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Abstract

Sex and temporal differences are assessed in relation to dietary habits and activity patterns in three ancient populations from Corinth, Greece. The skeletal sample spans time from the Geometric to the Early Byzantine Period (9th c. BCE-5th c. CE). Dental caries and tooth wear have been proven to be reliable dietary indicators. Similarly, spinal osteoarthritis, spinal facet remodeling and Schmorl's nodes, have been used to infer activity patterns.

A total of 727 teeth and 676 vertebrae surfaces were examined, from 46 individuals. The entire sample presents a caries rate of 6.1%, and males exhibit a much higher caries frequency than females. Males also exhibit significantly more tooth wear than females, which could be the causative factor of the caries rate difference between the sexes. Furthermore, males show significantly higher rates of osteophyte formation (16.5% vs.7.6%) and Schmorl's nodes than females. On the contrary, no significant differences were noted between the sexes in facet remodeling and osteoarthritis. However, the distribution of facet remodeling along the spine may indicate a possible gender division of labor. Finally, two important positive correlations have been found for the first time to our knowledge: one between facet remodeling and osteophytes, and one between Schmorl's nodes and facet remodelling, thus we cautiously propose the study of the aforementioned correlations, as indicators of intense physical activity in past or even modern populations. Finally, even though time-based differences regarding diet could not be established, temporal variations were found in relation to activity patterns.

Introduction

Comparing ancient populations from the same site over time can offer valuable information regarding the subsistence strategies of past peoples in relation to socio-cultural and historical changes. In the present study, three populations from the same archaeological site and the same ecological context are assessed over a vast span of time. The archaeological site is ancient Corinth, one of the most important cities of the Greek world. The three samples studied include burials that span from the Geometric period until the Early Byzantine times (9th century BCE - 5th century CE), albeit the vast majority of the individuals under study are dated to Roman times. Unfortunately, no information is available regarding the socio-economic status of the individuals under study, or whether they were farmers, fishermen or both. From the 46 burials selected for the study, artifacts were only recovered in 24 of them. Thus, dating is only available for a half of the skeletal material. Nonetheless, temporal comparisons will be cautiously attempted.

Diet is an integral component of the cultural heritage of ancient populations, and hence an indicator of social status. Dental caries is a strong indicator of diet, therefore a good indicator of social status, and differences between the two sexes. Dental wear is directly associated with dietary habits, and for that reason its study has been included in this research. Activity patterns in the past were also related to social status. Sex-based division of labor in past populations has been documented in several studies (e.g., Manzon and Gualdi-Russo, 2015; Merbs, 1983; Sofaer-Derevenski, 2000). A person's sex in the past was associated with their social status, although the factor of physical strength should not be ignored. Spinal osteoarthritis (OA), Schmorl's nodes, and spinal facet remodeling, are activity indicators, and therefore they can be regarded as strong indicators of social status.

The objectives of the present study are: a) to identify possible sex differences in relation to diet and activity, using the aforementioned dietary and activity markers, and b) to assess possible temporal variations in relation to important historical changes. We test the following hypotheses: 1) diachronically females are expected to present higher caries rates than males due to biological and cultural reasons. In particular, sex based dietary differences are expected to be found especially during the Classical period, as literary sources clearly refer to differential access to food items between the two sexes in that period, thus: 2) males are expected to show more intense physical activity markers in relation to females. Furthermore, it could be expected that during the Classical period labor activities would be more intense in relation to the Roman period for the overall sample, due to the harsher conditions that people faced in that period.

Ancient Corinth

The remarkable early prosperity of ancient Corinth is evident by her colonisation of Kerkyra (Corfu) and Syracuse during the 8th century BCE, as well as by the historical tradition of her powerful ruling family, the Bacchiads (Ancient Corynth, 1954). During the latter part of the 7th century BCE the city underwent a significant industrial and commercial development led by her tyrant Kypselos. During

Periander's (son of Kypselos) ruling in the 1st half of the 6th century BCE, the city met the height of her power. However, during the 6th and mainly in the 5th centuries BCE, the growth of Athens robbed Corinth of her flourishing market and reduced her to a city of a second rank. In addition, during the Peloponnesian War and the later Corinthian War (395-387 BCE), the city faced a decline of her wealth and population (Ancient Corynth, 1954). However, during the Hellenistic period (350-250 BCE) the city became once again the most prosperous and populous city of mainland Greece.

The next century Corinth's chief position in the Achaean League brought her into severe conflict with Rome. In 146 BCE, Rome declared war on the Achaean League and, after victories over league forces in the summer of that year, the Romans under Lucius Mummius besieged and captured Corinth (Shipley, 2000). Corinth remained largely deserted until Julius Caesar refounded the city as *Colonia Laus Iulia Corinthiensis* ('colony of Corinth in honour of Julius') in 44 BCE, shortly before his assassination. Under the Romans, Corinth was rebuilt as a major city in Southern Greece, having a large mixed population including Romans, Greeks, and Jews. The city was largely destroyed in the earthquakes of 365 CE and 375 CE, followed by Alaric's invasion in 396 CE. Even though the city was rebuilt after these disasters on a monumental scale, it still covered a much smaller area than previously.

The ancient Greek and Roman diets

The information regarding dietary habits of both ancient Greeks and Romans derives mainly from literary sources but also from stable isotope and archaeobotanical investigations (i.e. Bourbou et al., 2011; Papathanasiou 2003; Vika, 2013). One of the most revealing and extensive archaeological and multidisciplinary studies of the ancient Greek diet and resources (environment, agriculture, animal use, pots, storage places) was done on Metaponto (Metapontion, Greek colony, 7-2 c. BCE, southern Italy) by the team led by Joseph C. Carter (Carter, 1998).

Athenaeus' *Deipnosophistae* (Philosophers at Dinner) is a very significant source referring to the ancient Greek diet during the Classical period. As for the Roman diet the recipe book of Apicus (*The Art of Cooking*) describes gourmet meals, whereas Galen the physician wrote about the medical properties of certain foods (*On the Properties of Foodstuffs*). However, for both the ancient Greek and Roman diets, literary sources were mainly written by and for the upper classes. Both the ancient Greeks and Romans relied on the classical 'Mediterranean triad' of cereals, olive oil and wine. Wheat was the grain preferred by the upper classes, while barley was mainly consumed by the lower classes. In ancient Greece legumes such as lentils, chickpea, bitter vetch etc, may have constituted an important food source during times of famine (Brothwell and Brothwell, 1969; Flint-Hamilton, 1999; Garnsey, 1988; 1999).

Wine was usually consumed diluted with water. Furthermore, even though various varieties of millet were actually cultivated in ancient Greece, they were considered 'an emergency resource for small farmers' (Garnsey, 1988:52). Likewise, millet in the Roman world was mainly consumed in Southern Italy (Faas, 1994), as it did not constitute a favorite crop in the Mediterranean (Dalby, 2003).

According to zooarchaeological evidence in the ancient Greek diet, sheep and goats were the main source of meat during the Classical period (Lev-Tov, 2000), while pigs were also consumed. Ancient Greeks were particularly fond of cheese made from the milk of goats and sheep (Brothwell and Brothwell, 1969). In contrast, in the Roman diet, meat mainly derived from pigs and to a lesser extent from sheep and goats (Faas, 1994; Garnsey, 1999).

Fish in the ancient Greek diet was consumed in various ways, such as smoked or salted, albeit less frequently than other foods (Brothwell and Brothwell, 1969). Garum, or fish sauce was introduced by the Greeks in the 4th century BCE and was considered to be a marker of wealth and high status (Dalby, 1996; Purcell, 1995). In the Roman diet, even though specific marine species were prized as expensive food items (Frayn, 1993), fishing itself and more importantly a diet reliant on fish were considered to be signs of destitution (Purcell, 1995). However, marine resource consumption must have been important in Roman Corinth as archaeologists have found the remnants of a fish market as suggested by two inscriptions in Greek and Latin (Bredaki, 2009).

Literary sources clearly refer to women having less access to animal protein and other nourishing food items in the ancient Greek world, as females were viewed as inferior (Garnsey, 1999). In the ancient Greek symposia, only men had the right to attend and participate, with the exception of courtesans who were supposed to entertain males and who did not join them during the food consumption process. In contrast, in the Roman society, even though males had a higher political and social status, women dined with males at private and public occasions (Dunbabin, 2003;

Wilkins and Hill, 2006). Hence, at least at public events, there is no evidence that the two sexes had access to different food items, with the exception of wine.

Dental caries and tooth wear

Dental caries nature and prevalence is one of the main assessments used to reconstruct the diet of past populations (Hillson, 2001), and the most common pathology found in ancient human remains (Lanfranco and Eggers, 2010). Caries is a disease process characterized by the focal demineralization of dental hard tissues by organic acids produced by bacterial fermentation of dietary carbohydrates (Larsen et al., 1991). Therefore, caries is directly associated with the consumption of carbohydrates and for that reason caries can be used as a very useful tool to explore social differences between sexes in archaeological contexts. Dental caries is also associated with dental plaque bacteria (Keyes and Jordan, 1963). In addition, the gradual progressive nature of caries leads to a pattern of development that is strongly related to age (Manji et al., 1991, Thylstrup and Fejerskov, 1994). Thus, the factor of age must be taken into consideration when recording carious lesions in an ancient population.

A carious lesion may progress from an initial small brown spot into a cavity, which may in turn grow into the dentine and ultimately expose the tissues of the pulp to infection (Hillson, 2008). Thus, in its most extreme stage dental caries can lead to the total destruction of the tooth crown and finally to antemortem tooth loss (AMTL). However, antemortem tooth loss can also be caused by other factors, such as age and trauma (Hillson, 1996). Hence, antemortem tooth loss alone cannot be used as a reliable dietary indicator.

Apart from simple sugars, which constitute a major etiological caries factor, starches may also be associated with dental caries epidemiology (Lingstrom et al., 2000). As it has been mentioned above, cereals, and especially wheat, were a main component of the ancient Greek and Roman diets. Starches can have the potential to serve as substrates for bacterial acidogenesis in plaque and thus lead to cariogenesis (Lingstrom et al., 2000).

Caries has been widely studied in many populations and comparisons have been made, especially between hunter-gatherers and agriculturalists. This major transition of subsistence strategy was accompanied by a higher frequency of oral pathologies and specifically dental caries (Hillson, 1996, 2001; Larsen, 1997; Lukacs, 1996).

Identifying the subsistence strategy of a society through archaeological data is very important because this strategy can be associated with possible sex differences in dietary habits. For example, it may be suggested that the consumption of meat and animal proteins in a society with a mixed diet would probably be greater than that of a society with an agriculturalist's diet.

Dental wear is the tooth-on-tooth wear that creates wear facets on both teeth that are involved. Occlusal wear is usually recorded by scoring the pattern of dentine exposed as the enamel wear progresses (Hillson, 2008). Smith's (1984) scheme, which is used in the present study, is the most frequently used recognized standard (Buikstra and Ubelaker, 1994). Tooth wear has been correlated with diet as early as 1965, in Anderson's study, when it was concluded that dental wear and its various patterns could be clues used in the reconstruction of a population's subsistence. Several other studies since then have correlated tooth wear to the diet of a population (Littleton and Frohlich, 1993; Molnar, 1971; Scott, 1979; Smith, 1984). Contrary to increased caries rates, the transition from hunter-gatherer societies to agriculture was accompanied by an important decline in tooth wear frequencies (Anderson, 1965; Armelagos and Rose, 1972; Cassidy, 1984; Hinton 1981; Kennedy, 1984; Lubell et al., 1994; Molnar, 1971; Pastor, 1992; Powell, 1985; Walker, 1978). Populations that underwent agricultural intensification started to consume softer food sources, resulting in reduced wear rates. However, apart from the reduction of wear rates, the onset of agriculture also brought the differentiation of wear patterns. For instance, it has been documented that populations of hunter-gatherers presented evenly distributed flat wear, whereas agricultural communities a more angled wear (Eshed et al., 2006). Furthermore, a hypothesis of caries-attrition competition has been formed, based on the assumption that a beneficial effect of tooth wear is to avoid development of caries (Maat and Van der Velde, 1987). This effect is related to the slow and gradual rate of wear that can be advantageous, as it can remove potentially carious surfaces from teeth, smoothing the cusps and fissures of teeth. However, severe tooth wear may cause an enlargement of neighboring tooth fissures, resulting in particles of food being trapped in them. This, in turn, may lead to periodontal disease, and to the exposure of the cemento-enamel junction, leading to development of bacteria that causes dental caries. Therefore, it is vital to examine whether caries and tooth wear present a positive or negative relationship in Corinth's population.

Osteoarthritis, spinal facet remodeling, and Schmorl's nodes

Osteoarthritis is clinically characterized by cyst formation, porosity, osteophytes and subchondral sclerosis with joint space loss, and in some cases eburnation as an end result (Resnick and Niwayama, 1988). Moreover, other than dental diseases, osteoarthritis is one of the most common pathological conditions observed in human skeletal remains (Resnick and Niwayama, 1988; Weiss and Jurmain, 2007). Age, weight and mechanical loading have been considered to be some of the most important causes of osteoarthritis (Sofaer- Derevenski, 2000; Solano, 2002; Waldron, 1997; Weiss, 2005, 2006). It is believed that severe osteoarthritis of specific joints is the result of continued use of specific muscles and joints in daily and repetitive tasks (Weiss and Jurmain, 2007). Therefore, osteoarthritis is considered to be an important activity indicator, especially in past populations. However genetic, anatomical and body mass index influences must not be ignored in osteoarthritis epidemiology. Heritability estimates concerning osteoarthritis, have been obtained from contemporary urban populations, which in general do not engage in extreme mechanical loading (Weiss and Jurmain, 2007). Consequently, osteoarthritis can be a useful activity indicator, especially in past populations.

Schmorl's nodes have been extensively studied by and named after George Schmorl (Schmorl, 1926; Schmorl and Junghanns, 1959). This term has been mainly adopted to refer to the end result of the prolapsed disc, or the lesion that eventually is formed on the surface of the affected vertebral body (Faccia and Williams, 2008). Schmorl's nodes result from congenital defects of the spine, age or traumatic events (Resnick and Niwayama, 1978). However, according to Schmorl and Junghanns (1971), these lesions are usually a result of daily physical activity. A number of studies have used Schmorl's nodes as indicators of demanding physical activity (Angel et al., 1987; Baker, 1997; Coughlan and Holst, 2000; Kelley and Angel, 1987; Knusel, 2000; Knusel and Boylston, 2000; Manzon and Gualdi-Russo, 2015; Owsley et al., 1987). These lesions have also been used to assess differences in activity patterns between the sexes (Parrington and Roberts, 1990; Rathbun, 1987).

Bone remodeling is a skeletal response to applied stresses, in order to maintain integrity in support and movement (Rubin et al., 1990). Therefore, it is somewhat surprising that plastic change (bone remodeling and specifically spinal zygapophyseal facet remodeling) has been subject to less intensive study than osteoarthritis. Furthermore, according to Sofaer-Derevenski (2000) the biomechanical forces leading to facet remodeling could make it one of the most reliable indicators of activity and load bearing in particular. Consequently, studying the distribution of facet remodeling along the spine may provide specific information as to how the loads were carried (i.e., on the head or on the back, etc.) in a population.

Materials and methods

In 1896, The American School of Classical Studies at Athens started the first excavations of ancient Corinth, which revealed the Agora of the city, temples, baths, lodges, and fountains. The skeletons under study derive from cemeteries that were excavated from 1960 until 2004, during the construction works for the suburban railway. Three areas within the same archaeological site are selected for this study, due to the fact that they are composed almost entirely of individual burials. The skeletal remains are preserved in a very good condition. The three areas under study are: i) Delli's Property; ii) Soukouli's Property, and iii) Rota's Property. The skeletons under study span from the Geometric period (9th century BCE) until the Early Byzantine period (5th century CE). However, the vast majority of the burials found with artifacts derive from the Roman Era. Unfortunately, only 24 out of the 46 individuals are dated, due to a lack of archaeological evidence (Table 1). Thus, even though temporal comparisons are quite difficult, due to the small number of individuals, they will be cautiously attempted. Based on the fact that the 46 individuals selected from the three properties belong to the same archaeological site, it is appropriate to analyze them as a pooled group.

This skeletal collection of 46 individuals, consists of 23 males and 23 females. A detailed inventory of the individuals is presented in Table 1 including: 1) sex determination and age estimation; 2) the specific dating of the burials, based on the artifacts recovered, and 3) the number of teeth and vertebrae present in each skeleton under study.

INSERT Tables 1,2 ABOUT HERE

A total of 727 permanent teeth and 676 vertebral surfaces were studied (Table 2). Sex determination of the skeletons was conducted using the morphological criteria of the skull and pelvis (Bass, 1987; Buikstra and Ubelaker, 1994). Age estimation was based on pubic symphysis morphology, the auricular surface and the sternal end of the ribs (Byers, 2005). Individuals were separated into three age categories: young adults (20-35), middle adults (36-50) and older adults (51+).

Dental caries and dental wear: Teeth were recorded according to the FDI tooth numbering system. Dental caries was assessed by macroscopic examination and a dental probe. Recording was conducted according to the 'Standardized System for Recording Dental Caries in Prehistoric Skeletons' by Metress and Conway (1975). According to this system teeth were recorded as present or absent (antemortem tooth loss and postmortem tooth loss were also recorded), all tooth surfaces were observed and the degree of carious lesions was rated on a scale from 1 (minimal) to 4 (crown destruction).

Dental wear was recorded according to Smith's (1984) protocol, which was based on hunter-gatherers and agriculturalists. This specific protocol includes eight degrees of wear. The degrees ranging from 1 to 2 represent slight wear (no wear or very slight exposure of dentine), degrees from 3 to 5 represent moderate exposure of dentine, and degrees from 6 to 8 represent severe wear (nearly complete exposure of dentine).

Osteoarthritis, facet remodeling and Schmorl's nodes: Osteoarthritis was studied along the spine, according to the criteria formed by Rogers et al., (1987). These criteria are as follows: eburnation (EB), osteophytes (OP), pitting (P) and alteration of the joint contour (AJC). Eburnation leads directly to the diagnosis of osteoarthritis, otherwise two of the remaining criteria must be observed. An additional, more detailed recording of eburnation, osteophytes and pitting was conducted (Buikstra and Ubelaker, 1994). For each of the above criteria, the following three degrees were recorded: Degree 1- EB/OP/P occupy one-third or less of the total surface of the joint; Degree 2- EB/OP/P occupy between one-third and two-thirds of the total surface; and Degree 3- EB/OP/P occupy between two-thirds and the entire joint surface. Alteration of the joint contour was recorded only as absent or present. Schmorl's nodes were also recorded as present or absent.

Facet remodeling along the spine was recorded according to a four-stage system, formed by Sofaer-Derevenski (2000). According to this system, observations were made on the superior and inferior articular facets and changes such as the morphology of the margins were assessed giving the scores 0 to 3 for severity.

Statistical analysis: All frequencies of dental caries and wear were calculated according to the teeth present. Furthermore, frequencies of osteoarthritis, facet remodelling and Schmorl's nodes, were calculated according to the vertebrae present. The data did not follow a normal distribution, thus two non-parametric tests were performed; the Mann-Whitney's U test in order to compare males and females ($p < 0.05$), and the Kruskal Wallis's test, in order to compare the three age groups ($p< 0.05$). Spearman's rank correlation coefficient ($p<0.05$, or $p<0.01$) and a principal component analysis plot were used in order to test how strongly the variables were associated with each other. All the analyses were carried out using SPSS (Statistical Package for the Social Sciences) version 21.

Results

Dental caries and wear: The total caries frequency in the sample is 6.1% (44/727 teeth). Males show a higher caries frequency than females (males - 8.8%; females - 3.9%) and the difference between the two sexes is statistically significant. Males show significantly higher caries rates in all of the tooth surfaces apart from the distal surface, where the two sexes show almost equal percentages (Table 3). Furthermore, males also show greater caries severity. The total difference between the two sexes is again statistically significant (Table 4).

Caries frequencies were also compared between sexes, for each of the four types of teeth, as specific teeth are more susceptible in exhibiting carious lesions than others. None of the two sexes had any caries in the incisors and the canines. In all of the remaining two types, males had higher rates than females. Males showed caries in 27.6% of molars and 4.5% of premolars, while females had carious lesions in 10.8% of molars and 0.9% of premolars, respectively (Fig. 2).

INSERT Tables 3,4 AND Fig. 2 ABOUT HERE

The frequencies of dental wear in males and females are presented in Table 5. A significant difference is found between the two sexes. Severe wear (degrees 6 to 8) is more common in males than in females (males - 18.6%; females - 10.2%) (Table 5).

INSERT Table 5 ABOUT HERE

Finally, when comparing caries rates (for both sexes) between the different chronological periods, no statistically significant differences are found. The caries frequencies are at 2.7% (2/73 teeth) for the Classical period; 4.1% (10/243 teeth) for the Roman Era and 3.6% (2/55 teeth) for the Early Byzantine period, while no carious lesions have been found in the 20 teeth dated to the Geometric period. Surprisingly, even though males show significantly higher caries frequency in relation to females for the entire pooled sample, females show slightly higher caries rates than males, in both the Classical and Roman periods. However, it should not be overlooked that the number of individuals is very limited for each of the studied periods and, more importantly, a significant portion of the individuals under study has not been dated due to the lack of archaeological evidence.

Osteoarthritis, facet remodeling and Schmorl's nodes: The total frequency of vertebral osteoarthritis for the entire sample is just 2.7% (18/676 vertebrae surfaces). Males (3%) and females (2.2%) show almost equal frequencies of osteoarthritis. In contrast, the frequencies of osteophytes are much higher than those of osteoarthritis. Males show a frequency of 16.5%, whereas females 7.6% and the difference between the two sexes is statistically significant (Table 6). As expected, the highest frequency of osteophytes is observed in older adults (18.4%, 14/76 vertebrae). However, middle and young adults also show quite high frequencies (12.2% the former and 12% the latter). There is no statistically significant difference between the three age groups.

The two sexes present almost equal percentages of facet remodeling, (males 10% and females 9.8%). Young and older adults present almost equal percentages of remodeling (older adults 14.5%, young adults 14%), whereas middle adults present a frequency of 7.8% (35/450 vertebrae surfaces), and the difference between these age groups is statistically significant. When it comes to Schmorl's nodes, they are only present in males and this difference between the two sexes is statistically significant (Table 6).

INSERT Table 6 ABOUT HERE

The distribution of facet remodeling along the spine between the two sexes (including the sacrum), is also examined. Males show the highest frequency in the tenth thoracic vertebra (31%, 5 out of 16 vertebrae). The ninth thoracic and third lumbar vertebrae show equally high percentages of 25%, with 4 vertebrae with facets remodeled out of 16 vertebrae in each category (Fig. 3). Females present the highest frequency of facet remodeling in the first lumbar vertebra with 25%,(2 out of 8 vertebrae). Females also show higher percentages of remodeling in the cervical vertebrae than males (Fig. 3).

INSERT Fig. 3 ABOUT HERE

Furthermore, correlations between the spinal indicators of activity have been examined. Osteoarthritis shows its strongest (positive) correlation with pitting, and this correlation is statistically significant. Other positive and statistically significant correlations were found between osteophytes and facet remodeling, Schmorl’s nodes and facet remodeling and osteophytes and Schmorl’s nodes (Table 7). Correlations between the above activity indicators are graphically presented in the Principal Component Analysis plot (Fig. 4). Osteoarthritis and pitting are clearly clustered in the first component, whereas facet remodeling and Schmorl’s nodes are clustered in the second component. Osteophytes could be clustered in both of these groups; however they are mostly clustered with osteoarthritis and pitting in the first component (Table 8).

INSERT Table 7, Fig. 4, Table 8 ABOUT HERE

Finally, spinal indicators’ rates between the chronological periods have been compared. Frequencies for the Classical period are: osteoarthritis - 2.7% (2/75 vertebrae surfaces); facet remodeling - 5.3% (4/75 vertebrae surfaces); osteophytes - 14.7% (11/75 vertebrae surfaces); and Schmorl’s nodes - 6.7% (5/75 vertebrae surfaces). In contrast, frequencies for the Roman period are: osteoarthritis - 4% (6/150 vertebrae surfaces); facet remodeling - 25.3% (38/150 vertebrae surfaces); osteophytes - 24.7% (37/150 vertebrae surfaces); and Schmorl’s nodes - 3.3% (5/150 vertebrae surfaces). No significant differences were established between these two time periods. No results were available for the Geometric and Early Byzantine periods. In addition, it is of particular interest that spinal indicators show stronger correlations between them in the Classical period in relation to the Roman period. Facet remodeling shows positive correlations with osteoarthritis (Spearman's coefficient: 0.329; $p_{value:}$ 0.004); with osteophytes (Spearman's coefficient: 0.405; $p_{value:}$ 0.00) and pitting (Spearman's coefficient: 0.697; $p_{value:}$ 0.00) in the Classical period, whereas in the Roman period facet remodeling shows a negative correlation with osteoarthritis, and a positive, however not statistically significant, with osteophytes (Spearman's coefficient: 0.165; $p_{value:}$ 0.44).

Discussion

Dietary patterns/dental caries and wear

Based on the information presented in the introduction of this paper, the studied individuals are expected to have had a diet constituting of agricultural products, such as wheat, barley, olive oil, wine, fruits, as well as animal proteins. In addition, based on the archaeological finding of the fish market dated to the Roman period in Corinth (Bredaki, 2009), it is also highly possible that these individuals consumed fish to a significant extent. However, the exact types of foods consumed cannot be determined without an isotopic analysis. The total caries percentage for our sample is 6.1%, and according to the frequencies defined by Turner (1978; 1979) and Schollmeyer and Turner, (2004) our percentage falls within the mixed diet model (0.44%-10.3%).

Contrary to our initial hypothesis, males show a higher caries frequency when compared to females (8.8% and 3.9% respectively). Males also show greater severity. Higher carbohydrate intake leads to deeper lesions. It also causes carious lesions in surfaces other than occlusal (Lanfranco and Eggers, 2010). Thus, it is possible that males in Corinth consumed more carbohydrates than females. The above finding is not consistent with the general tendency of females having higher caries rates, both in ancient and modern populations (Hillson, 2001; Walker and Hewlett, 1990). Earlier eruption of teeth, biocultural differences, changes in salivary composition during pregnancy and lactation are indicated as the main factors for this difference between the sexes (Laine, 2002; Larsen, 1997; Walker and Hewlett, 1990). Males, due to their higher social and political status in Corinth, could have had a greater access to specific nutritional sources (such as wine), which could contribute to a greater carbohydrate intake. Corinth was the center of entertainment in the ancient Greek world; therefore it is probably safe to assume that Symposia took place quite regularly. The consumption of large quantities of wine and of other food items rich in carbohydrates on these occasions, may be one of the reasons leading to higher caries frequencies in males. With drinking, males used to consume confectionery made of honey, which supposed to absorb alcohol, thus aiming to prolong the Symposium time (Flaceliere, 1965). However, it must be stressed that these interpretations should be taken with caution, as our sample size is quite small.

Another explanation for the difference noted in our sample may be the higher burden of physical labor that males engaged in. This could have lead them to more frequent meals, an increased consumption of food and thus to higher caries rates. Other important factors that could lead males to present higher caries frequencies than females are oral hygiene and dental wear. For example, males and females could have possibly consumed food items with different texture. Males in the Corinth sample present significantly more severe wear (stages 6 to 8) than females. In addition, wear in males shows a statistically significant positive correlation with caries degree (Spearman's coefficient: 0.236; p_{value}: 0.00). On the other hand, females also present a statistically significant positive correlation between caries degree and wear, albeit weaker in relation to males (Spearman's coefficient: 0.167; p_{value}: 0.00) Consequently, it appears that males probably consumed more abrasive food items than females, leading to more advanced wear and possibly higher caries frequencies. As has been mentioned above, severe tooth wear may cause an enlargement of neighboring tooth fissures, resulting in particles of food being trapped in them. Therefore, in turn, this may lead to periodontal disease and to the exposure of a cemento-enamel junction, and to a development of bacteria that cause dental caries.

Other important factors that could explain the aforementioned variation between the sexes is age, as well as antemortem tooth loss. Age does not show any positive correlations with caries, caries degree or even wear. Wear shows a negative correlation with age for both males and females. In males this negative correlation is statistically significant. Therefore, it seems that the caries differences between the two sexes cannot be attributed to the factor of age. In addition, neither antemortem tooth loss, nor postmortem tooth loss show any significant differentiation between males and females. Total number of 82 teeth are found missing antemortem in males, while 38 in females, albeit this difference is not statistically significant. If the intake of cariogenic food can be claimed to be a direct causative factor in the prevalence of antemortem tooth loss, a simple linear association between caries and tooth loss cannot be applied. The interaction among all factors which are involved in the expression of oral disease is very complicated (Hillson, 2000), therefore calculus, age, gingival inflammation and periodontal disease play important roles in dental decay and thus in antemortem tooth loss (Hillson, 1996; Larsen, 1997). Thus, the caries difference between the sexes cannot be attributed to antemortem tooth loss, at least not as the primary factor of influence.

Even though the number of individuals is quite limited for each of the different time periods, there is a tendency of a higher caries frequency in the Roman period. Table 9 shows the majority of the published work regarding dental caries in Greek populations. The term “Greek populations” we use here as denoting origin (i.e. Apollonia Pontica, the Greek colony in Bulgaria) or geographical location. Interestingly, caries rate in ancient Corinth is far different from the one found by Fox (2005) in Roman Corinth (excavations of “The American School Of Classical Studies at Athens”), at 16%. In our studies, the frequency is again lower than that of Hellenistic/Roman Pafos (Cyprus) at 14.2% (Fox, 2005). The caries rate in the Corinth sample is closer to the one of the Early Iron Age (1150-650 BCE) populations (5.5%) studied by Angel (1944). Also, the Corynth sample’s rate in our studies (only for males not for females) is not much different from the rates for two samples from the prefecture of Macedonia (Olympus, 8.87%; Makrygialos, 9.92%) both dating to the Early Iron Age (Triantaphyllou, 2001). Whereas again, the caries rate in our sample, particularly the one in males, is not much different from the one found in rural Metaponto (6^{th}-3rh c. BCE) at 10.2% (Henneberg, 1998). Caries frequency in the Corynth sample is quite close to the frequency in an ancient population from Corfu (7.9%) dating between the Classical and Hellenistic periods (Michael and Manolis, 2014) and to a Roman population from Edessa (8.3%) (Michael, 2015). Therefore, this suggests that the Corinth population may have had a low carbohydrate diet, possibly including fluorides that contributed to a good oral hygiene. Fluoride and strontium elements are found in high quantities in marine foods (Malde et al., 1997; Siebert and Trautner, 1985) and are known to impede the formation of carious lesions (Keenleyside, 2008). Thus, it is possible, that the individuals examined in the sample studied here consumed fish to a significant degree, which resulted in a low caries prevalence. This hypothesis is further supported when considering that fish consumption became more frequent during the 5^{th} and 4^{th} centuries BCE in Greece

(Pingiatoglou, 2010) and that a Roman fish market has been recovered in the site of ancient Corinth (Bredaki, 2009).

Males showed higher caries rates than females in the sample from Olympus (Triantaphyllou, 2001), even though this difference was not statistically significant. The noted variation in the Macedonian sample was attributed to possible culture-driven differences between the two sexes, such as division of labor, the consumption of food items with different texture, or even differences in the food making process (Triantaphyllou, 2001). Likewise, in a sample from Eleutherna (Crete, 6^{th}-7^{th} c. CE) a differential access to food products was proposed between the two sexes, as males showed higher percentages of dental pathologies in relation to females (Bourbou, 2003). Consequently, we can suggest that when males show a higher caries rate than females in an ancient population, like the one in ancient Corinth, the reasons are cultural since the biological predisposition favors women to have higher rates.

Corinth's tooth wear pattern seems more advanced in relation to Edessa's and Corfu's. Both males and females in Corinth show much higher rates of severe wear in relation to the populations from Roman Edessa and Corfu (Michael, 2015). Corinth's wear pattern is, again, more severe in relation to the one from Apollonia (5^{th}-2^{nd} c. BCE) (Keenleyside, 2008). As for the two sexes, even though males show higher wear frequencies than females, the pattern is quite similar, as both sexes exhibit their highest rates in molars and premolars. According to Molnar (1971; 1972), it is quite likely that when the two sexes show a difference in dental wear rate, this may be attributed to the socio-economic status and the roles of non-dietary uses of the dentition.

Activity patterns/osteoarthritis, facet remodeling and Schmorl's nodes: Osteoarthritis frequencies in Corinth are very low in both males and females, while frequencies of osteophytes are higher in relation to the osteoarthritis in both sexes. Even though, osteophytes are one of the criteria of osteoarthritis, their presence alone does not indicate osteoarthritis (see Materials and methods). However, as osteophytes' presence has been linked to demanding activities, such as sports (Armenis et al., 2011; Spector et al, 1996), it is also important to examine them separately. Males show a significantly greater percentage of osteophytes than females. In addition, osteophytes are observed in a significant proportion of young adults (20-35 years old). As osteophytes are one of the four diagnostic criteria of osteoarthritis, their presence is highly influenced by age. However, the strong presence of osteophytes in young adults cannot be attributed to age; on the contrary, it can be associated with physical activity. In addition, age does not show any significant correlation with osteoarthritis, in neither of the two sexes. In contrast, males present a negative correlation between osteophytes and age, albeit not statistically significant (may be because of a small sample size). It is also notable that the higher frequency of osteophytes in males is in contrast with genetic influences. Osteoarthritis, especially along the spine, is strongly linked to genetics and some studies have documented that this hereditary effect is stronger in females than in males (Bergink et al., 2003; Sambrook et al., 1999; Spector and MacGregor, 2004; Wilson et al., 1990). The higher rate of osteophytes in males than in females in the Corinth's sample can be attributed to a more intense physical activity of males. The result for Corinth is closer to the results for Corfu Classical to Hellenistic periods at 3% (Michael, 2015). The Corinth's rate is quite close to the rates of Makrygialos at 4.57% (Macedonia, Early Iron Age; Triantaphyllou, 2001), and of Roman Edessa at 4.6% (Michael, 2015). In both Corfu and Edessa, males showed higher osteoarthritis rates in relation to females, whereas in Makrygialos both sexes had almost equal rates.

When it comes to spinal facet remodeling, the two sexes show almost equal total frequency values. While males show a negative and statistically significant correlation between spinal facet remodeling and age, females show a statistically significant positive correlation between age and remodeling. The two sexes show both similarities and differences in the distribution of facet remodeling along the spine. Females appear to have more severe remodeling along the cervical region, while males in thoracic vertebrae and especially in the lower thoracic region. On the contrary, the presence of spinal remodeling is almost the same for both sexes in the lumbar vertebrae. Load-carrying by tumpline, or on the head, have been associated with a high frequency of osteoarthritis in the mid-cervical, the thoracic, and also lower lumbar vertebrae (Bridges, 1994; Jurmain, 1990; Kilgore, 1984; Lovell, 1994; Shore, 1935; Steward, 1979). A peak in osteoarthritis specifically in the first thoracic vertebra has been associated with the method of carrying creels (Merbs, 1983; Miles, 1989; Sofaer-Derevenski, 2000). Even though the two sexes show no quantitative difference in facet remodeling, there seems to be some variation in the methods of load-carrying, leading to the assumption of a sexual division of labor. Since no specific information concerning the exact methods of load-carrying in Corinth exists, we can assume that loads were carried in several ways, such as on the head, with hands, or on the back. As in Corinth, males and females in Corfu show almost equal percentages of remodeling, while the entire sample exhibited a remodeling rate at 8.4%, similar to the one in Corinth (Michael, 2015). The rate in Corinth's sample is also similar to the one for Roman Edessa at 10.8%, even though in the Macedonian sample males showed significantly higher rate than females (Michael, 2015).

Schmorl's nodes are solely observed in males and the noted difference between the sexes is statistically significant. The same is also observed in Corfu and Edessa, where males show higher rates in comparison with females (Michael, 2015). The simultaneous presence of Schmorl's nodes and osteophytes on a joint surface is associated with more intense physical activity (Faccia and Williams, 2008). This positive correlation between the above indicators is also noted in the sample from Corinth. Two other positive and statistically significant correlations between the activity indicators under study have been observed: facet remodeling and osteophytes, and facet remodeling and Schmorl's nodes. The latter correlation is only related to males, as Schmorl's nodes are found exclusively in the vertebrae of male skeletons. Even though the above activity indicators may result from different causes, it is only natural to expect that the simultaneous presence of these indicators in a population, ancient or modern, could be associated with more intense physical activity. The correlation between Schmorl's nodes and facet remodeling has also been found in three other samples from Greece; in Corfu, in Medieval Thebes (13^{th}-14^{th} centuries CE) and in the Modern Reference Skeletal Collection of the Department of Animal & Human Physiology, University of Athens, (20th century) (Eliopoulos et al., 2007; Michael, 2015). Consequently, we cautiously propose the study of the above two correlations, as activity indicators in ancient and modern populations.

Based on the information presented above, it appears that in Corinth males engaged in more strenuous physical activities than females, even though the strong presence of facet remodeling in females could be interpreted as a cumulative result of both indoors (household activities) and outdoors physical activities. Despite the fact that the exact daily activities undertaken by each of the two sexes are not known, sex division of labor cannot be excluded, especially in light of some differences in the distribution of spinal facet remodeling between the two sexes.

Surprisingly, even though the numbers of individuals for the different time periods are very small, both in Classical and Roman periods, spinal indicators show some correlations between themselves. In particular, in the Classical period facet remodeling shows a significant and positive correlation with osteoarthritis. The osteophytes' correlation with remodeling is stronger in the Roman period than in Classical period. Schmorl's nodes are more frequently observed in the Classical period than in the Roman period (6.7% vs. 3.3%), albeit the difference between the two time periods is not statistically significant. Therefore, it can be cautiously proposed that individuals from the Classical period engaged in more strenuous physical activities compared to those from the Roman period, possibly indicating harsher living conditions.

In conclusion, sex differences in dietary and activity patterns have been found in the population of ancient Corinth. Dental results offered strong indications that males could possibly have had either a more carbohydrate-dependent diet than females, or that, they exhibited a higher caries rate. The difference in caries frequency between the sexes could be attributed to other possibilities; i.e., females could have consumed more cariostatic food items, (such as seafood) in relation to males, or that they could have a better dental hygiene. Therefore, we cannot be certain about the possible dietary differences between the sexes without a stable isotope analysis, which is the immediate future goal. Temporal dietary differences could not be established due to the very limited number of individuals. Hopefully, the scheduled isotopic analysis will shed light on dietary habits of the populations under study, particularly in relation to sex and different time periods.

Using osteoarthritis, spinal facet remodeling and Schmorl's nodes as activity indicators, it was concluded that males engaged in more intense physical activity than females. However, females must have been under physical stress as well, at least to some extent. The distribution of facet remodeling along the spine between the sexes suggests a possible sex division of labor. Temporal differences regarding activity patterns are suggested based on our results. Finally, the present study proposes the study of spinal facet remodeling as a reliable activity indicator. This indicator is associated with load-bearing in particular and can provide us with specific information concerning the methods employed for carrying loads.

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Legends of Figures

Fig. 1. The geographical location of Corinth

Fig. 2. Caries frequency among the sexes and in the four types of teeth. Number of individuals with carious lesions on premolars: males - 4; females -1. Number of individuals with carious lesions on molars: males - 11; females - 10.

Fig. 3. Frequency of the distribution of facet remodeling along the spine in relation to sex

Fig. 4. Component plot regarding the stress markers along the spine, for the population of ancient Corinth

Table 1. Inventory of the individuals under study (D: Delli's Property, S: Soukouli's Property, R: Rota's Property).

Code	Property	Sex	Age	Dating	N. teeth	N. vertebrae
T2	D	M	35-44		12	
T4	D	M	45+		8	1
T11	D	M	50-69	1st. c. CE	8	8
T13	D	M	45-60		4	
T19	D	M	35-39	4th c. BCE		10
T41	D	F	33-45		10	5
T68	D	F	40-44	4th c. BCE	26	7
T10.1	S	F	31-60		10	
T10.2	S	F	33-45		7	
T11.1	S	F	23-45	4th-5th c. CE	26	
T12	S	F	23-51		24	2
T13.16	S	F	28-60	1st-5th c. C.E	9	
T13.17	S	F	28-51	1st-5th c. C.E	12	
T13.18	S	M	31-60	1st-5th c. C.E	3	
T13.19	S	F	33-45	1st-5th c. C.E	13	
T13.20	S	F	31-60	1st-5th c. C.E	1	
T14.1	S	F	26-54	3rd-4th c. CE	26	
T14.2	S	M	35-60	3rd-4th c. CE	23	
T14.3	S	M	20-49	3rd-4th c. CE		15
T15	S	M	27-66	4th-5th c. CE	26	
T15B	S	F	39-49	4th-5th c. CE	15	
T24	S	F	25-35	1st. c. CE	27	
T26	S	F	25-34	1st. c. CE	29	
T28	S	M	17-25	4th-5th c. CE	3	
T31	S	F	29-60	4th-5th c. CE	5	9
T37	S	F	33-45		26	7
T40	S	M	25-20		30	3
T55	R	M	35-39		27	5
T59	R	F	50-60	1st. c. C.E	23	12
T63	R	M	20-29	1st. c. C.E	30	22
T71	R	M	30-45	9th c. BCE	20	
T78	R	M	20-30		24	3
T79	R	F	20-34		22	7
T79B	R	M	60+		4	
T81	R	M	37-52		20	15
T82	R	F	25-30		20	9
T84	R	M	25-30	1st. c. C.E	21	15
T88	R	M	29-39		15	13
T89	R	F	40-49		6	3
T97	R	M	35-45		7	4
T98	R	M	45-60		4	11
T99	R	F	30-39	1st. c. C.E	16	13
T100	R	F	40-44		28	8
T101	R	M	30-49		20	3
T102	R	M	40-49		12	9
T103	R	F	35-44	5th c. B.C.E	25	10

Table 2. The number of permanent teeth and vertebrae (surfaces) in relation to sex and age

Population groups	N. teeth	N. vertebrae surfaces
males	317	401
females	410	275
20-35 (both sexes)	273	150
36-50 (both sexes)	398	450
51+ (both sexes)	56	76
Total	**727**	**676**

Table 3. Frequency of caries by location in the two sexes

Tooth surfaces	males	females	Number of affected/Number of available individuals (males)	Number of affected/Number of available individuals (females)	Mann-Whitney's U (p-value)
Occlusal	4.1% (13/317)*	1.7% (7/140)*	7/23	6/23	**0.006** (Total caries difference)**
Buccal	1.9% (6/317)*	1% (4/410)*	4/23	4/23	
Lingual	0.3% (1/317)*	0%	1/23	0	
Mesial	1.6% (5/317)*	0.2% (1/410)*	3/23	1/23	
Distal	0.9% (3/317)*	1% (4/410)*	3/23	3/23	

* Carious teeth/present teeth, ** Bolded values are significant at the 0.05 level.

Table 4. Frequency of caries degree between the sexes

Caries Degrees	males	females	Number of affected/Number of available individuals (males)	Number of affected/Number of available individuals (females)	Mann-Whitney's U (p-value)
1	4.7% (15/317)*	2.4% (10/140)*	9/23	7/23	
2	1.9% (6/317)*	1.5% (6/140)*	5/23	5/23	**0.005** (Total degree difference)**
3	1.3% (4/317)*	0	4/23	0	
4	0.9% (3/317)*	0	3/23	0	

* Carious teeth/present teeth, ** Bolded values are significant at the 0.05 level.

Table 5. Frequency of dental wear by sex

Tooth wear	males	females	Number of affected/Number of available individuals (males)	Number of affected/Number of available individuals (females)	Mann-Whitney's U (p-value)
1	2.8% (9/317)*	2% (8/410)*	3/23	3/23	
2	18.9% (60/317)*	24.6% (101/410)*	10/23	17/23	
3	24.9% (79/317)*	34.4% (141/410)*	16/23	20/23	
4	17% (54/317)*	16.8% (69/410)*	11/23	16/23	**0.002** (Total wear difference)**
5	14.5% (46/317)*	10.7% (44/410)*	13/23	16/23	
6	10.4% (33/317)*	8.3% (34/410)*	9/23	9/23	
7	4.7% (15/317)*	2% (8/410)*	6/23	4/23	
8	3.5% (11/317)*	0	5/23	0	
intense wear (6-8)	18.6% (59/317)*	10.2% (42/410)*			**0.003** (Intense wear difference)**

* Teeth with wear/present teeth, ** Bolded values are significant at the 0.05 level.

Table 6. Frequencies in activity spinal indicators, between the sexes
*Affected vertebrae surfaces/present vertebrae surfaces, **Bolded values are significant at the 0.05 level.

Spinal indicators	males	females	Number of affected/Number of available individuals (males)	Number of affected/Number of available individuals (females)	Mann-Whitney U (p-value)
Osteoarthritis	3% (12/401)*	2.2% (6/275)*	3/17	2/12	0.52
Osteophytes	16.5% (66/401)*	7.6% (21/275)*	12/17	7/12	**0.001****
Eburnation	0.2% (1/401)*	0%	1/17	0	0.408
Pitting	3% (12/401)*	0,7% (2/275)*	5/17	2/12	**0.042****
Facet remodeling	10% (40/401)*	9.8% (27/275)*	11/17	10/12	0.947
Schmorl's nodes	4% (16/401)*	0%	6/17	0	**0.001****

Table 7. Correlation matrix (Spearman's correlation coefficients for the entire sample

Spinal Indicators	Osteoarthritis	Osteophytes	Eburnation	Pitting	Facet remodeling	Schmorl's nodes
Osteoarthritis	1.000	**0.266****	-0.006	**0.557***	0.037	-0.026
Osteophytes	**0.266****	1.000	-0.015	**0.192****	**0.227****	**0.173****
Eburnation	-0.006	-0.015	1.000	-0.006	-0.013	-0.006
Pitting	**0.557****	**0.192****	-0.006	1.000	**0.160****	0.046
Facet remodeling	0.037	**0.227****	-0.013	**0.160****	1.000	**0.079***
Schmorl nodes	-0.026	**0.173****	-0.006	0.046	**0.079***	1.000

* values are significant at the 0.05 level. ** values are significant at the 0.01 level

Table 8. Principal component analysis: Component table explaining Fig. 5

Spinal Indicators	Components	
	1	2
OA total	**0,775**	-0,425
R total	0,393	**0,506**
SN total	0,194	**0,679**
OP total	**0,610**	0,394
EB total	-0,031	**-0,077**
P total	**0,788**	-0,310

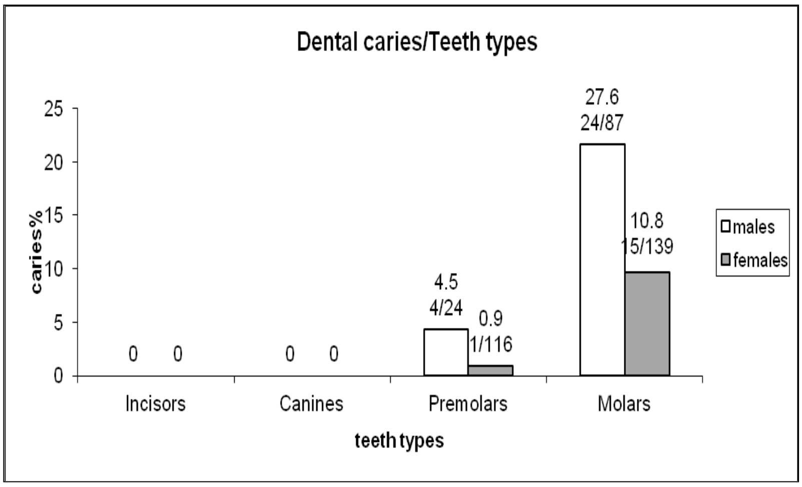
OA: Osteoarthritis; R: Facet remodeling; SN: Schmorl's nodes; OP: Osteophytes; EB: Eburnation; P: Pitting

Table 9. Dental caries frequencies in ancient Greek populations

*Total teeth, including AMTL; ** Total caries rate, including AMTL

Skeletal samples/ Chronological Period	**Number of teeth under study**	**Caries Frequencies% (per teeth)**	**Reference**
Leukanti (Iron Age)	113	9.7	Musgrave and Popham (1991)
Early Iron Age (1150-650 BCE)	724	5.5	Angel (1944)
Makrygialos (1100-700 BCE)	846	9.92	Triantaphyllou (2001)
Olympus (1100-700 BCE)	124	8.87	Triantaphyllou (2001)
Corinth (9th c. BCE- 5th C.E)	**727**	**6.1**	**Current study**
Classical Era	724	5	Angel (1944)
Metaponto (Southern Italy) 6th-3rd c. BCE	1828	10.5	Henneberg and Henneberg (1998)
Rural Metaponto (Pantanello) 6th-3rd c. BCE	2178*	10.2**	Henneberg, 1998
Urban Metaponto (Crucinia) 6th-3rd c. BCE	2093*	23.6**	Henneberg, 1998
Apollonia (Black Sea/ 5th-2nd c. BCE)	2939	7.7	Keenleyside (2008)
Corfu/ Classical to Hellenistic	381	7.9	Michael and Manolis (2014)
Corinth/ Roman Era	852	16	Fox (2005)
Corinth/Roman Era	**243**	**4.1**	**Current study**
Eleutherna/Crete/ 6th- 7th centuries CE	618	2.9	Bourbou (2003)
Messene/Peloponnese/ 6th- 7th centuries CE	632	3.6	Bourbou (2003)
Gortyna/Crete/ 6th-7th centuries CE	232	2.1	Mallegni (1988)
Kephali/Crete/ 6th-7th centuries C.E	156	8.3	Zygouri (2005)
Sourtara/Gree Macedonia/ 6th-7th centuries CE	699	4.7	Bourbou (2009, 2011)
Philotas/ Greek Macedonia/ 11th-12th centuries CE	527	8.1	Bourbou (2011)
Kastella/Crete/ 11th century CE	267	3.3	Bourbou and Richards (2007) Bourbou (2011)
Stylos/Crete/ 11th-12th centuries C.E	142	4.2	Bourbou (2009)

Fig. 1.



Dental caries/Teeth types
caries%
25
20
15
10
5
0
0
0
0
0
4.5
4/24
0.9
1/116
27.6
24/87
10.8
15/139
males
females
Incisors
Canines
Premolars
Molars
teeth types

Fig. 2.

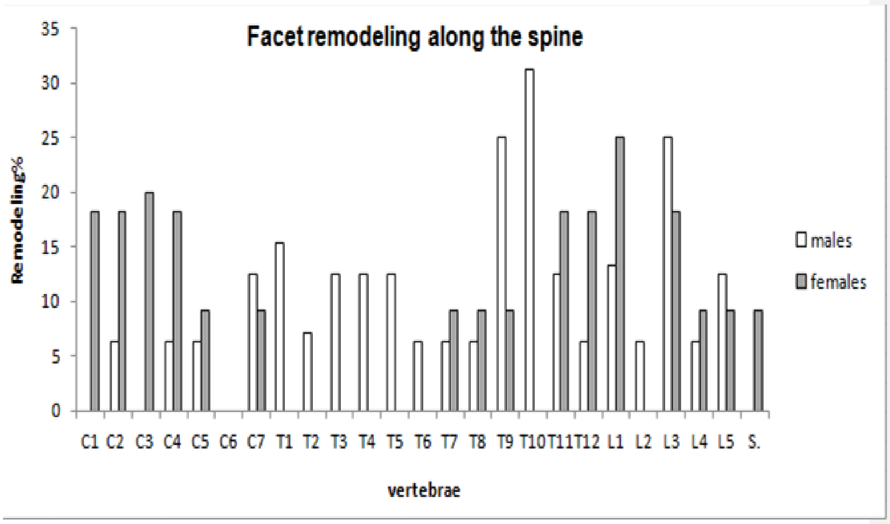
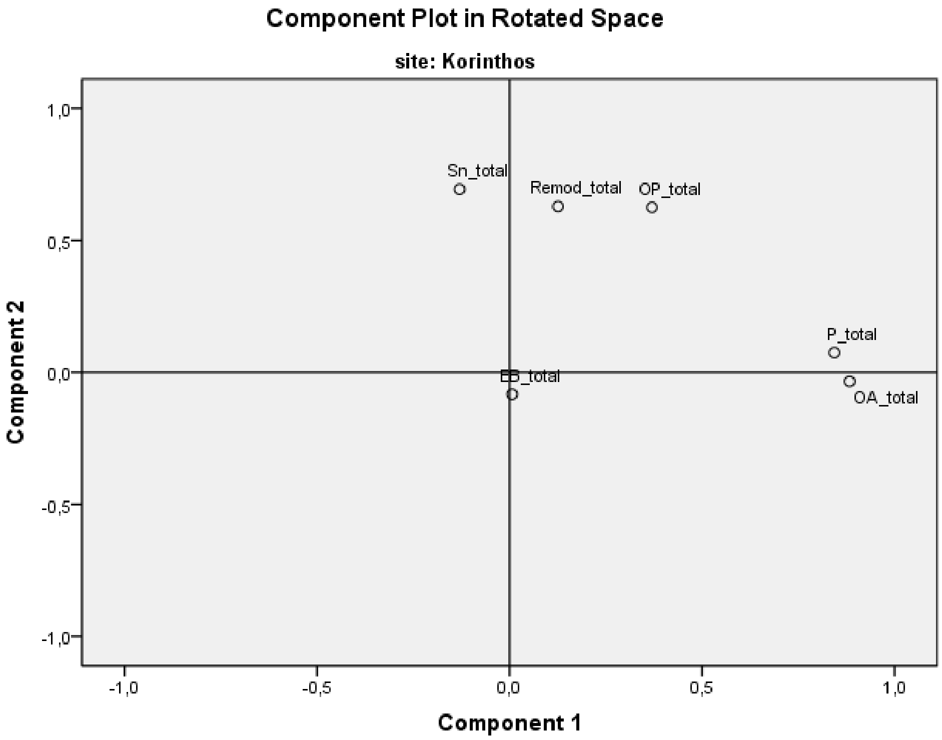

Facet remodeling along the spine
Remodeling%
35
30
25
20
15
10
5
0
C1 C2 C3 C4 C5 C6 C7 T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 L1 L2 L3 L4 L5 S.
vertebrae
males
females

Fig. 3



Component Plot in Rotated Space
site: Korinthos
Sn_total
Remod_total
OP_total
P_total
EB_total
OA_total
1,0
0,5
0,0
-0,5
-1,0
Component 2
-1,0
-0,5
0,0
0,5
1,0
Component 1

Fig. 4.