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COMPARISON OF HEALTH STATUS IN HUMAN SKELETAL REMAINS DISPOSAL IN SETTLEMENTS AND NECROPOLISES IN THE EARLY BRONZE AGE (IN CENTRAL MORAVIA, CZECH REPUBLIC)

ABSTRACT: The aim of this study is comparison of health status between two anthropological series dated back to the Early Bronze Age (circa 2000 – 1500 BC) excavated in the area of Central and South Moravia (Czech Republic). The reason for this research is the fact of unexplained phenomena of human skeletal remains disposal in settlement pits, which are typical for Central Europe in Early Bronze Age. In this study some selected osteological markers were observed representing the quality of life under which is possible to assess social status and find the reason for different funeral practice. Therefore the two series investigated in this paper differ in burial practice. One of them is individual disposal in haphazard burial positions in settlement pits and the other are individuals buried in graves typical for this period. The question is if there is a relation between the burial type and the social status of the individuals. To accomplish this, seven representative markers of health (markers of long-term life in worsen conditions) were investigated: mean stature of individuals, dental caries, dental calculus, linear enamel hypoplasia, ante mortem tooth loss, cribra orbitalia and metabolic diseases and compared in 43 skeletons from archeological sites in South and Middle Moravia (Czech Republic). The results indicate that female and male average stature in settlement pits was slightly higher than in graves, but the difference was not significant ($p > 0.05$). Prevalence of dental caries, calculus and premortem tooth loss was higher in individuals buried in graves, but only differences in dental calculus affection were significant ($p < 0.05$). Linear enamel hypoplasia occurred only in the pits. Prevalence of dental calculus and caries was observed only in females, and premortem tooth loss affected above all males buried in graves and females buried in settlement pits. Cribra orbitalia was recorded more in graves than in settlement pits ($p < 0.05$), most frequently in juvenile individuals, males and least of all in females. Only in female and indifferent individuals in graves ($p < 0.05$) appeared metabolic diseases (bowing deformities on long bones). Despite the low number of investigated individuals, the data suggest the osteological and dental markers of health to be more frequent in graves than in settlement pits. These results contradict our assumption that individuals buried in settlement pits had a lower social status, supposedly demonstrated by their worse health condition..

KEY WORDS: Early Bronze Age – Health reconstruction – Settlement pits – Graves – bone – Teeth

INTRODUCTION

The health reconstruction has been undertaken on the human skeletal remains dated back to the Early Bronze Age. The study is based on detection of prevalence of pathological traces and stress markers on bones and teeth of two groups of individuals, which differ in type of burial. One of these groups are individuals buried in haphazard burial positions in settlement pits, usually in storage pits (these pits served primarily as grainery, secondarily they could serve as drass tray) and the other group are individuals buried in graves typical for this period (fairly crouched individual laying on right side in a rectangular grave with or without grave goods, usually orientated S– N). We do not distinguish whether it is a ritual or non-ritual disposition of individuals. Either form may be a reflection of very sophisticated funeral. Therefore, both phenomena are called "burial" – burial in settlement pit and burial in grave. If we would use the word "burial" only for those individuals buried in graves we would exclude the possibility of ritual disposition of individuals in settlements.

Burials in the settlement pits are a special phenomenon ignoring specificity of funeral practice of particular ethnic groups in any time in prehistory and history (from Neolithic to Early Middle Ages). This type of burial among particular ethnic groups differs in quantity, for some groups it is a standard type of burial and for others it is an exceptional phenomenon. The interpretation of this funeral practice is not clear, because even the manner of burial in settlement pits differs from site to site, in number of individuals buried in one pit and also according to age and sex (e.g. Rulf 1990, Salaš 1990, Kandert 1982, Sosna 2007, Stuchlíková 1990). Most numerous skeletons in the settlement pits are recorded from the Bronze Age, especially Early Bronze Age and at the turning point of the Middle and the Late Bronze Age in the Central Europe.

There are several basic theories for such a treatment of inhumation. According Rulf (1990) this phenomenon may be explained in several different ways e.g. these burials could have been religious, emergency or sanitary: when there was a need to bury dead quickly because of epidemics, war conflicts or natural disasters. The ethnographic study (Holý 1956), documenting burials in middle, east and South Africa, shows significant variability of such burials. For example only those who died a natural death could have been buried in such a way, those who died unnatural death had to be buried further away from the living population, since their death was claimed to be evidence of evil forces. This means that those individuals who died of contagious disease, in violent death, suddenly, criminals, debtors, individuals committing suicides, individuals killed by lightening, handicapped individuals, those who were drowned, leprous etc. were never buried in settlement pits. In other parts only specific groups were buried in these pits. In some tribes the selection is based on age e.g. only children or only elderly individuals could be buried there. In other tribes it could be for example only married men, single men were buried in other manner. Another reason for this can also be that even after death the individual is not to be separated from the companionship of their relatives (Holý 1956) or the dead may want to come back to those who were close to them (Binford 1971). Certainly these individual examples occur in dependence on geographical location.

Other anthropologic researches show impaired health condition of the individuals buried in this way. Jelínek (1988) and Smrčka *et al.* (1988) confirm that a part of observed individuals buried in settlement pit dated to the Early Bronze Age suffered from chronic diseases of anaemic character. In Brno – Tuřany site there were examined both, conventional graves and burials in settlement pits. According to Kala *et al.* (2008) those buried in pits were physiologically disrupt in some way. These defects could have been the reason of their social status and the result could have been the burial in pits near burial site (Kala *et al.* 2008). Another example of pathological sample buried in a storage pit is described Einwögerger and Teschler-Nicola (2008). They identified individual affected by Langerhans cell Histiocytosis inhumane in Early Bronze Age storage pit on the site Ziersdorf, Lower Austria. Authors explained this finding as an exclusion from certain social activities and, ultimately, from a regular burial in a common burial ground (Einwögerger, Teschler-Nicola 2008). And other individuals buried within the settlement of this archeological site exhibit a high prevalence of peri-mortem skull trauma (Einwögerger, Teschler-Nicola 2008). Otto *et al.* (2006) summarized skeletons with trauma and pathological change from Early Bronze Age settlements. From 376 skeletons (Austria, Bohemia, Moravia and Slovakia archeological sites) 69 were affected certain pathological or trauma change (in total it represents 18 %). But question is, if this amount of pathological skeleton is significant and what does it mean. If there are 69 individuals buried in a settlement pit because of their disability, why are healthy individuals also buried in there? Is it possible that they died before the disease affected bone or that signs of violence were of such manner that it did not leave traces on the bones? Pathological skeletons buried in settlement pits were found in many archeological settings Czech Republic as well as in other territories of Central Europe, and these disruptions may be a possible cause of this phenomena (Stloukal, Vyhnánek 1975, Einwögerger, Teschler-Nicola 2008, Otto *et al.* 2006). On the other hand, Salaš (1990) rejects this theory for lack of evidence. He argues excessively that there are only few pathological findings to support this fact.

Burials in settlements can display social status of individual and we can use representative markers of health which are results of long term life in worsen conditions. The society in Early Bronze Age was stratified into groups whose actual lifestyles differed in terms of diet, health, stress and activity. Elite and commoner mortuary practice can be distinguished through the archeological evidence and health and lifestyle can be distinguished through skeletal stress indicators (Robb *et al.* 2001). We understand stress as physiological disruption resulting from impoverished external conditions, which results in poor health and worsened living condition (Goodman *et al.* 1988). Usefulness of skeletal lesions in evaluating health and social status of a past population has been demonstrated in many researches (Larsen 1997, Lucas 1992, Oxenham *et al.* 2005, Ortner 2003, Steckel, Rose 2002, Goodman, Martin 2002, Hillson 1992, Robb *et al.* 2001) and the limitation of such studies (Wood *et al.* 1992, Buikstra, Cook 1980, Porčič, Stefanovič 2009).

In Early Bronze Age in Europe, stronger social stratification takes place thanks to the expansion of new metallurgy and craft industry, this milestone is important in the socio-cultural evolution of societies in this period (e.g. Bintliff 1984, Gilman 1981, Harding 2000, Sosna 2007). It can be supposed that certain groups of individuals will be exposed to impoverished environment and worsened access to resources, this could then lead to the mortuary variability (O'Shea 1996, Binford 1971). This would mean that high ranking individuals should have been superior in a quality of life, which could mean that they do less laborious and physically demanding activities than the commoners (Porčič, Stefanovič 2009) and this way of life could leave traces on the bones. Physical anthropologists can provide some methods for studying social differentiation and relationship between activity and social status (Marchi 2005, Sládek *et al*. 2006, Sládek *et al.* 2007). In this study is supposed that the lower classes may have been suffer from biological stress, polluted living sites, poor medical care and long hours of work. This paper predicts that the lifestyle may be different among social ranks and low status burials bear signs of nonspecific stress markers, different diet and malnutrition in contrast to high status burials. Physiological stress which influences a juvenile individual is caused by variety of elements such as malnutrition, diet, vitamin deficiency, infectious diseases, resulting in total growth disruption and disruption in development of an individual and leaves traces on bones and teeth (Buikstra, Cook 1980, Ortner 2003, Selye 1973, Goodman, Rose 1990, Aufderheide, Rodriguez-Martin 1998).

In our study we focus partly on non-specific traces of stress, where cribra orbitalia and linear enamel hypoplasia (LEH) belongs. Next to these non-specific traces we assess health condition of teeth (dental carries, calculus and ante mortem tooth loss) which is closely related to diet, and together with that also with access to the resources and finally we observe a metabolic diseases in adults. The purpose of this study is a comparison of health status in two series of individuals, which differ in mortuary treatment, dated back to the Early Bronze Age. The question is whether there is a relation between the burial type and prevalence of stress markers and pathological lesions on bones and teeth, which can show social status of the individuals and if that condition could be responsible for a special treatment of the person and consequently for a different funeral practice.

Human skeletal remains

Skeletal remains investigated under this study originate from four archeological settings of South and Middle Moravia (*Figure 1*): 1) State farmhouse in Mušov (Stuchlík 1987, Stloukal 1987); 2) Olomouc Slavonín – Horní Lán (Kalábek 2001, Dobisíková 2002); 3) Hulín Pravčice 1 and 4) Bystročice 1 (Tajer 2009, Pankowská 2009 a, b), dated back in to Unetice culture and věteřov group (2000 – 1500 BC).

Of the 43 individuals examined, 23 were buried in settlement pits and 20 in standard graves (*Table 1*). Human skeletal remains from graves were excavated in the settings Mušov, which was discovered thanks to a construction of water work Nove Mlyny built in 1976, Stanislav Stuchlík was entrusted by former AÚ ČSAV to lead extensive rescue research in continuation of former researches on this site (Stuchlík 1987). Last activity in this site is dated back to 1985, there were 35 graves (Unetice culture) discovered in total. The anthropological analysis was performed by Milan Stloukal and the skeletal remains are now stored in National Museum's depository in Horní Počernice.

The early rescue excavation in the site Olomouc-Slavonín Horní Lán has begun in the spring of 2001. The archeological research, lead by Museum in Olomouc was a continuation of former researches on this site. It is a multicultural archeological setting. Dating to Early Bronze Age, eight settlement pits were preserved and in three of these pits, five human skeletons were found. The anthropological analysis was performed by Miluše Dobisíková from Anthropological department of National Museum in Prague, where are the skeletal remains stored now.

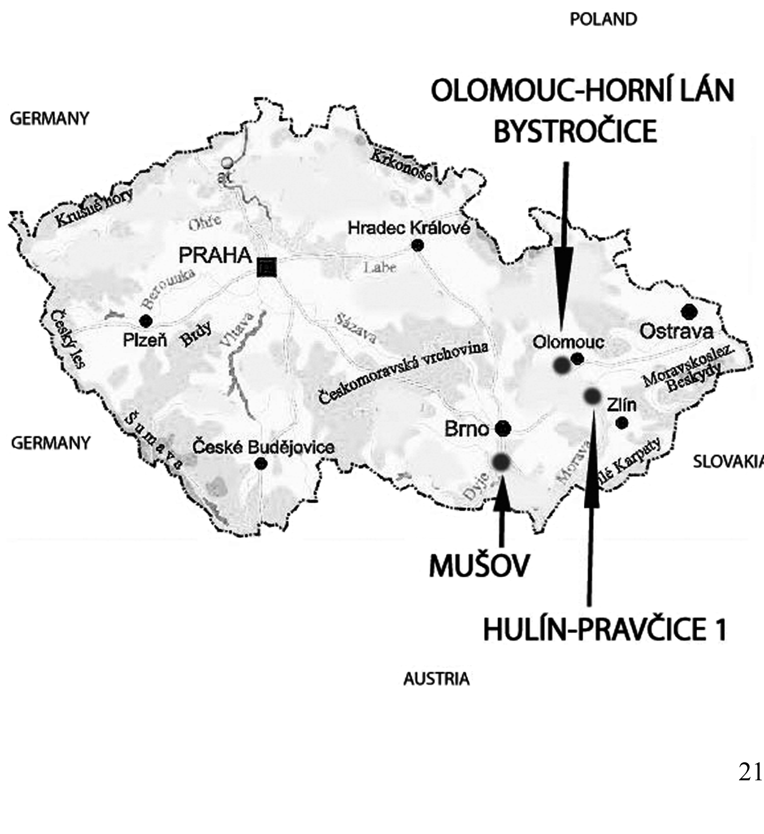

FIGURE 1. Map of Czech Republic, showing location of sites with skeletal remains examined in this study.

TABLE 1. Study sample summary.

SITE NAME	BURIALS (n)	TYPE OF BURIAL	DATE OF EXCAVATION	PRINCIPAL RESEARCHER	ANTHROPOLOGICAL RESEARCHER	CURRENT LOCATION
State farmhouse in Mušov	20	graves	1976–1987	Stanislav Stuchlík	Milan Stloukal	National Museum in Prague
Olomouc, Slavonín – Horní Lán	5	pits	1995/7–2001	Marek Kalábek	Miluše Dobisíková	ACO
Hulín Pravčice 1	14	pits	2006–2009	Martin Paulus Miroslav Daňhel	Anna Pankowská	ACO
Bystročice	4	pits	2007–2008	Arkadiusz Tajer	Anna Pankowská	ACO
TOTAL	**43**					

N – number of skeletons
ACO – Centre of Archeology in Olomouc

The excavation in Hulín-Pravčice site was caused by the construction of highway D1 in section Kroměříž – Říkovice. The field works was begun in October 2006 and finished in spring 2009 and was lead by Archeological centre in Olomouc (orally Bc. Martin Paulus, archeologist of Archeological centre in Olomouc). It is a multicultural archeological setting, in which among others, fourteen human skeletons were found in eleven settlement pits dated to věteřov group.

The rescue excavation in Bystročice took place in winter 2007/2008 under the supervision of Archeological centre in Olomouc, the impulse to this was a construction of utility lines and roads for planned construction of family houses (Tajer 2009). On this occasion 75 settlement pits were examined in total, of which 14 is dated back to věteřov group (Tajer 2009). In two of these 14 settlement pits human, skeletal remains were found. The anthropological research in Hulín-Pravčice and Bystročice was performed by the author of this article, the skeletal remains are now stored in Archeological centre in Olomouc.

METHODS

Remains of 43 individuals were included in the study. Evaluation of preservation was assigned to each individual, following the guidelines Stojanowski *et al*. (2002). Estimation of living stature from adult limb bone lengths are based on non-ethnic formula (Sjøvold 1990). Age was estimated to each skeleton (Brooks, Suchey 1990, Lovejoy 1985, Ubelaker 1989, Ferembach *et al*. 1980) and sex was determinated in adults only (Brůžek 2002, Ferembach *et al.* 1980).

Teeth and bones were examined for pathological lesions by means of simple macroscopic visual observation. For evaluation of biological status some representative non-specific signs of disease were examined. We focused mainly on the evaluation of teeth because of their good preservation and the fact that after the development of enamel formation they do not change, while bone changes over a time. Teeth represent a sufficient sample for the evaluation of population group. Diet and preparing food have been connected with social status and therefore used as a criterion for evaluation of social status (Stránská *et al.* 2008). To bone diseases, we evaluated non-specific metabolic disorders (softening of the bones due to defective bone mineralization and cribra orbitalia). The quality of diet, compound of food and access to resources closely linked with social status. Similarly, stature of individuals belong among essential indicator of nutritional and health status (Dobisíková *et al.* 2008). Stature is sensitive sign of living condition (Larsen 1997).

Teeth

A total of 735 permanent teeth (340 maxillary and 395 mandibular) were examined for other dental diseases (dental caries, calculus, dental hypoplasia and premortem tooth loss). The numbers of affected teeth for each disease were calculated as percentage of total number of observed teeth in order to determinate the prevalence of each disease. Caries lesions are recorded by a two digit code, firstly the location on the tooth where the lesion has occurred (1. – occlusal; 2. – lingual; 3. – buccal; 4. – aproximal; 5. – site of origin cannot be determined; 6. – root surface) and secondly the severity of the lesion (1. – enamel only; 2. – enamel + dentin, pulp chamber not exposed; 3. – enamel + dentin, pulp chamber exposed; 4. – crown destroyed). The amount of calculus deposit is recorded following Brothwell (1981). Premortem tooth loss was scored according alveolar resorption and only linear enamel hypoplasia LEH generally visible as one or more transverse grooves of varying depths on the crown surface of teeth, were observed.

Bones

Within this sample, 58 orbits were inspected for evidence of presence cribra orbitalia and 207 long bones (forearm, femur and tibia) and its bowing were also investigated. For recognition of softening of the bones (rickets, residual rickets or osteomalacia) analogy was used with the find in the collection of the 2nd Pathological Institute of the National Museum (Smrčka *et al.* 2009) and consultation with these authors of the Atlas of Diseases in Dry Bones. With all human bones there can be difficult to estimate what is normal and when the bowing of the bone may indicate a pathological lesions. The degree of deformity was classified according Brickley *et al*. (2008). Bones in which the changes were only

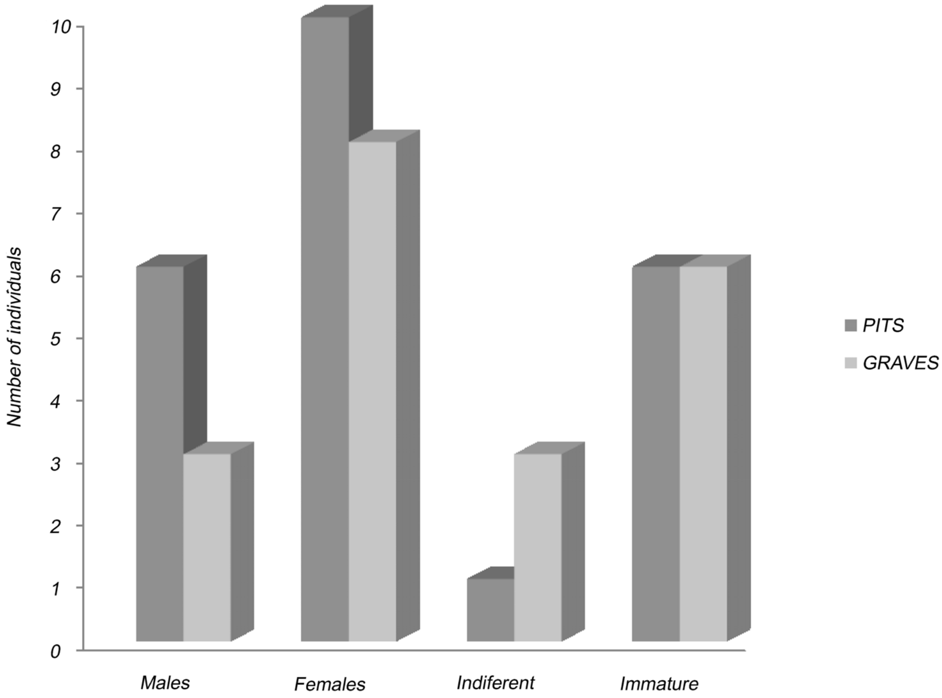

FIGURE 2. Summary of demographic profile of two archeological series.

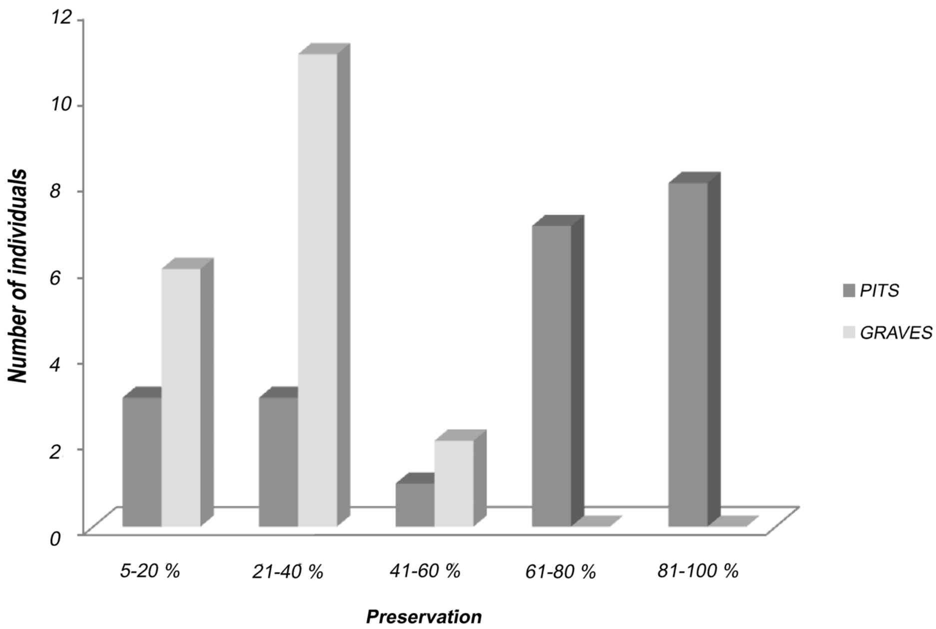

FIGURE 3. Preservation degree of two series following the guidelines Stojanowski *et al*. (2002).

marginally different from normal were assessed as "slight", when deformity was present in more aspect than one, it was classified as "marked" and the extreme changes as "severe" (Brickley *et al.* 2008). Aspects of bending were recorded as anterior, lateral, medial. Deformity can occur on mandible, ribs and on upper and lower limbs (Ortner 2003). Mays *et al.* (2006) found 86 % rickets deformity on lower limbs. In this study we observe only bones of upper and lower limbs.

Cribra orbitalia was recorded as present or absent on individuals whose orbital roofs were present (right and left). This defect is recorded following the guidelines of Horáčková *at al.* (2004) to three stages (1. – porotic; 2. – cribrotic; 3. – trabecular).

RESULTS

Figure 2 summarized individuals according type of burial, sex and age and *Figure 3* summarized preservation in relation to type of burial. The preservation status of skeletons is an important condition for the assessment of pathology lesions. From assessment of preservation immature individuals were excluded. Worse preservation was marked in series of grave burials than in settlement burials. Moreover, the Chi-Square test shows a statistically significant difference between type of burial and preservation degree ($p<0.05$). We assume that funeral practise (often with burial chamber or coffins with organic grave goods) or grave-robbery can be responsible for this findings.

Stature

Female stature range from 149.5 – 167 cm, the mean is 158 cm. In males, stature ranges from 163 – 175 cm, the mean is 169.2 cm. Difference in type of burial are mentioned in *Table 2*. The results indicate that female and male average stature in settlement pits was slightly higher than in graves, but the difference (Mann Whitney U test) was not significant (p>0.05).

TABLE 2. Summary of estimated statures for females and males.

	FEMALES	MALES
Pits	160,1 [1]	169.2
Graves	155.5	167.8
Significance[2]	not	not
p-value	p>0,05	p >0,50

1 – Measurements are in cm;
2 – Mann Whitney U test (p) probability are indicated to test the null hypothesis that there is no statistical significance between the statures in settlement burials and grave burials at the 0,05 level.

Dental health status

Table 3 and *Figure 7* summarized the dental health status from 43 individuals independent on the type of burial. A total of 735 permanent teeth (340 maxillary and 395 mandibular) were examined for presence of dental caries, LEH and dental calculus. The total number of observed teeth in individuals who were buried in pits is 441 and the number of teeth of individuals buried in graves is 294. The number of total observed alveoli was 762. In pits there were 463 preserved alveoli and in the graves 299 alveoli (*Figure 4*).

Caries

Of these, 1.2 % female teeth only, were carious. Lesions were slightly more common in maxillary teeth (1.5 %) than in mandibular teeth (1 %). The highest frequency of carious lesions was found on mesial and distal surfaces. Within the maxilla, the highest frequency was found in third molars. In the mandibular teeth, the frequency was same in molar and premolar (*Figure 7*). Lesions were more frequent in dentition of females buried in graves (1.7 %) than females buried in pits (0.9 %). The Chi-Square test doesn´t show a statistically significant difference between type of burial and frequency of caries (p>0.05).

LEH

In series, only linear enamel hypoplasias (LEH) were observed. Of these, only 3 teeth or 0.4 % from the individuals of indifferent sex buried in the settlement pits, had enamel hypoplastic lesions. The affected teeth were right second incisor, left and right first incisor only from maxillary dentition (*Figure 7*). The Chi-Square test doesn´t show a statistically significant difference between type of burial and frequency of LEH (p>0.05).

Calculus

Calculus distribution were observed on nine teeth (1.2 %) only of females and indifferent individuals. These deposits were more common in maxillary teeth (2 %) than in mandibular teeth (1 %). Within the maxilla, the highest frequency is found in incisors followed by the canine, the premolar and two molars (*Figure 7*). In the mandibular teeth, the occurrence of calculus is in incisors. Deposits were more frequent in dentition of females buried in graves (2 %) than females buried in pits (0.5 %). The Chi-Square test shows a statistically significant difference between type of burial and frequency of dental calculus (p<0.05).

AMTL

Antemortem tooth loss (AMTL) was recognized if the tooth was not present and the alveolus presented evidence of remodelling. Of 762 observations for ante mortem loss, 27 teeth were missing antemortem (3.5 %). Antemortem loss of teeth was more common in males (8.5 %) than in females (7.5 %) and more frequent in maxillary teeth (8.8 %) than in mandibular teeth (4.8 %). The highest occurrence is among molars followed by premolars (*Figure 7*). Premortem tooth loss affected above all females buried in graves and males buried in settlement pits. Higher frequency of premortem tooth loss is in individuals buried in graves (4 %) than in individuals buried in pits (3 %). The Chi-Square test doesn´t show a statistically significant difference between type of burial and frequency of AMTL (p>0.05).

Skeletal health status

Cribra orbitalia was scored in right and left superior area within the *orbits* (*Table 4*). The overall prevalence of this defect in series is 7 orbits (12 %). Within subadults, *cribra orbitalia* was found in 1 of 6 right *orbits* (16 %) and 3 of 8 left *orbits* (37 %). Of female orbits, 0 of 14 right orbits and 1 of 14 left orbits (7 %) displayed the modification. Of males, 1 from 8 left orbits even right orbits exhibits *cribra orbitalia* (12.5 %). Only one subadult buried in grave exhibits defects on both of orbits. There is no statistical significance between the frequency in males, females and subadults at the 0.05 level. *Cribra orbitalia* was recorded more in graves (31 %) than in settlement pits (4.7 %) and it´s significant. All manifestations of *cribra orbitalia* were of fine porosity (porotic).

Bowing deformities of 207 long bones (forearm, femur and tibia) were also investigated. Deformity was observed in 7 bones (3.3 %). Within females, bowing deformities were found in 2 left of 50 examined femurs (*Figure 6*). The other bowing deformities were recorded in individuals whose sex could not be determinated (2 right femurs, left and right ulnas from one individual and 1 tibia). There is significant different among male, female and indifferent individuals. Skeletons whose sex does not be determinated have the highest prevalence of all. All deformities were classified as marked, tibiae were curved medial in distal parts, femora were curved anterior and *ulnas* lateral in proximal parts. *Figure 4* shows comparison of right bowing femora from object 13 (Mušov site) with bone dissection n. 2328 from the collection of the

TABLE 3. Distribution of dental caries, linear enamel hypoplasia (LEH), and dental calculus.

SIDE		RIGHT								LEFT									
CARIES	**MAXILLA**	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**	**N**	**%**
	Males	0/6	0/6	0/8	0/6	0/6	0/8	0/6	0/7	0/7	0/6	0/5	0/7	0/7	0/6	0/6	0/6	0/103	0
	Females	2/9	0/11	0/11	1/11	1/11	0/10	0/8	0/12	0/9	0/9	0/9	0/7	0/8	0/9	0/9	1/8	5/151	3,3
	Indiferent	0/3	0/8	0/8	0/5	0/4	0/6	0/5	0/4	0/6	0/6	0/6	0/6	0/3	0/8	0/6	0/2	0/86	0
	TOTAL	2/18	0/25	0/27	1/22	1/21	0/24	0/19	0/23	0/22	0/21	0/20	0/20	0/18	0/23	0/21	1/16	**5/340**	**1,5**
	MANDIBULA	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**		
	Males	0/7	0/7	0/9	0/8	0/8	0/8	0/9	0/8	0/6	0/7	0/7	0/6	0/6	0/8	0/10	0/6	0/120	0
	Females	1/10	0/14	0/14	1/13	0/13	0/12	0/11	0/9	0/9	0/8	0/9	0/10	0/13	1/14	1/13	0/9	4/181	2,2
	Indiferent	0/3	0/8	0/8	0/4	0/5	0/7	0/4	0/4	0/6	0/5	0/6	0/5	0/5	0/10	0/9	0/5	0/94	0
	TOTAL	1/20	0/29	0/31	1/25	0/26	0/27	0/24	0/21	0/21	0/20	0/22	0/21	0/24	1/32	1/32	0/20	**4/395**	**1**
LEH	**MAXILLA**	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**	**N**	**%**
	Males	0/6	0/6	0/8	0/6	0/6	0/8	0/6	0/7	0/7	0/6	0/5	0/7	0/7	0/6	0/6	0/6	0/103	0
	Females	0/9	0/11	0/11	0/11	0/11	0/10	0/8	0/12	0/9	0/9	0/9	0/7	0/8	0/9	0/9	0/8	0/151	0
	Indiferent	1/3	0/8	0/8	0/5	0/4	1/6	0/5	0/4	1/6	1/6	0/6	0/6	0/3	0/8	0/6	0/2	3/86	3.5
	TOTAL	1/18	0/25	0/27	0/22	0/21	0/24	0/19	0/23	1/22	1/21	0/20	0/20	0/18	0/23	0/21	0/16	**3/340**	**1.0**
	MANDIBULA	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**		
	Males	0/7	0/7	0/9	0/8	0/8	0/8	0/9	0/8	0/6	0/7	0/7	0/6	0/6	0/8	0/10	0/6	0/120	0
	Females	0/10	0/14	0/14	0/13	0/13	0/12	0/11	0/9	0/9	0/8	0/9	0/10	0/13	0/14	0/13	0/9	0/181	0
	Indiferent	0/3	0/8	0/8	0/4	0/5	0/7	0/4	0/4	0/6	0/5	0/6	0/5	0/5	0/10	0/9	0/5	0/94	0
	TOTAL	0/20	0/29	0/31	0/25	0/26	0/27	0/24	0/21	0/21	0/20	0/22	0/21	0/24	0/32	0/32	0/20	**0/395**	**0**
CALCULUS	**MAXILLA**	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**	**N**	**%**
	Males	0/6	0/6	0/8	0/6	0/6	0/8	0/6	0/7	0/7	0/6	0/5	0/7	0/7	0/6	0/6	0/6	0/103	0
	Females	0/9	0/11	0/11	0/11	0/11	0/10	0/8	1/12	1/9	1/9	0/9	1/7	0/8	1/9	1/9	0/8	6/151	4.0
	Indiferent	0/3	0/8	0/8	0/5	0/4	1/6	0/5	0/4	0/6	0/6	0/6	0/6	0/3	0/8	0/6	0/2	1/86	1.2
	TOTAL	0/18	0/25	0/27	0/22	0/21	1/24	0/19	1/23	1/22	1/21	0/20	1/20	0/18	1/23	1/21	0/16	**7/340**	**2.0**
	MANDIBULA	**M3**	**M2**	**M1**	**P4**	**P3**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**		
	Males	0/7	0/7	0/9	0/8	0/8	0/8	0/9	0/8	0/6	0/7	0/7	0/6	0/6	0/8	0/10	0/6	0/120	0
	Females	0/10	0/14	0/14	0/13	0/13	0/12	1/11	0/9	1/9	1/8	0/9	0/10	0/13	0/14	0/13	0/9	3/181	1.6
	Indiferent	0/3	0/8	0/8	0/4	0/5	0/7	0/4	0/4	0/6	0/5	0/6	0/5	0/5	0/10	0/9	0/5	0/94	0
	TOTAL	0/20	0/29	0/31	0/25	0/26	0/27	1/24	0/21	1/21	1/20	0/22	0/21	0/24	0/32	0/32	0/20	**3/395**	**1.0**

N – number of teeth observed, % – percentage of observable teeth with defects, affected/observed.

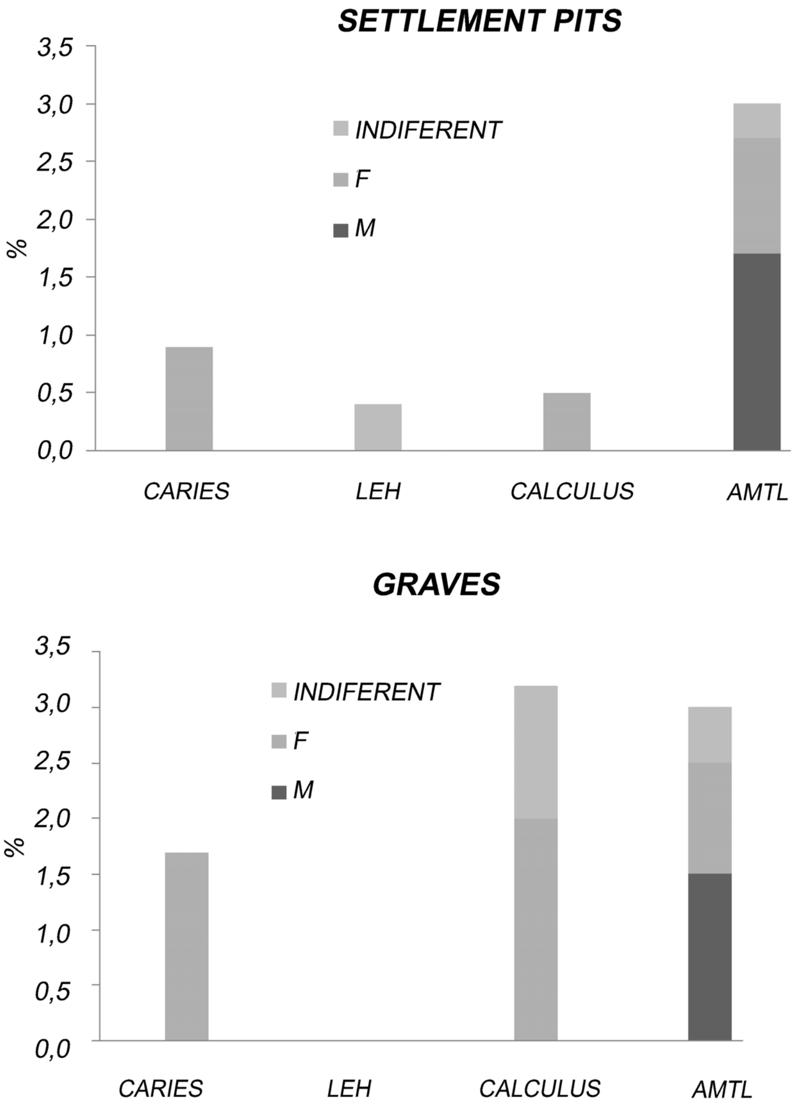

FIGURE 4. Comparison of dental health status in two groups of individuals (skeleton in settlement pits and skeleton in graves).
LEH – linear enamel hypoplasia; AMTL – ante mortem tooth loss; M – males; F – females

2nd Pathological Institute of the National Museum. Bowing deformities were recorded only on skeletons in graves. These defects were diagnosed as an osteomalacia or residual rickets. It can be supposed that vitamin D deficiency during childhood can persist to adulthood (Brickley *et al.* 2008, Mays *et al.* 2006). D deficiency might have been cyclical possibly during the winter (Brickley *et al*. 2008, Aufderheide, Rodríguez-Martin 1989). And in many cases it may not be possible to say whether bowing deformities are residual rickets or osteomalacia (Brickley *et al*. 2008) According Brickley *et al.* (2008) there is a range of differential diagnoses which can cause these bowing deformities, e.g. congenital bowing, Paget´s disease or traumatic bowing deformities. Nevertheless these conditions are very rare and unusual and there is some specification in direction of bowing, different in radiographs or frequency of occurrence according to bone. The Chi-Square test shows a statistically significant difference between type of burial in frequency of bowing long bones ($p<0.05$).

SUMMARY

Table 5 and *Figure 5* summarized the results of comparison of skeletal and dental health status between studying series. There is some difference between these two investigated series in mean stature, prevalence of dental caries, LEH, dental calculus, AMTL, *cribra orbitalia* and bowing deformities on long bones. The results of the stature indicate that female and male average stature in settlement pits was slightly higher than in graves, but result is not significant ($p>0.05$). Dental health shows that only woman were carious. Caries lesions were more frequent in dentition of females buried in graves than females buried in pits, but differences are not significant. Linear enamel hypoplasia occurred only in the pits (statistically not significant), calculus and premortem tooth loss was higher in individuals buried in graves, but only difference in calculus affection is significant ($p<0.05$). *Cribra orbitalia* was recorded more in graves than in settlement pits. All manifestations of *cribra*

TABLE 4. Frequencies of *cribra orbitalia* according side, age, sex and type of burial.

Object	orbits	afected	observed	%	x^2	p value	significance[1]
Pits	M sin	1	6	16	1.94	>0,05	not
	M dx	0	6	0			
	F sin	0	10	0			
	F dx	0	10	0			
	subadults sin	1	6	16			
	subadults dx	0	4	0			
	all the parts sin	**2**	**22**	**9**			
	all the parts dx	**0**	**20**	**0**			
Graves	M sin	0	2	0	4.95	>0,05	not
	M dx	1	2	50			
	F sin	1	4	25			
	F dx	0	4	0			
	subadults sin	2	2	100			
	subadults dx	1	2	50			
	all the parts sin	**3**	**8**	**37**			
	all the parts dx	**2**	**8**	**25**			
TOTAL		**7**	**58**	**12**			

M – males; F – females; sin – left side; dx – right side; indiferent individuals are excluded from the table because the orbits were not preserved.

[1] Chi-square (x^2) probability are indicated to test the null hypothesis that there is no statistical significance between the frequency in males, females and subadults at the 0.05 level.

orbitalia were porotic. Only in the female and indifferent individuals in graves marked deformity on long bones appeared. Differences in the occurrence of defects in the orbit and bowing of long bones were statistically significant ($p<0.05$). Three of the seven signs of worsen health in two investigated series are statistically different at the 0.05 level (*Table 6*). The higher prevalence of dental calculus, *cribra orbitalia* and bowing deformities on long bones is recorded in individuals buried in graves. These results do not support our assumption that individuals buried in settlement pits had a lower social status, supposedly demonstrated by their worse health condition.

CONCLUSION AND DISCUSSION

This review of several skeletal markers of health and indicators of physiological stress, recorded in two series of 43 prehistoric (Early Bronze Age) skeletons from archeological sites in South and Middle Moravia (Czech Republic) provides preliminary assessment of health and disease of these two series which differ in funeral practice. Size of the sample and its preservation is not characteristic enough to confirm whether there is a difference in prevalence of indicators of health and physiological stress and social status between individuals buried in graves and those buried in settlement pits. With more individuals investigated in further studies the result may differ. But it can be concluded that there is no direct correspondence between funerary treatment and biological status in this study. In general, the data analyzed here suggest that people buried in different ways were not clear in terms of skeletal stress markers did not covary among themselves. Actually, results indicate that more stress indicators were observed on skeletons excavated from graves in Mušov site.

The presented results in this study are affected by a great variety of factors. One of them is different preservation between the two observed series. In spite of the fact that individuals buried in graves show significantly lower preservation than individuals disposed in settlement pits, higher prevalence of diseases is observed in the former. There are several causes of lower preservation in addition to natural factors; significantly, the state of preservation is affected by cultural factors, such as secondary manipulation, which are often documented in Mušov site (Stuchlík 1987). If the skeletons in the graves were better preserved there could be a higher prevalence of disease and the differences would be intensified. Distortion of the results due to preservation is evident in both the number of individuals, as well as the number of bones and teeth. *Table 5* shows all numbers of observed bones and teeth, in most cases these particular elements are represented in half amount in graves than in pits. Nevertheless there is higher prevalence of observed pathological traces, which are not caused by

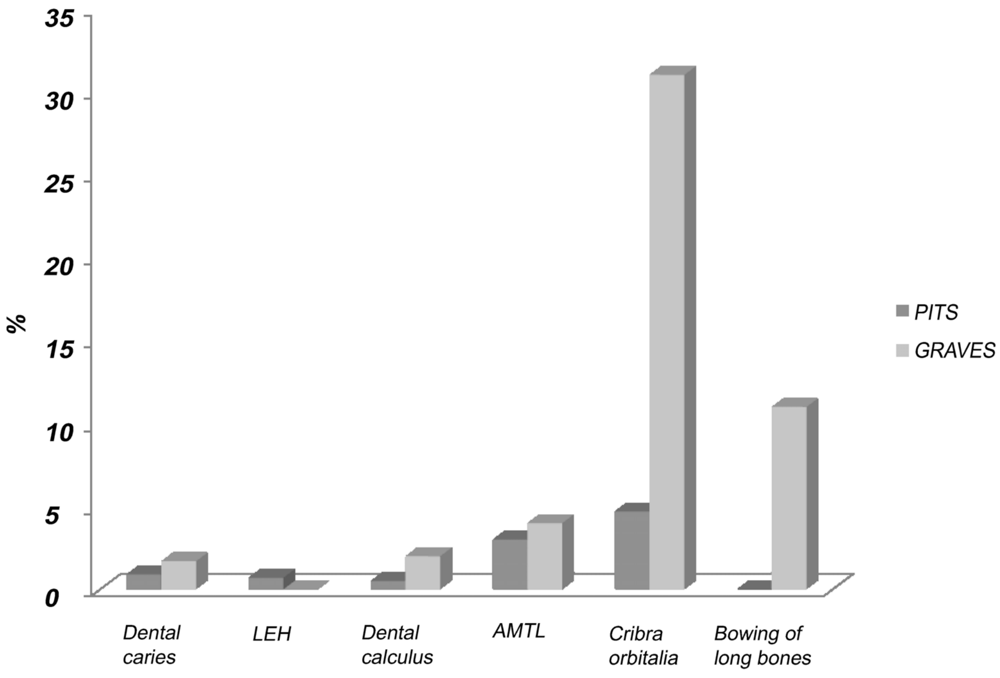

FIGURE 5. Frequencies of osteological and dental markers of health in skeletons disposal in settlement pits and graves.
LEH – linear enamel hypoplasia, AMTL – ante mortem tooth loss.

TABLE 5. Frequencies[1] of osteological and dental markers of health in skeletons disposal in settlement pits and graves.

DEFECTS	**PIT BURIALS**		**GRAVE BURIALS**		**TOTAL**		**SIGNIFICANCE**[3]		
	A/O [2]	%	A/O	%	A/O	%	x^2	*p*- value	
Dental caries	4/441	0.9	5/294	1.7	9/735	1.2	0.919	> 0,05	not
Dental enamel hypoplasia (LEH)	3/441	0.7	0/294	0	3/735	0.4	2.01	> 0,05	not
Dental calculus	2/441	0.5	7/294	2	9/735	1.2	5.42	< 0,05	significance
AMTL	15/463	3	12/299	4	27/762	3.5	0.318	> 0,05	not
Cribra orbitalia	2/42	4,7	5/16	31	7/58	12	7.66	< 0,05	significance
Bowing of long bones	0/146	0	7/63	11	7/209	3	16.8	< 0,05	significance

[1] Frequencies of occurrence include right and left sides
[2] A/O = affected/observed
[3] Chi-square (x^2) probability are indicated to test the null hypothesis that there is no statistical significance between the frequency in settlement burials and grave burials at the 0.05 level

sudden epidemic, infection or war wounds, but by long-term life in worsen conditions. This means that these individuals were exposed to impaired environment.

Another limitation was the demographic distribution of the series. There was a marked disparity between the number of man buried in graves and in the pits. There were recorded about half as much male skeleton in graves than in pits. Therefore, we do not deal with frequency of diseases based on sex and age. Demographic imbalance would distort the comparisons.

The first evaluated indicator of stress was mean stature, which does not differ between these series. Mean stature was estimated only in 23 individuals (9 males and 12 females). Man's mean height was about 10 cm higher than the female. Although the stature is a very sensitive indicator of living conditions (Maat 2005), our study did not show significant difference.

The second evaluated indicator of stress was dental health, which differ between these series. Overall preservation of teeth between the two series differed. There are 141 fewer teeth found in individuals buried in gravis than in pits. Nevertheless more pathological traces occurred there. Teeth in graves were more affected by dental caries. Frequency of caries was observed on 1.2 % teeth, particularly on molars and premolars, which are appropriate places for appearance of dental caries in its cusps. Similar conclusions are given in other studies (e.g. Wasterlain *et al.* 2009, Hillson 2001, Strouhal 1964). Caries occurred only on female´s skeletons and more on mandible. Higher prevalence of caries in female skeletons are supported by other studies in other time periods (Watson 2009, Stránská *et al.* 2008) and is explained by the biological determination of the female sex. Same prevalence of caries in both groups indicates a similar diet composition, access to resources and

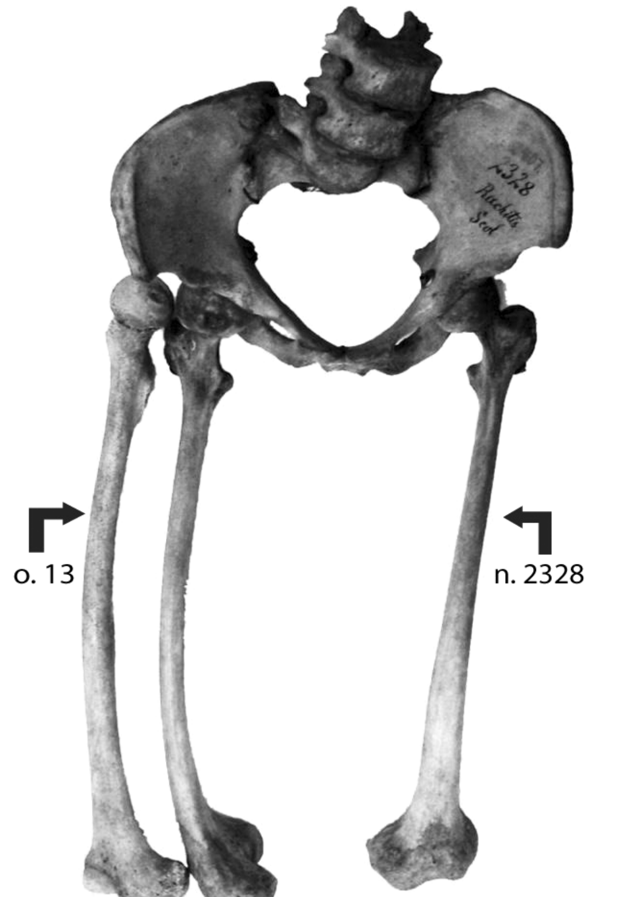

FIGURE 6. Comparison of right bowing femora from object 13 (Mušov site) with bone dissection n.2328 from the collection of the 2nd Pathological Institute of the National Museum.

preparation of food. The prevalence of caries correlated with low protein diet (e.g. Hillson 2001, Larsen 1997), therefore a lower prevalence of caries in both groups may indicate a more protein diet, which was for this period also confirmed by isotopic analysis of selenium and zinc (Smrčka *et al.* 2010). Low prevalence of caries may also be associated with higher dental abrasion, which averts caries formation in cusps. Indeed we cannot determine the true prevalence of dental caries due to premortem tooth loss, though it's not frequent (3.5 %). Premortem tooth loss could be caused by dental caries (Lucas 1992), although there are many other causes, for example, may be caused by periodontal diseases, dental calculus, abrasive diet, which causes the exposure of dental pulp and subsequent abscess, furthermore, mechanical (Lucas 2007), mastication, but also use teeth for other activities than mastication (Larsen 1997). In series, more ante mortem tooth loss was observed in males and again in molars and premolars, which is unusual for the loss of teeth caused by trauma (Lucas 2007) and therefore this may explain the absence of caries in men. The higher prevalence is in the alveoli of the upper jaw, which is probably related to differences in the anatomical structure of both jaws (Strouhal 1964) and as a non-cultural factor is confirmed by for example Hall *et al.* (1986). Ante mortem tooth loss is caused also by dental calculus, which occurred again only in females and undetermined individuals in particular on front teeth. This phenomenon is confirmed by clinical studies, which noted calculus formation at salivary gland aperture, on lingual surface of front teeth (Macpherson *et al.* 1995). Calculus is generally associated with lower dental hygiene and overall poorer dental health (Ubelaker, Freire 2005). The formation of plaque is influenced by; inter alia, high protein diet (Ubelaker, Freire

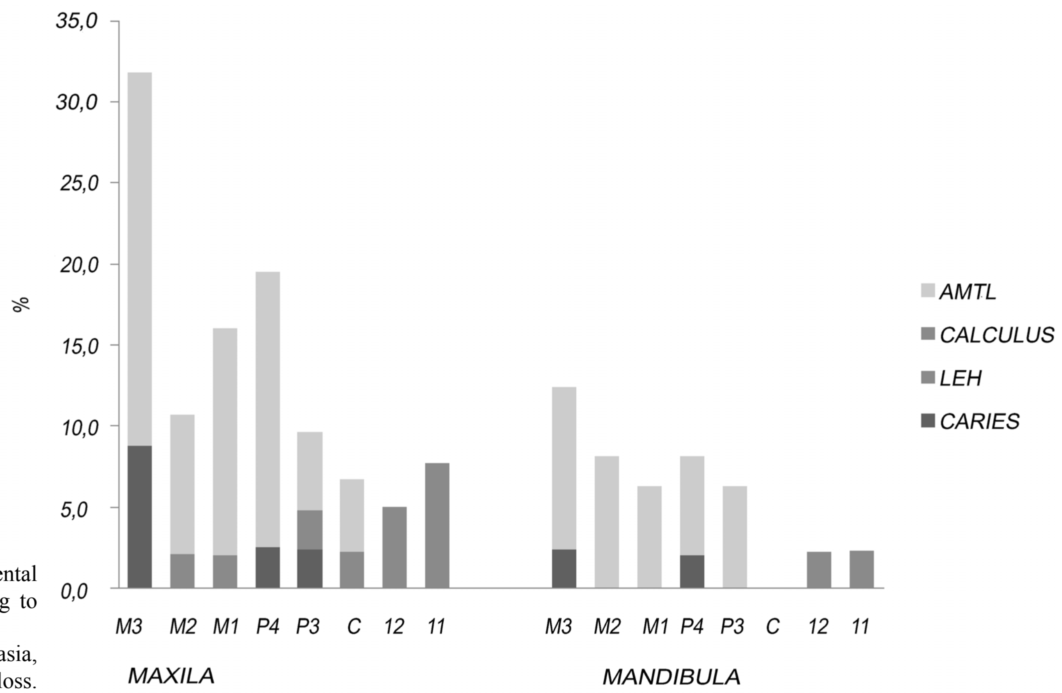

FIGURE 7. Frequency of dental pathological traces according to different kinds of teeth.
LEH – linear enamel hypoplasia, AMTL – ante mortem tooth loss.

2005). The prevalence of dental disease was different between the two examined series, more were observed in individuals buried in graves, which also corresponds to other results relating to skeletal health status, and it probably is relevant to the overall health of the population in Mušov site. Regarding prevalence of dental disease compared with other archeological series and studies from this period, particularly suitable for this is frequency of dental caries and the intravital tooth loss. The comparison was made with the results of Strouhal (1964), who in his publication provides further comparative series. Frequency of dental caries in our case was very low (1.2%) compared with the results of Strouhal (1964), which indicates the frequency of 2.2%, which he interpreted as a low prevalence. In spite of raising portion of cereal in ancient diet, imperfect grinding and leaving shells in the product caused that the ancient cereal products were rich in protein, fats, mineral salts and vitamins (Stokar 1951 in Strouhal 1964). Other studies, presented by Strouhal (1964) correspond to the frequency of 2.2 to 2.5% for the Early Bronze age. In later periods of Bronze Age the prevalence is increasing, the highest prevalence is recorded in the Cézavách Blučina (8%) (Pavlíková – Bílý 1956). Concerning intravital loss of teeth, our results are close to the results of Strouhal (1964), who indicates the occurrence of 4.3%, which is in our case 3.5%.

Assessment of skeletal health status was again limited to the state of preservation and disparity of the parts of the skeleton between two series. Orbits in the graves formed only one third of those observed in the pits and the long bones in the graves formed only half of those present in pits. The prevalence of osteomalacia in the graves is probably due to the specific environment and living conditions typical for the site Mušov.

There is no apparent higher prevalence of stress indicators on the skeletons buried in settlement pits, which could predict their social status. It is not therefore possible that such funeral practice is non-ritual and does not concern individuals with lower social status. But there are many other generally explanations for this conclusion:

1) archeological evidence (funerary treatment) may not reflect economic status or differences in lifestyle sufficiently;
2) investigated series do not involve the whole social spectrum;
3) in this period (Early Bronze Age) it can be supposed that burial type reflects social status or wealth of person, but this needn´t suggest that the individuals reflect their physiological condition;
4) elite and commoners may have suffered from similar health risks or diseases and nutrition may not have had a visible effect on skeleton;
5) the other explanation is concerns the sensitivity of biological indicators incident on the skeleton. These indicators may not be adequate to expose fine differences in lifestyles;
6) last but not least is to note which skeletal features are socially significant. It depends on locally specific environment and nature of the biological stresses. Correlation of health, lifestyle and access to resources and social status depend on archeological and skeletal evidence from sites to sites.

The issue of burials in settlement pits phenomenon is still open. A clear answer, as to why next to typical necropolis occur so many burials in settlement pits, layers or borrow pit in Early Bronze Age cannot be answered. Variability of such burial is expressive from complete skeleton in anatomical position to non-anatomical disposal of separate bones, which can be evidence for secondary funeral. It can never be established whether these practices are ritual or non-ritual and whether they were individuals who were excluded from the society. From ethnographic researches is known that secondary manipulation with human remains were practiced entirely with individuals of higher status (Sosna 2007). This study, which will be complemented and extended by other material in future, still exclude, based on available data, the possibility that those individuals could be of lower social status. There remain other ways to explain this phenomenon, which are reported in other studies (Rulf 1996, Salaš 1990, Tomková 2003, Drozdová, Šedo 2004, Hanuliak 1997) and could be individually remit to testing.

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