Human remains from Marina el-Alamein

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> To dwell upon bone is to contemplate the fate of Man. Bone is the keepsake of the earth, all that remains of a man when everything else has long since crumbled away.
> Richard Selzer

1. Introduction

The investigation of human remains from archeological settings is the subject matter of physical anthropology, also known as bioanthropology. Physical anthropology has been preoccupied with human variation from the beginning (Hrdlička 1927: 206).[1] Profound changes have occurred in recent years in the field of physical anthropology. New tools, including high-speed computers, microscopic, radiological, molecular/DNA and immunological techniques, tomograms and CT scans, magnetic resonance imagining (MRI), all have pursued research problems believed impossible to investigate a mere decade ago. Nonetheless, the application of these new tools and technologies in field conditions at an archeological site is beset with limitations due to poor preservation of remains and the risk of losing them before the documentation process has been completed. Therefore, morphological and anatomical observations and measurements remain of prime importance in collecting as much data as possible before the remains disappear or decay.

Research interest in human skeletal biology has grown markedly in recent years. The inquiry has focused chiefly on human ecology and human ecology of disease in particular. Ancient human population health has been defined in terms of adaptability and related to complex systems of interactions among habitat (environment) population and cultural behavior. Health is a "continuing property" that can be measured by "an individual's ability to rally from a wide range and considerable amplitude of insults, insults being chemical, physical, infectious, psychological and social" (Audy 1971: 140). The term "ability" is equivalent to the terms "stimuli" or "hazard to insults". Such "stimuli/hazard" may be either negative or positive and the physiological response positive (normal growth and development) or negative (disease) respectively.

[1] Hrdlička states that physical anthropology focuses on the place of man in nature. Humans are viewed as a biological phenomenon. Physical anthropologists have a long history of studying human variation and physiological growth and behavior in numerous populations within many spatial and temporal frameworks.

Human ecology of disease describes the interaction between biology/behavior and the role of the environment on a population's life activities and health status. Data from skeletal samples, widely believed to represent the sensitive indicators of biocultural changes, are essential to our understanding of how the adaptive success of the human populations has varied through time and space. They permit insights into microevolution, population relationships, demography, growth and development, diet and health. There exist, however, theoretical and methodological limitations on the interpretation of skeletal records, resulting from the fact that all the cases making up a skeletal series are dead. A sample of the dead is a perfectly random sample of all who have died, but it can hardly be considered as representing the original living population. In their article "The Osteological Paradox"(1992), Wood and associates pointed out three conceptual problems in the interpretation of data derived from skeletal samples: (i) *demographic nonstationarity*, which refers to the departure of a population from a stationary state, which is characterized by closure to migration, constant age-specific fertility and mortality, zero growth rate, and an equilibrium age distribution; (ii) *selective mortality*, which means that the sample in a given age category is highly selective, because not all individuals at risk of death from a particular cause will die from it; and (iii) *hidden heterogeneity in risks*, which means that there is a varied susceptibility to disease and death within a population (Wood *et alii* 1992: 344). It is thus important to consider the osteological paradox limitations while interpreting skeletal data.

The aim of this study is to draw a health profile of a past human population and to study levels of adaptation of a population to the environment in which it lives.

2. Methodology: conceptual framework, skeletal inventory and scoring procedures

Skeletal inventory is an important tool for sample description and comparative statistical analyses. Several attempts have recently been made to standardize human skeletal data collection. Current data recording standards may be found in Buikstra and Ubelaker (1994), and in *The Global History of Health Project. Data Collection Codebook* (Steckel *et alii* 2006).

A consistent methodological approach to data collection and analysis can extend the possibilities for comparing various aspects of life in the past. For example, accurate counts of individuals and frequency of evidence indicative of diseases is essential for comparative analyses of health across groups under different subsistence regimes. The total number of observations and the count of individuals in a sample are unlikely to be identical due to many factors that limit bone recovery and preservation. Therefore, the first and foremost question in any study of human skeletal samples is the degree of preservation.

With regard to the site of Marina el-Alamein on the Mediterranean coast of Egypt, the human osseous material, available for anthropological examination from excavations carried out between 1989 and 2005 in the Graeco-Roman necropolis dated on archaeological grounds from the 2nd century BC and the 1st century AD (most recently, Daszewski 2011), consisted mainly of bones and teeth, as the bodies were poorly mummified [***Fig. 1***]. High humidity and salinity of the burial microenvironment have effected fragmentation and post-mortem damage of the skeletal material. Additionally, a considerable amount of damage had been inflicted by tomb robbers, most of the plundering being done already in antiquity of burials. Skeleton condition was assessed macroscopically and recorded according to the categories and descriptions supplied by Buikstra and Ubelaker (1994): excellent, complete or relatively complete, mixed, incomplete, and isolated bones. Three categories of preservation were distinguished: poor, fair and good, depending on the degree of fragmentation, the completeness of the skeleton and dentition, and the degree of post-mortem damage. A poor preservation level reflected a high degree of fragmentation and post-mortem damage, with a high degree of surface erosion and less than 25% of the elements being present. From 25% to 50% presence with limited fragmentation and a small degree of surface erosion was described as fair, and good reflected from 50% to 80% of present elements and minimal fragmentation. Most of the

Fig. 1. *Bodies of adult individuals excavated in the main burial chamber of Tomb 21. Evident traces of mummification in the form of shrouds and bandage wrappings. Skeleton preservation level assessed as being from fair to good (Photo W.A. Daszewski, PCMA)*

remains were classified in the poor to fair preservation categories (58.6%) resulting in varied sample sizes acquired for statistical computation.

Subadult[2] skeletons have recently started to contribute more significantly to studies of health levels in past human populations because of improvements in research methods and new technologies of age and sex determination. Investigations in the field of molecular genetics have provided a more accurate method of sexing juvenile skeletons based on ancient DNA rather than the previously proposed methods based on morphometric indicators of sex. Critical reviews of the advantages and disadvantages of using molecular techniques in bioarcheological studies have been forthcoming (Stone, Stoneking 1999; Roberts, Manchester 2005; Roberts, Ingham 2008). Bones of subadult individuals are likely to be less well preserved compared to those of adults and are frequently lost for analyses. Of the 928 individuals examined by the present author in the Marina el-Alamein sample, 233 burials belonged to subadults.

Both the adult and subadult dead were found in single, double and multiple burials in all the different forms of tombs and graves reflecting social stratification (most recently, Daszewski 2011; for subadult burials, see also Daszewski, Zych forthcoming). Subadults were often buried together with their adult relatives(?),[3] either males or females. In many cases, subadult dead were commingled with adults.

All examinations were carried out on site during the archeological excavations. Anatomical and morphological details on bones and teeth were examined macroscopically using a 10x magnifying glass. For the purposes of the present study, an inventory procedure and recording form were modifying Buikstra's and Ubelaker's proposal (1994: 328). Commingled skeletal remains were sorted according to forensic techniques and counted as a number of individuals (Ubelaker 2002; Byrd, Adams 2003). The mummified dead were unwrapped. Since however only bones and teeth were preserved in the studied mummies, they were considered in the skeletal series.

The pattern of mortality was assessed using biological attributes such as estimates of sex and age at death. Sex determination was limited to individuals who had survived past adolescence to manifest changes in the skeleton reflective of sex. While there have been several studies investigating morphological traits that might be sexually dimorphic in infants and juveniles with sufficient levels of accuracy to warrant their application in osteological analyses (DeVito, Saunders 1990; Schutkowski 1993; Majo *et alii* 1993), morphological standards for diagnosing sex in juvenile skeletons that would be acceptable to most osteologists have yet to be developed (Saunders, Hoppa 1993). Analysis of ancient DNA (SRY, amelogenin) by means of modern molecular techniques seems to be very promising for its precision in sex determination (Cunha *et alii* 2000).

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[2] In this paper, the term "subadult" refers to individuals who had not reached biological maturity at the time of death, including fetuses, newborn, infants, children and youngsters. Biological maturity was assessed using indicators of dental and skeletal developmental stages.

[3] Assessment of biological relationship is based on genetic analyses. As no such examinations were carried out, we may only presume about this relation.

In this study nevertheless all individual sex and age-at-death data were estimated macroscopically. The distinction between males and females was determined mainly on the basis of observation of the anatomical traits on pelvis and skull, but due to bone fragmentation and overall poor level of preservation, scoring covered nearly all bones of the skeleton known for dimorphic distinction (Buikstra, Ubelaker 1994: 328; Acsádi, Nemeskéri 1970: 75–100). Several sexually dimorphic skeletal features of the cranial and postcranial skeleton, such as nuchal crest, processus occipitalia externa, processus mastoideus, shape of mandible, mandible angle and mental eminence, supraorbital parts and shape of orbit, prominence of glabella, os coxae, subpubic region including: ventral arc, subpubic concavity, ischiopubic ramus ridge, greater sciatic notch, and preauricular sulcus were observed.

Sex determination criteria also included measurements of dimorphic dimensions, such as the maximum diameter of the femur head, maximum facial breadth (bizygomatic diameter) or the size of processus mastoideus. Bones of the skeleton and the extremities in particular are in the end effect more robust in males than in females. A multivariate method including all features indicative of sex was applied whenever possible.

Sex indicators are known to be unequally developed within individual populations, therefore a scoring system was established for determining variation in morphological features associated with either male or female sex and dimorphic dimensions of a study population from Marina. This scoring system served the purpose of "population-adjusted" sex determination.

Age-at-death determination was based on physiological-age criteria that reflect developmental changes in tissues correlated to chronological age. The skeletons were first divided into two groups, subadults and adults. The closure of the *synostosis spheno-occipitalis* was used as the main criterion for distinguishing subadults (fetuses, newborns, infants, children and juveniles) from those who survived above the age of 18 and died in adulthood. For the purposes of this study, age at death of subadults was determined using standards to designate dental development. The tooth formation and eruption timing were described against reference standards developed by Moorreess *et alli* and improved by Ubelaker (Moorreess *et alli* 1963; Ubelaker 1999).

The appearance and fusion of bony epiphyses and diaphyseal length were used as the basis for growth assessment. However, when dental development was unobservable, as was in a few cases, the fusion of bony epiphyses and diaphyseal length were used for age determination. Standards for epiphyseal closure timing were taken from Ubelaker (1989). In the skeletal remains under study, it was extremely difficult to distinguish between prenatal and perinatal periods, therefore these periods in conjunction with the neonatal one were collected together in the age group 0–3 years. Individuals revealing neonatal development were grouped in the newborn category.

With regard to adult individuals, age determination is commonly based on observation of morphological changes on the articulatory surfaces of the symphysis ossis pubis and condition of the sutures. Changes in the morphology of the pubic symphysis for both females and males were checked against the Suchey-Brooks standards (Brooks, Suchey 1990), while cranial suture closure was scored based on a system adopted from Buikstra and Ubelaker (1994). Considerable variability in the age of cranial sutures closure has been claimed to reduce their importance for age estimation (Masset 1989). Consequently, the age of adult individuals in this study was determined according to age-related anatomical changes in the skeleton covering a lifespan between 20 and 70 years of age. While the criterion is regarded as uncertain in age determination of the adult skeleton, it can be used to distinguish between three age groups: young, middle, and old adult. Young adult/*adultus* refers to individuals between 20 and 35 years of age; in this group, the three major sutures on the skull are all open or have just started to close. Individuals with cranial sutures in various stages of closing form an age group from 35 to 50 years, designated as middle adult/*maturus*. Finally, old adult/*senilis* describes individuals over 50 years with all the sutures completely or almost completely closed.

Skeletons were divided first into two groups: subadults and adults. Then, based on dental age, children and juveniles were assigned to the following age categories: 0–3 years, 3–7 years, 7–11 years, 11–15 and 15–18 years. Adults were assigned to ten-year-interval age groups.

Standard indices of health status of a population were analyzed in order to determine the subadult patterns of morbidity and mortality using the protocol described in Steckel *et alli* (2006).

The morbidity pattern was based on skeletal and dental evidence of disease and nutritional status. Paleopathological indicators of chronic diseases, such as dental caries, tuberculosis, infectious diseases, i.e., scurvy and rickets, were observed (Aufderheide *et alii* 1998; Ortner, Putschar 1985; Roberts, Manchester 2005).

Dental attrition was recorded using a surface wear scoring system for incisors, canines, and premolars modified by Smith and the system for scoring surface wear in molars developed by Scott (Smith 1984; Scott 1979).

Skeletal and dental indicators of physiological stress associated with environmental stressors, such as malnutrition and nutritional and weaning stresses, were included in the health status assessment. The presence of the following non-specific indicators of stress throughout the growing years was observed: cranial porosities (porotic hyperostosis and cribra orbitalia), micro-structural enamel defects (enamel hypoplasia), and reduced growth rates resulting from diseases and nutritional harm (Goodman, Rose 1990; Goodman 1989; Saunders 1992; Saunders, Hoppa 1993).

Porotic hyperostosis and cribra orbitalia are supposed to be linked to iron-deficiency anemia (acquired and genetic), vitamin deficiencies (e.g. folic acid, vitamin C), and parasitic infection(Ortner *et alii* 1999; Ortner *et alii* 2001; Schultz 2001; Wapler *et alii* 2004). According to the *Cambridge Encyclopedia of Human Paleopathology* (Aufderheide *et alii* 1998: 348–349), "porotic hyperostosis (PH) is characterized by usually symmetrically distributed cranial lesions involving the outer table only of the frontal and parietal bones and much less frequently of the occipital bone. In the fully developed lesion, the involved areas of the skull are thickened by the expanded diplotic layer and the outer table overlying the lesions has been absorbed completely … The lesion is commonly most fully developed in infancy (but not at birth)" and "Cribra orbitalia (CO) is a similar but smaller lesion located in the orbital roof, usually predominantly in the anterolateral portion; 90% are bilateral. Both PH and cribra orbitalia are found predominantly in infants and younger children." Porotic hyperostosis was recorded as present when porosity with coalescing foramina was apparent on the ectocranial surfaces of the cranial vault, most frequent on the squamosal portions of the occipital and parietal bosses. The degree of severity was recorded using scoring procedures recommended by Steckel *et alli* (2006: 13–14). Cribra orbitalia were recorded as porosity of the roof areas of the eye orbits, and the degree of severity was recorded again using scoring standards recommended by Steckel *et alli* (2006: 12–13).

The term "enamel hypoplasia" (EH) is applied to non-specific, systemic stress indicators and defined as a deficiency in enamel thickness resulting from a disruption of tooth development, the process of amelogenesis (Aufderheide *et alii* 1998: 405). This condition is associated with the presence of systemic metabolic stress caused by infectious disease, malnutrition, and other factors (Goodman 1991; Goodman, Martin 2002). It is commonly recognized as a deficiency in enamel thickness that marks the point of disruption of ameloblasts, which are responsible for enamel development in the course of amelogenesis. Abnormal development of enamel may be caused either by disease or systemic metabolic stress or some combination thereof (Goodman, Armelagos 1985; Goodman *et alii* 1987).

The developmental distribution of defects in skeletal samples consistently peaks between two and four years of age (Goodman 1989).

A hypoplastic lesion is usually identified macroscopically, using dental probe and magnifying glass, as the presence of continuous linear horizontal grooves/lines/bands of decreased enamel thickness or series of pits on the buccal surface of the tooth. This condition, clearly visible to the naked eye, was recorded using a dental hypoplasia standard developed by Schultz (1988). The rate of enamel hypoplasia was assessed by separate tooth type. All deciduous and permanent teeth, except for third molars which are considered to be too variable in developmental timing, were scored for the presence of enamel hypoplasia. The poor condition of teeth, e. g. antemortem tooth loss, severe attrition, caries, parodontopaties and others, are usually the main factors for estimating the prevalence of enamel hypoplasia in the skeletal series.

Persistent childhood nutritional deprivation and disease can affect growth, resulting in a reduced growth rate and reduced adult stature (Zakrzewski 2003). Diaphyseal lengths of 93 femora, 69 tibiae, and 89 humeri were measured using an osteometric device. Measurements were taken in millimeters to the nearest whole millimeter, mostly on the left bone but also on the right, if the left bone was not available. Based on this data, skeletal growth curves were plotted against developmental ages and smoothed using the locally weighted regression method. Difference in growth rate, based on growth in diaphyseal femur length, was then analyzed in the studied samples. Stunted growth in childhood and adolescence, disclosed in the attained adult stature, was estimated based on the femur length for its high correlation with the stature. According to Bhavna and Surinder Nath (2009), tibial length exhibits the overall highest value of correlation (r=0.765) with stature followed by fibular length (r=0.758) and femur length (r=0.743). For further details on the relationship between femur length and stature in children between the ages of 8 and 18 years, see Feldesman (1992). For reconstructing the stature of ancient Egyptians see Raxter *et alii* (2008).

The health profile of the Marina population was compared to other populations, in particular to the Saqqara sample coming from the Ptolemaic period (Kaczmarek 2008).

All statistical computations were performed using the STATISTICA data analysis software system, version 9.0 (2009) www.statsoft.com. The level of significance was set at $p \leq 0.05$.

3. Palaeodemography: demographic structure of the population, mortality pattern

The sex and age distribution in the Marina sample is shown in ***Table 1***. The sample consisted of 233 subadults and 696 adults; of the latter 431 were males (62%) and 254 females (36.4%); there were 10 adult individuals whose sex could not be determined. The sex ratio in this sample was 2:1 in favor of the male, differing significantly from the theoretically expected equal sex representation of one male to one female. It may be supposed that this unusual sex ratio is associated with selective mortuary rituals favoring males.

Table 1. *Sex and age distribution of the skeletal sample from Marina el-Alamein. Subadult and adult components of the population combined*

Age group (years)	Number of Individuals Sex				% Population
	Indeterminate		Male	Female	
0	21				2.4
1–3	79				8.6
4–7	45				4.9
8–14	33				3.7
15–18	28		3	9	3.2
Indeterminate	27				2.9
Adult		10	16	9	3.9
20–30			96	101	21.4
30–40			107	83	20.5
40–50			141	37	19.3
50–60			64	15	8,7
60–70			4		0.5
Total	**233**	**10**	**431**	**254**	**100**

In the Saqqara sample dated to the Ptolemaic period, the author found the sex ratio to be 1.3 male to 1 female, which is very close to the theoretical expectations (Kaczmarek 2008). A similar sex ratio was found by Strouhal and Bareš in two combined series from Abusir, where males constituted 55.3% and females 44.7% of the total sample, indicative of a ratio of 1.2 males to 1 female (Strouhal, Bareš 1993:145). This slight difference in favor of males in the skeletal sample is said to be due partly to the fragility of female skeletons which tend not to be preserved as well as the male ones. This explanation, however, does not corroborate with figures found in the Marina sample.

Female mortality calculated at 39.7% was the highest in the 20–30 years age group. Frequent childbirth with potentially deadly complications is thought to be the most likely explanation of this phenomenon. The highest mortality among men was distributed equally between two age groups, 30–40 years and 40–50 years, yielding 32.7% of the total adult sample. Overall, the difference in the pattern of mortality rate between men and women based on chi-square test computation, did not appear to be statistically significant.

The sample included 2.4% infants who died at birth, 8.6% infants aged 1–3 years, 4.9% children aged 4–7 years, 3.7% older children aged 8–14 years, and 3.2% adolescents aged 15–18 years. Age at death of almost 3% of subadult skeletal remains could not be determined. Altogether, subadults represented 25.1% of all individuals studied. This gives a 1:3 ratio of subadults to adults in favor of adults. Subadult mortality, based on this data, should be judged as moderate, the expected proportion of subadult dead in that time being about 50% of a population (Kamp 2001).

The share of children in material from various archaeological cultures and sites tends to vary significantly. Very low child mortality rates have been reported from Egyptian and Sudanese Nubia. In Egyptian Nubia, the rate of child mortality ranged from 12.3% in the Predynastic period, through 16.2% in the Old and Middle Kingdoms, 11.4% in the Ptolemaic period, and 27.4% in the Christian period (Smith, Wood Jones 1908). In Sudanese Nubia, this rate varied from 14.3% in the Pharaonic period to 35.1% in the Christian sample (Vagn Nielsen 1970). In a sample from Tombos in New Kingdom Nubia, subadults represented only 8% of all individuals studied and there were almost no infants aged 0–3 (Buzon 2006). Elsewhere, the share of children in the mortality rate was found to be higher, e.g., in the cemetery inside and around the ruined mastaba of Ptahshepses at Abusir, operating between the 7th century BC and the 1st century AD, the ratio between subadult and adult skeletons was almost 1:1, with 49.7% of subadults versus 50.3% of adults (Strouhal, Bareš 1993). Similar findings were shown by Armelagos (1969) for the skeletal sample from a Christian cemetery near Meinarti dated to AD 1050–1150, where subadult individuals consisted 40% of the total sample.

This bias in demographic profile in favor of adults is likely due to a combination of factors. Cultural and socio-economic factors may have influenced burial locations, whereof infants were buried differently and/or not in the same places as adults (Kamp 2001). There is also greater susceptibility to decay of subadult bones as compared to adult ones, resulting in the absence of subadult skeletal material at excavation sites (Pfeiffer, Crodwer 2004). Finally, it may be the research designs that do not include subadults in the skeletal inventory. And for reasons mentioned above, the subadults available for examination in the Marina sample may represent a biased sample of the population rather than reflecting the actual demographic situation. Therefore, interpretations must be cautious given the relatively small sample sizes.

When analyzing the mortality pattern among subadults [***Fig. 2***], it was found that infants dying at age 0–3 years were the largest group and consisted 48.5% of all subadults. This rate was almost two times higher than the percentage of children (21.8%) dying at age 4–7 years. For children dying at age 8–14 years the rate was 16.1% and for those dying at age 15–18 years it was 13.5%.

The overall mortality pattern points to a high mortality rate among infants and children with 86.5% dying before the age of fourteen and a much lower mortality rate for adolescents (13.5%). The weaning effect commonly observed in earlier human populations, was not found in the Marina sample. The percentage of children dying after weaning, at the age 4–7 years, was 21.8%.

In the Saqqara sample from the Ptolemaic period, for example, the highest death rate, 33.8% of the total subadults, was observed within the 3–7 years age group, supporting the suggestion of a weaning effect. It is believed that weaning in ancient Egypt occurred at the age of three (Strouhal 1977). Weaning a nursing infant places it at a variety of risks, including increased morbidity and mortality as a result of infectious and parasitic diseases. After this critical period in human life, the mortality rate falls as demonstrated by the adolescent age group in both study samples, which corresponds to data for modern living populations. This is because in adolescence individuals stop being dependent on adults for care and support and can provide food for themselves, their immune system effectively protecting against parasites and microbes and making the juveniles less vulnerable to infectious diseases. This fosters survivorship into adulthood (Bogin, Smith 1996). Lovejoy and associates have argued that most infant deaths in

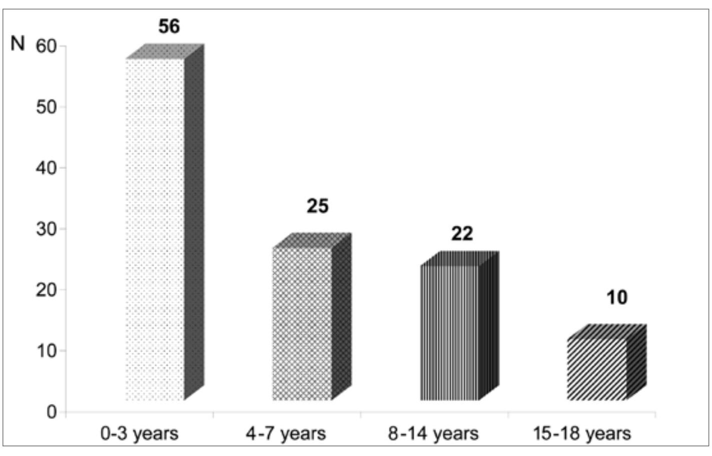


Fig. 2. *Age distribution of subadults from the Marina el-Alamein sample*

earlier populations were the result of acute diseases, which should not drastically alter the pattern of dental or skeletal maturation (Lovejoy *et alii* 1990). This can also explain why almost no individuals displayed evidence of tuberculosis or other chronic diseases. However, poor preservation state of skeletal remains may challenge this interpretation.

The mortality pattern found in the Marina sample corresponds to that found commonly in modern populations. The greatest mortality rate in the perinatal period is generally the result of birth (genetic) defects or trauma (Smith, Avishai 2005). However, specific cultural practices like infanticide or infant sacrifice may also account for a greater number of dead in the said period as compared to death by natural causes.

With regard to adults, the average adult age at death, calculated from the age-at-death data for adult individuals, revealed males being more likely to survive to an older age than females. An average age at death of males was 38.1 years (SD=3.9 years) and that of females was 33.4 years (SD=4.1 years). The difference in survivorship between males and females was statistically significant at the 0.05 level, indicating that the number of male survivors tended to exceed that of female survivors throughout the entire lifespan. The differences between male and female survivors grew substantially in the 20–30 years age group, reflecting high female mortality at the childbearing phase in life.

Palaeodemographers have observed a fairly steady increase in lifespan over time (Acsádi, Nemeskéri 1970: 138–259). For example, Angel's data for Greeks have set the average adult age at death in Early Neolithic times at 33.6 years for men and 29.8 years for women, compared to the Classical period when it was 44.1 years and 36.8 years, respectively (Angel 1968). Figures calculated for the present study appear to corroborate this general tendency.

4. Physiological stress: disruption of growth and maturation

Physiological stress is an important concept in the study of human adaptability. For purposes of bioarchaeological studies, stress is defined as a physical disruption resulting from impoverished environmental conditions and/or exposure to infectious pathogens that affect health at both the individual and population levels. Since the specific cause of stress is usually unknown, a "general stress perspective" is undertaken to determine health in past human populations (Goodman, Martin 2002). Stressful events not always result in skeletal lesions. The skeletal response to stressors depends on the duration and magnitude of the stressor and the individual's biological reserves for resisting the stressor. Prolonged exposure to unhealthy conditions, particularly during childhood, often manifests itself in skeletal remains as several pathological conditions such as enamel hypoplasia, cribra orbitalia/porotic hyperostosis, and osteoperiostitis.

Indicators of physiological stress were examined separately in adults and subadults. Only four of 219 adult and none of subadult individuals demonstrated porotic hyperostosis of the cranial vault. Cribra orbitalia was more common [***Fig. 3***]. Thirty eight of 197 subadult individuals under study displayed cribra orbitalia, which is 19.3% of the subadult sample. This frequency of cribra orbitalia was significantly lower than the rate in the Saqqara sample, 27.3% ($p<0.05$). However, caution must be exercised when formulating interpretations, given the relatively poor preservation state of nonadult skulls.

Enamel hypoplasia was examined in subadult individuals having deciduous, mixed or permanent dentitions. Surprisingly, the rate of hypoplasia was very low. Only four out of 85 individuals displayed enamel hypoplasia on deciduous central incisors (4.1% of the total subadult sample examined for this lesion) and three out of 49 individuals on permanent incisors (6.1%). None of the individuals having deciduous canines displayed enamel hypoplasia. This lesion was observed in one individual having a permanent canine [*Fig. 4*].

Enamel hypoplasia was also found in young adult individuals aged between 20 and 25 years. In the total sample, enamel hypoplasia was observed on eight out of 65 permanent incisors, giving a frequency of 12.3%. These frequencies were significantly different between two samples compared (at $p<0.01$). The overall frequency of enamel hypoplasia in the Saqqara adult sample ranged from 17.2% for permanent central incisors (five cases in a sample of 29 teeth), through 18.1% for permanent lateral incisors (four cases in a sample of 22 teeth) to 21.8% for permanent canines (seven cases in a sample of 32 teeth). These figures must be said to reflect a moderate frequency of enamel hypoplasia. Data for porotic hyperostosis, cribra orbitalia and enamel hypoplasia in the subadult component of the sample is shown in **Table 2**.

Fig. 3. Cribra orbitalia present on roof areas of both eye orbits in a seven-year-old child from the Marina-el Alamein sample (Tomb 21, Loculus 7, Individual No. 5) (Photo U. Wicenciak, PCMA)

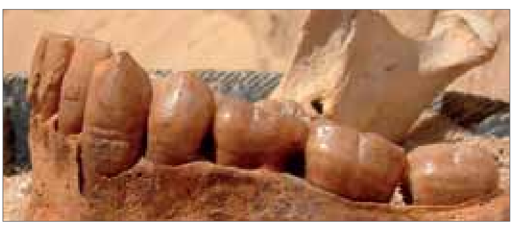


Fig. 4. Enamel hypoplasia displayed on a mandibular canine of a 12-year old individual from the Marina-el Alamein sample (Tomb 21, Loculus 11, Individual No. 2) (Photo A. Błaszczyk, PCMA)

Table 2. Subadult individuals displaying indicators of physiological stress

Stress indicator	Sample	
	Marina el-Alamein	Saqqara
Porotic hyperostosis	o/182	0/64
Cribra orbitalia	38/197	18/67
Enamel hypoplasia		
Deciduous incisor	4/85	0/29
Deciduous canine	0/79	0/32
Permanent incisor	3/49	3/23
Permanent canine	1/29	2/26

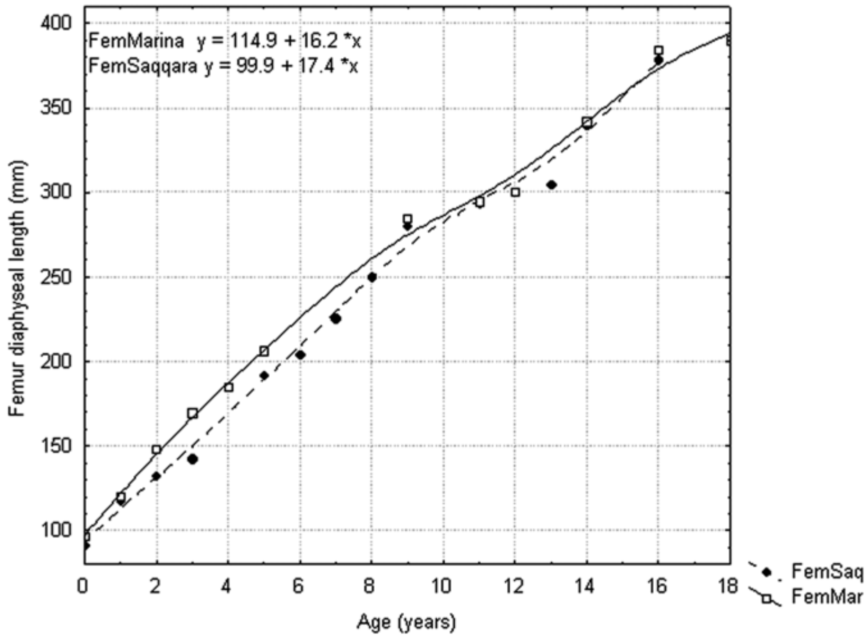
The pattern of non-specific stress indicators revealed a mixed picture of subadults' health at Marina. The cribra orbitalia rate in the Marina sample proved to be relatively low (19%) and significantly lower as compared to the Saqqara sample (26.9%). Compared to the frequency rate for this trait among children (0–14 years old) in the Late Period sample from Abusir (41.9%), the two samples studied displayed a significantly lower frequency of this condition. When adults were included in the Abusir counts, the frequency fell to 26.8%, bringing it closer to the results for the Saqqara Ptolemaic sample and closer to the Marina sample.

Enamel hypoplasia was examined on anterior deciduous and permanent teeth. When assessing the rate of enamel hypoplasia by separate tooth type, the issue of sample representativeness emerged. Many individuals examined in this study did not have preserved anterior teeth due to postmortem loss and damage. This poor state of dentition confounded an estimation of the prevalence of enamel hypoplasia in the study sample. Enamel hypoplasia was recorded in four individuals aged 2–4 years and in four older children, revealing very low frequency. Comparative data taken from Tombos (Buzon 2006), indicated one individual out of 11 with enamel hypoplasia. Generally, earlier human populations, experiencing undernutrition and exposure to infectious agents, are thought to have enamel hypoplasia (Rose *et alii* 1985). However, the findings are not consistent as to the frequency of this trait in the Egyptian population. Unlike the present data, Lovell and Whyte found that 48% of the individuals in samples from the Old Kingdom, First Intermediate, and Graeco-Roman periods at the ancient Egyptian site of Mendes had at least one tooth with hypoplasia (Lovell, Whyte 1999).

Nerlich and colleagues found two cases of transversal enamel hypoplasias in a socially upper-class population in Thebes and Abydos (Nerlich *et alii* 2002).

Physiological stress was also assessed by examining possible stunted growth. Data for the diaphyseal lengths of femur, tibia and humerus across age groups are shown in ***Table 3***. Overall, the mean values of the diaphyseal length of the three long bones considered, revealed a continuous increment in skeletal growth throughout childhood and adolescence in a very similar way to that observed in children in modern times (Kaczmarek 2001).

Femur and tibia skeletal growth has been plotted for the Marina and Saqqara samples [***Fig. 5***]. The distance curves plotted for femur and tibia diaphyseal lengths showed that sub-adults from Saqqara were likely to be shorter than their peers from the Marina sample. The difference was statistically significant ($p<0.05$). However, around puberty (11–12 years of age), individuals from Saqqara demonstrated accelerated growth, catching up with the individuals from Marina. As of the postpubertal stage of growth, the two curves followed the same trajectory, indicating almost the same skeletal stature of adolescents from the two groups studied. The graphs illustrate a continuous increment in skeletal growth throughout childhood and adolescence. The pattern of growth is similar to that in living populations. However, it must be remembered that skeletal growth curves are not true growth curves in the sense used in living growth studies (Kaczmarek 2001), because they have been obtained from dimensions that represent deceased indi-



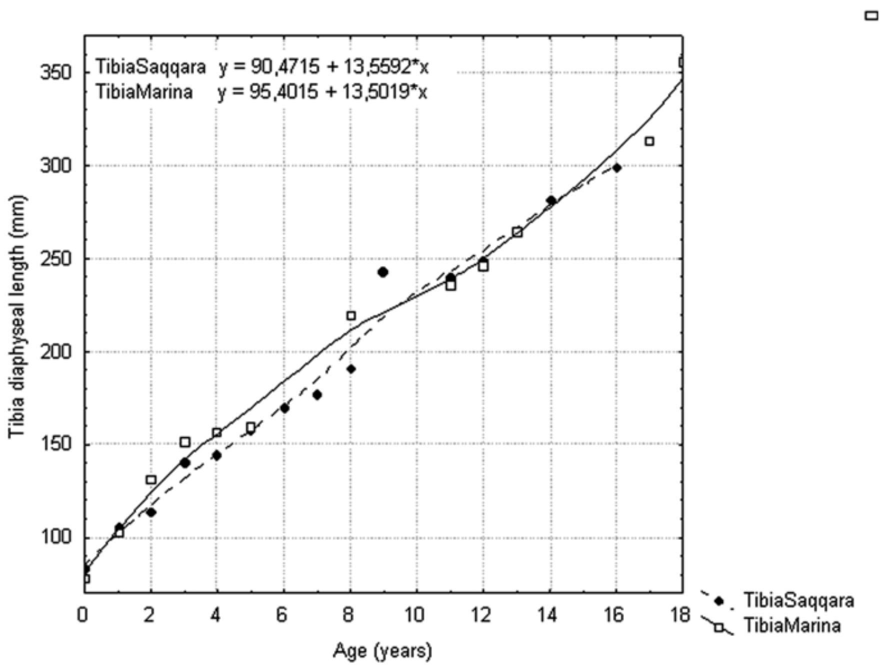


Fig. 5. *Femur (top) and tibia (bottom) diaphyseal lengths plotted against dental age for the Marina el-Alamein and Saqqara subadult samples*

viduals who never reached maturity and thus became part of a biased, mortality sample (Johnston 1963). On the other hand, Lovejoy and colleagues have argued that most infant deaths in past populations were the result of acute diseases, which should not drastically alter the pattern of dental or skeletal maturation (Lovejoy *et alii* 1990). Assuming that the length of long bones reflect not only genetic differences between the study groups, part of the difference between the two samples may have been caused by poor health reflecting the living conditions in Marina and Saqqara. Growth trajectories indicate that harmful environmental conditions evidently modified prepubertal growth in the two samples studied. It corroborates well with the well known phenomenon of larger prepubertal susceptibility of growing child to harmful or permissive environmental conditions (Tanner 1988).

Table 3. Descriptive statistics of diaphyseal lengths for femur, tibia and humerus from the Marina-el Alamein subadult sample

Age group	Femur (93)			Tibia (69)			Humerus (89)		
(years)	n	Mean	SD	n	Mean	SD	n	Mean	SD
Newborn	6	97	7.4	8	78	4.5	4	78	6,4
1	8	120.5	7.4	8	103	6.7	12	98	4
2	10	148	7.7	8	131	6.9	4	118.4	8.1
3	13	171	6.5	4	151	6.3	8	132	7.1
4	14	185.6	6.4	12	156	2.6	10	140	3.0
5	2	206	3.2	3	160	4.8	2	153.4	4.1
6	0			0			4	160.8	3.1
7	0			0			4	169	2.4
8	0			2	220	5.1	2	186	3.9
9	2	285	4.3	0			4	198	4.2
10	0			0			3	202.8	5.1
11	4	297	3.8	3	236	4.6	3	202	2.9
12	2	300	5.1	3	246	2.8	3	214	3.7
13	3	315	4.8	2	264	3.9	3	237	4.9
14	3	342	4.9	0			3	242.9	5.6
15	4	365	5.1	0			2	259.7	4.8
16	6	384	4.6	0			2	276.4	5.3
17	8	389	4.9	8	313	3.6	8	293.2	4.6
18	8	392	5.2	8	356	3.1	8	310	3.4

Notes: Age is mid point of age category in years (e.g. the one-year age class includes individuals whose estimated age falls into the range from six to 18 months (0.5 to 1.49 years); N — sample size; Mean — arithmetic mean; SD — standard deviation; all measurements in millimeters.

5. Paleopathological conditions in skeletal remains

Recorded pathological conditions included nutritional diseases, osteoporosis, lesions and fractures, joint pathology. Osteoarthritic changes and dental diseases were the two predominant pathological conditions.

Osteoarthroses were common in both males and females aged over 30. In the study series, degenerative changes were found on the vertebral bodies of various parts of the spine, mainly the thoracic and lumbar parts. Vertebral pathology was most often identified as age-related structures, such as Schmorl's depressions and osteophytic expansions of the vertebral bodies.

Two serious pathological conditions, *ankylosing spondylitis* (AS) and rheumatoid arthritis (RA), were identified in adult individuals. The simultaneous presence of the two diseases suggests a relationship between the two, but the definition of the actual relationship is still open. Indeed, the pathological changes in the active phase of AS are practically identical with those of rheumatoid arthritis. *Ankylosing spondylitis* is known as a progressive inflammatory disease of unknown etiology, primarily affecting the diarthrodial joints of the spine, costovertebral joints, and sacroiliac joints. In our sample, it is manifested as extensive calcification of anterior longitudinal and some adjacent spinal ligaments. Disk edge elevations generate a bamboo-like appearance. Rheumatoid arthritis is a generalized connective tissue disease of unknown etiology with the most significant involvement of joints. The disease manifests itself in adult and juvenile form. Degenerative arthritis is the most common of all articular diseases. This disease develops on the basis of ageing changes and degeneration of articular cartilage. Many examples of this disease were recorded in our sample [***Fig. 6***].

Trauma was another pathological condition noted in the skeletons. Paleopathologists describe trauma as affecting the skeleton in any of four ways: partial or complete break-

Fig. 6. *Ankylosing spondylitis of the spine and probable rheumatoic arthritis, severe exostosis of the sternum (Tomb 21, loculus 7, burial 3 in situ) (Photo I. Zych)*

ing of bone; abnormal displacement or dislocation of bone; disruption in nerve and/ or blood supply, and artificially induced abnormal shape or contour of bone (Ortner, Putschar 1985: 55). In the Marina study sample, trauma was exhibited as a break in the bone.

Other changes frequently observed on adult skeletons included *foramina olecrani* in humeri, probably due to overwork.

Dental diseases were very common in the present sample. Their etiology commonly reflects variations in human genetic, dietary and physiological aspects. Dental attrition, known as tooth-to-tooth wear, is one of several regressive changes in dental hard tissues that are generally associated with a coarse diet and the ageing process. Pulp exposure as a result of enamel and dentine erosion caused the living tissue inside the tooth to die, leaving empty root canals that easily became a source of chronic infection and abscesses. Attrition appears to have played a major initiating role in periapical and periodontal abscess formation, root caries, *antemortem* tooth loss and temporomandibular joint disease. Severe attrition (grade 8–10) of the maxillary first molar was found in 51.8% of the teeth studied. The overall attrition level in the Marina-el Alamein sample was likely to be significantly higher as compared to the Saqqara sample (42.2% in males and females combined). Patterns of dental attrition corresponding to this paleopathological condition were also found in subadults, both in deciduous and in permanent teeth. The attrition rate on the maxillary canine tooth was scored as grade 4, that is, as moderate dentin exposure which no longer resembles a line. Horizontally worn cusps of the first deciduous molars in maxilla made their occlusal surfaces flat, but the dentin had not been exposed yet. Moderately to severely worn deciduous and permanent teeth were observed in other subadult individuals, e.g. the seven-year-old individual shown in ***Fig. 7a***.

Periodontitis was the second biggest dental health issue in adults. Periodontitis is a disease that results in the loss of the bony support of the teeth and is often associated with plaque forming dental calculus on the teeth. The ultimate effect of periodontitis is extensive periodontal disease and loss of teeth.

Dental caries or cavities were frequent in the study sample, both in adult (19.5%) and in three of the subadult individuals of various ages. This pathological condition was observed in the teeth of an individual aged 8.5 years [***Fig. 7b***]. A large cavity was noted on the occlusal surface of both second deciduous maxillary molars. A large and deep round hole was located on the mesial quadrants of the occlusal surface on each of the affected teeth; that on the left tooth was much larger than on its right antimer. An example of interproximal carries in an adult individual is shown in ***Fig.7c***.

Another dental condition recorded in the sample under study was *antemortem* tooth loss known as primarily resulting from caries and/or periodontal infection. As Brinch and Møler-Christensen have pointed out, there appears to be a tendency for a proportion of infected teeth to be less firmly held in their sockets and thus more likely to fall out than healthy ones (Brinch, Møler-Christensen 1949). As a result of applying modern dental practice to studies of past populations, much of the tooth loss in a group is considered as resulting primarily from caries or periodontal abscesses.

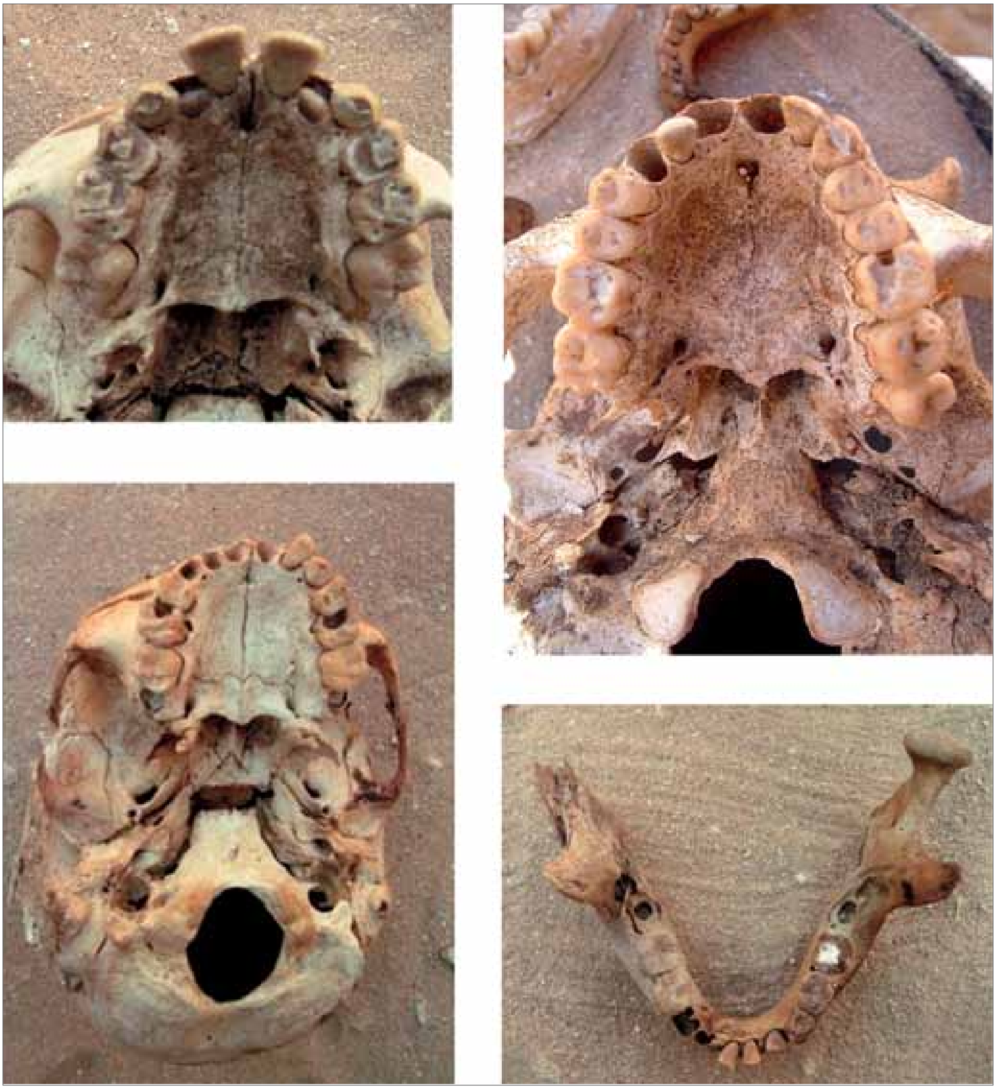


Fig. 7. *Dental diseases observed in the Marina-el Alamein sample: severe attrition on upper deciduous canines and molars of a seven-year-old child (Tomb 21, Loculus 5, Individual No. 5) (top left); dental caries (maxillary deciduous second molars, bottom left) and dental attrition (bottom left and right) observed on deciduous canines and molars in an 8.5-year old child (Tomb 21, Loculus 7, Individual No. 6); interproximal carries in the first upper permanent molar (Tomb 21, Loculus 11, burial 1) (top right) (Photos U. Wicenciak, A. Błaszczyk, PCMA)*

It should always be kept in mind that estimates of the dental health of any past population can be biased because of staining and erosion during the postmortem period, as well as postmortem tooth loss, especially of the anterior teeth. With this cautionary remark, it can be said that the dental health profile of the individuals from the Marina sample presents a rather poor picture. The overall wear level observed on both deciduous and permanent teeth was moderate to severe. Severe levels were scored 5 (two dentinal patches coalesced) and 6 (three or four dentinal patches coalesced with an inland of enamel) in terms of the molar wear codes. Although no subadult individuals displayed pulp exposure through attrition or the often associated chronic abscess, the pattern of attrition was characteristic and included canines and molar teeth. Interestingly, the deciduous molars of the six-year-old shown in ***Fig. 6*** underwent rapid wearing down in the six years that had passed between tooth eruption and his death. This was due presumably to consumption of grit and a coarse diet, proving that subadults consumed the same coarse diet as adults.

There are many difficulties in interpreting the dynamics of mastication in individuals studied at the moment of death. Studies on food preparation by ancient Egyptians have pointed out that the flour used for making bread was blunt with crude utensils such as quarts, mica, ferromagnesium, minerals and other foreign bodies, including germs (Strouhal 1992; Brothwell 1998; Shaw 2000; Alcock 2006). And bread was the staple of the ancient Egyptians' diet, children as well as adults, peasants and the rich alike.

The study revealed the presence of carious lesions on deciduous teeth (three out of 113 cases studied). According to Larsen *et alii*, "dental caries is a disease *process* characterized by the focal demineralization of dental hard tissues by organic acid produced by bacterial fermentation of dietary carbohydrates, especially sugars", ultimately leading to the formation of cavities in the crown or root surface (Larsen *et alii* 1991: 179). The etiology of dental caries is multifactorial, but diet is an essential factor in its cause. There is also a characteristic pattern in dental caries seen in living human populations with a westernized diet. For all types of carious lesions, molars are most commonly affected, followed by premolars and then anterior teeth. Pits and fissures of premolars and molars are the most frequently affected sites of tooth. Fewer caries are found on the proximal crown surfaces of posterior and anterior teeth. Coronal caries is largely a disease of children, and more common in girls than in boys. This may be due to more advanced dental maturation and earlier eruption of permanent teeth in girls (Hillson 1996).

The pattern of caries found in the permanent dentition of adults from the Marina sample appeared to be different from the one described above. Coronal caries was much less common, replaced by cervical lesions. However, in the deciduous dentition, only coronal caries was found. This finding shows that there is a difference in the pattern of carious lesions between deciduous and permanent dentitions.

Diachronic analyses of dental caries or cavities in ancient Egyptians or Nubians revealed that these conditions occurred apparently less frequently than in modern populations (Harris *et alii* 1998). For example, in the comparative sample of permanent teeth from the Saqqara series, if a caries condition was present, it was most often in the pit on top of the tooth crown. The frequency of teeth with carious lesions was 6.2% for upper molars and 8.6% for lower molars.

It has been speculated that the low frequency of caries in ancient Egyptians was due to the absence of sugar from their diet and the extreme attrition, which provides a more difficult environment for decay to begin. In fact, severe attrition was noted in both samples studied and has been taken as the greatest single problem in the dental health of past Egyptian populations. It is probable, however, that part of the difference in the prevalence of dental caries results from problematic statistical evaluation, poor preservation state of skeletal remains and small sample size.

The concept of "hidden heterogeneity in risks" suggests that individuals may vary in their susceptibility to disease and death within a population owing to various factors. For instance, while diet is known to be a controlling factor in several common groups of dental diseases, it is very difficult to specify the cause of physiological responses to harmful environmental conditions. Stress can be defined as a physical disruption resulting from unhealthy environmental conditions that have deleterious consequences at both the individual and population levels. Because the specific cause is unknown, the present study has used a "general stress perspective" (Goodman, Martin 2002).

6. Concluding statements

The health profile of the skeletal sample from the Graeco-Roman period assemblage found at Marina el-Alamein presented in this paper has been based on the mortality and morbidity rates estimated for skeletal remains. The survivorship pattern revealed that the average adult age at death was 38.1 years (SD=3.9 years) in males and 33.4 years (SD=4.1 years) in females. Female survivorship was likely to have been shorter throughout their lifespan, starting from the 20–30 years age group.

Anatomical indicators of environmental stress in the skeletal sample studied revealed that the overall frequency of *cribra orbitalia* was 19.3% among subadult individuals and 22.3% among adults. Based on skeletal growth observed in the most vulnerable subgroups of a population, that is, infants and children, the suggestion is that the inhabitants of the ancient town in Marina-el Alamein lived a stressful life in an impoverished environment and their diet was inadequate to deal with the problems of anemia.

Very poor dental health and osteoarthroses were the most common pathological conditions encountered. Severe attrition and periodontopaties were very common and constituted an important part of the group's health profile. Extensive *ante mortem* tooth loss and a high frequency of caries constituted further indicators of poor dental health in the studied sample. Overall, dental pathological conditions were more frequent in females and the difference was statistically significant. Numerous indicators, like relatively high rates of arthritis and degenerative diseases of the spine and major joints, changes in the vertebral body due to Schmorl's nodes and high frequency of *foramina olecrani*, were suggestive of the people of Marina suffering heavy workloads.

The health profile of the Marina el-Alamein sample revealed a picture suggestive of sufficiently stressful life to increase significantly the mortality rate of infants and children and a burdening with harmful environmental factors that caused a variety of pathological conditions.

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ABBREVIATIONS

AA	*Archäologischer Anzeiger*, Berlin
AAAS	*Annales archéologiques arabes de Syrie*, Damas
ABSA	*Annual of the British School of Athens*, London
AJA	*American Journal of Archaeology*, New York
APF	*Archiv für Papyrusforschung und verwandte Gebiete*, Leipzig, Stuttgart
ASAE	*Annales du Service des Antiquités de l'Égypte*, Le Caire
BAAL	*Bulletin d'Archéologie et d'Architecture Libanaises*, Beirut
BABesch	*Bulletin antieke Beschaving,* Louvain
BCH	*Bulletin de correspondance hellénique*, Paris
BdÉ	*Bibliothèque d'étude,* Le Caire
BEFAR	*Bibliothèque des Écoles françaises d'Athènes et de Rome,* Rome, Paris
BIFAO	*Bulletin de l'Institut français d'archéologie orientale*, Le Caire
BSFE	*Bulletin de la Société française d'égyptologie*, Paris
CCE	*Cahiers de la céramique égyptienne,* Le Caire
CCEC	*Cahiers du Centre d'études chypriotes*, Nanterre
CdÉ	*Chronique d'Égypte*, Bruxelles
CRAI	*Comptes rendus de l'Académie des inscriptions et belles-lettres*, Paris
CSEL	*Corpus Scriptorum Ecclesiasticorum Latinorum*, Vienna
EtTrav	*Études et travaux*, Varsovie
GM	*Göttinger Miszellen*, Göttingen
GRBS	*Greek, Roman and Byzantine Studies*, Durham, NC
IEJ	*Israel Exploration Journal*, Jerusalem
JbAC	*Jahrbuch für Antike und Christentum*
JEA	*Journal of Egyptian Archaeology*, London
JGS	*Journal of Glass Studies*, New York
JHS	*Journal of Hellenic Studies*, London
JJP	*Journal of Juristic Papyrology*, Warsaw
JRA	*Journal of Roman Archaeology*, Ann Arbor, MI
JRS	*Journal of Roman Studies*, London
KHKM	*Kwartalnik Historii Kultury Materialnej*, Warszawa
LIMC	*Lexicon iconographicum mythologiae classicae*, Zurich
MDAIA	*Mitteilungen des deutschen archäologischen Instituts, Athenische Abteilung*, Berlin
MDAIK	*Mitteilungen des deutschen archäologischen Instituts, Abeilung Kairo*, Wiesbaden
MEFRA	*Mélanges d'archéologie et d'histoire de l'École française de Rome. Antiquité*, Paris
MIFAO	*Mémoires publiés par les membres de l'Institut français d'archéologie orientale,* Le Caire
NC	*Numismatic Chronicie*, London
NumAntCl	*Numismatica e antichità classiche*, Logano
OLA	*Orientalia Lovaniensia analecta*, Louvain
PAM	*Polish Archaeology in the Mediterranean*, Warsaw
RACrist	*Rivista di archeologia cristiana*, Cité du Vatican
RBK	*Reallexikon zur byzantinischen Kunst*, Stuttgart

RDAC	*Report of the Department of Antiquities, Cyprus*, Nicosia
RdÉ	*Revue d'égyptologie*, Paris, Louvain
REPPAL	*Revue du centre d'études de la civilisation phénicienne-punique et des antiquités libyques*
RMNW	*Rocznik Muzeum Narodowego w Warszawie*, Warszawa
RSO	*Rivista degli studi orientali*, Roma
RTAM	*Recherches de théologie ancienne et médiévale*, Gembloux
RTAM	*Recherches de théologie ancienne et médiévale,* Gembloux, Louvain
SAAC	*Studies in Ancient Art and Civilization*, Kraków
VetChr	*Vetera christianorum,* Bari
ZPE	*Zeitschrift für Papyrologie und Epigraphik*, Bonn

* * *

DACL	F. Cabrol, H. Leclercq, *Dictionnaire d'archéologie chrétienne et de liturgie,* Paris, 1907–1953
LCI	E. Kirschbaum, W. Braunfels (eds), *Lexikon der christlichen Ikonographie*, Rom: Herder, 1968–1976
RealEnc	A. Pauly, G. Wissowa, W. Kroll, K. Mittelhaus, *Real-Encyclopädie der classischen Altertumswissenschaft,* Stuttgart–Münich, 1893–1980

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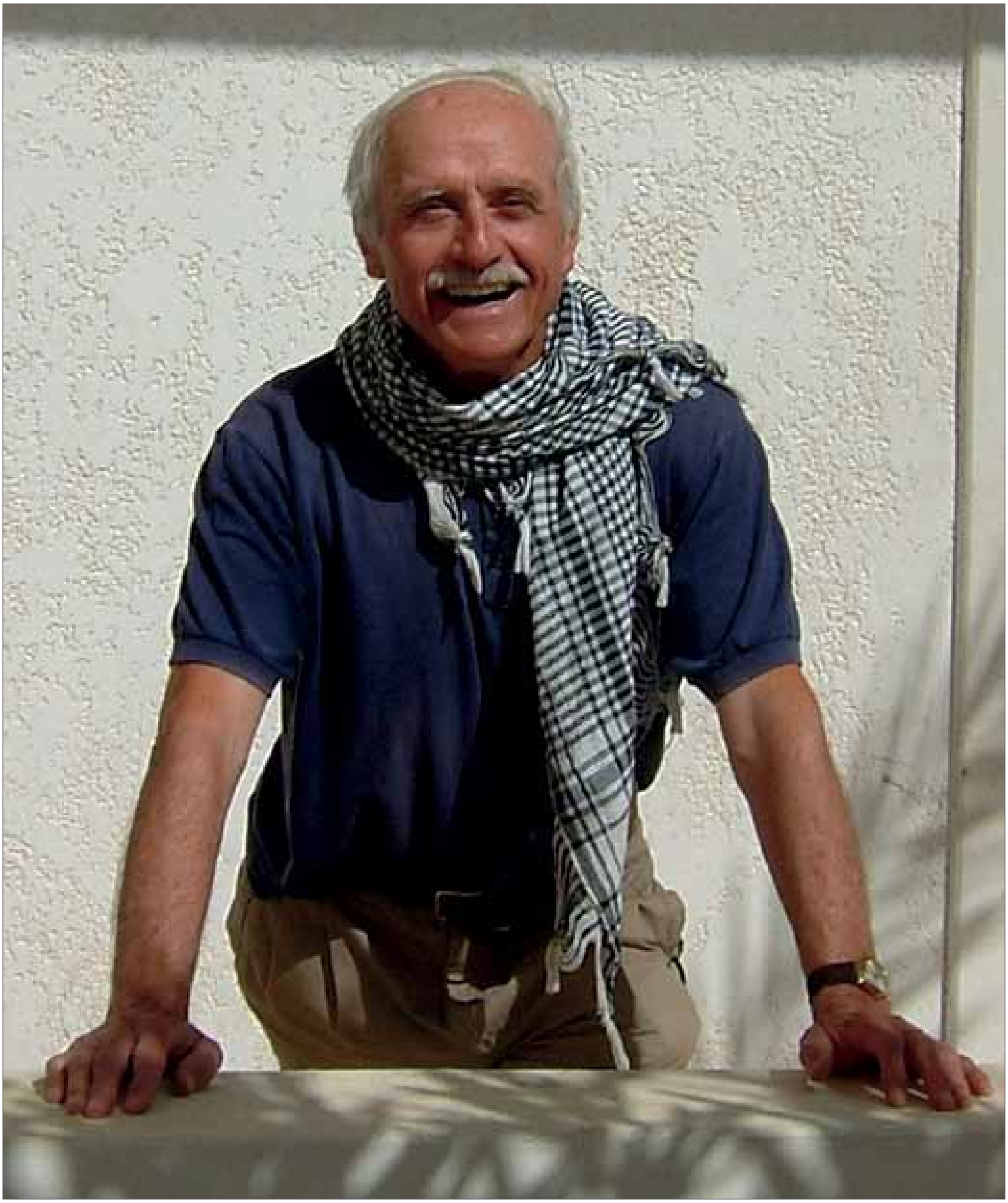

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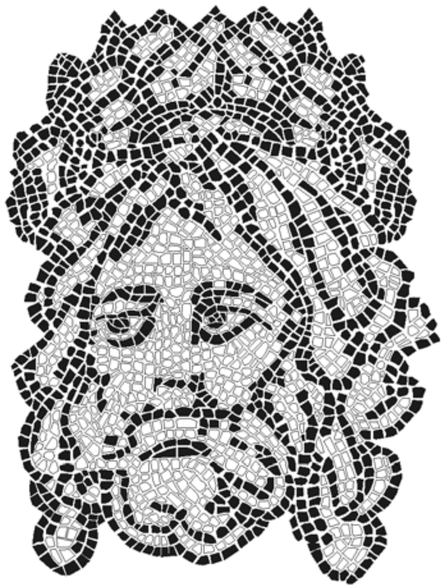

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Wiktor Andrzej Daszewski
on his 75th Birthday

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