USING DENTAL CARIES AS A NUTRITIONAL INDICATOR, IN ORDER TO EXPLORE POTENTIAL DIETARY DIFFERENCES BETWEEN SEXES IN AN ANCIENT GREEK POPULATION

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ABSTRACT

Dental caries is commonly used to provide information about the diet of populations, both archaeological and modern. A skeletal sample of 32 adults from the site of Almyros in Corfu, dating from the late Archaic (7th century B.C.) to the 2nd century A.D., was studied for caries and ante-mortem tooth loss (AMTL) with a special interest in sex differences. According to archaeological information the population of Almyros had a poor economy with a minimal consumption of proteins and vegetables. Literary sources suggest sex discrimination in ancient Greek diet but no such difference was known until now in the population of Almyros. Therefore, the goal of this study is to explore possible dietary differences between sexes in the Corfu population using caries frequency, locations and degree as nutritional factors. According to our results females present a higher percentage of caries than males (13.6% females, 4.3% males) and a difference is noted on location and degree as well. However, the same difference is not noted in AMTL where males present slightly higher frequency than females. This study provides valuable data for the population of Almyros and highlights the significance of caries degree and caries locations in reconstructing diets of ancient populations.

INTRODUCTION

Bibliographic sources referring to the ancient Greek diet suggest sex differences as women had less access to the consumption of meat and other nourishing food items (Detienne and Vernant, 1989; Garnsey, 1999). However, literature from the site of Almyros in Corfu does not mention such difference between sexes (Magou *et al.*, 1997). Furthermore, no other data exist that could illuminate us regarding the dietary differences between sexes in that site, as no stable isotopic analysis or study of chemical elements was conducted separately for each of the two sexes; however an analysis of chemical elements does exist for the entire population (including both sexes). This specific analysis suggested a mixed diet for the population of Almyros (again for both sexes) with low amounts of both carbohydrates and proteins (Magou *et al.*, 1997). Therefore, the basic aim of this article is to try to explore potential dietary differences between sexes at the site of Almyros, in Corfu, using dental caries (frequency, location and degree) as a nutritional indicator. Secondly, another significant aim is to elucidate the kind of diet the population of Almyros had by examining the possibility of caries rates actually representing a mixed diet, as suggested by the element analysis (Magou *et al.*, 1997) and compare our dental results to those of other Greek studies.

Caries is a dental pathology and it is defined as 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). Eventually this can lead to pulpar necrosis and ante mortem tooth loss (AMTL). However, it must be pointed out that AMTL is caused by other factors as well, like periodontal disease and trauma (Hillson, 1996). Its differential etiology in archaeological samples has yet to be fully understood (Larsen, 1997).

Dental caries epidemiology is one of the most important ways in which the diet of past populations can be reconstructed (Hillson, 2001). In addition, caries is the most common pathology found in ancient human remains (Lanfranco and Eggers, 2010). Caries is directly associated with the consumption of carbohydrates, therefore in archaeological contexts caries can be used as a very useful tool in order to explore social differences between sexes or between individuals with different social status as they would have had an increased access to certain food items. It is also used to investigate dietary changes over time (Lillie, 1996). Dental caries has been widely studied in many populations all over the world, especially in populations of hunter-gatherers and agriculturalists and that is because this transition of subsistence strategy was accompanied by a higher frequency of oral pathologies and specifically of caries (Lukacs, 1996; Larsen, 1997; Hillson, 1996, 2001). Furthermore, studies have examined caries rates in different types of societies. According to these studies, hunter-gatherers present caries frequencies between 0%-5.3%, populations with mixed diets 0.44%-10.3% and agriculturalists from 2.2%-26.9% (Turner, 1978, 1979; Schollmeyer and Turner, 2004).

Consequently, one would expect that the consumption of more carbohydrates (for example in agricultural populations) would lead to higher frequencies of caries whereas the consumption of more meat and fish to lower frequencies of caries. Fluoride and strontium elements are found in high quantities in marine foods (Siebert and Trautner, 1985; Malde *et al.*, 1997) and are known to impede the formation of carious lesions (Keenleyside, 2008). However, recording caries frequencies is not alone a reliable indicator in order to make assumptions about the diet of a population. That is because the oral micro-flora is different according to the location in the mouth (Frostell *et al.*, 1967; Gibbons *et al.*, 1974). For example, in dental fissures the micro-flora is nourished by saliva and diet while in smooth surfaces the micro-flora is grown from the proteins and glycoproteins secreted along with the crevicular fluid (Lanfranco and Eggers, 2010). Therefore, the study

of carious location is essential in order to reconstruct the paleodiet of a population. The higher the carbohydrate ingestion is in frequency and quantity, the higher the probability that lesions are found in surfaces other than occlusal fissures and that the lesions tend to develop faster, reaching deeper dental tissues (Lanfranco and Eggers, 2010). It is therefore established that a low carbohydrate intake leads only to enamel caries whereas diets richer in carbohydrates lead to lesions that reach dentine or pulp (Nikiforouk, 1985; Seif, 1997; Perez *et al.*, 2005).

The earliest studies referring to ancient Greek skeletal samples were conducted by Angel (1944) before the 2nd World War who examined teeth from the Neolithic era until the Classical period. A sample from the Middle Minoan Period of 1498 teeth was studied by Carr in 1960. Hadjimarkos and Bonhorst in 1962 examined the relationship between dental caries and selenium and fluoride elements in both modern and archaeological samples. Samples from the Minoan civilization were used in two more studies; in 1975 by Becker (Kato Zakro, Middle Minoan) and in 1976 by Musgrave (Knossos, 7th and 8th c. AD). McGeorge (1992), studied a population from Khania and Armenoi from the Late Minoan Period and Musgrave and Popham (1991) examined caries in a population from Lefkandi (Iron Age). More recent studies (Henneberg 1998; Papathanasiou, 2005; Keenleyside, 2008; Vanna, 2011) dealt with various oral pathologies including caries.

Biocultural context of Corfu: To date two ancient cemeteries have been found in Corfu, the one at Almyros and the other at Garitsa. Magou *et al.*, in 1997 studied the material from both sites (Almyros and Garitsa) using 14 chemical elements (including strontium and zinc) in order to identify diet and socioeconomic status of the people from both sites. The findings from the study of strontium and zinc showed that Almyros was a closed economy with agriculture being the main activity of the residents and a diet that consisted of small amounts of proteins (mostly from seafood) and small amounts of vegetables (both strontium and zinc= 152.6 ppm). In contrast, people from Garitsa developed a populous society based on handicrafts and exportations with a rich diet especially enriched with seafood (strontium= 318 ppm, zinc= 269.7 ppm). Unfortunately, the stage of preservation of the bones from Garitsa was poor, not enabling us to collect any useful dental data. There was no separate analysis using zinc and strontium for males and females for the site of Almyros or the one from Garitsa, therefore we cannot be certain about the potential dietary differences between sexes in either of the sites. Lastly, we cannot safely assume that people in Almyros (or in Corfu in general) had the same diet in such a long period of time (7th century B.C. - 2nd century A.D.), as no archaeozoological studies have been carried out in that site. Therefore, we cannot be certain about the types of animals exploited by this population. Moreover, the chemical analysis of Almyros dealt with the same population we studied, therefore the results from zinc and strontium refer to this entire period of time.

Symposia and Sacrifices: On the other hand, bibliographic sources clearly refer to women having less access to animal proteins than men and specifically in two occasions that were very important in the lives of the ancient Greeks, in Symposia and Sacrifices. Greeks showed a particular interest in Symposia where, apart from eating and drinking, philosophical issues were discussed (Pingiatoglou, 2010). In the ancient Symposia, animal proteins (meat and seafood) were consumed as well but only men had the right to attend and participate, with the exception of courtesans who were supposed to entertain males and they definitely did not join them during the food consumption process. However, in Symposia males were also exposed to carbohydrate-rich alcoholic beverages and foods as well, therefore we cannot be certain that Symposia could lead males to present lower frequencies of caries. In contrast, we can be more certain about the influence that

meat from sacrifices had on the ancient Greek diet. In both Archaic and Classical Periods, Greeks had a frugal diet as meat was rare and consumed almost only after sacrifices (Pingiatoglou, 2010). In sacrifices, particularly in blood ones, women could not function fully as adults with equal rights and that was due to the fact that a meat-eating diet was connected with political practice. Most of the times after sacrifices, when and if women had access to meat they were third in the hierarchy behind their husbands and sons (Detienne and Vernant, 1989).

Therefore, even though there are no specific data supporting the idea of dietary differences between males and females at Almyros in Corfu, on the basis of the information presented above we cannot exclude the possibility that males had preferential access to animal proteins, specifically to meat. As we have mentioned according to results from chemical elements the Almyros population had a poor diet which was mainly based on small amounts of carbohydrates and animal proteins (mainly from seafood). However, we can safely assume that people from Corfu and specifically from Almyros engaged in ancient Greek traditions such as sacrifices, which were the main source of meat during the Archaic and Classical Periods. It is also known that ancient Greeks were quite respectful of their Gods, regardless of their socio-economic status and that religious celebrations that included blood sacrifices were major events in Greek societies. In Corfu, the most significant ancient temples were built in the 7th and 6th centuries B.C. and they were dedicated to Hera, Artemis, Apollo and Dionysus. It is safe to assume that in the temples sacrifices took place and women were lower in the hierarchy of meat-eating (as was common in other parts of Greece), thus consuming less meat or meat of lower quality (the best parts were consumed by their husbands and sons who ate first). Consequently, even though there is no information of deviation in diet specifically between sexes at Almyros, based on what was happening on other parts of Greece we can assume that women in Almyros probably consumed less meat than men and thus lower amounts of animal proteins.

Nevertheless, different access to specific foods between sexes is not the only reason causing higher caries frequency to females. Apart from the social factors analyzed above, there are also very strong behavioral and biological factors that could contribute to a higher caries frequency in females. Consequently, if we take into consideration all the factors mentioned above, such as differential access to specific foods (especially to meat) in ancient Greek diet in general, behavioral and biological factors, we can expect that females would probably present higher caries rates than males at Almyros.

MATERIALS AND METHODS

A total of 60 skeletons were exhumed from the two cemeteries in Corfu (28 from Garitsa and 32 from Almyros). Unfortunately, we are in no position to know the total number of teeth recovered from these sites. As mentioned above, the skeletal remains from Garitsa were in a very poor condition and it was impossible to make a satisfactory dental study, therefore only the site from Almyros was studied.

The cemetery of Almyros is located in the north of the island and it extends to the coast by the same name. According to archaeological information it belonged to an expanded settlement or settlements. The dating of the cemetery according to the findings of the graves classifies it between the late Archaic Period (7th century B.C.) and the 2nd century A.D. The condition of the bones which were found in sandy soil was very good (Preka-Alexandri, 1988).

Thirty two adult skeletons were examined in this study, 18 males and 14 females and a total of 381 teeth. Sex determination of the skeletons was conducted using the morphological and metric criteria of the skull and pelvis (Bass, 1987; Buikstra and Ubelaker, 1994). Age estimation was based on pubic symphysis morphology, the au-

ricular surface and the sternal end of the ribs (Byers, 2005). Individuals were separated in three age groups: young adults (20-35), middle adults (36-50) and older adults (51+).

Teeth were recorded according to the FDI tooth numbering system. Dental caries was assessed by macroscopic examination and a dental probe. Dental caries was recorded according to the 'Standardized System for Recording Dental Caries in Prehistoric Skeletons' by Metress and Conway (1975). According to this system: **1**) the frequency of dental caries is calculated separately for the maxilla and mandible, **2**) three categories of missing teeth are recorded, post-mortem loss, ante-mortem loss and section of tooth row missing, **3**) five locations are recorded, i) occlusal, ii) buccal/labial, iii) mesial, iv) distal and v) lingual, **4**) the occurrence of the decay of the neck is noted as present or absent, **5**) the degree of involvement of carious lesions is noted as follows; degree 1 pit or slight fissural start of lesion; 2, lesion ranging from more than the first degree involvement to involvement of less than one half of the tooth crown; 3, destruction of one half or more of the tooth crown; 4, complete destruction of enamel with only the root socket remaining.

All frequencies of dental caries were calculated according to present teeth with the exception of the frequency of caries per individual. We performed the Pearson chi-square test (p<0.05) to examine if our variables are related to each other in a significant way and we also used nonparametric tests (as our variables did not follow a normal distribution) to compare independent groups: 1) Mann-Whitney U test to compare males and females (p < 0.05) and 2) the Kruskal-Wallis test to compare age groups (p< 0.05). All the analyses were performed using SPSS (Statistical Package for the Social Sciences) version 21.

RESULTS

According to the recording method of Metress and Conway (1975) described above, the total number of potentially pre-

sent teeth is 1024, from which 381 (37.2%) are actually present and 35 (3.4%) are lost ante-mortem (Table 1). From the 381 present teeth, 234 belong to males and 147 to females (Table 2). The distribution of teeth between age groups is also presented.

Table 1. Number of teeth in relation to presence post-mortem and ante-mortem tooth loss.

	Frequency (No of teeth)	Percentage (%)
not present*	460	45
post-mortem	148	14,5
ante-mortem	35	3,4
present	**381**	37,2
total	1024	100

* as not present we recorded the teeth which their entire section row was missing.

Table 2. Number of teeth present in relation to sex and age

	20-35	36-50	51+	Total
Males (N. of teeth)	148	58	28	**234**
Percentage (%)	63.2	24.8	12	100
Females (N. of teeth)	97	50	0	**147**
Percentage (%)	66	34	0	100

Females present a higher percentage of caries, 13.6 % (20/147) compared to males 4.3% (10/234) and the difference between them is statistically significant (p=0.001) (Table 3). The total percentage of dental caries for the entire population is 7.9% (30 teeth out of 381). We also estimated the frequency of dental caries according to the total number of individuals (of the 32 individuals that were studied). Therefore, the Almyros cemetery population examined presents a frequency of 46.9% (15 out of 32 individuals). Females show a percentage of 57.1% (8/14 individuals) and males 38.8% (7/18 individuals).

Table 3. Frequencies of dental caries and caries locations in relation to sex

	Males	Females	Total
Number of carious teeth	10/234	20/147	30/381
Percentage (%)	4.3	13.6	7.9
Mann-Whitney U	p= 0.001		
Location of cari-	Males	Females	

ous lesions		
Occlusal (%)	1.7	4.8
Buccal (%)	1.3	2.0
Lingual (%)	0	0
Mesial (%)	0.9	2.7
Distal (%)	0.4	4.1
Chi-Square	0.548	**0.05**
Mann-Whitney U	**p= 0.001**	

Males present the highest percentage of dental caries in the occlusal surface (1.7%) and secondly in the buccal surface (1.3%). Females also present their highest rate in the occlusal surface (4.8%) but they also present high percentages in the extra-occlusal surfaces, 4.1% in the distal surface and 2.7% in the mesial surface (Table 3). The statistical difference between sexes is significant (Mann Whitney U, p=0.001). There is no significant difference between males and location (chi-square, p= 0.548), whereas a significant difference is noted between females and location (chi-square, p= 0.05) (Table 3).

The examination of caries degree demonstrates that females have higher rates in all four degrees. An interesting finding is that males only have the first two degrees of caries (degree 1= 3% and degree 2= 1.3%), whereas in females we found all 4 degrees. Females present their highest rate in degree 1 (7.5%) and degree 2 (3.4 %). However, in both degree 3 and 4 they present equal percentages (1.4%) (Table 4). Again the difference is statistically significant between sexes (Mann Whitney U, p=0.001). The difference between degree and males is not statistically significant (chi-square, p= 0.095) while in females it is so (chi-square, p= 0.05) (Table 4).

Table 4. Frequencies of caries degree between sexes

	Percentage %	
Caries Degree	males	females
Degree 1	3	7.5
Degree 2	1.3	3.4
Degree 3	0	1.4
Degree 4	0	1.4
chi-square	0.095	**0.05**
Man Whitney U	**0.001**	

We also examined the presence or absence of caries in the neck of the teeth. Males showed no presence, however females presented 2.7% presence of neck caries (chi-square, p=0.264). The difference is also statistically significant (Mann Whitney U, p=0.011) between males and females.

Table 5. Frequency of dental caries in relation to age (for both sexes)

	20-35	36-50	51+
N. of teeth	16(245)	11(108)	3(28)
Percentage (%)	6.5	10.2	10.7
chi-square	0.197	0.175	0.901
Kruskal-Wallis		p= 0.343	

Table 6. Frequencies of AMTL in relation to sex and age

	Males	Females
AMTL		
Percentage (%)	54.3	45.7
Mann Whitney U/KW		p=1.00
	Both sexes	
AMTL	20-35	36-50	51+
Percentage (%)	42.9	34.3	22.9
Mann Whitney U/KW		p=1.00	

Furthermore, we examined the relationship among carious teeth and age groups for both sexes together (Table 5). The oldest group of 51+ presented the highest rate 10,7% (3 out of 28 present teeth), the group 36-50 followed with 10,2% (11 out of 108 teeth) and lastly the youngest group presented the smallest percentage 6,5% (16 out of 245 teeth). In this case, the difference between age groups was not statistically significant (p=0.343).

Lastly, we also examined AMTL in relation to sex and age. A total of 35 teeth were lost ante- mortem, as mentioned above. Males present a higher rate of AMTL compared to females, however the difference between them is not statistically significant (males= 54.3% (19/35 teeth) females= 45.7% (16/35 teeth), p=1.00) (Table 6). Comparing the three age groups (for both sexes), 42.9 % (15/35) which is the highest percentage is found in the youngest age group of 20-35. The group of 36-50 comes next with 34.3% (12/35) and the oldest age

group 51+ comes last with 22.9% (8/35). There is no statistically significant difference between these age groups (Kruskal-Wallis, p=1.00).

DISCUSSION

Different methodologies in diagnosing and recording dental caries make it difficult to compare our results with the ones from other studies (Hillson, 2001). Another difficulty we face is that very few studies have been conducted to examine dental pathology in ancient Greek populations and even fewer that deal with sex differences. However, we believe that our results merit discussion and comparison with those of other studies based on Greek samples.

We calculated the total percentage of caries in the population of Almyros at 7.9%. According to the frequencies defined by Turner (1979), our percentage falls within both the mixed diet (0.44-10.3%) and the agricultural diet (2.2-26.9%) but we can propose that the diet of people at Almyros was closer to the mixed one. According to Magou *et al.*, (1997), the mean values for both strontium and zinc elements are exactly the same (152.6 ppm). Strontium is a typical element that is used as a dietary discriminant (Toots and Voorhies, 1965; Brown, 1973). It appears in much higher concentrations in vegetarians than in the meat-eating populations. However, when the diet of a population consisted mostly of seafood, the amount of strontium is higher than in vegetarians (Schoeninger and Peebles, 1981; Kyle, 1986).

Zinc on the other hand, is considered as the main dietary indicator of proteins and therefore its presence is related to a great consumption of meat, seafood, walnuts etc. (Rheingold, 1983). Consequently, it seems that people from Almyros had a balanced diet between proteins and carbohydrates. According to Magou *et al.*, (1997) the population of Almyros seemed to be poor with a low level of production. They might have been consuming small amounts of proteins (mostly from seafood) and their main plant product might have been roots. This balance between carbohydrates and proteins seems to be verified by the intermediate rate of caries in our population. Our caries rate is closer to the one of the Greek colony at Apollonia (5th to 2nd centuries B.C.) on the Black Sea, which was 7.7% (Keenleyside, 2008). It is also very close to the rate found at Kato Zakro (Middle Minoan), at 7.2% (Becker, 1975) and to the Hellenistic population from Demetriada (Vanna, 2011), at 8.6%. In comparison with the Classical sample that Angel (1944) studied, the frequencies are not so far (5.0%). The frequency of caries at Corfu differs the most from Khania (Late Minoan) 36.9% and Armenoi (Late Minoan) 17.7 % (McGeorge, 1992).

According to our results females present a significantly higher frequency of caries compared to males (females 13.6% - males 4.3%). Furthermore, females show higher rates of caries degree. Degrees three (3) and four (4) are the ones that involve lesions which reach the dentine and the pulp cavity and suggest a diet richer in carbohydrates. Only females show percentages in degrees 3 and 4 and in addition, females are the only ones to present carious lesions at the neck of the teeth. Lastly, females present more carious lesions in surfaces apart from the occlusal ones. When we compare our results with those of other studies we see that at Metaponto, a Greek colony in Italy (7th-2nd centuries B.C.), females also show significantly higher rates of caries (64%) than males (46%) (Henneberg and Henneberg, 2003). This significant difference was also verified by stable isotopes analysis in the population at Metaponto. In contrast, at the Greek colony of Apollonia females showed slightly more caries than males but this difference was not statistically significant, suggesting that both sexes had a similar diet (Keenleyside, 2008). The same low prevalence of caries in females was also found in Hellenistic Demetriada where females presented a frequency of 8.8 % and males of 8.5% (Vanna, 2011).

Females in general tend to present higher rates of caries in both modern and archaeological samples (Walker and Hewlett,

1990; Hillson, 2001). Earlier eruption of teeth, biocultural differences, changes in salivary composition during pregnancy and lactation are the main factors of this difference between sexes (Larsen, 1997; Walker and Hewlett, 1990; Laine, 2002). The main biological factors include saliva, hormones and pregnancy which are considered to be critical etiological forces contributing to sex differences in dental caries rates (Lukacs and Largaespada, 2006). Moreover, the higher rates of caries in females can also be attributed to behavioral and cultural factors. According to Larsen *et al.* (1991), women who are restricted mainly to household activities tend to eat more frequently during the day especially when preparing the meals for their family. In contrast, males who engage in much more outdoor activities tend to eat more stable and defined meals. Therefore, women increase in this way the possibilities to have residuals remaining in their mouths and prolonging the time of exposure to bacterial reactions (Larsen *et al.*, 1991; Hillson, 1996).

The economy of Almyros was closed and poor, therefore it was probably a traditional society where women were restricted to their homes spending their time preparing meals and taking care of their children. Therefore, we cannot attribute the higher rate of caries in females only to nutrition. Both behavioral and biological factors can contribute to this difference as well. The fact that females also present higher caries degree and presence of lesions in more extra-occlusal surfaces (including carious lesions at the neck) seems to support the idea that women possibly had a more carbohydrate-dependent diet. This is supported by studies that report that higher carbohydrate intake leads to deeper lesions and lesions in other surfaces than occlusal ones (Lanfranco and Eggers, 2010).

The best cariogenicity markers are caries depth / degree and location. The most direct indicators of cariogenicity and thus to carbohydrate dependence are dentine caries (caries that reaches the dentine) and extra-occlusal lesions (Lanfranco and Eggers,

2010). Caries depth/degree reflects the relative rate of formation and chronicity of carious lesions (Seif, 1997). Furthermore, occlusal lesions can provide information but they can be eliminated by extensive dental wear and progress to pulp exposures (Lanfranco and Eggers, 2010). Experimental animal models suggest that sucrose, sucrose combined with starch and fructose, stimulate the production of smooth surface lesions (lingual and buccal) whereas maltose and simple starches preferentially cause neck lesions (Frostell *et al.*, 1967).

Lastly, experimental research on animals showed that the longer the duration of sucrose intake, the greater the severity of approximal (distal and mesial) and smooth surface caries (lingual and buccal) (Frostell *et al.*, 1967; Seif, 1997; Love and Jenkinson, 2002). Consequently, the fact that females present greater depth (degrees 3 and 4) of caries and more lesions in extra-occlusal surfaces (higher frequencies in buccal, mesial and distal surfaces plus neck lesions) strongly indicates a more carbohydrate-dependent diet than that of males.

While examining ante-mortem tooth loss we found a total frequency of 3.4% (35 teeth). Males presented a higher frequency in AMTL than females, even though this difference is not statistically significant. If intake of cariogenic food can be claimed to be a direct causative factor in the prevalence of ante mortem 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 AMTL (Hillson, 1996; Larsen, 1997).

Consequently, AMTL rates alone are not a safe way to explore dietary habits in past populations. This difference between sexes seems to agree with the Greek colony at Apollonia, where males also presented higher AMTL rates than females (Keenleyside, 2008). Angel (1944) in his broad study

of Greek teeth from the Neolithic Era until Modern times also examined AMTL. He found frequencies from 8.5% (Middle Bronge Age) to 18.4% (Cephallenia 1200-1000 B.C.). Papathanasiou (2005) also found a high frequency in AMTL in Alepotrypa (Neolithic period) 18.4% (14 out of 76 individuals). Therefore, our percentage (3.4%) is quite small and probably could lead us to the assumption that the general dental health was good for the Almyros population, especially if we take into consideration that teeth from this site did not present high rates of dental wear.

Few studies have been conducted with reference to the ancient Greek populations and their social differences associated with nutrition between males and females. This study contributes significantly to our knowledge of the ancient Greek diet as it offers new dental data for this period of time and this specific area. Until now no dietary differences were known between males and females at the site of Almyros. However, this study identifies strong indications that females actually had a more carbohydrate-dependent diet. Furthermore, this study is not only focused on caries rates as most studies, but to caries degree and caries locations as well, which is essential when using caries as a nutritional indicator. The study of caries degree and especially of caries locations is still not so common globally (Lanfranco and Eggers, 2010) and is even rarer in Greek populations, making the present research unique and thus valuable.

CONCLUSIONS

The analysis of caries rates and specifically the study of depth/degree and location of lesions can provide an insight about diet and dental disease in populations of the past and offers proof of the series of socioeconomic, biological and behavioral factors that are involved in oral pathology (Cucina and Tiesler, 2003). In contrast, AMTL alone cannot be considered as a safe nutritional indicator as it is associated with many other factors apart from diet. The prevalence of dental caries at Almyros seems to agree both with the archaeological data and the study of chemical elements (zinc and strontium) that suggested a mixed diet. Our results from the analysis of caries rates, locations and degree of carious lesions also tend to agree with the bibliographic sources referring to sex differences in diet among the ancient Greeks but we cannot definitely attribute the ascertained caries difference only to nutrition and ignore other factors like behavioral and biological.

Unfortunately, we have no other data deriving either from stable isotope or element technique for each of the two sexes in order to be certain about differential access to food between them. Nevertheless, the results from caries degree and caries locations combined offer strong indications of females having a more carbohydrate-dependant diet and reveal the important part that caries, especially degree and location, can play in reconstructing the diet of past populations.

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