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BONE LOSS OF THE ANCIENT MEDITERRANEAN LUMBAR VERTEBRAE: IASOS, 6TH CENTURY AD

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ABSTRACT

Evaluation of bone mineral density (BMD) of the ancient peoples has received great interest by anthropologists. The aims of this study are to investigate the lumbar vertebrae of the Iasos people during the Byzantine period, in order to determine the prevalence of bone loss and to interpret dietary conditions of ancient Mediterranean populations. Lumbar vertebrae belonging to twenty eight skeletons of the 6th c AD were analyzed by radiographs and dual energy X-ray absorptiometry. The BMD values for each biologic sex and age group were compared. The correlation between the BMD and radiological features was also analyzed. The mean BMD was 0.940 g/cm^2. BMD was decreased by aging in both sexes, but it was not significant. Osteopenia was found in 11 (39%) and osteoporosis in 4 (14.3%) out 28 vertebrae. The BMD was normal in 13 (46%) out of 28 vertebrae. Osteopenia was present in 7 (38%) of 18 male vertebrae and 4 (40%) of 10 female vertebrae. The spine score was high in the male group and there was a strong positive correlation between the BMD and spine score for both sexes. This study revealed that the BMD decreased by aging and that osteopenia was a problem in both sexes of the Iasos people during the 6th c AD. There was no correlation between the BMD and radiological features for age groups and biological sexes.

KEYWORDS: Iasos; Bone loss; Byzantine period; Vertebrae; Mediterranean diet

1. INTRODUCTION

Iasos is located on a peninsula, surrounded by sea on three sides, within the Kiyikislacik village, 28 km. from Milas (Akarca and Akarca, 1954). According to Thucydides (1910), it was set up by Pelopolonnesians arriving from Argos, in the 5th century BC and was named Iasos. This city was originally founded on an island which, with the filling up of the isthmus, became a peninsula. The major buildings of the city are located on the peninsula. The necropolis and a funerary monument in the form of a Corinth temple called by the local people as the "fish market" are outside of the walls which are thought to date from the Hellenistic period (Bertocci, 2003). Because of its reach marble sources (Sevin, 2001), Iasos had been inhabited since the early bronze age (Baldoni, 2004; Berti, 1988). According to Strabon, Iasos has a harbor; and the people gain most of their livelihood from the sea, for the sea here is well supplied with fish, but the soil of the country is rather poor (Strabon, 1924).

The site of Iasos has been settled continuously since the Early Bronze Age (Alpagut, 1988). Levi (1986) and Laviosa (1958, 1977) suggested that the site's inhabitants enjoyed close contacts with the Aegean islands, and especially with Minoan Crete. They also suggested that Iasos was a Minoan colony going back to 1900 BC. Iasos became of a member of Attica-Delos sea league at 5th c. BC (Hornblower, 1982). Persian Empire ruled Iasos between the 5th and 4th c. BC (Hornblower, 1982) and governed by Amorges, a Persian noble (Herodotos, 1920). During the Peloponnesian war, Iasos was attacked and sacked by the Spartians and all the inhabitants were slaughtered or sold into slavery (Thucydides, 1910).

After Spartian power in the Aegean was destroyed by Conon in 394 BC (Straus, 1984), Iasos was rebuilt, possibly with the aid of Knidos, and it joined a league of Aegean states that included Ephesos, Rhodes, and Samos. Following the Peace of Antalcidas in 386 BC (Underhill, 1896), Iasos was dominated by Hekatomnos, later by Mausolos and the satrapy of Caria (Rhodes, 2010). Iasos was later liberated by Alexander the Great (Rhodes, 2010) , but in 125 BC, it, along with all of Caria, became part of the Roman province of Asia. City of Iasos survived throughout the Roman and Byzantine periods (Ozer, 2007). In Late Roman times, Iasos flourished into a center of the Christian faith and a bishopric under the metropolis of Aphrodisias.

Among the bishops of Iassos, Themistios (421), Flacillos who participated in the Synod of Chalcedon (451), David (787) and Gregory (878) are known (Laviosa, 1977). In the 6th c. AD, Iasos has an important and strategic position related to the fleet that was stationed in the region as part of the defensive-administrative system of *Quaestura exercitus* established by Byzantine Emperor Justinian (Maas, 2005) (Figs. 1 and 2). Iasos gradually declined in the Ottoman period.

Figure 1: The extent of the Byzantine Empire at the 6th century A.D.

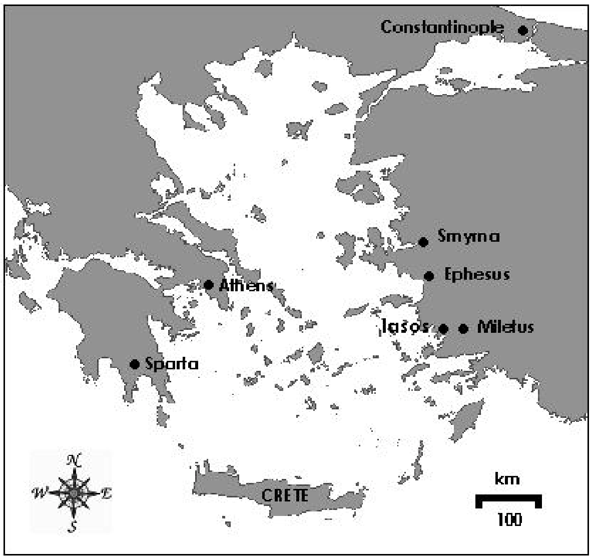
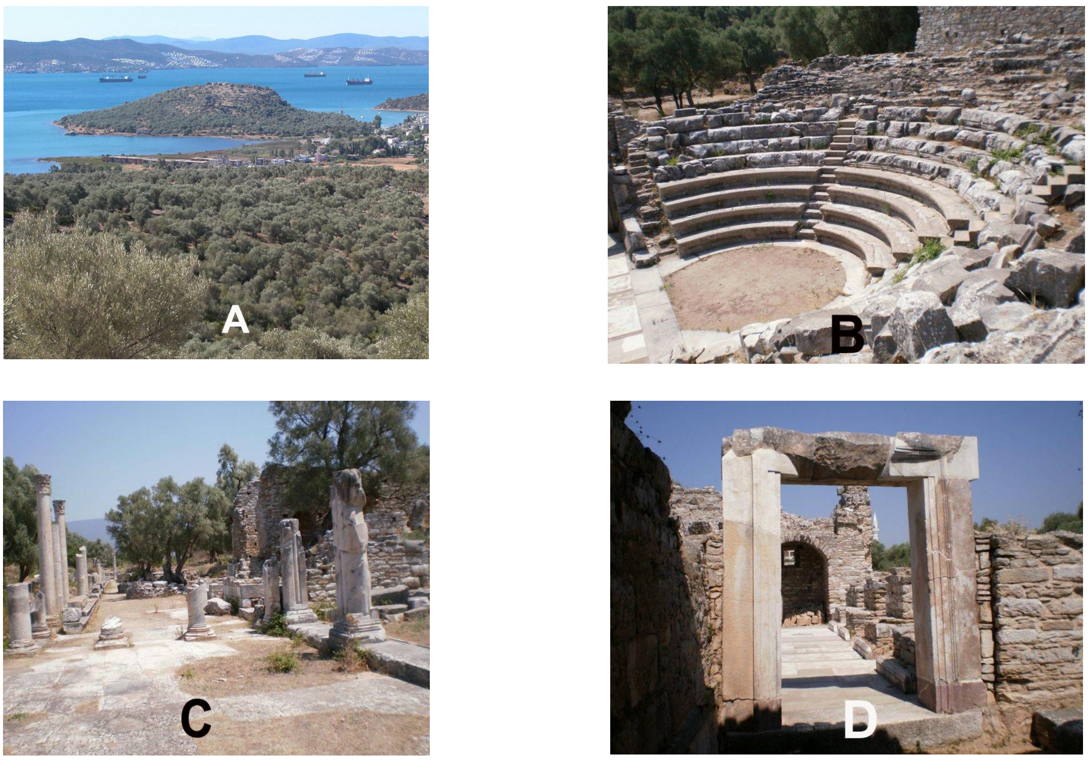


Figure 2: Important cities at the both sites of Aegean sea during the Justinian period.

In early times, Iasos was influenced by the Greek culture of the Cycladic islands.

Outstanding remains in Iasos include an Artemis stoa and Roman villas (Berti, 1986, 1987, 1987). The main deities of Iasos seem to have been Apollo and Artemis (Bean, 1987). One of the inscriptions discovered in Iasos mentions Artemis Astias, apparently a mixture of old Carian deity Goddess with Artemis the hunter. On the other side, theatre and festivals arranged for Dionysus shows also the importance of god Dionysus in Iasos. This Dionysean festival made Iasos a musical and drama center (Vicogliosi, 1958). Among the noteworthy monuments unearthed, there are the agora which has been partly excavated, the well preserved Odeon dated to the Roman Imperial Period, the Ceasarium where main deities of the city were worshipped, the ruins of a Roman theatre dedicated to Dionysus and to the people of Iasos, a Roman villa where the Italian team discovered the remains of Roman Mosaics and frescoes, and a shrine dedicated to Demeter and Kore (Berti, 1987). Some of the coins discovered at Iassos show the dolphin and a young boy. This reminds us of the story of a young boy who was befriended by a dolphin, a story both mentioned by Plinius (Plinius, 1669) and Aelian (Aelian, 1997). According to Plinius, Alexander the Great was so charmed with the story of Dolphin and young boy, that he took the youth along with him on his campaign to Asia and made the boy the head of the priesthood of Poseidon, the god of Sea (Baldoni et al., 2004).

After some preliminary research by Charles Texier (2002) in 1835, the site of the settlements in Iasos has been excavated regularly by the Italian School of Archaeology at Athens under the directorate of Doro Levi (1960-1972), Clelia Laviosa (1972-1984) and Fede Berti (1984-). The excavations started in 1960s by Doro Levi and revealed that the oldest part of Iasos was on the top of the Acropolis hill. The city is mainly situated on the rocky peninsula (Fig. 2) with the exception of the city walls and necropolis. There are numerous Roman buildings, including an agora, theatre, aqueducts, cisterns, gymnasium, baths and a bouleuterion in the city. An ancient harbour wall and a tower are in the sea (Fig. 2). The necropolis is situated on the mainland (Serin, 2005). Italian archaeologists have found Minoan houses and Mycenaean pottery which indicates that the site had been inhabited at a much earlier date than the arrival of later Greek peoples. The archaeological excavations revealed that the earliest occupation dates back to the end of 3000 BC (Levi, 1986).



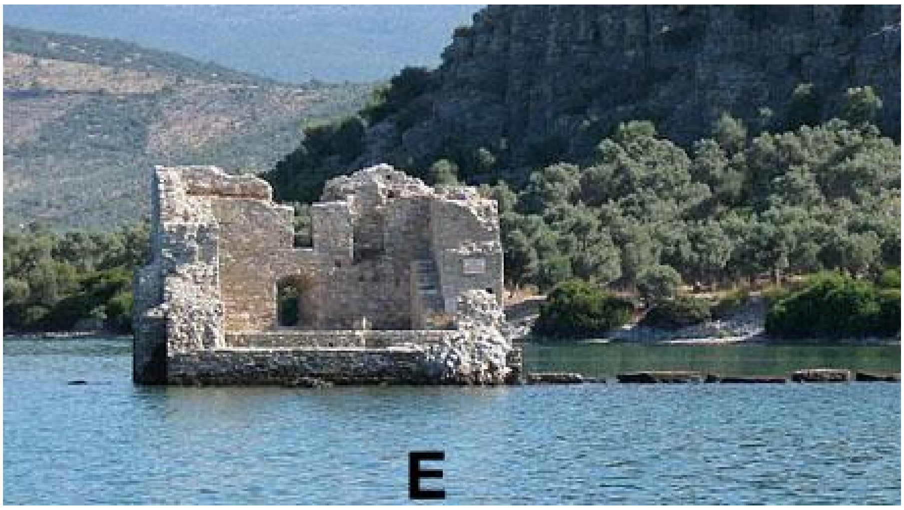


Figure 3: Iasos is located on a peninsula (A). There is a bouleterion found in the northern part of the site (B). The colonnade at Iasos (C). The entrance of bouleterion from the agora (D). Byzantine tower constructed near the peninsula (E).

Histomorphometry is useful in the assessment of trabecular bone mass and thus, in the estimation of the prevalence and intensity of osteopenia in ancient populations. The use of nondestructive methods, such as double-energy X-ray absorptiometry (DEXA) is preferred in the determination of bone density and the diagnosis of osteopenia and osteoporosis in ancient skeletons. Bone mineral density (BMD) assessed by DEXA accurately estimates the bone mass in living individuals. This method is usually employed in the diagnosis and follow-up of osteopenia or osteoporosis (Kanis et al., 1994). DEXA is preferred, in ancient skeletons, to the more invasive and destructive histomorphometrical assessment of trabecular bone mass in undecalcified bone samples (González-Reimers et al., 2002).

The aims of the present study are to try to characterize the bony structure of Iasos people the people of Iasos solely from the lumbar vertebral material, and to construct a database on spinal BMD for future comparative studies of large skeletal populations. The lumbar vertebrae were selected for 3 reasons. First of all, the most preserved vertebrae of the unearthed skeletons were the lumbar vertebrae. Second, the baseline values of the DEXA measurement system has been developed according to the normal human lumbar vertebrae. Third, the lumbar vertebrae are the most appropriate bones to show the bone loss in the human body (Blake and Fogelman, 2010).

2. MATERIAL AND METHODS:

All the relatively well preserved lumbar vertebrae of adult Byzantine individuals (lumbar vertebrae having both body and neural arch, with ring epiphyses fused) who lived in Iasos, a total of 28, were studied. The Byzantine cemetery was excavated by Dr. Laviosa and Dr. Berti between 1979 and 1987.

Approximately 300 graves were excavated and 262 skeletons of human individuals have been recovered. Twenty-eight (10.7%) of 262 skeletons were selected for the present study. The demographic features of 262 skeletons, which were unearthed from this site, could not be provided due to the lack of integrity of all skeletons. Bones required for sex and age discrimination, such as skull and pelvis could not be obtained in all skeletons.

These 28 vertebrae were intact, and the entire skeletons of 28 individuals from which the vertebrae were obtained had age and sex indicators preserved. The principal technique for estimating the age of death was dental wear (Brothwell, 1981). Wear stages were recorded using the system of Brothwell (1981) taking into account recently suggested modifications. Brothwell system for scoring surface wear in molars is useful for age determination.

Dental wear has been demonstrated to be a reliable means of estimating age in a variety of populations, both living and death (Mays et al., 1995). This information allowed the skeletons to be classified into four age groups such as:

young adult (18-25 years), middle adult (>25-35 years), late adult (>35-45 years) and maturus (>45 years). Sexes were determined using dimorphic aspects of the pelvis and skull (Cox and Mays, 2006).

Five (17.9%) vertebrae were from young adults, 18 (64.3%) were from middle adults, 2 (7.1%) were from late adults and 3 (10.7%) were from maturus groups. Eighteen (64.3%) of them were male and 10 (35.7%) were female skeletons. Three vertebrae were from L1, 17 (60.7%) were from L2, 5 were from L3 and 2 were from L4 levels.

The distribution of the vertebrae among age subgroups and biological sex subcategories is given in Table 1.

Table 1: The distribution of the vertebrae according to the age and sex groups.

		Age groups				Biological sexes	
Level	Number	Young adult	Middle adult	Late adult	Maturus	Male	Female
L1	4	2	2			1	3
L2	17	3	10	2	2	13	4
L3	5		5			3	2
L4	2		1		1	1	1

The sample may not be as adequate in some areas of this study. For each vertebra, the following examinations were performed:

Radiographic examination:

Anteroposterior and lateral radiographs of each vertebrae were obtained. Vertebrae were classified into four groups regarding the degree of preservation of trabecular pattern, such as: normal trabecular pattern (Grade 1), mild affection (Grade 2), moderate affection (Grade 3) and severe loss of trabecular pattern (Grade 4) (Gonzales-Reimers et al, 2004). The osteophyte formation was noted morphologically and radiologically as none osteophyte, mild osteophyte formation and significant osteophyte formation (Fig. 4).

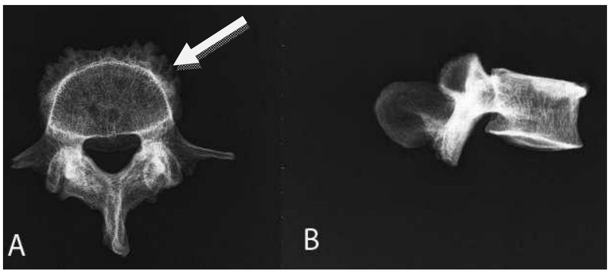


Figure 4: The axial (A) and sagittal (B) radiographs of a L2, middle adult, male individual showing significant osteophyte formation. Arrow indicates the osteophytes.

Presence or absence of central body collapse was assessed by the calculation of spine score: 2 x *m*(middle point of the vertebral body) / *a*(anterior height) + *p* (posterior height) (Gonzales-Reimers et al, 2004). Presence of wedge vertebrae, anteriorly collapsed vertebrae, was analyzed by calculating the wedge index (a/p) (Gonzales-Reimers et al, 2004). The prevalence of biconcave or wedge-shaped vertebrae was determined by these measurements. Biconcave vertebra was defined as spine score ≤0.80. The spine score and wedge index are documented in Table 2.

Table 2: Spine score and wedge index of the lumbar vertebrae.

Age-group	Number	Radiographic examination	
		Spine score (mean)	Wedge Index (a/p) (mean)
Female	10	0.909	0.908
Young adult	1	0.98	0.93
Middle adult	6	0.957	0.872
Late adult	1	0.98	1
Maturus	2	0.695	0.960
Male	18	0.956	0.899
Young adult	4	0.958	0.818
Middle adult	12	0.976	0.951
Late adult	1	0.91	0.76
Maturus	1	0.76	0.74

Absorptiometric examination:

DEXA was performed on all bone samples at the lumbar vertebrae (Fig. 5). Four levels were selected: L1,L2,L3 and L4. We determined the mean BMD (g/cm^2) of each of these vertebrae shown in Table 3. BMD was measured using a hologic QDR-4500 system (Barthe et al., 1997). According to World Health Organization criteria, osteopenia was defined as a T score <-1, and osteoporosis as a T score ≤-2.5 (WHO Scientific Group on the Prevention and Management of Osteoporosis, 2003, p.57). These parameters were used in correlation studies and contingency tables to calculate sensitivity and specificity of different BMD values in the diagnosis of osteopenia and osteoporosis.

Table 3: The documentation BMD measured by DEXA.

Age-group	Number	BMD g/cm^2	
		Mean	SD
Female	10	0.880	0.140
Young adult	1	0.671	-
Middle adult	6	0.965	0.099
Late adult	1	0.800	-
Maturus	2	0.769	0.110
Male	18	0.974	0.132
Young adult	4	0.987	0.087
Middle adult	12	0.991	0.148
Late adult	1	0.852	-
Maturus	1	0.842	-

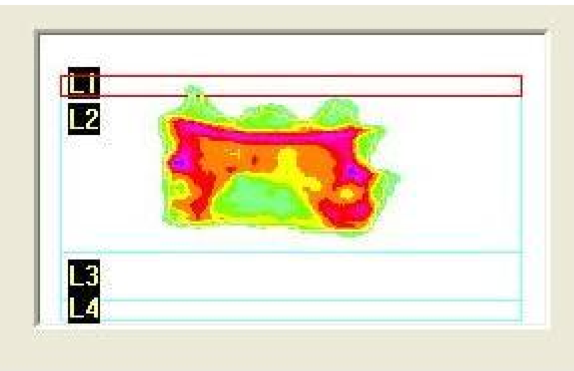


Figure 5: Ventral view of L2 vertebrae of a maturus female. The T-score is -3.1 indicating osteoporosis according to WHO classification.

The indices and the BMD values were compared according to the age groups and sexes by using the Chi-square test, Student's T test and Spearman rho correlation test (Jekel, 2007).

The spine score and the wedge index were compared between the biological sexes with Mann-Whitney U test. Osteophyte formation and trabecular pattern were compared between the biological sexes with Chi-square test.

The radiological features of the vertebrae could not be compared statistically for age groups because the samples were not adequate for the age groups.

The BMD and radiological features were also compared for biological sexes and age groups with Spearman's rho test. Computed tomography of the vertebrae, that were significantly osteoporotic, was also taken to show the bone loss in 3-dimensional images (Fig. 6)

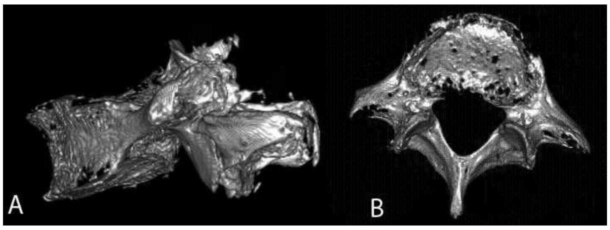


Figure 6: Computed tomography of a L2, female, late adult individual with three-dimensional reconstruction showing significant bone loss and osteophyte formation from a left sagittal (A), and (B) an (superior) axial viewpoint.

3. RESULTS:

The trabecular pattern was Grade II in 5 (17.9%) verterbrae, while grade III in 7 (25%) vertebrae and grade IV in 16 (57.1%) vertebrae. Osteophyte formation was not observed in 11 (39.3%) vertebrae, mild formation in 11 (39.3%) vertebrae and significant formation in 6 (21.4%) vertebrae.

Since age group and biological sex are both nominal variables not numerical, it is not possible to investigate the correlation between the radiological features of the vertebra and biological sex and age groups.

Mean values of BMD were (in g/cm^2): 0.880 for females and 0.974 for males (Table 3) Osteopenia was detected in 11 (39.3%) vertebrae and osteoporosis in 4 (14.3%) vertebrae. The distribution of bone pathologies among the vertebra levels are shown in Table 4. The BMD was normal in 13 (46.4%) vertebrae. The density of lumbar vertebrae, such as osteopenia, normal or osteoporosis, did not change with age ($p=0.273$) and with sex ($p=0.780$). The comparison was performed using Chi-Square test.

Table 4: The distribution of pathologies according to the vertebra levels.

Level	Normal	Osteopenia	Osteoporosis
L1	2	1	1
L2	9	6	2
L3	2	2	1
L4		2	

When the whole group is analyzed, BMD is decreased with age but it is not statistically significant when compared using Spearman rho correlation test (p=0.107, r=-0.311). BMD is also decreased with age in the female group and in the male group but this is also not statistically significant (for women, r=-0.178, p=0.622; for men,r=-0.269, p=0.281).

BMD is high in male group when compared with female group. The comparison was made using Student's T-test and this difference is not statistically significant. (p=0.091).

There was a statistically significant difference between the male and female groups with respect to spine scores. (Table 2) The spine score was found high in the male group when compared with the female using Mann Whitney-U test (p=0.035). Spine score was below 0.80 in 3 (10.7%) of 28 skeletons. These vertebrae were considered as biconcave, and the other 25 vertebrae were not biconcave.

There was no difference between the male and female groups for osteophyte formation (p=0.645), trabecular pattern (p=0.354) and wedge index (p=0.588).

There was a positive correlation between the BMD and spine score for male group (r=0.56, p=0.016) and for female group (r=0.70, p=0.025) and these scores were statistically significant.

There was a positive correlation between the BMD and spine score for the middle adults group (r=0.52, p=0.027) and this was statistically significant. There was also positive correlation between the BMD and spine score for the young adults (r=0.73, p=0.165), and maturus groups (r=0.99, p=0.069), but this was not statistically significant. No correlation has been detected for the late adults group because of sample limitations for this group.

There was no correlation between the BMD and other radiological features (trabecular pattern, wedge index and osteophyte formation) for age groups and biological sexes.

Spine score was high in male the group when compared with the female and this was independent from the age groups. This difference was observed when a correction was made for age by the Ancova analysis (Jekel, 2007).

4. DISCUSSION

This study shows that BMD decreased with age in both genders. Average BMD of the males was equivalent to that of females at all ages. There was a strong correlation between the BMD and spine score. The incidence of biconcave vertebra was very low. The other radiographic features were not correlated with BMD. Statistically insignificant results were due to small sample size for each group. Larger groups of vertebrae may provide more significant results. Based on radiographic and absorptiometric criteria on the total sample, the overall prevalence of bone loss (osteopenia and osteoporosis) in lumbar vertebrae of the adult Byzantine population of Iasos of any age was found 53.6 %. One of the limitations of the present study is that the samples may not be representative enough for the larger Byzantine population at Iasos. Only the best preserved lumbar vertebrae were selected for this study. New excavations are required to collect more skeletons and further researches with more skeletal remnants are needed to determine the bone loss and to identify the risk factors for osteoporosis among the Iasos people.

Iasos was excavated by the Italian Archeological Team since 1960, and 262 skeletons of 6th c. AD Byzantine period were found in the necropolis (Berti, 1986, 1987, 1988; Laviosa 1983, 1984, 1985; Levi, 1986). Only one morphometric study was performed on these skeletons until the present study by Dr. Alpagut in 1988. (Alpagut, 1988). There was no other physical or anthropological study on these skeletons. The bones, which were collected from the necropolis, were stored in the Department of Anthropology at Ankara University. The bones were preserved in dry iron boxes coded with a serial number showing the year of unearth. The spinal bones were not examined in detail especially for bone density and bone loss (Alpagut, 1988).

Excavations of ancient Iasos yielded bones in various states of preservation. Very often, scientists have to try to reconstruct the anthropological profile of the population from a huge mass of fragmentary bony material. Such as the case at Iasos cemetery, a necropolis in the city of Iasos. The cemetery, excavated between 1979 and 1987 by Dr. Fede Berti, is considered one of the important burial sites of the Christian-Byzantine population of the city in the 6th century AD. According to a previous publication (Berti, 1988) approximately 100 bodies were buried in this cemetery. The total number of skeletons belonging the excavations of Iasos, which were carried out between 1979 and 1987, was 262 (Alpagut, 1988). Regrettably, much of the recovered skeletal material from Iasos was in a very poor condition, leaving only disarticulated small bones, such as the patellae, vertebrae, bones of the hands and feet, and teeth. With such a mass of bones, construction of the anthropological profile of a population is difficult. Among these skeletons, the best preserved 28 (10.7%) lumbar vertebrae, with reliable skeletal indicators for age and sex, were selected and examined with radiographs and DEXA.

BMD is a measured calculation of the true mass of bone. It generally correlates with bone strength and its ability to bear weight. The World Health Organization (2003) has used BMD to define specific diagnostic categories. It should be noted that all "normal" values of BMD are based on Caucasian data. It is well documented that there is a significant variation in BMD between ethnic groups. For example, African Americans in general have a greater BMD as compared to Caucasians of the same age and weight (Nelson et al., 2008). Interpretation of results must take this difference into account. In the present study, BMD was measured for a Mediterranean people and bone loss was shown in this population. It is believed that the bone loss is less frequent among the Mediterranean populations because of the sunny climate (Manios et al., 2007). But bone loss is not only relevant to sunlight. Age, weight, height, menopause, low intakes of calcium and low Vitamin D along with poor sunlight exposure are the major factors contributing to bone loss (Kadam et al., 2010).

BMD assessed by DEXA accurately estimates the bone mass in living individuals, and thus, this is the method usually employed in the diagnosis and follow-up of osteopenia. Central (hip, spine) DEXA devices are more sensitive than peripheral (arm, forearm, wrist, hand) DEXA devices for the diagnosis of osteopenia or osteoporosis (Blake and Fogelman, 2010). Spinal DEXA was used in the present study to determine the BMD of the vertebrae and the diagnosis of the bone loss. It was found that the overall prevalence of bone loss (osteopenia and osteoporosis) in lumbar vertebrae of the adult Byzantine population of Iasos of any age was 53.6 %.

The BMD analysis may provide information which may be corroborated with nutritional status issues, stressful episodes, and dietary habits of past populations. Stressful episodes (eg, trauma, hard working, conflicts, psychological stress) stimulates the adrenal glands to produce cortisol that is much higher and lasts longer in older adults than in younger (Mastorakos et al., 2005). This results in a decrease in bone mass and an increased risk of osteoporosis. The Iasos people lived by the sea and were often fed with seafoods because the soil was poor for agriculture (Strabon, 1924). Although the main diet of Byzantine population consisted of bread, vegetables, and cereals prepared in varied ways (Rautman, 2006), the people of Iasos was not rich and did not have fertile soil for agriculture. But, today, Iasos is famous for its olive grove and abundant fish, like in ancient periods. Isotope analysis was not performed for dietary investigation of Iasos people.

Because Iasos was settled in a small peninsula far from the major conflict areas, the city has never been a site of war. During the Justinian period at the 6th c AD, the Byzantine army consisted of small infantry battalions or horse regiments called a “tagma” or “numerus” (Holmes, 2006). The soldiers were usually recruited from the subjects of the empire in the highlands of Thrace, Illyricum and Isuria. There were also marcenery soldiers from the Huns and Goths (Holmes, 2006). Although the region of Caria was not one of the main recruitment sources of Byzantine army and the lack of references indicating so, some of the male population in Iasos may be involved in military affairs of this army. There were no records of a war in the 6th c AD around Iasos. But in Justinian period, the Byzantine Empire conducted many military campaigns against the Sassanid Empire in Iberia, Caucasia, and Mesopotamia, Vandals in North Africa, Goths in Italy, and Visigoths in Spain. These campaigns were mostly carried out by his general Belisarius (Holmes, 2006). During the campaign of North Africa, the Byzantine Army was transported to Africa by the Byzantine fleet in 4 months. The fleet would always pass through the eastern coast of Aegean sea during its travel from Constantinople to Africa. The fleet accompanied to General Belisarius during his march along the North Africa. Another catastroph, a pandemic plague, afflicted the Byzantine Empire, including its capital Constantinople, in the years 541–542 AD (Little, 2006). In the 6th century, it was nearly worldwide in scope, striking central and south Asia, North Africa, and Europe. The disease spread to port cities around the Mediterranean and weakened the Byzantine Empire (Little, 2006). But there is no records on the plague affection of Iasos during the 6th c AD. Although the Byzantine Empire had the most powerful economy in the world until the arrival of the Arabs in the 7thcentury, the expenses of the empire increased tremendously due to uninterrupted wars and plague, which both harmed the economy during the Justinian period (Hendy, 1985). All of these events would be a source of stress for Iasos people, but there was no record on the books concerning the 6th c AD that the people of Iasos was involved in a war or suffered from plague or economical crisis.

Causes of bone loss may include a decrease in osteoblast function, a change in parathyroid activity as a compensatory factor for decreased calcium absorption, and often a combination of either less sun exposure and/or a decreased ability to synthesize Vitamin D, or insufficient dietary intake of Vitamin D (Bikle, 1994) Additional causes include sedentary lifestyle (Gonzales Macias et al., 2009), genetic factors (Mitchell and Yerges-Armstrong, 2011), hyperthyroidism (Cooper, 2010), and kidney disease (Kalantar-Zadeh et al., 2010). An elevated prevalence of bone loss among female individuals may be related to the effects of nutritional stress and sedentary lifestyle. Moreover, osteopenia and osteoporosis occur earlier and more frequently in females than males, which may be related to the hormonal changes that accompany the menopause in females (Kanis et al., 1994; Syed et al., 2010) Osteoporosis is also a problem in men. It has a heterogeneous clinical entity: whereas most men experience bone loss with aging, some men develop osteoporosis at a relatively young age, often for unexplained reasons (idiopathic osteoporosis). Declining sex steroid levels and other hormonal changes likely contribute to age-related bone loss, as do impairments in osteoblast number and/or activity (Khosla et al., 2008). These factors may have contributed to the bone loss of this ancient people.

The importance of osteoporosis has stimulated interest in its occurrence in earlier populations, and studies have been conducted on excavated skeletal remains around the world (Agarwal and Grynpas, 1996; Mays, 1999). A number of published studies investigated osteoporosis in earlier Anatolian populations (Gültekin et al., 2008). However, differences between studies in methodologies, both for measuring bone mineral status and for estimating age at death, generally make comparisons problematic. The present study is the first radiographic and absorptiometric investigation of lumbar bones in ancient skeletal remains from Iasos. Gültekin et al. (2008) analyzed BMD of ancient Anatolian populations and found that females had lower BMD levels than males and this difference was more obvious as age increased. The skeletons were excavated from six different regions of Anatolia and dated to different time periods such as Chalcolithic, Bronze, Iron, Hellenistic, Roman, Medieval ages and nineteenth century. This study was performed on 255 skeletons and the proximal femoral BMD was measured. Gültekin et al. (2008) have not found a high prevalence of clinical osteoporosis among the Anatolian populations. But Anatolia, in regards to its human population, is biologically and genetically a heterogeneous region. The bones were collected from different archaeological sites and therefore this study did not reflect the bone morphology of a spesific area in specific time period. The people of Iasos at the 6th c AD was Mediterranean type and quite homogeneous. The present study is focused on a spesific area and spesific time period.

Modern civilization was born around the Mediterranean Sea. Ancient Greeks and Romans created a culinary culture that lasted for centuries, into present times. Iasos people was a Mediterranean population and gained most of their livelihood from the sea. But the soil of the country was rather poor (Strabon, 1924). It is assumed that their Mediterranean diet included high olive oil consumption, moderate to high consumption of fish, low consumption of meat and meat products, and moderate to high wine consumption. (Pérez-López et al., 2009) Due to rocky and nonarable condition of the soil in Iasos, fresh fish and seafood were assumed to be commonly consumed. Fish, dairy products and olive oil produce net acid loads in the human body. It is assumed that the Iasos people used olive oil as their main source of fat instead of animal meat. Unless fruits and vegetables were consumed enough, eating these acid-rich foods would actually promote bone loss and osteoporosis (Cordain, 2002). The diet style might have contributed the bone loss of Iasos people. But this hypothesis should be tested in the future studies with further analysis.

Gonzalez-Reimers et al. (2004) performed a study on 51 vertebrae from El-Hierro, Canary Islands for the noninvasive estimation of bone mass in Ancient vertebrae. They assessed the presence of biconcave and wedge-shaped vertebrae by radiographic examination, DEXA and histomorphometric studies. They used spine score, wedge index and trabecular pattern classification to obtain the radiographic variables of vertebrae for the diagnosis of osteopenia. The same techniques and indices were used in the present study to analyze the lumbar bones radiologically, but the vertebral body was not sectioned for histomorphometrical analysis. In the present study, the diagnosis of osteopenia and osteoporosis was made in ancient lumbar vertebrae by DEXA examination.

Agarwal and Grynpas (2009) investigated the age- and sex-related patterns in vertebral BMD and relationship between BMD and osteophytosis using a specialized peripheral densitometer in lumbar vertebrae of a British medieval village Wharram Percy. They used the fourth lumbar vertebrae of 58 individuals from a deserted medieval village in England and the BMD of each vertebrae was measured on thick sections that were cut from the vertebral body. Their study emphasized the unique pattern of bone loss in trabecular bone of the axial skeleton and highlighted the importance of consideration of degenerative joint disease in archeological BMD studies. In the present study, the vertebrae bodies were not cut in order to preserve the structure of the bones and noninvasive techniques were used for the evaluation of the vertebrae. It was found that the bone loss with age was obvious among the ancient Mediterranean people, but theres was not a statistically significant difference between male and female groups.

Mays (2006) studied age-dependent cortical bone loss in adult females between the 3rd and 4th centuries AD using metacarpal radiogrammetry. In this study, cortical bone thickness was measured radiologically in the second metacarpal of 39 skeletons which were found in Ancaster (Lincolnshire, England). Cortical thickness and cortical index were calculated and the author concluded that women from a 3rd-4th c AD community in Britain showed a greater degree of postmenopausal loss of cortical bone and osteoporotic fractures. This study could not reflect the life style and dietary conditions of female Britain people because metacarpal bones are not adequate to evaluate the BMD. In the present study, the lumbar bones were used for the analysis of cortical bone loss because these bones reflect the cortical bone loss more precisely than the metacarpal bones (Blake and Fogelman, 2010).

Limitations of the present study included the small number of vertebral bones when distributed across the whole Iasos excavation site and the fragmentary condition of the bone samples. Twenty-eight (10.7%) of the 262 skeletons, which were found in Iasos, were examined. It was not possible to estimate the age-group and biological sex in other skeletons.

5. CONCLUSION

This study shows the age- and sex-related patterns of change in lumbar spine BMD at Iasos that emphasize the unique pattern of bone loss in spine and highlight the importance of consideration of osteopenia in archeological BMD studies. A high prevalence of osteopenia was found among the population of Iasos during the 6th c.AD. The BMD was significantly lower in the older individuals than in younger ones, and BMD was also significantly lower in female individuals. BMD was correlated with spine score and this correlation was higher in male vertebrae. The reason for the different sex-related patterns in bone loss is unclear. DEXA-assessed BMD combined with spine score measured by radiographic studies may be useful in detecting bone loss in ancient Mediterranean populations.

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