96 The coefficient of variation measures sample variability relative to the central tendency of the group (independent of the mean). See: Thomas [1986:84]; Sheridan [1992:70]; Siegel [1956:30].

97 Using a one-tailed unpaired Students' t-test.

98 Termed "microsemic" by Vallois [1965] and Stewart [1940, 1965].

99 For a list of measures, see Schwartz [1995:325]. These measures are presented for descriptive purposes only, they are of minimal use unless conducting racial classification. It is the opinion of the authors that race is not a biologically real construct, and the values are presented simply for completeness of the metric analysis. A discussion of the fallacy of racial classification is outside the parameters of this paper, thus the reader is directed to the following resources for more information: Marks [1995]; Gould [1996]; Goodman [1997], Armelagos and Goodman [1998], Armelagos and Van Gerven [2003].

100 Wolfe and Gray [1982].

101 See Bogin [1988] for a discussion of chronic conditions affecting subadult growth. Huss-Ashmore *et al.* [1982]; Goodman et. al. [1984]; Larsen [1987]; Steckel [1995]; Albert and Greene [1999] and others provide excellent reviews of the role of nutrition, disease stress, activity patterns and other environmental constraints on the growing skeleton.

102 Larsen [1997:13-19]. "The close ties between stress - especially poor nutrition - and stature are abundantly documented in research developing out of a growing interest in anthropometric history" [p. 13]. Related to stature at Qumran, Zias [2000:233] stated that "…individual stature is a variable largely controlled by genetics, and therefore, the endogamous nature of ancient societies tended to limit the range of biological variability within these groups as compared to today's modern world." The plasticity of the human skeleton precludes such generalizations, especially for a collection of such limited size. As noted by Brothwell "even in comparatively small collections of skeletal material, there may be considerable variability in measurement or general form within a group…" [1981:77]. Ironically, the very next line in the reference cited by Zias states "…it is also clear from numerous studies that the health of the individual is also a significant component affecting stature" [Ortner and Putschar, 1981:33]. Given the emphasis placed on the estimation of stature in Zias' article, it seems a shame more credence was not given to the subsequent passage.

103 Neves and Costa [1998]; Chiarelli [1977].

104 Ubelaker [2000:57].

105 Crooks [1998:339].

106 De Mendonça [2000:39].

107 Bass [1995:26]; De Mendoça [1998:39-40].

108 Trotter and Gleser [1952, 1958,1977].

109 Additional methods using the vertebra [Jason and Taylor, 1995], bones of the foot [Holland, 1995], the metacarpals [Meadows and Jantz, 1992], and fragmentary remains [Holland, 1992] are also available, though these methods have not undergone the rigorous testing of the Trotter and Gleser formulae. They were not used in the current study, but will be tested in future analyses.

110 Röhrer-Ertl et. al. [1999:table insert]. It is important to note that the method used for Vallois' estimate is not indicated. It is unclear if he used a discriminate function such as Trotter and Gleser, or whether this estimate is based on a full body measurement (the "anatomical method") taken from head to toe at graveside. Based on the notes from de Vaux, the later is quite possible (for information on the utility of the later method, please see De Mendoça [1998:40] and Formicola [1993:351]). Also of note, Vallois designated this individual (Tomb 7) as "female?", although it appears in Table 11 as a male based on our reclassification.

111 Formicola [1993:352].

112 Please note that the German team did not report standard deviations with their male and female stature estimates, hence their absence in Table 11. For the combined German and French average however, we calculated these values, which appear in the text and Table 12.

113 Arensburg *et al.* [1980:178]. Method of stature estimation not provided in the literature. Arensburg and Belfer-Cohen [1994].

114 Arensburg and Smith [1983:134]. Number of individuals used in stature estimation not provided, nor is the method used for estimation of stature.

115 Nathan [1961:171].

116 Hass [1970:40-49]. Method used for stature estimation is not provided.

117 Smith *et al.*[1992:61]. Number of individuals used in stature estimation is not provided.

118 Zias [1992b:100].

119 Rahmani [1960:148]. The method used to the estimate stature of the individual is not provided.

120 Smith *et al.* [1981:114].

121 Frohlich [1987:52, 54-56].

122 Little [1969:237]. The method used to estimate the stature of the individual is not provided.

123 El-Najjar and Al-Shiyab [1998:15]; Karaki [1991].

124 Mesiodistal diameter, buccolingual diameter, labial crown height, lingual/buccal crown height, and buccomesial/linguodistal distance, and buccodistal/mesiolingual distance were measured.

125 Moorrees [1957]; Moorrees *et al* [1957].

126 Brace and Ryan [1980].

127 Scott and Turner [1997:99].

128 Brace *et al.* [1991:36]; Hillson [1996:70].

129 Given the potential for inter-observer error in many dental measurements, comparison to other collections will await data collection by the authors.

130 Mays [1998:102-121]; Berry [1975]; Goldstein *et al.* [1980].

131 Special thanks to Prof. Christy Turner II and Dr. Diane Hawkey, both of the Arizona State University Department of Anthropology, for their help with this analysis. This segment of the study was conducted by the second author.

132 Turner *et al.* [1991].

133 Please refer to Turner *et al.* [1991] or Hilson [1996:86-105] for full definitions and diagrams/photos of each of the dental variants listed. Also see Smith [1977; 1995] and Sofaer *et al.* [1986] for discussions of Near Eastern traits.

134 Scott and Turner [1997:206].

135 Data collected by Lipschultz [1996].

136 Ibid

137 Data collected by Alexandersen [1978], Carbonell [1958], Lipschultz [1996], Roler [1992], and Senyurek [1952a, b]; compiled by Hawkey [1998].

138 Data collected by Dahlberg [1951], Enoki and Dahlberg [1958], Hanihara [1976], Morris [1975], Morris *et al.* [1978], Sciulli *et al.* [1984], Scott [1973], and compiled by Hawkey [1998].

139 Lipschultz [1996:37].

140 Ibid.

141 Hawkey [1998:Table 3.3].

142 The analysis was completed using a "Mean Measure of Divergence program" written by Williams [1992]. The program includes a correction for small samples.

143 Turner, personal communication.

144 Taylor [1998:303, n. 64].

145 The detailed tomb map will be completed by J. Rosenberg. A magnetometer study will be conducted under the direction of Hanan Eshel of Bar Ilan University.

146 Such as phytolith analysis of dental calculus [Fox *et al.*, 1996; Arensburg, 1996]. Issa Sarie [Hebrew University-Jerusalem] has volunteered to conduct this analysis.

147 Arensburg *et al.* [1985]; Lewis and Roberts [1997].

148 A forthcoming article, resulting from the Brown University Center for Old World Archaeology and Art titled "Qumran: The Site of the Dead Sea Scrolls," will take a forensic perspective on the members of the French collection.

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