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BIOARCHAEOLOGICAL RESEARCH OF THE ŠTRBINCI SKELETAL SERIES

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Osteological data from 26 skeletons recovered during systematic excavations of the Late Antique Štrbinci cemetery provide insight into health, disease, and stress levels in Late Antique continental Croatia. The sample consists of 9 subadults and 17 adults (8 female and 9 males). The average age at death of adults (males - 39.3; females - 35.5) is roughly comparable to other Late Antique series such as those recovered from Linz (Austria), Tokod (Hungary) and Split. The series is characterized by high frequencies of subadult stress, developmental anomalies and differential male/female activity patterns.

Key words: Štrbinci, Đakovo, Late Antiquity, osteological analysis *(Ključne riječi: Štrbinci, Đakovo, kasna antika, osteološka analiza)*

INTRODUCTION

The Štrbinci skeletal series was recovered during two campaigns. The first campaign was supervised by Z. Gregl in 1993 (Gregl, 1994), the second by B. Migotti in 1999. The site, which covers about 63 hectares and is situated approximately 3 km. southeast of Đakovo, had previously been known in archaeological literature for it's prehistoric artifacts and Roman finds. At present, there is a considerable amount of evidence (archaeological, numismatic and epigraphic) linking the site with the Roman town Certissia (Migotti, 1998).

The series contains the remains of 26 individuals. The majority of the remains were recovered from single primary inhumations. Only one grave (grave 27) contained two individuals, a young adult woman and a poorly preserved subadult. The series is characterized by excellent bone preservation.

Croatian skeletal series from the Late Antique period have, so far, received little attention. Biological data has been published for a small sub-sample of the Štrbinci series (Šlaus, 1998), and for a small series from Split on the Dalmatian coast (Šlaus, 1999). This is unfortunate as this is an important period of time characterized by numerous changes (political, religious and social), related to the political and economical crises which led to the fall of the Western Roman Empire. One reason for our current lack of knowledge is the absence of investigated Late Antique cemeteries, particularly in continental Croatia. Ongoing investigations of the Mursa cemetery in Osijek and the Zmajevac cemetery in Baranja may rectify this in the future.

With the osteological material from Štrbinci available, a bioarchaeological research project was developed with the aim of deriving osteological information about the health, nutritional status and lifeways of this Late Antique population. Although of marginally significant size for statistical analysis, the data presented in this communication represent the largest amount of osteological evidence currently available for this period.

MATERIALS AND METHODS

The Štrbinci cemetery was inadvertently discovered in 1991 by Croatian troops digging defensive trenches during the 1991 conflict which followed the dissolution of the former Yugoslavia. The initial find of a Late Antique grave decorated with a fresco led to rescue excavations in 1993, and to systematic excavations in 1999. Material artifacts (pottery, jewelry, and coins) from the cemetery date the skeletal remains to the 4th century AD. Excavation and documentation of the burials followed standard archaeological procedures.

Bone preservation ranged from excellent to poor. The completeness of the individual skeletons also varied, but the majority are substantially complete (missing only a few bones). Due to fragmentation, considerable restoration of the skeletal material was necessary. Once dry, the bones were relatively stable, and because trace element analysis is planned for the future, no preservative was applied.

Accurate determinations of sex, age and precise bone element baseline counts are essential for sample comparisons between different skeletal series. Cross-population interpretations of mortality trends and morbidity patterns are based on sound demographic profiles established through careful consideration of applicable up-to-date morphological, metric, and multivariate criteria.

The criteria selected for determination of sex include pelvic (Phenice, 1969) and cranial morphology (Krogman and Iscan, 1986). These criteria generally provide accurate results. From a sample of skeletons of known sex, Meindl et al. (1985) report a 3% error

rate when both the pelvis and skull were evaluated. When these elements were missing, sex was determined by recently developed discriminant functions for sexing adult femora (Šlaus, 1997). These functions are very successful with an accuracy rate of between 87% to 95%. No attempt was made to estimate the sex of subadult individuals.

Adult age at death was estimated using as many methods as possible, including ectocranial suture fusion (Meindl and Lovejoy, 1985), pubic symphysis morphology (Brooks and Suchey, 1990; Gilbert and McKern, 1973; McKern and Stewart, 1957; Todd, 1920, 1921), auricular surface morphology (Lovejoy et al., 1985), and sternal rib end changes (Iscan et al., 1984, 1985). In subadults, age at death was estimated using epiphyseal fusion, diaphyseal lengths and dental eruption criteria (McKern and Stewart, 1957; Bass, 1987; Fazekas and Kósa, 1978; Moorrees et al., 1963).

Detailed bone inventories were obtained for each skeleton. The coding format used in this procedure is designed for computer analysis and provides a comprehensive inventory of the entire skeleton. This detailed format is essential for paleopathological analysis. In general, it is seldom adequate to base the frequency of pathological observations on the total number of individuals present in a skeletal series. This approach, although perhaps ideal, is impractical because of the vagaries of skeletal preservation and recovery. While some skeletons may be well preserved and nearly complete, others may be only partially recovered. Specific cultural practices such as secondary inhumations in which, for instance, only the skull and femurs are buried, can also cause erroneous frequency tabulations. Given this variation in cultural practices, bone preservation and recovery it is essential to list the elements present in any skeletal collection being investigated. Such a system enables precise bone counts by side including proximal and distal joint surfaces for all major long bones. Thus, when evaluating arthritic changes in the distal humerus, it is possible to tabulate the number of complete and partial distal humeral epiphyses by side, sex and age.

All skeletal elements were, therefore, coded for their presence and completeness (i.e., complete or partial). A bone was scored as complete if more than 50% of the bone was preserved. As described, completeness does not reflect total bone preservation but identifies the number of elements that are nearly complete and can be scored for the presence or absence of pathological features.

Detailed dental inventories were also completed for each skeleton. All teeth were coded for their presence as: present, lost antemortem, lost postmortem, partially erupted or unerupted. The presence of carious lesions was noted and scored according to location as: occlusal, buccal, lingual, interproximal or root (at the cementoenamel junction). The presence of alveolar abscesses was also scored when present.

Bone pathological features were scored using a hierarchical approach that coded lesions descriptively according to the predominant osteoclastic or osteoblastic response

as: 1) bone loss, 2) bone increase, or 3) bone loss and bone increase. This general classification refers to the major changes possible in living bone. Following this determination, a second more precise designation was recorded using descriptors that defined the nature of the lesion. For example, pathologies identified as representing bone loss were classified within several subcategories, such as 1) bone loss owing to resorptive (lytic) lesion, 2) bone loss owing to porosity (pinpoint to coalesced), 3) bone loss owing to osteoporosis or osteopenia, or 4) bone loss caused by benign cortical defect. All lesions were further coded for: 1) severity (i.e., mild, moderate, severe), 2) state (i.e., active, healing), 3) extent of involvement (i.e., localized, widespread), and 4) specific location on the bone. Changes caused by degenerative bone disease were scored for presence, location and severity of hypertrophic bone formation (marginal, lipping, osteophytes), porosity, and eburnation (Ortner and Putschar, 1981; Steinbock, 1976).

Traumatic injuries (fractures) were coded separately using a similarly detailed descriptive computer coding format. Skull fractures involving the frontal, occipital, parietals, and temporals were coded for shape, presence of radiating fractures, size and presence of healing. Fractures involving the zygoma, maxillae, and mandible were coded for presence and state.

The inventory and pathology coding procedures used in this investigation are a modified version of those developed by Owsley (Owsley et al., 1987; Owsley et al., 1991).

While all pathological changes noted in the analyzed skeletal material are reported on, not all are summarized. The specific disease categories summarized for the Štrbinci skeletal series are: dental pathology - including caries and alveolar bone disease, stress indicators - including dental enamel hypoplasia and cribra orbitalia, infectious disease as evidenced by the presence of periostitis and osteomyelitis, physical stress - including osteoarthritis on major joints, the spinal column, and the presence of Schmorl's depressions in vertebral bodies, and trauma. These categories were chosen for two reasons. First, the pathological conditions comprising these categories are relatively common and leave relatively unambiguous traces in the skeleton. Second, when taken together, these categories create a composite profile of general health and the quality of life.

Dental pathology data are tabulated for alveolar bone disease and caries. Dental caries is a complex infectious disease of the external surface of the tooth. Various bacteria, primarily *Streptococcus* spp., produce decalcifying acids, which, if left unchecked, cause dissolution of the enamel and dentin (Bhaskar, 1981). Physiological and possibly external environmental factors may be related to caries incidence (Hildebolt et al., 1988). In a study of lower Great Lakes populations Schneider (1986) reports that zinc, copper and iron when present in enamel have a cariostatic effect whereas nickel has a cariogenic effect. Results such as these suggest that diet may play a multifaceted role in the production of

carious lesions. Alveolar bone disease is for the purpose of this report defined as the presence of periodontal or periapical abscesses and antemortem tooth loss.

Dental enamel hypoplasia or chronological aplasia is generally defined as any macroscopic defect in the enamel surface (Pindborg, 1970, Sarnat and Schour, 1941, 1942). Hypoplastic defects can range from minor depressions in the enamel surface, with no dentin exposure, to a complete disruption of the enamel. These defects appear as band-like depressions (linear enamel hypoplasia) or as pits. They result from a disturbance of the enamel development in the growing deciduous or permanent tooth bud (phase of amelogenesis). The causes of the hypoplastic defects are commonly attributed to a variety of factors including physiological stresses such as malnutrition, infectious disease, psychological or physical trauma, or other metabolic disruptions (Goodman et al., 1980; Goodman and Rose, 1991; Kreshover, 1960). Hypoplasias remain visible until the affected enamel is worn away through dental attrition, providing a nearly permanent record of developmental arrest during infancy and early childhood. While the development of enamel hypoplastic defects cannot be attributed to a specific disease or episode in the life of a deceased individual, studies of living children document the association between higher frequencies of hypoplastic defects and poor nutrition and low socioeconomic status (Goodman et al., 1991, 1992).

Data on enamel hypoplasias were collected on the permanent maxillary central incisors and canines, and on the permanent mandibular canines. The selection of these tooth categories for study was dictated by the following considerations: 1) central incisors and canines are considered to be more susceptible to stress than other teeth (Goodman and Armelagos, 1985; Goodman and Rose, 1990); 2) canines have a long developmental period, from around four months to 6 years (Gustafson and Koch, 1974); and 3) incisors and canines in general display a relatively small amount of dental calculus which obscures enamel in other teeth. Only macroscopic, linear enamel defects - transverse grooves or rows of pits on the crown surface - are counted in these data. Other enamel defects such as circular pits in deciduous dentition, hyperplastic defects, and zones of discoloration were observed in the dental remains, but are not treated in this study. Hypoplasia frequencies are tabulated by individual. As some of the skeletal series are poorly preserved and the recovered individuals are incomplete even in their dental remains, it can be argued that counting all teeth, instead of only one antimere per individual, may create a bias towards well preserved individuals, as those with more teeth contribute more to the data set than those with only the right or left preserved. Therefore, to avoid any possibility of artificially altering frequencies, enamel hypoplasia data are presented by considering only one tooth from each tooth category per individual. Enamel defects were counted on teeth from the right side of the mouth, with teeth from the left side being substituted if the one on the right was missing.

Cribra orbitalia is recognized by the presence of sievelike lesions or pitting on the orbital roof. The etiology of this lesion is not fully established, and several diseases have been implicated (El-Najjar, 1976; Mensforth et al. 1978). Of these, iron deficiency anemia is the most often attributed cause (Stuart-Macadam, 1985).

Skeletal evidence for infectious disease was determined by the presence of periostitis and osteomyelitis. Periostitis involves inflammation of the periosteum as evidenced by the deposition of new bone on the outer surface of the affected element (Mann and Murphy, 1990; Ortner and Putschar, 1981, Steinbock, 1976). Osteomyelitis, which results from an acute or chronic infection, affects both the marrow and the bone cortex. Inflammation accompanies the infection and causes bone remodeling and expansion (thickening of the cortex), often with a draining sinus (cloaca) (Mann and Murphy, 1990; Ortner and Putschar, 1981, Steinbock, 1976). The primary causes of these conditions are difficult to determine. Especially in the case of periostitis, many factors (for example trauma, hematogenous infection originating in another part of the body, venous insufficiency, and scurvy) contribute to localized or widespread dissemination throughout the skeleton.

Several skeletal features were used to evaluate physical stress. These features are: degenerative osteoarthritis in major joints, vertebral degenerative changes, and the occurrence and frequency of Schmorl's depressions in vertebral bodies.

Degenerative osteoarthritis is characterized by the progressive formation of osteophytes around the edges of an articular joint surface. In advanced cases the normally smooth articular surface develops ossific nodules, porosis or eburnation. These changes are associated with the wear and tear of everyday activities and are distinguished from traumatic arthritis which is caused by disruption of the biomechanical functioning of a joint. Degenerative changes in spinal columns were assessed in the vertebral bodies (osteophytosis and osteoporosis of centra) and the articular surfaces of the posterior elements (osteoarthritis of facets).

Schmorl's depressions are lesions which result from herniation and displacement of intervertebral disc tissue into the adjacent vertebral body. The presence of Schmorl's depressions can be idiopathic, or related to a variety of reasons including among others certain diseases and congenital factors that produce a weakening of the subchondral bone and a disruption of the cartilaginous end-plate, and strong compression caused by traumatic injury. However, the most common cause of Schmorl's depressions according to Schmorl and Junghanns (1971) are degenerative changes associated with ordinary stress on the vertebral column.

Skeletal evidence for trauma was determined by the presence of fractures, dislocations involving joints out of articulation or alignment as a result of force, and entheso-

phytes. The latter include bone spurs, heterotopic bone formations, and traumatic myositis ossificans. They form in response to torn ligaments or muscles, and other types of injury and biomechanical stress that result in calcification of inflamed tissue.

Some of the described diseases, for instance dental disease and degenerative osteoarthritis, are age-dependent (i.e., increase with advanced age). Therefore, when tabulating the data, age was controlled by dividing the sample into two broad categories: young adults, defined as individuals aged between 16-35 years, and old adults, individuals older than 36 years.

RESULTS

TABLE 1: Age and sex distribution in the Štrbinci series

Age category	Subadult		Female		Male		Total	
	N[1]	%[2]	N	%	N	%	N	%
Birth -1	1	11.1					1	3.8
2- 5	3	33.3					3	11.6
6-10	3	33.3					3	11.6
11-15	2	22.3					2	7.7
16-20			0		0		0	
21-25			0		2	22.2	2	7.7
26-30			1	12.5	2	22.2	3	11.6
31-35			4	50.0	0		4	15.4
36-40			1	12.5	0		1	3.8
41-45			2	25.0	2	22.2	4	15.4
46-50			0		1	11.2	1	3.8
51-55			0		1	11.1	1	3.8
56-60			0		0		0	
60+			0		1	11.1	1	3.8
Total	9	100.0	8	100.0	9	100.0	26	100.0
Mean age at death[3]			x = 35.50		x = 39.33			
			sd = 5.34		sd = 14.73			

[1] N = number of individuals dying.

[2] % = % of individuals dying.

[3] Mean age at death is calculated using median values of each age category (for example, 23 for the age category 21-25), and 65 for the age category 60+.

The age and sex distribution of the series is presented in Table 1. The series is characterized by an underrepresentation of subadults from the youngest (0-1 year) age category, and an even distribution of males and females. Subadults comprise 34.6% (9/26) of the total sample. Peak mortality for females is between 31-35 years (50.0% of females died during this interval). Males show no clear peak mortality period. Females, however, appear to be at greater risk during young adulthood than males. Only 37.5% of adult females live longer than 35 years, compared to 55.6% of males. The average age at death for adult females is 35.5 years (SD = 5.34), for adult males 39.3 years (SD = 14.7).

TABLE 2: Frequency of alveolar bone disease in the Štrbinci series

Age category	Subadult		Female		Male	
	A[1]/O[2]	%[3]	A/O	%	A/O	%
Young adult[4]			0/83	0.0	1/126	0.8
Old adult			6/94	6.4	7/69	10.1
Total	1/52	1.9	6/177	3.4	8/195	4.1

[1] A = number of tooth sockets with periodontal or periapical abscess, or antemortem tooth loss.

[2] O = number of tooth sockets observed.

[3] % = % of tooth sockets with periodontal or periapical abscess, or antemortem tooth loss.

[4] Young adult = individuals aged between 16 to 35 years; Old adult = individuals older than 36 years.

TABLE 3: Frequency of carious lesions in the Štrbinci series

Age category	Subadult		Female		Male	
	A[1]/O[2]	%[3]	A/O	%	A/O	%
Young adult[4]			2/77	2.6	7/120	5.8
Old adult			6/58	10.3	20/96	20.8
Total	0/60	0.0	8/135	5.9	27/216	12.5

[1] A = number of teeth with carious lesions.

[2] O = number of teeth observed.

[3] % = % of teeth with carious lesions.

[4] Young adult = individuals aged between 16 to 35 years; Old adult = individuals older than 36 years.

The frequencies of alveolar bone disease and carious lesions are summarized in Tables 2 and 3. Alveolar bone disease is rare in subadults (1.9%). Males exhibit slightly higher frequencies (4.1%) than females (3.4%), but the overall adult frequency is low (14/372, 3.8%).

Adult caries frequencies are slightly higher; 5.9% in females, 12.5% in males, and 10.0% overall. Subadults exhibit no carious lesions. Controlling for age, young males and females exhibit similar frequencies of lesions (2.6% females, 5.8% males), while old adult males exhibit twice as many carious lesions as old adult females (20.8% in males compared to 10.3% in females). This difference is not, however, statistically significant and as frequencies in the young adult age category are similar, probably reflects a higher average male life-span.

Both males and females display the same modal category for severity of carious lesion. A four scale grading system was used to evaluate the severity of carious lesions: grade 1 – a pit or slight fissure, grade 2 – more than a pit but less than half of the surface destroyed, grade 3 – more than half of the surface destroyed but not the complete crown, and grade 4 – complete destruction of the tooth crown. The modal category for severity of lesion is grade 2 in both males and females in both the young adult and old adult age categories.

TABLE 4: Hypoplasia frequencies by individual in the Štrbinci series

Tooth	N[1]	NwLEH	%wLEH
Maxillary I1[2]	9	5	55.5
Maxillary C	13	10	76.9
Mandibular C	14	8	57.1

[1] N = number of teeth observed; NwLEH = number of teeth with one or more LEH; %wLEH = % of N with one or more LEH.
[2] I = incisor; C = canine.

The distribution of carious lesions in both sexes is also similar. Carious lesions are most frequently located interproximally (in 21/27 or 77.8% of all carious lesions in males, and in 5/8 or 62.5% of all carious lesions in females). In males the only other location of carious lesions was on the root of the tooth (in 6/27 or 22.2%), while in females lesions were recorded on the buccal surface (in 2/8 or 25%) and the root (1/8 or 12.5%) of the tooth.

Enamel hypoplasia frequencies are summarized in Tables 4-6. Hypoplasias are most frequent in the maxillary canines – 76.9%, followed by mandibular canines – 57.1% and maxillary central incisors – 55.5%.

TABLE 5: Hypoplasia frequencies in the Štrbinci series for subadults and adults

	Subadults		All adults		Females		Males	
Tooth	Nw/N[1]	%wLEH[2]	Nw/N	%wLEH	Nw/N	%wLEH	Nw/N	%wLEH
Maxillary I1[3]	2/3	66.7	3/6	50.0	0/1	0.0	3/5	60.0
Maxillary C	3/3	100.0	7/10	70.0	2/4	50.0	5/6	83.3
Mandibular C	2/3	66.7	6/11	54.5	3/5	60.0	3/6	50.0

[1] Nw = number of individuals with one or more LEH; N = number of individuals observed.

[2] %wLEH = % of N with one or more LEH.

[3] I = incisors; C = canines.

Subadults are poorly represented in the analyzed sample. Only 9 teeth were available for analysis (3 central maxillary incisors, 3 maxillary and 3 mandibular canines). Most of these teeth, however, exhibit deep hypoplastic defects (Table 5) with the highest frequency (3/3) recorded in maxillary canines. Adult frequencies are slightly lower than subadult with the highest frequency recorded, once again, in maxillary canines (7/10). A breakdown of the adult sample by sex shows that adult males and females exhibit similar frequencies of hypoplastic teeth.

TABLE 6: Mean number of hypoplasias in incisors and canines in the Štrbinci series

	Subadults			All adults			Females			Males		
Tooth	Mean	N	S.D.	Mean	N	S.D.	Mean	N	S.D.	Mean	N	S.D.
MaxillaryI1[1]	0.67	3	0.58	0.67	6	0.82	0.00	1	0.00	0.80	5	0.83
Maxillary C	1.00	3	0.00	0.80	10	0.63	0.75	4	0.96	0.83	6	0.40
Mandibular C	1.00	3	1.00	0.82	11	0.87	0.80	5	0.83	0.83	6	0.98

[1] I = incisors; C = canines.

The mean number of hypoplasias per tooth (Table 6) shows a slightly higher number of hypoplastic defects in subadults for maxillary and mandibualr canines. Male and female values are similar.

Cribra orbitalia frequencies are summarized in Table 7. Only two subadult frontal bones with intact orbits were available for analysis one of which exhibits active, severe cribra orbitalia. Two males (2/9 or 22.2%) also show healing cribra orbitalia lesions. None of the 5 females with intact orbits exhibits this condition.

Periostitis is noted on the endocranial surface of the cranial vault and on the tibiae. One subadult exhibits healed periostitis on the endocranial surface of the parietals and

occipital bone (1/4 recovered intact subadult cranial vaults). None of the 13 adult (6 female and 7 male) cranial vaults exhibits this condition. Periostitis on the medial surfaces of the tibiae is noted in 6/9 (66.7%) recovered subadult tibiae and in 3/31 (9.7%) adult tibiae (0/18 male and 3/13 or 23.1% of female tibiae). In comparison to adults, subadults show less resistance to infectious disease. Four of the six recorded cases of tibial periostitis are active at time of death, while all adult cases are healed. No cases of osteomyelitis are noted in the series.

TABLE 7: Frequency of occurrence of cribra orbitalia in the Štrbinci series

	Cribra orbitalia			Active lesions	
Age/sex	O[1]	A1[2]	%	A2[3]	% of A1
0 – 0.9	1	0	0.0	0	0.0
1 – 3.9	1	1	100.0	1	100.0
4 – 9.9	0	0	0.0	0	0.0
10 – 14.9	0	0	0.0	0	0.0
All subadults	2	1	50.0	1	100.0
Adult females	5	0	0.0	0	0.0
Adult males	9	2	22.2	0	0.0
All adults	14	2	14.3	0	0.0

[1] O = number of frontal bones observed.

[2] A1 = number of frontal bones in which at least one orbit shows evidence of cribra orbitalia.

[3] A2 = number of frontal bones in which cribra orbitalia is active at time of death.

Three healed fractures, all recorded in adult males, are noted in the series. Two are healed depression fractures of the cranial vault (in 2/7 intact male cranial vaults or in 28.6%), both on the left parietals, and one is a healed fracture of the second right rib. Both cranial fractures exhibit smooth floors and rounded margins, and neither penetrated the inner table of the skull.

Enthesophytes are common in the series and are recorded on the patellae and calcanei. Both sexes show similar frequencies. Enthesophytes are recorded on 4/17 (23.5%) male calcanei, on 2/6 (33.3%) female, and on 2/10 (20.0%) recovered male patellae and on 2/8 (25.0%) female patellae.

The series is characterized by high frequencies of developmental anomalies. Congenital anomalies are recorded in 3 males and 1 subadult and include dental and skele-

tal disorders. The following anomalies are noted. The adult male from grave 2 exhibits a small facial (globulomaxillary) cyst. The cyst has a diameter of approximately 2 mm and is located on the left maxilla, between the second incisor and the canine. This individual also exhibits marked mandible ramus asymmetry - the right mandibular ramus is 12 mm higher than the left. While differences in mandible ramus heights are common, such a large difference may reflect localized growth disturbance. This individual also exhibits several dental abnormalities. The second left maxillary incisor is rotated 90° in the anterior direction, the maxillary first left premolar is rotated and placed in the position of the canine while the canine is located anterior to the first and second left premolars. The right second maxillary molar and premolar are congenital absent. The male from grave 17 also exhibits dental and skeletal abnormalities. This individual exhibits scoliosis of the upper thoracic spine. The condition is apparent in the vertebrae, which show asymmetrical ("twisted") vertebral bodies and spinous processes, and in the sternum and first two ribs which exhibit different curvature. This individual also exhibits talocalcaneal coalition on the left foot, and a small supernumerary tooth between the central maxillary incisors. The male from grave 18 exhibits a palato-gingival groove on the left maxillary second incisor while the subadult from grave 3 exhibits 13 thoracic vertebrae.

The series is also characterized by relatively high frequencies of benign cortical defects. These defects appear as elongated depressions or pits with smooth cortical margins and generally porous floors at ligamentous or tendinous attachment sites. They are normal variants in growing bone were they reflect rapid bone remodeling and pulling stresses in the immature skeleton. Their presence in fully developed adults may reflect repeated chronic physical stress related to muscular exertion (Mann and Murphy, 1990; Owsley et al., 1991). In the Štrbinci skeletal series their presence is noted in subadults and adults. In subadults, two cases of rhomboid fossae are noted on medial clavicles (in 2/7 recovered subadult clavicles or 28.6%). The rhomboid fossa is located on the inferior surface of the medial clavicle and is the attachment site for the costoclavicular ligament. Both cases are deep, with sharply defined cortical margins and porous centers. In adults, cortical defects are noted only in males and are present in 2/15 (13.3%) recovered male humerii (at the insertion sites of the pectoralis major muscle), 2/14 (14.3%) radii (at the insertion site of the biceps brachii muscle), and on 5/15 (33.3%) recovered clavicles (rhomboid fossae). Benign cortical defects are present in 9/44 (15 humerii, 14 radii and 15 clavicles) analyzed bones in the male sub-sample, or in 20.4%.

Osteoarthritis frequencies in the series are summarized in Table 8. The overall frequencies are low with no significant differences in frequencies between the sexes. All of the cases reported reflect mild or moderate degrees of osteoarthritis. Of the four major joints in the skeleton, osteoarthritis is most frequently recorded in the shoulder.

TABLE 8: Frequency of occurrence of osteoarthritis at major joints in the Štrbinci series

	Shoulder		Elbow		Hip		Knee	
	A[1]/O[2]	%	A/O	%	A/O	%	A/O	%
Female								
Young adult[3]	0/2	0.0	0/2	0.0	0/4	0.0	0/3	0.0
Old adult	1/3	33.3	0/3	0.0	0/3	0.0	1/3	33.3
Total	1/5	20.0	0/5	0.0	0/7	0.0	1/6	16.7
Male								
Young adult	1/4	25.0	0/4	0.0	0/4	0.0	1/4	25.0
Old adult	0/3	0.0	1/4	25.0	0/4	0.0	0/5	0.0
Total	1/7	14.3	1/8	12.5	0/8	0.0	1/9	11.1

[1] A = number of joints affected with osteoarthritis. Osteoarthritis was scored as present if at least one joint element showed evidence of osteoarthritic change.

[2] O = number of joints observed. A joint was scored as present if at least one joint element was completely present, or if two or three elements were partially present.

[3] Young adult = individuals aged between 16 to 35 years; Old adult = individuals older than 36 years.

TABLE 9: Frequency of occurrence of vertebral osteoarthritis in the Štrbinci series

	Cervical		Thoracic		Lumbar		Total	
	A[1]/O[2]	%	A/O	%	A/O	%	A/O	%
Female								
Young adult[3]	0/0	0.0	0/18	0.0	0/5	0.0	0/23	0.0
Old adult	0/17	0.0	4/32	12.5	0/15	0.0	4/64	6.3
Total	0/17	0.0	4/50	8.0	0/20	0.0	4/87	4.6
Male								
Young adult	0/28	0.0	0/47	0.0	0/20	0.0	0/95	0.0
Old adult	4/15	26.7	5/24	20.8	1/10	10.0	10/49	20.4
Total	4/43	9.3	5/71	7.0	1/30	3.3	10/144	6.9

[1] A = number of vertebrae affected with osteoarthritis or osteophytosis.

[2] O = number of vertebrae observed.

[3] Young adult = individuals aged between 16 to 35 years; Old adult = individuals older than 36 years.

The overall frequency of vertebral osteoarthritis in the series is low (14/231 or 6.1%). Comparing the different regions of the spine (Table 9), the greatest involvement occurs in the thoracic spine (9/121; 7.4%), followed by the cervical (4/60; 6.7%) and lumbar (1/50; 2.0%) regions. Male and female frequencies are similar.

The frequencies of Schmorl's depressions in the series are summarized in Table 10. The overall frequency of Schmorl's depressions in the sample is 8.8% (15/171). Schmorl's depressions are more common in lumbar (7/50; 14%) than in thoracic (8/121; 6.6%) vertebrae. Females exhibit higher frequencies of Schmorl's defects in all segments of the spine but these differences are not statistically significant.

TABLE 10: Frequency of occurrence of Schmorl's depressions in the Štrbinci series

	Thoracic		Lumbar		Total	
	A[1]/O[2]	%	A/O	%	A/O	%
Female						
Young adult[3]	0/18	0.0	0/5	0.0	0/23	0.0
Old adult	5/32	15.6	5/15	33.3	10/47	21.3
Total	5/50	10.0	5/20	25.0	10/70	14.3
Male						
Young adult	0/47	0.0	2/20	10.0	2/67	3.0
Old adult	3/24	12.5	0/10	0.0	3/34	8.8
Total	3/71	4.2	2/30	6.7	5/101	4.9

[1] A = number of vertebrae with Schmorl's depressions.

[2] O = number of vertebrae observed.

[3] Young adult = individuals aged between 16 to 35 years; Old adult = individuals older than 36 years.

DISCUSSION

The analysis of the skeletal series from the Štrbinci site and comparisons with published data and other ongoing studies help to expand our understanding of the biological history of the inhabitants of continental Croatia. The accumulation of osteological data from skeletal collections is an important step in evaluating conclusions from historical, archaeological and economic sources, as well as for expanding empirical evidence not available through these sources. Although of marginally significant size for statistical analysis, the data represented above represent the most skeletal evidence currently available from this time period. Conclusions and interpretations derived from this sam-

ple are open to revision when larger and better documented series become available.

Longevity and mortality are important measures of the life context of any group. The Štrbinci sample is comprised of 9 subadults and 17 adults. The youngest individual is aged from 0.5 to 1.0 year, while the oldest age category represented in the series is 60+ years. The sample of adults (15 years and older) includes 8 female and 9 males.

The under-representation of infants in cemetery samples is an almost ubiquitous problem. In the Štrbinci series, in spite of good bone preservation, and all efforts to identify subadult burials, there is still an obvious under-representation of subadults, particularly in the youngest, birth to 1 year, age category. Even so, subadult mortality is high in the analyzed sample with 34.6% of the population dying before the age of 16 years.

The average age at death of adults over 15 years (males - 39.3; females - 35.5) is roughly comparable to other Late Antique populations. In the Linz cemetery in Austria, dated from the 4th to the 5th century, average age at death for adult males and females is 47.8 and 47.4 years respectively (Wiltschke-Schrotta and Teschler-Nicola, 1991), in the Hungarian Tokod series also dated from the 4th to the 5th century, adult males live on average 46.7 and adult females 44.7 years (Ery, 1981), and in the small Late Antique "Ad Basilicas Pictas" skeletal series from Split males live on average 41.0 years and females 37.5 years (Šlaus, 1999).

The slightly higher mean average life span of males is reflected in the frequencies of alveolar bone disease and carious lesions. In both of these males exhibit slightly higher frequencies. Controlling for age, differences in the young adult age category are minimal while differences in the old adult age category are more pronounced, a pattern consistent with a slightly higher male average life-span.

Of interest are the relatively high frequencies of enamel hypoplastic defects, particularly in subadults, where 7 of the 9 teeth available for analysis exhibit deep hypoplastic defects. Adult teeth also exhibit high frequencies of enamel defects (16/27 or 59.2%), with the highest frequency recorded in maxillary canines (7/10 or 70%). Cribra orbitalia frequencies are also relatively high, 50% in subadults and 14.3% in adults. With a caveat for small sample size, these data are suggestive of high levels of subadult stress in the series.

Subadults also appear to be more susceptible, and show less resistance to infectious disease. Periostitis is present on 6/9 recovered subadult tibiae (66.7%). In 4/6 cases the lesion was active at time of death (a 4/9 or 44.4% total frequency of active periostitis). Adults, on the other hand, exhibit lower overall frequencies (3/31 or 9.7%) with all of the lesions healed at time of death.

Healed fractures are recorded only in males and are confined to the cranial vault and ribs.

The most surprising and interesting characteristic of the series is the high frequency of developmental anomalies and benign cortical defects, both recorded only in males

and subadults. A total of 12 developmental anomalies, 5 skeletal and 7 dental are recorded in the series. The incidence of these anomalies in modern Croatian populations varies from 1 to 6%. Bearing in mind that because of small sample size cautious interpretation remains appropriate, the high incidence of developmental anomalies in the analyzed sample is suggestive of a reproductively isolated community.

The high incidence of benign cortical defects in adult males is consistent with high levels of physical stress. Due to the nonspecific nature of these changes, etiological determinations of specific activities are inappropriate. What is clear from the skeletal data is that males in the series exhibit significantly higher frequencies of benign cortical defects located in the humerii, radii and clavicles, indicating some type of physical activity involving the arms and shoulders, while females exhibit higher frequencies of Schmorl's depressions in vertebral bodies, indicating greater stress to the vertebral column. These data are suggestive of differential male/female activity patterns.

CONCLUSION

Examination of the Štrbinci skeletal series provides a rare opportunity to address questions concerning health, disease, and stress in Late Antique continental Croatia. There is very little comparable bioarchaeological information from this region and time period. Hence, the biological and pathological information collected from Štrbinci provides an important data base for future osteological research. Data collected from Štrbinci indicates high levels of subadult stress, high frequencies of developmental anomalies, and differential male/female activity patterns. Continued research and comparison with other skeletal series are necessary to determine if the collected data is a realistic reflection of life in Late Antique continental Croatia, or the result of random variation in a small sample.

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Sažetak

Bioarheološko istraživanje niza kostura sa Štrbinaca

U radu su prikazani rezultati osteoloških analiza provedenih na 26 kostura s kasnoantičkog nalazišta Štrbinci kraj Đakova. U analiziranom uzorku prisutni su ostaci devetoro djece i 17 odraslih osoba (8 žena i 9 muškaraca). Prosječne doživljene starosti za odrasle osobe (muškarci 39,3 godine, žene 35,5) slične su vrijednostima evidentiranim na drugim kasnoantičkim nalazištima kao što su Linz (gdje muškarci u prosjeku dožive 47,8, a žene 47,4 godina), Tokod (muškarci 46,7, žene 44,7) i Split (muškarci 41,0, žene 37,5 godina).

Uzorak karakteriziraju visoke učestalosti razvojnih anomalija, hipoplazije zubne cakline i različita distribucija pokazatelja fizičkog stresa (benigni kortikalni defekti i Schmorlove depresije) kod muškaraca i žena. Promjene uzrokovane intenzivnim fizičkim stresom kod muškaraca razmještene su u rukama i ramenom obruču, a kod žena u leđima.

Ključne riječi: Štrbinci, Đakovo, kasna antika, osteološka analiza