South Tombs Cemetery 2010: bioarchaeology report

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Introduction

Analysis of the skeletal material recovered during the sixth excavation season of the Amarna South Tombs Cemetery project was conducted from 14 May to 9 June 2010. The analysis was directed by Professor Jerry Rose, Dr. Melissa Zabecki, Dr. Dolores Burke, and Robert Taylor Montgomery, who were assisted by an osteology team from the University of Arkansas that included Sarah Chapman, Danielle Frank, Jessica Galea, Charlotte Green, Erin Lombard, Caitlin Smith, Preston Stephens, Kaitlyn Stiles, Ashley Valdes, Merritt Young, and Melissa Zolnierz.

The research questions and the specific data sets required to address them were derived and modified from the questions and analyses conducted during the previous four years of research. The unusual demographic profile with the unusually high number of juvenile deaths continued to be of great interest. The variation in ages at death was compared between the three excavation sites: the Upper, the Lower, and the Wadi mouth locations. The extensive evidence for childhood malnutrition and stress acquired during the previous seasons prompted us to conduct more nuanced analyses of cribra orbitalia, enamel hypoplasias, rates of long bone growth, and adult stature. In particular, the frequencies of these stress indicators by ages of death were collected and variation in growth rates between the arms and legs were examined. The expanded excavation permitted us to look for variation throughout the cemetery. The elevated frequency of healed fractures of the arms, legs, and spine prompted more attention to be paid to the details of the skeletal lesions. Detailed examination of the muscle attachments of the arms encouraged us to do the same for the leg muscles. Data collected concerning malocclusion of the teeth last year indicated that major dental problems were rare, but minor displacement of the front teeth was common. A detailed analysis of the mandibular incisors was thus conducted. We continued to collect the standard osteological data sets and to address the previous researched questions. Analysis will continue throughout the coming year while our preliminary results are presented here. All team members contributed to the collection of data, the analyses and the text presented in this report of the 2010 season. We thank our inspectors Mr. Atta Makramallah Mikhail and Mr. Ahmed Fathy for facilitating our access to the skeletal collections.

Methods

The excavated burials were arranged on laboratory tables by excavation units so that they could be analyzed within their archeological contexts and to enable the bones scattered by grave robbers to be compared and matched with the partial skeletons recovered within their grave contexts. All bones were cleaned by dry brushing with soft brushes so that delicate indicators of disease would not be destroyed. All bones were cleaned over empty plastic basins to assist in recovering any dislodged bones or cultural items. The debris recovered from each burial was sieved and the larger particles examined for significant finds. All nonskeletal materials such as hair, body tissues and fingernails, along with cultural items such as linen, matting and ceramics were bagged and labeled with their proveniences and stored in separate crates for future analysis by specialists.

After cleaning and arranging the bones in anatomical order standard data collection protocols were followed (Buikstra and Ubelaker 1994). Included within this standardized protocol were bone and tooth inventories and measurements, age at death, sex, and pathological observations. Additional specialized data were collected following methods obtained from recent publications. Dental malocclusion was scored using the detailed (but not aggregated) dental tooth position scores of Harris and Corruccini (2008). Cervical diameters of all permanent teeth were taken using a new technique and specially made calipers developed by Hillson et al. (2005). These measurements from known sex adults will eventually be used to determine the sex of those juveniles with permanent teeth. A detailed analysis of foot bones has been conducted to ascertain whether the commoners of Amarna regularly wore sandals (Trinkaus 2005). The long bone lengths of infants and children were obtained to determine growth rates using dental development as the standard for age so that we may compare these to
modern standards (Maresh 1970). Measurements of all of the long bones were taken for individuals 18 years of age and older. A formula created by Raxter et al. (2007) developed specifically for calculating stature for ancient Egyptian populations was utilized. Measurements used for stature estimations included femur maximum length, femur bicondylar length, tibia maximum length, tibia length without eminence, humerus maximum length, radius maximum length, femur maximum length plus tibia maximum length, femur bicondylar length plus tibia length without eminence, and humerus maximum length plus radius maximum length as outlined by Raxter et al. The measurements from the right side were used to calculate stature. The last season proved how completely interrelated the indicators of childhood stress were and we were prompted to recalculate their interrelationships by ages at death (Bennike et al. 2005, Buzon 2004; Goodman and Armelagos 1989). A recent article by Hawass et al. (2010) prompted us to look for indicators of specific diseases. Other specialized methods are mentioned in the results section where they can be more meaningfully used.

**Results and discussions**

The 2010 excavations were conducted in three locations within the Amarna South Tombs Cemetery. A strip of seven 5m x 5m squares were excavated north of and adjacent to the previous excavations at the upper site for a total of 28 5m x 5m squares. A strip of nine 5m x 5m squares were excavated north of and adjacent to the previous 2m by 3m excavation unit. This year excavation of ten 5m x 5m squares distributed across the Wadi Mouth was conducted. In total 75 burial individuals, one cluster individual was assembled from skeletal elements scattered by ancient robbers, and 14 isolated skulls that could not be matched to any of the headless skeletons were recovered and subjected to osteological analysis. The condition of the skeletal material varied greatly, from very well preserved recovered from intact and unrobbed graves; to well preserved, but scattered by ancient robbers; to salt-encrusted and complete bone; to poorly preserved and crumbly material that had been sun-bleached after having been thrown to the surface by ancient robbers. The maximum amount of data was collected from each bone regardless of the condition, but some basic analyses, such as determination of age, sex and stature, were impossible to accomplish because of poor preservation of some bones.

The Upper Site excavation produced one premature birth/death, 2 infants (0-2.9 years old), 4 young children (3-6.9 years), 6 older children (7-14.9 years), 4 adolescents (15-24.9 years), 6 young adults (25-34.9 years), and 5 mid-adults (35-49.9 years). There was one adult who could not be aged. The Lower Site excavation produced 3 infants (0-2.9 years), 6 young children (3-6.9 years), 4 older children (7-14.9 years), 7 adolescents (15-24.9 years), 6 young adults (25-34.9 years), 3 mid-adults (35-49.9 years), and one old adult. The Wadi Mouth Site excavation produced 5 infants (0-2.9 years), 2 young children (3-6.9 years), 2 older children (7-14.9 years), 4 adolescents (15-24.9 years), 1 mid-adult (35-49.9 years), and 3 adults who could not be aged. These data are displayed graphically in Figure 1. The Wadi Mouth sample has a more normal age distribution, when compared to the others, with the highest proportion of skeletons aged from birth to 2.9 years and dropping to a low between 7 and 24.9 years. Unfortunately, we have only 14 aged individuals from the Wadi Mouth Site and this situation is probably the function of small sample size. The Upper Site with the second largest sample of 29 shows essentially an inverted distribution from 3 to 6.9 years with 14% to 21% belonging to the group from 7 to 14.5 years when the rate should be lowest, and then a decline to 14% between 15 and 24.9 years. The Lower Site with the largest number of individuals (30) has a more normal concave curve with a high proportion (20%) between 3 to 6.9 years and dropping to a normal low of 13% between 7 to 14.9 and the rising to 23% for the group between 15 and 24.9 years.

The data presented in Figure 2 employs all the ages at death from all seasons, but sorted by individual excavation site. The few unaged adults are not included. The Wadi Mouth sample has a more normal age distribution, when compared to the others, with the highest proportion of skeletons aged from birth to 2.9 years (36%) and dropping to a low between 14% in each of the age groups between 3 and 14.9 years, and a high of 29% for those dying...
between 15 and 24.9 year. Unfortunately, we have only 14 aged individuals from the Wadi Mouth Site and this situation could most probably be a function of small sample size and one of the reasons that the excavation sites were increased in number this season. The Upper Site with the largest total sample shows an upward distribution with 13% from 3 to 6.9 years to 16% belonging to the group from 7 to 14.5 years when the rate should be low, to a high of 21% between 15 and 24.9 years when the rate should be lowest. The Lower Site with the next largest number of individuals has an inverted curve with a high proportion (19%) between 3 to 6.9 years, declining to 12% between 7 to 14.9 and about the same at 13% for the group between 15 and 24.9 years.

**Figure 1.** Age-at-death of the individuals excavated in 2010, divided according to excavation area.

**Figure 2.** Age-at-death of the individuals excavated from 2006–10, divided according to excavation area.
The Amarna demographic profile and its surplus of juveniles has been of interest since the first analysis in 2006. Under the most common circumstances the age group between seven and 20 years should have the fewest numbers in any burial group (Margerison and Knusel 2002). Archeologists and demographic modelers (e.g. Caster 2000; Gowland and Chamberlain 2005; Magerison and Knusel 2002) have indicated that such a demographic anomaly as we find at Amarna may indicate a catastrophic death assemblage. The identification of a virulent form of malaria during the 18th Dynasty (Hawass et al. 2010) suggests that this anomalous demographic pattern may be meaningful and evidence for other epidemic disease may be found.

Searching for causes of this demographic picture we have investigated a number of data sets that can evaluate the level of childhood stress. One of these is stature which can indicate the total malnutrition and disease load during childhood. The sample size was composed of 33 individuals: 18 males and 15 females. The individuals were divided into groups based on the site from where they were recovered: Upper site, Lower site, and Wadi Mouth site. Based on these divisions, there were a total of 14 individuals from the Upper site consisting of 6 males and 8 females; 16 individuals from the Lower site consisting of 10 males and 6 females; and a total of 3 individuals from the Wadi Mouth site consisting of 2 males and 1 female.

The average height of males and females from the different sites was calculated and recorded in centimeters and feet. The average height of males from the Upper site was determined to be 162.4 cm or 5.3 ft; average height of males from the Lower site was determined to be 162.2 cm or 5.3 ft; and average height of males from the Wadi Mouth site was determined to be 164.7 cm or 5.4 ft. The average height of females from the Upper site was determined to be 155.2 cm or 5.1 ft; average height of females from the Lower site was determined to be 157.4 cm or 5.2 ft; and average height of females from the Wadi Mouth site was determined to be 152.1 cm or 5.0 ft. The data are depicted in Figure 3. The Wadi Mouth site has the tallest males and shortest female. The Lower and Upper sites have males of the same size, while the Upper site has the shortest females. These short statures do indicate extensive childhood stress.

These short adult heights prompted us last season to ask the question as to whether life at Amarna was conducive to adequate childhood growth. Dental development is the standard method for calculating age for subadults because the growth of teeth is least affected by malnutrition, disease and other stresses. Thus growth rates are best estimated by comparing changes in long bone lengths by dental ages. Last season when this was done the
Analysis showed that the Amarna children grew at a slower rate than the Maresh (1970) growth standards. This growth rate clearly resulted in the lower adult heights. Figure 4 shows the average femur lengths by age for Amarna plotted against the male and female Maresh (1970) growth standards. The Amarna children are clearly growing at a reduced rate. The growth rates of the Amarna femora and humeri are plotted in Figure 5. The humerus grows at a slower but similar rate until 11 years old when the rate slows compared to the femur. Not only did this work corroborate the slower rate of Amarna growth, it clearly showed that when bone length and development were used to age children it always produced an age that was approximately two years younger than the dental ages. Thus individuals without teeth can only be aged by comparing long bone lengths to those children who do have teeth and thus known dental ages.

Because the teeth are least affected by poor diet and health they will grow to their genetically programmed size. If growth during childhood has been impacted by poor diet and disease the jaws will not have grown to a size sufficient to accommodate the unaffected teeth. This mismatch between tooth and jaw size results in malocclusion (e.g. misaligned, rotated and crowded teeth). Last year’s analysis produced a summary score for each individual. This year specific data on each component of malocclusion was collected. All skulls were examined and in the end 38 individuals could be analyzed. The teeth were checked for rotation and/or displacement within the jaws. Next, occlusion between maxilla and mandible was examined for buccal segment relationship (BSR), overbite/overjet, canine relationship, presence of a crossbite, midline deviation, and midline diastema. BSR, overbite/overjet, and presence of a crossbite proved to be the most frequent problems.

Figure 4. Growth rate of Amara femur lengths against dental age compared to the Maresh (1970) standard.
Age groups: 1 – Ages 0-2.9; 2 – Ages 3-5.9; 3 – Ages 6-10.9; 4 – Ages 11-15.9; 5 – Ages 16-20.9.
Eighty four percent of the individuals experienced either rotation and/or displacement of one or more anterior teeth. The average number of rotated teeth is 1.5. The average number of displaced teeth is 1.6. The average number of rotated and/or displaced teeth is 2.7. The total percentage of individuals with rotated teeth is 55% and the total percentage of individuals with displaced teeth is 66%. The most frequently rotated tooth is the mandibular right canine and the most frequently displaced teeth are the right and left central incisors. Most of the crowding is occurring in the mandible. 88% of the individuals with a mandible and maxilla experienced some mandibular crowding. Only 42% also experienced maxillary crowding. The total percentage of those with overbite and/or overjet is 29%. The total percentage of those with a discrepancy in buccal segment relationship on one or both sides is 16%. The total percentage with either a buccal or lingual crossbite is 35%. The percentage of buccal crossbites is 23%. The total percentage of those with midline deviation is 13%. Finally, the total percentage of those experiencing malocclusion excluding the rotation and displacement of the anterior teeth is 47%. The high frequency of rotated and displaced teeth indicates that the individuals at Amarna had been exposed to some deficiency in the environment and/or diet. Crowding is caused by a lack of room in the alveolar bone for all of the teeth. The Amarna people experienced more crowding than is expected in an ancient population. Because there is such a large discrepancy in the percentages of crowding in the mandible versus the maxilla, it is reasonable to conclude that there is some deficit in mandibular growth.

Grooves on teeth, called enamel hypoplasia, are the consequence of childhood disease suffered under conditions of poor nutrition and enable us to examine childhood stress in those who survived to be adolescents and adults. The anterior teeth of 22 individuals or isolated skulls were found to have at least one hypoplasia. Eight of these were male and 8 were female with 6 not being sexed. Five (22.7%) of the individuals with hypoplasias were between the ages of 7 and 15 years. Eight (36.4%) of those with hypoplasias were between the ages of 17 and 30 years. The analysis shows that women have a higher frequency of hypoplasias than males, and more children and...
young adults had hypoplasias. This suggests a high frequency of childhood stress and the younger ages at death indicate that stress in childhood contributed to an earlier death.

There is other evidence of childhood stress at Amarna. Deficiencies in certain nutrients such as iron, Vitamin C, D, and B12 can result in skeletal lesions such as pitting within the upper portion of the eye orbits and this condition is called cribra orbitalia. The high frequency of childhood stress indicators prompted the analysis of the co-occurrence of hypoplasia and cribra orbitalia. Of the 90 individuals and isolated skulls recovered in 2010 only 27 (4 isolated skulls and 23 individuals) had both the skull and teeth necessary to examine the co-occurrence of hypoplasias and cribra orbitalia. Of these, four had cribra orbitalia, eight had at least one hypoplasia, and five had both cribra orbitalia and at least one hypoplasia. All those with cribra orbitalia were between the ages of 7 and 25 years. Individuals in the 25 to 50 age category had hypoplasias, but no cribra orbitalia. The results that one-third of observable individuals suffered from cribra orbitalia, and of these one-third, more than one-half also had hypoplasias, suggests that there were considerable problems with child nutrition and stress at Amarna.

A comparison was also made on the prevalence of cribra orbitalia and hypoplasias by site. There were eight observable individuals from the Upper site, fourteen from the Lower, and five from the Wadi mouth. Interestingly, the Wadi mouth had a higher proportion of stressed individuals (two with hypoplasias and two with cribra out of five total) compared to the other two sites. The Upper and Lower sites had precisely equal proportions of stressed individuals (4/7 and 8/14 respectively), but the Lower site yielded four individuals with both conditions, as opposed to the single individual suffering both cribra and hypoplasias from the Upper site.

Having established the high stress level for the children of Amarna, we turn to the state of health of the adults. First we will provide a short summary of the general paleopathology of the 2010 skeletal series which consists primarily of trauma, most caused by accidents, and secondarily minor infections. Detailed analyses of specialized topics will follow. Although the spine will be covered in detail below, the major spinal trauma are also included in this overview. The Upper section had three instances (50%) of trauma related lesions among the six unsexed individuals: healed rib fracture, healed fracture of the right humerus and spondylolysis of the spine. The females exhibited five instances of trauma (63%) among the eight observable individuals: fractured patella that had not healed; spondylolysis of the spine; a healed rib fracture and unhealed ulna; spondylolysis and healed rib fracture. The seven observable males had the fewest individuals impacted (43%), but one individual had multiple lesions (fracture of the hand, left clavicle and left femur), while the other two exhibited compression fractures of the thoracic 2 to 5 vertebrae and the other a fractured left metatarsal of the foot.

The Lower section had no trauma exhibited by the 13 unsexed individuals. Four Females (57%) of the observable seven individuals exhibited: healed fracture of the left maxilla; two healed rib fractures; and one healed ulna fracture. Six males (54%) of the 11 observable individuals exhibited trauma with one having five healed fractures: right and left scapulae, right humerus, ribs and both feet. The other five exhibited: healed fractures of the ribs and radius; rib; femur; and femur.

The Wadi Mouth site had three individuals (23%) of the 13 observable unsexed individuals with trauma: spondylolysis of the spine; myositis ossificans of the hip; and a left distal ulna. Of the two females only one (50%) exhibited a fracture of the occipital. This is one of the few instances that might not have been an accident. The one male exhibited healed fractures of the nose, ribs, and hand.

The infections observed this season have all been cases of mild healed or healing cases of periostitis. The Upper section had no infections among the 12 observable unsexed individuals. Two females (25%) of the eight observable skeletons showed infections of the left fibula and left femur respectively. Only one male (14%) of the seven observable individuals showed periostitis of the left and right tibia. At the Lower site no infections were
found among the 13 unsexed observable individuals. One of the six observable females (17%) had periostitis of the left tibia and fibula. Three males (27%) of the 11 observable had periostitis of: the left femur; left fibula and tibia; and right and left tibia. The Wadi Mouth section had three individuals (38%) of the eight unsexed observed specimens exhibit: periostitis of the left femur; left foot; and right and left tibia. There were no infections found on the one Female and one Male.

Dental decay (caries) and loss of teeth before death (antimortem tooth loss) can tell us much about the state of adult diet and general health. Too much sugar and carbohydrates can lead to dental decay and tooth loss while extreme dental wear caused by stone grinders can also wear the teeth down and result in loss. The 2010 season produced 65 individuals who could be studied for caries and antemortem tooth loss. Of those 65 individuals, 32% had caries. For the 54 individuals with maxillary teeth, the average number of caries per person is 0.7. For the 57 individuals with mandibular teeth, the average number of caries per person is 0.6. Examining the occurrence of caries in the part of the cemetery where they originated, it is important to note that the overwhelming majority of the individuals had less than five caries. Out of the three different sites, the Lower site tended to have more individuals with caries than the Upper or Wadi Mouth sites. It is also noteworthy that the majority of caries occurred on the premolars and molars with their more complex morphology for retaining the caries causing bacteria.

Of the 65 observable individuals, 21.5% had antemortem tooth loss. For the 54 individuals with maxillary teeth, the average number of lost teeth per observable person is 0.6. For the 57 individuals with mandibular teeth, the average number lost per observable person is 1.0. In the analysis of the occurrence of antemortem tooth loss by site of origin, it is noteworthy to point out that the overwhelming majority of individuals did not have any antemortem tooth loss and most of these without loss are from the Lower site. Most of the individuals with antemortem tooth loss are from the Upper site. Although the sample sizes are small, the variation in location of most caries and antemortem tooth loss does suggest some dietary differences between two of the cemetery sections. The Lower site with more caries suggests a diet higher in sugar while the reduced tooth loss may indicate a more refined food processing procedure. The Upper site with fewer caries had less sugar and with more tooth loss more grit in the diet from a less refined food processing procedure.

Vertebral pathology has been frequently noted in past seasons and again was the subject of scrutiny focusing on osteophytic growth of the vertebral body (arthritis), Schmorl’s nodes (indicating a traumatic compression of the disc between the vertebrae, spondylosis (separation of the vertebral arch from the vertebral body by trauma early in life), ankylosis (fusion of damaged vertebrae together by osteophytic bone growth), and compressed and collapsed vertebra due to a major spinal injury. Thirty-six individuals had sufficient vertebrae to be studied. Overall, 23 (63.9%) showed spinal pathology, and half exhibited at least one type of spinal trauma. Ten (27.7% of total, 55% of pathologies) had Schmorl’s nodes on at least one vertebra. Four had at least one compressed vertebra (11.11% of total, 22.2% of pathologies). Four individuals also exhibited spondylosis. Five (13.9% of total, 27.8% of pathologies) had ankylosis of at least two vertebrae. Fifteen (41.6%) individuals exhibited arthritic lipping due to arthritis.

In this study, fourteen (38.9%) were female, 17 (47.2%) were male, and five (13.9%) could not be sexed. Ten females (71.4%) exhibited a spinal pathology. Half of all females and seven (70.0%) of those with pathology exhibited some type of spinal trauma. Three (21.4%) of females (30.0% of those with pathology) had at least one Schmorl’s node. Three also showed ankylosis of at least two vertebrae. Two (14.3%) of females and 20.0% of those with pathology showed compression fractures, and two showed spondylosis. Half showed arthritic lipping. Twelve (70.6%) males exhibited a spinal pathology. Ten (58.8%) of these were due to trauma. Seven (41.2% of all males, 58.33% of those with pathology) suffered Schmorl’s nodes on at least one vertebra. Two individuals (11.8% of males, 16.7% of those with pathology) had ankylosis of at least two vertebrae, and two showed spondylosis.
Two also had compression fractures. Eight (47.0% of males, 66.7% of those with pathology) individuals exhibited arthritic lipping. Spinal pathology appeared more frequently in females than in males, though trauma was slightly more common in males. Males were more prone to Schmorl’s nodes. Ankylosis was more prevalent in females. Rates of spondylolysis and compression were slightly higher in females. Females were significantly more likely to develop osteophytes.

Musculoskeletal stress markers (MSM’s) have been used to reconstruct workload patterns in skeletal populations. However, our work at Amarna in previous seasons has focused on the upper limbs. As there is no method available for lower limb scoring techniques, a scoring system was developed using Hawkey and Merbs (1995) as a guide. Leg bones from 22 individuals from the 2010 excavations were seriated and scored for each of the 31 muscle attachment sites of the lower body. Representative examples of each score for each attachment were photographed. The scoring was done on a continuum from 0-6 where the 0-3 scores were correlated to increasing robusticity and bone growth due to muscle use, while the 4-6 scores relate to lesion formation due to the overuse of muscles. Preliminary results are discussed and a comparison is made to the only publication available on lower limb MSM analysis which was done on Eskimo populations (Street and Lane 1998). Comparison of MSM scores between the sexes showed that the mean MSM score for females (1.5) was higher than that of the males (1.4). This result was unexpected but might mean females carried heavier loads. Correlations between MSM and body mass showed only a slightly positive correlation, meaning that body mass may influence MSM. There were not enough individuals to analyze sex by site, however a total site-by-site analysis was done and there were only slight differences between locations, with the Lower site having the highest mean MSM score of the three locations. It should be noted that all sites scores were very low. Finally, comparisons was made to Street and Lane’s (1998) data for lower limb MSM scores taken from two Alaskan populations: Golovin Bay and Nunivak Island populations. Comparisons between the mean MSM scores for the same 30 attachment sites of both males and females of each population showed that the Eskimo samples were higher or only slightly higher than those from Amarna. Because the Eskimo populations tend to be the most robust skeletal populations because of their harsh lifestyle, these results suggest the extensive workloads of the people of Amarna. This follows the findings for the high rates of spinal pathology.

One project of interest was an attempt to determine the overall robusticity of the feet of the people of Amarna to see if the results might indicate the habitual footwear use. Trinkaus (2005) explains that Ground Reaction Forces (GRFs) are dispersed across the bones of the feet differently based on the presence or absence of footwear in addition to the substrate upon which the person habitually moves. Furthermore, Trinkaus (2005) states that barefoot locomotion produces additional bending forces on the toes that are otherwise lessened by a constricting sole or border surrounding the feet.

Measurements of the feet include the length, midshaft height, and midshaft breadth of the metatarsals and proximal phalanges. Body mass has also been calculated using the femur head diameter. As there are no current Egyptian samples for comparison we use data from late prehistoric/early historic Native American population and modern Americans provided by Trinkaus (2005). Although a larger samples would provide more reliable results, these show that Amarna feet are closely comparable to the habitually barefoot Native American population, although these individuals possessed a form of deer skin moccasins/boots, they would not have been sturdy enough to constrict the foot and lessen the GRF’s and impact of their substrate (see Table 1). The Amarna results fall in between those of the Native Americans and the Inuits, although the difference in body mass may put the closest comparison to that of the Native Americans. This would suggest that in general, the ancient Egyptians buried within the Amarna cemetery were primarily travelling barefoot and without any sort of constricting footwear or ones having a stiff, rigid sole which would diffuse the impact of daily movement.
The study of Amarna demography requires great precision in determining the age of adolescents and young adults. We, thus, attempted to adapt an age method developed by Ríos and Cardoso (2009) on an archaeological sample, which was then tested on a sample of 27 individuals from the Terry Collection (St. Louis, USA). This scoring system was tested on the ribs from 15 Amarna individuals. The degree of fusion in the vertebral rib ends, and the presence/absence of the articular and non-articular tubercles were scored. This method requires that all rib positions be known, and thus, all ribs for each individual were seriated by number. After the ribs were identified by side and number, the presence or absence of the articular and non-articular tubercles was recorded. Then, the degree of fusion was scored: 1- no union; 2- partial union; 3-completed union.

Table 1. Frequency of rotation and displacement per tooth type in maxillae and mandibles at Amarna.

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For the purpose of the Amarna analysis, individuals were placed into age ranges based on patterns observed in the growth and development of the population as a whole. In this study, two of these age ranges are most important: 7-15 and 15-25. After assigning age ranges based on the tables in Ríos and Cardoso (2009) it became clear that the Amarna population showed protracted, as well as later, fusion when compared to the published Portuguese sample. Therefore, it was necessary to create population specific age ranges/score tables for Amarna based on the data collected. These ranges can be applied to age individuals from Amarna in the future.

As expected, the individuals from Amarna show statistically significant sex differences in fusion at the head epiphysis. A chi-square test was used and the articular and non-articular tubercles do not show statistically significant sex differences. Ríos and Cardoso observed later fusion in individuals from lower socioeconomic backgrounds. They hypothesize that late fusion can be used to gauge the environmental conditions in which people lived. The Terry collection is composed of mostly lower income individuals whose bodies were either donated or not claimed. The individuals from Amarna exhibit a delay in fusion of about 4 years. The ages estimated for individuals are averages of age ranges of 4 years. Given that the age could be plus or minus 2 years, it is likely that the delay in fusion is actually only 2 years. This late fusion is indicative of poor general health and nutrition, which has been observed in the population generally through the presence of cribra orbitalia, porotic hyperostosis, enamel hypoplasias, and stunted growth of the long bones. It is likely that the ages estimated in this population based solely on epiphyseal union are also under aging these individuals. Overall, more analysis is needed in order for this method to be utilized on this population as a reliable tool for age estimation.

Conclusions

The 2010 season produced 75 individuals and 14 skulls that could not be assigned to one of the individuals. There are 29 individuals from the Upper site, 30 from the Lower site, and 17 from the Wadi Mouth site. The large proportion of late childhood and adolescent deaths have remained of concern since the first season of
analysis. The few specimens from the Wadi Mouth site produced a more normal demographic curve with the highest proportion of infants. Both the Upper and Lower sites continue to have high proportions of children and adolescents in their samples. These are the ages when the skeletons should be fewest. The persistent high proportion of dead between 10 and 20 years suggests that the South Tombs Cemetery represents evidence of a catastrophic burial assemblage. Another line of evidence for high childhood nutritional stress is short adult stature at all the excavation sites. The male and female statures respectively for the Upper site are 162.4cm and 155.2cm; Lower site are 162.2cm and 157.4cm; and the Wadi Mouth site 164.7cm and 152.1cm. The femur growth rate is far below that of the modern standards and the humerus was growing at a reduced rate from the femur. Again there is extensive evidence a poor childhood nutrition. Dental malocclusion commonly consisted of rotated and displaced mandibular incisors and canines. This clearly resulted from failure of the mandible to grow sufficiently during childhood. Dental hypoplasias and cribra orbitalia were both common and reinforced all the other evidence for poor childhood health and nutrition. Application of a new technique to age adolescents by fusion of the rib epiphyses suggests that not only is bone growth retarded, but that epiphyseal union may be delayed up to two years.

Adult health is also poor. Dental decay was found in 32% of the 65 individuals with teeth. The Lower site had more decay and less tooth loss than the Upper site suggesting that they had a slightly more refined diet. Frequent healed fractures of the arms, legs, hands, feet, and spines suggests frequent accidents often involving the carrying of heavy loads. A new muscle attachment site scoring system was developed for the legs and preliminary results show that the Amarna people are just below the Eskimo samples indicating an arduous life style for the Amarna people. A preliminary study of the foot bones suggest that the Amarna foot-ware was similar to that of the Native Americans living in the deserts of the American southwest which had flexible, not ridged, soles.

Bibliography


