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A health assessment for Imperial Roman burials recovered from the necropolis of San Donato and Bivio CH, Urbino, Italy

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Summary – *Imperial Roman burials recovered from the sites of San Donato and Bivio CH, located in the city of Urbino, Italy were examined for skeletal lesions. Observed pathologies include arthritis, trauma, periostitis, cranial pitting and enamel hypoplasia. All of the adults exhibited at least one enamel hypoplasia. In general, the adult males exhibit greater rates of skeletal pathologies than the females. Clearly, chronic health problems appear to be common among all adults; nearly 89% of them exhibit at least one form of skeletal lesion. This is in stark contrast to what is seen for the sub-adults. Only one sub-adult showed skeletal lesions. Acute health problems may have been the primary contributing factors for the death of the children recovered from the site. Despite previous research and attention to malaria as a critical health problem of Roman sub-adults, it does not seem to be an issue for this burial sample. We compare the frequency of cranial pitting and periostitis for the Urbino burials to several other Imperial Roman skeletal samples as a means to assess the potential for malaria and other casual factors for the observed lesions. In conclusion, we see the extreme rate of skeletal lesions for this community as indication of an extremely poor quality of life for these Romans.*

Keywords - *Health, Skeletal lesions, Roman Imperial Age, Italy .*

Introduction

Generally, health assessments for Imperial Roman burials are not widely available (Cucina *et al.*, 2006). Previous reports have focused primarily on very specific health issues. For example one such project examined dietary deficiencies determined by the presence of cranial pitting (Salvadei *et al.*, 2003) while others have looked at enamel defects (hypoplasia and Wilson bands) as indictors of childhood nonspecific stressors (Belcastro *et al.*, 2007; Bonfiglioli *et al.*, 2003; FitzGerald *et al.*, 2006).

A lack of direct biological health data for the Roman people is in stark contrast to the amount of anthropological and historic research that has focused on Imperial Roman politics and architecture (for example, Ermatinger, 2004; Ward-Perkins, 2005; Watson, 1999). In reality, we know comparatively very little of the biology of individuals and communities that created and maintained the Roman Empire.

Goodman *et al.* (1988) has offered suggestions for how the intertwining of cultural effects and biological states of health could be deciphered from prehistoric and historic skeletal samples. Unfortunately, a complete application of the biocultural approach has yet to be realized by anthropologists and historians studying Roman Empire. To begin to correct for the lack of biological knowledge for a culture so well studied, we offer a detailed paleopathological assessment of 71 discrete burials (44 adults and 26 sub-adults) found at the necropoli of San Donato and Bivio CH of Urbino, Italy. The skeletal material is of the 1st - 3rd century A.D. (Mercando *et al.,* 1982) and it comes from the Marche region of Italy (Fig. 1).

Urbino is about 45km from the present day coastal city of Pesaro, Italy. The necropolis of San Donato and Bivio CH are about a half kilometer from each other and they are considered to be of the same community and cultural period (Mercando *et al.,* 1982). The archaeological record has not provided clear information of their social status but it appears that these individuals were not living in the extreme positions of Roman society; they were members neither of high social rank nor of the enslaved.

We compare the skeletal data gathered here to other known assessments of Roman health to understand how these individuals faired compared to Roman citizens of the same period. Specific attention is paid to documenting lesions related to osteo-arthrtitic changes, non-specific infections (periostitis), trauma, dietary deficiencies and enamel hypoplasia. We examined the frequency of lesions to determine the level of significance between Urbino males and females for these lesions, and to determined if there are differences in the frequency of cranial pitting between Urbino burials and burials from several other Roman necropolis. This work is done in the attempt to provide a clearer understanding of the state of health for common Roman citizens from the Imperial period, a cultural setting characterized by extreme materialistic accomplishments for a very few individuals of the elite class.

***Fig. 1 - This is a map of Italy and the site location found in the region of Marche* (http://www.roangelo.net/valente/regioni.html).**

Materials and Methods

The Roman necropolis of San Donato yielded 101 tombs with 41 burials, 60 cremations and 1 unrecognized burial type (Mercando *et al.,* 1982). The Roman burial site of Bivio CH yielded 92 tombs, 48 burials and 48 cremations (Mercando *et al.,* 1982). There are 24 discrete skeletons available for examination from the San Donato site and there are 47 discrete skeletons available for examination from the Bivio CH site. A general demographic profile of the burials is provided in Table 1.

We provide a life table for the combined burial groups in Table 2a. Life expectancy at birth is about 24.8 years. If we add age estimations for the 25 cremations that are available from the San Donato site, our sample increases to 96 individuals and the life expectancy rises to 26.6 years (Tab. 2b). Both estimated life expectancies are low. Considering that these individuals come from the Imperial Roman period this comes to us as a surprise. The life expectancy at birth reported for populations living during the Neolithic period is 26 years (Swedlund & Armelagos, 1976). Even modern gatherer-hunters have a higher life expectancy at birth than the Urbino Romans. The !Kung have a reported life expectancy of 30.0 years, the Hadza have a life expectancy of 32.5 years, and the Ache have a life expectancy of 37.1 years (Jones *et al.,* 2002).

Tab. 1 - Age and sex profiles for the Urbino samples.

Age groupings	sub-adults	females	males	total
Natal-1 years	5	-	-	5
1.5- 5	10 (1)	-	-	10 (1)
5.5-10	3	-	-	3
10.5-15	7	1	-	8
15.5-20	1	1 (1)	1	3 (1)
21-29	-	4 (4)	7 (6)	11 (10)
30-39	-	8 (5)	8 (8)	16 (14)
40-49	-	4 (4)	7 (7)	11 (10)
50-57	-	2 (2)	1 (1)	3 (3)
total	26 (1) 3.8%	21 (16) 76%	24(22) 92%	70 (39) 56%

(*) parenthesis indicates the number of individuals with a skeletal lesion for each age group. The one adult, for whom sex could not be determined, is 30 years old. This individual is not listed here.

Collecting data on the state of health

The preservation of the discrete burials from these sites is fair to excellent with some fragmented remains (Figs. 2-6). In general, the skeletal elements consist of cortical bone with excellent surface structure. The cremations are not examined and they will not be included in the health assessment of this study. This limits our sample size to a total of 71 adults and subadults. An examination of each discrete skeleton for lesions using standard data collecting methods suggested by Buikstra & Ubelaker (1994), and Steckel & Rose (2002) has been undertaken. To assess the health of this sample, skeletal lesions were inventoried by discrete burial and by skeletal element for the presence of enamel hypoplasia, periostitic lesions, trauma, dietary lesions (porotic hyperostosis and *cribra orbitalia*) as well as by joint for appendicular degenerative joint disease (DJD) and vertebral osteoarthritis (OA). DJD and OA are determined by the presence of bone modeling with the addition of hyper-trophic osteophytes at the edge of the joints and macroporositic lesions found on the surface of the joints as well as the presence of eburnation (Jurmain, 1980). Traumatic lesions are defined using criteria modified from Merbs (1989), Lovell (1997), and Mann & Murphy (1990). These lesions are recorded by trauma, location, and when possible measured for length and width. We followed Goodman & Martin's (2002) suggestion and lumped porotic hyperostosis (cranial pitting) and *cribra orbitalia* together as indicators of dietary health. See Table 3 for the listing of sample sizes by skeletal element. Oral pathologies (enamel hypoplasia, are recorded for

Tab. 2a - Life-table for the Urbino skeletons.

Age classes	Dx	dx	lx	qx	Lx	Tx	ex
0-0	3,33	4,70	100,00	46,95	97,65	2485,19	24,85
1-5	10,72	15,09	95,31	158,37	431,61	2387,54	25,05
6-10	4,05	5,70	80,21	71,04	387,98	1955,93	24,38
11-15	6,64	9,36	74,51	125,57	349,79	1567,95	21,04
16-20	3,98	5,60	65,16	85,94	309,33	1218,16	18,70
21-25	6,03	8,49	59,56	142,61	278,35	908,83	15,26
26-30	8,26	11,63	51,06	227,72	225,93	630,48	12,35
31-35	8,28	11,66	39,44	295,72	169,29	404,55	10,26
36-40	7,21	10,16	27,77	365,73	113,26	235,26	8,47
41-45	5,81	8,19	17,62	464,66	68,08	122,00	6,93
46-50	3,91	5,50	9,43	583,69	31,41	53,92	5,72
+50	2,79	3,93	3,93	1000,00	22,51	22,51	5,73
	71,00	100,00					

Tab. 2b - Life-table for the Urbino skeletons with cremation burials added to the sample.

Age classes	Dx	dx	lx	qx	Lx	Tx	ex
0-0	3.33	3.47	100.00	34.72	98.27	2659.61	26.60
1-5	11.72	12.20	96.53	126.44	445.25	2561.34	26.53
6-10	4.05	4.21	84.32	49.98	411.94	2116.09	25.09
11-15	6.64	6.92	80.11	86.38	383.70	1704.15	21.27
16-20	4.86	5.06	73.19	69.18	352.92	1320.45	18.04
21-25	9.85	10.26	68.13	150.60	317.32	967.53	14.20
26-30	13.59	14.16	57.87	244.68	254.30	650.21	11.24
31-35	14.53	15.14	43.71	346.36	182.16	395.91	9.06
36-40	12.44	12.96	28.57	453.53	110.28	213.74	7.48
41-45	7.51	7.82	15.61	500.87	58.89	103.47	6.63
46-50	4.37	4.55	7.79	583.54	25.96	44.58	5.72
+50	3.12	3.25	3.24	1000.00	18.62	18.62	5.74
	96.00	100.00					

Tab. 3 - Adult Urbino sample size by skeletal element.

Skeletal element	Male	Female	Total
Skull	21	16	37
Long bones, at least one	22	20	42
With at least one joint	22	20	42
With vertebral bones	21	13	33

all teeth and are reported by individual burial according to standards suggested by Cucina *et al.* (2006), Goodman & Armelagos (1985), and Hillson (2001).

Since the data sets are clearly small, statistical evaluation of these findings is done using the Fisher's exact test, two–tailed (Guo & Thompson, 1992). We created a 2 X 2 data matrix for testing each null hypothesis to determine if there are sex specific lesion patterns for the Urbino population and for a larger context by determining if there are site-specific patterns among the Urbino skeletons and several other Roman burial samples.

Results

An accurate age and sex assessment is available for the Urbino burials in an unpublished report kept in the anthropological lab, Department of Animal & Human Biology, University of Rome, "La Sapienza", Rome, Italy. Standard sex and age assessment criteria were employed to develop the demographic profile of the Urbino skeletons (Bass, 2002; Buikstra, Ubelaker, 1994; Lovejoy *et al.,* 1985; Meindl & Lovejoy, 1985; Meindl *et al.,* 1985). Metric analysis of height for the burials was previously calculated (Corrain *et al.,* 1982). The average male height is 164.7cm (64.8 inches, nearly 5'5"). The average female height is 150.8 cm (59.3 inches, 4'11").

Presence of skeletal lesions in the adult sample

Females represent 45% of the Urbino adults while males represent 55% of the adult sample. For reasons not well understood, the Urbino females are most likely under-represented. Of the adult males, 83.3% of them exhibit at least one skeletal lesion. Of the adult females, 85% of them exhibit skeletal lesions (Tab. 4). The rates of skeletal lesions by sex for arthritic problems (osteoarthritis of the vertebral bones, DJD of the long bones, and vertebral nodes), trauma, dietary/metabolic lesions, and non-specific infection (periostitis), oral pathologies (enamel hypoplasia) are presented in Table 4.

Arthritic skeletal lesions.

Arthritic lesions are very common among humans, regardless of cultural setting or geographic location (Jurmain, 1980; Larsen, 1997). The Urbino burials are no different from any other burial sample and they exhibit a high rate of arthritis. The frequency of OA for men is 47% (mean age of 40 years) and for women it is 58% (mean age of 34 years; see Table 4).

The presence of vertebral nodes (Fig. 3) is often a sign of trauma and or strenuous labor. The frequency of nodes found in males is 38% (mean age is 29 years with a range of 24-41 years) and the frequency of nodes found in females is 42% (mean age of 35 years and an age range of 24-47 years).

Data on the occurrence of DJD (based on the presence of osteolythic lesions and osteophytes found the surface of the joint) of the long bones and temporo-mandibular joint are presented in Table 4 and Figures 4 and 5. Males show a frequency of DJD at 68% (mean age of 34 years) and females exhibit a DJD frequency of 55% (mean age of 39 years).

Skeletal injuries

Trauma is recorded for each individual and all adults with a skeletal element are considered. The trauma rate for the entire adult Urbino population is high at 20.4%; with 20% (4/20) of the females showing traumatic lesions. Two females exhibit stab wounds, a third female shows a blunt force injury to the cranium and a fourth female exhibits a blunt force injury to the vertebral column. Twenty-one percent (5/24) of the males exhibit trauma. Two males exhibit stab wounds, a third male has a dislocated shoulder, the fourth male shows several healed rib fractures, and a fifth male exhibits a healed blunt force injury to the cranium (Fig. 6).

Dietary lesions

Skeletal indicators (cranial pitting and *cribra orbitalia*) related to dietary health are also very common for this population. The frequency for cranial pitting is high with females at 37% and males at 48% (Tab. 4).

Tab. 4 - The frequency of skeletal lesions exhibited by the Urbino adults.

Skeletal lesion	Male	n	Female	n	Total	n
Osteoarthritis	47%	21	58%	13	52%	34
Vertebral nodes	38%	21	42%	13	39%	34
DJD	68%	22	55%	20	62%	42
Cranial pitting	45%	21	37%	16	41%	37
Trauma	21%	24	20%	21	20%	45
Periostitis	41%	22	20%	20	31%	42
Enamel hypoplasia	100%	21	100%	14	100%	35

n = total number of individuals with skeletal elements available for assessment.

Fig. 2 - Here is a side profile of the skull showing the general condition of bone from the Urbino sites. The skull is from a thirty-year-old male.

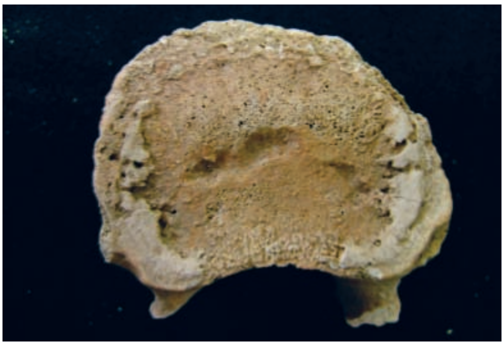

Fig. 3 - This is a vertebral body with a Schmorl's node. The vertebral bone is from a Urbino male 35 years of age.

Non-specific skeletal lesions (periostitis)

Another very common skeletal indicator of poor health is the presence of periostitis (Fig. 7). It is often characteristic of non-specific infections and it is sometimes related to infections that are exacerbated by malnutrition. The skeletal elements that exhibited periostitic reactions include the femoral shaft (one female and one male) the tibia shaft (four males) and the fibula shaft (one male). One sub-adult showed periostitic lesions on the humerus and tibia shafts. The Urbino females exhibit periostitic lesions at a frequency of 20%, while men exhibit a frequency of 41% (Tab. 4).

Oral pathologies

The frequency for enamel hypoplasia (EH) exhibited by this skeletal sample is very high for both sub-adults and adults. Only individuals with teeth available for analysis are considered in these frequencies. Both females and males show an extreme rate of EH at 100% (Tab. 4). Figure 8 shows an example of a linear enamel hypoplasia defect seen on a maxillary first molar.

Sub-adults

Thirty-eight percent of the Urbino burials are under the age of 16 years. Sub-adult individuals are most likely underrepresented in this sample. Very few lesions were present in the sub-adult sample. In fact, only one sub-adult showed skeletal lesions. Only the sub-adult burial number 81a exhibits a skeletal lesion of any type. This four-year-old child from the Bivio CH portion of the Urbino site exhibits frontal bone pitting, and periostitis of the right humerus and right tibia.

Despite the paucity of skeletal lesions in sub-adults, dental lesions were observed at very high frequencies. All of the sub-adults with teeth available for examination exhibited enamel hypoplasia. The presence of enamel hypoplasia is considered by many to be a clear indicator of stress during early growth and development (Goodman & Armelagos, 1985; Goodman, 1989). The Urbino rate of EH among the sub-adults suggests that early childhood was a difficult period for the Urbino Romans.

Discussion

There are many ways that the state of health can be viewed for an archaeological sample; stature and the rate of skeletal lesions are two means that can offer insight to this issue (Goodman & Martin, 2002). Both Urbino males and females are short in stature, 164cm and 150cm respectively (5'4" and 4'11"). These measures of height might be considered short for most populations but to illustrate our point we provided height data from other Italian populations from different cultural periods (Formicola & Holt, 2007; Giannechini & Moggi-Cecchi, 2008) see Table 5. The Urbino samples are short even compared to these populations.

Children who experience poor nutrition and severe illnesses often develop into adults with stunted height (Goodman & Martin, 2002; Morfin *et al.,* 2002). Along with reduced height, the estimated life expectancy of the Urbino sample is low, with a range of 24-26 years. Together, both indicators provide a clear assessment that life was harsh and difficult for members of the Urbino community.

Most skeletal health indicators observed on the adults show that males have higher rates of lesions than females. This pattern suggests that males may be experiencing physiological stress at greater degree than females. This is specifically true for DJD, trauma, cranial pitting and periostitis. Females show higher rates of Schmorl's nodes and osteoarthritis than males. Given the brief life expectancy and the short stature, it is not surprising to see the high frequency of lesions exhibited by the Urbino Romans.

Adult health patterns

Skeletal trauma can be accidental, self-inflicted or intentionally caused by others as the result of inter-personal violence (Larsen, 1997). Twenty percent of the Urbino adults exhibit lesions specific to trauma. The nature of most of these injuries (specifically blade wounds, which represent four of the nine cases) suggests that some of trauma experienced by the adults were the result of intentional violence by others.

Fig. 4 - This is the knee joint of a forty-year-old Urbino male. This knee joint shows severe DJD with eburnation of the distal joint surface of the femur and the posterior surface of the patella.

Fig. 5 - Two metacarpal bases, from a forty-year-old female. Here is an example of eburnation of the joints.

Fig. 6 - This is the cranial bone of an Urbino male, thirty-five years old. This is a well-healed circular fracture to the cranial bone.

Fig. 7 - This is periostitis on a tibia shaft.

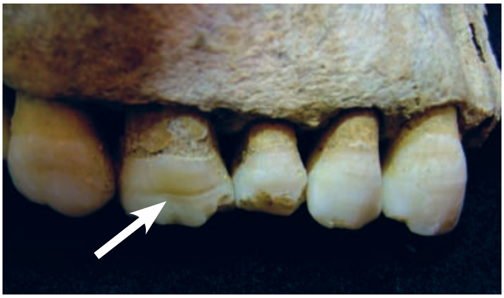

Fig. 8 - An example of an enamel hypoplasia.

Although, we cannot rule out the possibility that the compressed cranial fractures might be the result of accidents, their placement makes this unlikely. The healed rib fractures and the dislocated shoulder exhibited by two males may be the result of accidental injury.

Skeletal indicators such as arthritic lesions, periostitic and cranial pits provide an assessment for the quality of life. The Urbino burials have these lesions in abundance. DJD manifest as an inflammatory problem of the joint associated with aging or traumatic injuries. The cartilage cells of the joint are affected so they are no longer able to maintain the cartilage matrix (Jurmain, 1980; Mann & Murphy, 1990). DJD is also a useful skeletal indicator for the interpretation of how culture affects human biology regardless of age, class, and sex. DJD reflects chronic behavior and therefore can help show lifestyle and the quality of life for prehistoric peoples.

The average age for the presence of DJD for males is 34 years with an age range of 24-45 years. For the females, the mean age is 39 years with an age range of 24-57 years. It appears that DJD may be associated with labor and not simply specific to the aging process. The most common joints afflicted in males are the right and left hips (n = 9) and the most common joint damaged by DJD for females is the right shoulder (n = 3). Interestingly, males show DJD on the right side of the body at 34 locations while only showing 18 cases for the left side. This might be a reflection of preservation but it may also suggest a preference of using the right side of the body during strenuous labor. Not only is DJD extreme in its frequency it is extreme in its presentation, in many cases the Urbino burials show considerable eburnation of joint surfaces (see Figs. 4 and 5).

Osteoarthritis of the spine illustrated with marginal osteophytes and macroporosity of the body surface and articulations is a common occurrence in the elderly and those who work at heavy labor (Mann & Murphy, 1990). Common in most prehistoric skeletal samples, OA begins to manifest itself in individuals around 30 years of age and affects most adults by the time they are 60 years old (Goodman & Martin, 2002; Steinbock, 1976).

The adults from Urbino show high rates of vertebral osteoarthritis (Tab. 4). The difference between the males and females is not significant, $P < 0.05$ (Tab. 6). Still, the Urbino females do show a higher rate of OA compared to males. They express the pathology at a younger age than expected and this suggests that OA is not necessarily age specific but it maybe also be related to activity and possibly social/economic status.

Schmorl's nodes typically result from herniated vertebral discs and can be circular, linear, or a combination of both forms of depressions (Kelley, 1982; Mann & Murphy, 1990; Ortner & Putcshar, 1981). Schmorl's nodes are found on both the superior and inferior central of thoracic and lumbar vertebrae. Commonly found in elderly individuals, as a skeletal marker related to age degeneration, nodes seen in younger adults can be markers for trauma or for heavy labor (Mann & Murphy, 1990). The female mean age with nodes is 35 years, while the mean age for males is 29 years. It appears that for both males and females the expression of nodes may also be labor and or stress related.

Robb *et al.* (2001) found that proto-historic Italian males with Schmorl's nodes tended to have fewer artifacts present in their graves. They suggest that a lack of grave goods were an indication of lower social ranking and they draw the conclusion that these males were subject to strenuous labor which accounts for the presence of Schmorl's nodes. Seven hundred years later this pattern may still be the case. The Urbino samples with Schmorl's nodes quite possibly reflect strenuous labor for the younger individuals of low to middle social/economic status.

Periostitis is a skeletal lesion associated with an inflammation of the periosteum and this inflammation can be the result of site-specific trauma, infection, varicose veins, or dietary deficiencies (Mann & Murphy, 1990; Ortner & Putcshar, 1981). A lack of key dietary elements can affect the immune response to infections, which can then lead to the development of periostitic lesions of the long bones. Ironanemia and scurvy are the usual dietary deficiencies associated with these lesions (Larsen, 1997; Powell, 1991; Stuart-Macadam, 1987, 1992). Recently, however, niacin deficiency (vitamin B_3) has also been shown to be linked with the formation of periostitis on long bones (Brenton & Paine, 2000, 2005, 2007). Although this finding is not specific for the Urbino Romans, we would like to point out that the menu for influencing the formation of periostitis should include niacin deficiency, specifically for maize dependant or niacin stressed communities.

The rate of periostitis for the Urbino skeletons is high (Tab. 4). A difference in the rate of periostitis between Urbino males and females is not significant, P = 0.190 (Tab. 6). Arguably, many Romans were exposed to toxic levels of lead via cultural habits such as the use of make-up and vessels used for drinking, eating and cooking (Grandjean, 1975; Schneider, 2003). Aufderheide

Tab. 5 - Height trends in prehistoric Italy.

Cultural period	Male	Female
[a]Early Upper Paleolithic	172.2	169.9
[a]Late Upper Paleolithic	165.6	153.5
[b]Iron Age	166.6	154.3
[b]Rome Imperial	164.4	152.1
[b]Medieval	166.9	154.4
Urbino, Rome Imperial	164.0	150.0

[a] data comes from Formicola & Holt, 2007;
[b] data comes from Giannechini & Moggi- Cecchi, 2008.

Tab. 6 - Results of the Fisher's exact tests by sex for the Urbino adult samples.

Health problems	n	P	S.E.
Osteoarthritis	33	0.720	0.0008
Vertebral nodes	33	1.000	0.0000
DJD	42	0.524	0.0013
Trauma	43	1.000	0.0000
Cribra orbitalia	36	0.740	0.0007
Periostitis	42	0.190	0.0012
Enamel hypoplasia	35	1.000	0.0000

There is no significant difference (at $p < 0.05$ level) between the Urbino males and females when it comes to skeletal/dental indictors of stress.

et al. (1992) offer trace element results to support this position and they show that Imperial Roman remains often have ten times more lead in their skeletal system than their predecessors. Still, linking high levels of lead to periostitis is difficult. The Roman- Byzantine burials recovered from the archaeological site of *Elaiussa Sebaste* (Turkey) exhibit extremely high levels of lead toxicity (Bartoli & Bertoldi, 2003). Pb/Ca values over 0.20 are considered toxic (Bartoli &

Bertoldi (2003). Paine *et al.* (2007) found that for the 19 *Elaiussa Sebaste* individuals tested for lead, those with periostitic lesions had a Pb/Ca ratio value of 1.83 and individuals without periostitis had a mean value of 1.65. There is no statistical difference in these values. Since both groups show extreme toxic levels of lead, it appears that lead toxicity is not a predictor for the presence of periostitic lesions. It may be for the Urbino samples that other environmental factors might be causing the high frequency of periostitis. Although lead toxicity cannot be ruled out as a reasonable cause for the high frequency of long bone periostitis exhibited by the Urbino Romans, it seems unlikely since there appears to be no association with lead levels and the presence or absence of periostitic lesions (Paine *et al.*, 2007).

Cribra orbitalia and cranial pitting

Cranial pitting is often viewed as a non-specific response to anemia caused by a number of factors. These factors include genes, diet, parasites, and several other non-specific environmental conditions (Aufderheide & Rodriguez-Martin, 1998; Brothwell, 1967; Buikstra, 1992; Cohen & Armelagos, 1984; Cook, 1984; El-Najjar, *et al.*, 1976; Garn, 1992; Goodman, *et al.,* 1984; Kent, 1992; Larsen, 1987, 1994.1997; Larsen & Milner, 1994; Larsen *et al.*, 2002; Ortner & Aufderheide, 1991; Ortner & Putcshar, 1981; Powell *et al.,* 1991; Richman, *et al.,* 1979; Steckel & Rose, 2002; Stuart-Macadam, 1989, 1992). In general, the presence of porotic hyperostosis and *cribra orbitalia* lesions, regardless of their origin is associated with a poor quality of life (Cohen & Armelagos, 1984; Larsen, 1997; Larsen *et al.,* 2002).

The Urbino adult skeletons show a high frequency of cranial pitting (43.2%). Only one sub-adult exhibits cranial pitting (3.84%). Males are more affected (48%) than females (37%) although the difference is not significant (Tab. 4 and 6).

There appears to be a concern among skeletal biologists working on the health assessment of Roman burials in regards to the origin of cranial pitting, specifically they have focused on malaria as a likely sources for the lesions. A number of researchers have examined this issue (Ricci *et al.*, 1997; Salvadei *et al.,* 2001; Facchini *et al.,* 2004; Cucina *et al.,* 2006). The focus on this specific topic among Roman bio-archaeologists is in part due to a response to the paleopathological findings of Angel (1966). Angel suggested that malaria was the origin for the cranial lesions found in burials from Roman coastal communities; this concept has firmly taken hold among anthropologists working with these samples. In addition, the findings by Soren *et al.* (1995) on sub-adults also lend support to the idea that malaria is the most likely cause of cranial lesions seen in Roman Age burials.

The community level profile for genetically generated anemic lesions (cranial and long bone pitting) often includes a large number of sub-adults showing active lesions (Hershkoritz *et al.,* 1997; Mann & Murphy, 1990) and adults with facial pitting as well as orbital and cranial pitting. Stuart-Macadam (1992) suggests that cranial pitting due to malaria is uncommon relative to the frequency of lesions due to acquired anemia.

It appears to us that the Urbino adults and sub-adults do not express cranial pitting that reflects malaria infection, nor do they show lesions common to sickle cell anemia. There is no evidence for active cranial lesions in any of the Urbino skeletal samples. Therefore, it is reasonable to conclude that the cranial pitting for the Urbino adults is related to chronic environmental origins, either by diet deficiency, non-malarial parasites, lead toxicity, or by some other undetected environmental factor. Only one sub-adult shows a combination of cranial and long bone pitting (81a). This sub-adult is the only possible candidate for malaria infection, however, a dietary or other parasitic origin for these lesions cannot be ruled out. What makes it less likely a case of malaria is the fact that the cranial lesions of 81a are not active; active pitting is one of the indicators of a malaria infection (Ortner & Putcshar, 1981).

Urbino adult health, compared to other Imperial Roman burials

Although not all skeletal indicators presented in this paper have been reported by other researchers, there are several Imperial Roman skeletal collections available for partial comparison. In general, the paleopathological literature concerning the health of Roman citizens is incomplete. Only a few papers specific to dietary deficiencies indicated by cranial pitting are available for comparison (Ricci *et al.,* 1997; Salvadei *et al.,* 2001; Facchini *et al.,* 2004; Cucina *et al.,* 2006). Other reports include evidence of trace element analysis of bone looking for micronutrients deficiencies (Prowse *et al.,* 2003); bone loss the rib (Cho & Stout, 2003); and dental health (Manzi *et al.,* 1991; Cucina *et al.,* 2006; FitzGerald *et al.,* 2006; Hoover *et al.,* 2005). Our comparative analysis is therefore limited to cranial pitting and dental health, since other studies do not address the frequency of periostitis, trauma, and arthritic problems.

The following contemporary Roman skeletal samples were used for comparative analysis.

Fifty-three Imperial Roman adults from the Ravenna and Rimini necropoli near from the Adriatic Sea coastal cities of Emilia-Romagna, Italy (Facchini *et al.,* 2004).

Seventeen burials from the Vallerano necropolis. These burials date to the I-II century AD and it is located just out side of Rome, in an area referred to as the *Suburbium,* Lazio (Ricci *et al.,* 1997; Cucina *et al.,* 2006).

Sixty-seven adult burials from the site of *Lucus Feroniae* in *Latium* just north of Rome, in the county of Lazio (Salvadei *et al.,* 2001). The site dates to I-II century AD. The sample consists of common laborers, war veterans, slaves and free persons. Manzi *et al.* (1999) has characterized them as mainly Roman slaves.

Table 6 shows the results of the Fisher's test for cranial lesion data between the Urbino adult burials and each of these Roman samples. The Urbino adults (males and females combined) exhibit a frequency of cranial pitting of 43% and they are affected more than the *Lucus Feroniae* burials (19%); the difference is significant ($P < 0.02$).

Salvadei *et al.* (2001) have concluded that the origin for cranial pitting for *Lucus Feroniae* burials is most likely environmental factors other than malaria. They suggest that these Romans acquired cranial pitting from a combination of poor diet, hygiene problems and parasitic infections. This interpretation was supported in part by a high rate of infant deaths with little or no skeletal lesions (Salvadei *et al.,* 2001). The 67 adults show cranial pitting at a rate of 19.4%, females show these lesions at a rate of 24.2% (8/33) and males show a rate of 14.8% (4/27). They also attributed the higher rate of cranial pitting seen in females to pregnancy and lactation, which can result in a poor diet or poor absorption of nutrients by women during their reproductive years. The frequencies of the cranial pitting between the two female samples were compared. The Urbino females are more affected (6/16: 37%) than the *Lucus Feroniae* females (8/33: 24.2%), although the difference is not significant ($P< 0.05$). The difference in the two populations comes from the significant in difference the frequency of cranial pitting in the males. The Urbino males are much more affected (10/21: 48%) than the *Lucus Feroniae* males (4/31: 12.9%) and the difference is significant ($P < 0.02$). Following the interpretation of (Salvadei *et al.,* 2001) we cannot rule out that the reproduction process could account for the high rate of cranial pitting for the Urbino females (37%), although this interpretation does not explain why the males are at a higher rate (48%). Since malaria is not the likely source of infection for the adults, hygienic problems and other parasitic infestations must be considered.

The Urbino adult skeletons are less affected than the Vallerano samples for cranial pitting. The Vallerano rate is nearly 65%; the difference between the two skeletal collections is not significant (Tab. 7). Cucina *et al.* (2006) does not rule out the possibility of genetic anemia as the origin for the cranial pitting seen in the Vallerano burials but they appear to suggest that the harsh environment coupled with the potential of food shortages and lack of predictable food sources would better account for the poor state of health for this rural sample.

Tab. 7* - Cribra orbitalia *comparison by archaeological sites.

Sites	n	P	S.E.
Urbino to Valleranno	54	0.245	0.001
Urbino to *Lucus Feroniae*	104	0.012*	0.001
Male to Male	52	0.009*	0.001
Female to Female	49	0.499	0.001
Urbino to Rimini & Ravenna	90	1.000	0.000

* Donates statistically significant results at $p < 0.02$.

Tab. 8 - The frequency of oral pathology, by site.

Enamel hypoplasia	Male	Female	Total
Urbino	100%	100%	100%
Quadrella	92%	100%	95%

The Quadrella data comes from Bonfiglioli *et al.* (2003).

The Urbino adult skeletons exhibit a cranial pitting at a level that is slightly less than the 45% of the affected burials in the Ravenna and Rimini burial samples (Facchini *et al.,* 2004) the difference is not significant (Tab. 7). Besides suggesting dietary deficiencies, parasitic exposure, and poor living conditions, Facchini *et al.* (2004) also make the case for the possibility of lead toxicity as the origin for the cranial pitting in some of the Ravenna and Rimini burials. We agree that lead toxicity might be the origin of these lesions, but work recently done on the Roman-Byzantine burials recovered from the archaeological site of *Elaiussa Sebaste* shows that this does not have to be the case (Paine *et al.,* 2007).

Linear enamel hypoplasia defects result from abnormal crown formation due to an impaired function of ameloblastic cells (Bonfiglioli *et al.,* 2003). As a result, they are an excellent form of permanent marker for systemic physiological stress experienced during early childhood. In general, linear enamel hypoplasia defects are attributed to acute fevers, chronic infectious agents, parasitism, and seasonal dietary deficiencies (Corruccini *et al.,* 1985; Goodman & Armelagos, 1985; Malville, 1997). They are used by paleopathologists as critical clues to non-specific stress indicators found on permanent teeth. Goodman (1989) has determined that longevity is affected by the development of enamel hypoplasias. An individual with them will have a life expectancy of 10 years less than individuals without them.

Linear enamel hypoplasias typically develop during late infancy and early childhood, between 2-5 years of life (Corruccini *et al.,* 1985; Goodman & Armelagos, 1985). Corruccini *et al.* (1985) found that linear enamel hypoplasias were markers of childhood morbidity associated with weaning for Barbados slave skeletons. The presence of enamel hypoplasias is also correlated with other anthropometric indicators of nutritional status such as height, weight, and its presence is linked to poor socio-economic status (Goodman *et al.,* 1988). The presence of linear enamel hypoplasias may be specifically related to protein-calorie under-nutrition (Malville (1997).

Bonfiglioli *et al.* (2003) offer data on the frequency of oral pathologies for a Roman Imperial necropolis (1^{st}-4^{th} centuries AD) from the burial site of Quadrella, Molise, Italy. Their finding closely matches the Urbino in pattern and frequency (Tab. 8), with an extremely high enamel hypoplasia rate. It is clear that linear enamel hypoplasia rates are extremely high for Romans; this trend follows a pattern observed by Cucina (2002) in which linear enamel hypoplasia rates increase in time in Italy, from the Neolithic and Copper Age up to the early Bronze Age. Cucina (2002) based his conclusion after observing 62 individual; he suggests that dietary changes to carbohydrate foods may account for this increase rate in enamel hypoplasia seen in prehistoric Italian communities. Whatever the causal origins for enamel hypoplasia in these prehistoric populations, it is clear that Roman life did little to improve the dental health of the Italians.

Urbino sub-adult health compared to other Roman sub-adult burials

With the exception of burial 81a, no Urbino sub-adults show any skeletal indicators of ill health. It appears that the health problems for sub-adults were predominately acute and that they did not suffer from chronic ailments. If they had suffered from chronic illnesses, one would have expected to observe visible skeletal markers of these ailments. The demographic profile of the Urbino sample shows that it consists of 38.5% sub-adults; all of them are under the age of 16. More importantly, thirty-eight percent of the Urbino sub-adults died between the ages of 1.5 and 5 years. A high death rate in the infant-childhood age group is often attributed to dietary deficiencies, poor hygiene and living conditions which can bring on acute infections (typically *Staphylococcus* and *Streptococcus*) that kill without leaving skeletal indicators (Larsen, 1997). This seems to be the most likely explanation for these deaths.

Soren *et al.* (1995) reported different findings for Roman infant burials located in Teverina, Italy. Of the 47 infant burials recovered from this site, six (13%) of them showed signs of pathology (cranial and long bone pitting) and they were all older than four months old. Soren *et al*. (1995) attributes these skeletal lesions to malaria. It is clear that the death profile and lesion frequencies of the Urbino sub-adults and the infant burials from Teverina are different. They concluded that malaria was a common health concern for the Roman community of Teverina. There are 21 Urbino sub-adults over 1.5 years of age and only one of them (4.76%) exhibits signs of lesions of any type. From this, we conclude that malaria was not a considerable health problem for the Urbino Roman community and that the younger members of this burial group most likely suffered from acute health problems related to diet and fast acting infectious agents. We do not discount the possibility that burial 81a experienced an anemia problem associated with malaria. We simply suggest that if it was present as a health problem, malaria appears to have occurred at a very low rate for the Roman Urbino community

Conclusion

Considerable insight on general health indicators for the Urbino Roman burials has emerged from the assessment of skeletal lesions. This information requires an evaluation specific to the question of how does the presence of skeletal lesions reflect the health of an individual, burial sample, and population. Most critically, can burials provide data that accurately represents the state health of past communities? This debate came into focus with Wood *et al.* (1992) and the comments made by bio-archaeologists to their article (Cohen, 1992; Eisenberg, 1992; Katzenberg, 1992, to name a few of the commentators). Specific to this argument is whether skeletons with lesions represent extremely ill individuals or those who are survivors. Are the survivors healthy? Alternatively, are they simply individuals who are marginally living? If one dies without exhibiting skeletal lesions, does this death represent one caused by an acute illness or simply one caused by agents that do not affect the skeletal system? These primary issues have been discussed by paleopathologists (for example; Goodman *et al.,* 1988; Steinbock, 1976) before Wood *et al.* (1992) provided their ideas concerning this academic debate. These are not easy questions to resolve and it appears that 15 years after Wood *et al*. (1992) called upon bio-archaeologists to work on these problems; these issues are still clearly unresolved. However, it appears to us that today most paleopathologists work under the assumption that individuals who exhibit skeletal lesions are individuals who have suffered from chronic stressors and individuals who die young with few or no skeletal lesions are individuals who died from acute ailments (Goodman & Martin, 2002; Larsen, 1997; Steckel & Rose, 2002). After all, few if any individuals have lived without illness and those that have lived long enough have a good chance to have suffered from one form of chronic illness or another. The act of living longer than others in a community setting shows that some adults are indeed survivors and their skeletal systems can and have offered profound witness to their survivorship and to their health history.

We interpret the patterns of pathological lesions observed for the Urbino sample using this perspective and we use a biocultural approach to interpret the context of the observed pathological changes in the skeleton (Goodman *et al.,* 1988).

It is clear from historic records (Ermatinger, 2004; Ward-Perkins, 2005; Watson, 1999) that the Imperial Roman citizens of Urbino were placed under considerable economic stress related to the burden of supporting the city of Rome and the numerous military campaigns that took place during the 1^{st}-3^{rd} centuries A.D. to expand and maintain the Empire. The common people "*humilores*" (Ermatinger, 2004) were the backbone of the Roman citizenry; as urban labors and rural farmers they were heavily taxed (food and money) to support the Empire's activities. It is quite likely that the high rate of skeletal lesions observed in the Urbino remains reflects the biological outcome of this economic burden. Belcastro *et al*. (2007) provides a list of the common foods typically consumed by Romans of the lower classes. Theses foods include bran breads, vegetables, garlic, chickpeas, olives, and some fruits. Little or not portions of meat were consumed. This coupled with a limited variety of food and small potions of food supports our assessment that the diet and economic burden lead to chronic health problems for the Roman burials from the Urbino necropolis.

The Urbino remains offer an excellent example of how culture and lifestyle can increase the rate of morbidity for a community. Despite the considerable advantage that the Roman cultural infrastructure and all of its benefits provided, Roman citizenship came at a considerable biological price, exemplified by chronic ailments and a short life span.

Here are several critical observations made for the Urbino burials.

1) Urbino males show a higher frequency of DJD than females and this may indicate a greater workload than the females.
2) Urbino males show a higher frequency of periostitis than females. This is another skeletal indicator of how culture and the environment can produce stressful living conditions, apparently males had a more difficult time fending off non-specific infectious agents
3) Vertebral OA is not significantly different between Urbino males and females. Females show a slightly higher frequency of vertebral OA than males and they show these lesions at younger age. This rate of lesions suggests that physical work activity and not age progression is a key factor to the presence of this pathology for Urbino females.
4) Cranial pitting is also common between the Urbino males and females but occurs in only one sub-adult (4 years old). There is no case of active cranial pitting observed among the Urbino skeletons. The lesions exhibited by the adults do not appear to reflect episodes of malaria. These lesions can be accounted for by episodes of seasonal dietary deficiencies, a lack of hygienic living conditions, and other environmental factors that lead to chronic problems related to absorbing micronutrients, specifically iron.
5) The nine cases of traumatic lesions seen for the Urbino population reflect both accident and inter-personal violence. A 20% trauma frequency is high for any burial sample and speaks to the harsh politic-social conditions faced by the Urbino Romans as they labored for the Empire.
6) Even though cranial pitting and periostitis of the long bones is common for the Urbino burials, lead toxicity need not be the cause of these lesions. Future isotopic research will help confirm or deny this assessment.
7) The extreme overall rate of skeletal lesions for the adults and the lack of skeletal lesions for the sub-adults both speak to the harsh living conditions. The sub-adults appear to die from acute health problems. The adults appear to have been suffering from chronic ailments often associated with poor living conditions compounded by dietary deficiencies, violence and other non-specific environmental factors.

8) Burial 81a may be the only case of malaria related infection for these skeletons suggesting an endemic disease pattern. Still, this evidence is problematic since the cranial pitting does not represent an active lesion. A number of other environmental factors easily could account for the lesion seen on this child; for example malnutrition, and other parasites.
9) Low life expectancy and reduced statue for the Urbino skeletons also contributes to the impression that Imperial Romans did not live a life free of bio-physiological stressors. Both of these factors match well with the overall picture provide by the skeletal elements for a poor quality of life defined by chronic health problems.
10) The frequency of enamel hypoplasia is very high for the Urbino skeletons with males, females, and sub-adults equally affected. The presence of so many individuals with enamel hypoplasia makes a strong case for the argument for poor living and dietary condition. This frequency enamel hypoplasia also occurs in other Roman Imperial burials suggesting a widespread health problem. Given the historic accounts of the Roman diet, seasonal protein-calorie deficiency during the weaning period cannot be ruled out as a factor for the formation of linear enamel hypoplasias. Certainly as Goodman (1989) suggests, the presence of linear enamel hypoplasias can account for the low life expectancy of 24-26 years.

A better understanding of the health of Romans living and dying in the Urbino area during the Imperial Age by the paleopathological assessment of these burials is offered. Yet, more research is required before a clearer understanding of the impact behavior and cultural decisions had on the life of these people. It is apparent that we still know little about the biology and state of health for common Imperial Roman citizens. Additional skeletal samples should be added to an overall assessment of life and health profiles of Roman peoples. For this to take place, we will need the continued cooperation of archaeologists, bio-archaeologists and skeletal biologists to further this research objective.

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