ANTHROPOLOGIE • XLII/2 • pp. 189–194 • 2004

ZUZANA OBERTOVÁ, MILAN THURZO

CRIBRA ORBITALIA AS AN INDICATOR OF STRESS IN THE EARLY MEDIEVAL SLAVIC POPULATION FROM BOROVCE (SLOVAKIA)

ABSTRACT: Several paleopathological indicators examined in skeletons are caused by stress during childhood and remain visible in adults. In this study, the prevalence and distribution of cribra orbitalia *was observed in 451 individuals from the Early Medieval (8th – beginning of 12th c. AD) skeletal series at Borovce (Piešťany District, Slovakia). Three hundred forty-two skulls were scored for the presence of* cribra orbitalia. *Almost half of the individuals with one or both orbits present displayed* cribra orbitalia. *The number of subadults (0–19 years old) with the orbital lesions was significantly higher than that of adults. No significant differences in the occurrence of orbital lesions were found between males and females. Demographic analysis revealed a significantly lower life expectancy at birth for individuals with* cribra orbitalia *than for those without this disorder. It has been shown that the high prevalence of* cribra orbitalia *and underlying iron deficiency anaemia has had a severe impact on the surviving of individuals especially during periods of rapid growth and development. The results show that the Borovce population lived under conditions of high environmental pathogen load, and probably also suffered some nutritional deficiencies.*

KEY WORDS: Skeletal remains – Orbital lesions – Middle Ages – Paleodemography – Slovakia

INTRODUCTION

First described by Welcker (1888), *cribra orbitalia* refers to a sieve-like porosity involving the orbital roof. The orbital lesions develop as a result of hypertrophy and hyperplasia of the red bone marrow that occurs as part of the body's response to the inadequate oxygen carrying capacity of the blood.

The majority of researchers at present suggest that *cribra orbitalia* found in archaeological samples is the result of anaemia and, in the majority of populations, acquired iron deficiency anaemia (Stuart-Macadam 1992).

Increased frequency of the orbital lesions has been repeatedly found in sedentary populations with inadequate sanitation, high pathogen load, and consequent infectious diseases and possible nutritional deficiencies (Kent 1986, Walker 1986, Stuart-Macadam 1992).

MATERIAL AND METHODS

The Early Medieval cemetery (8th – beginning of 12th century AD) is situated in the village of Borovce, 10 km SW from Piešťany (Slovakia) (*Figure 1*). The location has been reported to show the greatest concentration of niche graves of the "podmola" type, and also the northernmost occurrence of the "tunnel" type niche graves in Central Europe (Staššíková-Štukovská 2001). The "podmola" niche graves have sporadically occurred in the Central European region during the Roman era and the Migration Period. They were often found at nomadic cemeteries, and therefore related to the Avar settlement on the present-day Slovak territory (Štefanovičová 2002). The "tunnel" niche graves have been concentrated in the Tisa river basin, and were found at the Avar Khaganat burial sites. However, the Borovce burial site is located in a region where no

FIGURE 1. Burial site location – Borovce, Slovakia.

Avar-Slavic cemeteries have been reported, and is considered to be uniformly Slavic (Staššíková-Štukovská 2001).

The examined skeletal series consists of 451 individuals recovered from 439 graves. The sample is comprised of 189 (41.9%) juveniles (0–19 years old), 111 (24.6%) adult males, 135 (29.9%) adult females, and of 15 (3.3%) adults of undetermined sex. The collection is well suited for paleopathological investigation, mainly because there is no obvious underrepresentation of the juveniles, a common problem in archaeological samples.

Cribra orbitalia were examined macroscopically two times (after a longer time span) by two independent observers, M. Krčmářová (technical assistant at the Department of Anthropology of the Slovak National Museum) and the first author (Z. O.). Inter- and intraobserver reliability was assessed to obtain the information on the differences in determining the presence/absence and intensity of expression of the lesions. Agreement between the two observers was found in 73.7% and 72.8% cases, respectively. Repeatability (intraobserver reliability) was 82.5% for the first observer (M. Krčmářová), and 94.4% for the author. These results supported the decision to use for further analysis only the data of the first author's second observation.

FIGURE 2. Severe *cribra orbitalia* in a 2-year-old infant (Borovce).

Three hundred forty-two skulls were scored for the presence/absence and intensity of expression of the orbital lesions according to the scoring scale by Hengen (1971) with the modification by Hauser *et al.* (1983): H0 – no evidence of *cribra orbitalia*; H1 – net of shallow furrows with a number of fine foramina in the *lamina externa* of the orbital roof; H2 – more numerous, scattered foramina with a diameter up to 1 mm; H3 – numerous foramina (1–2 mm in diameter) with a tendency to cluster together but still preserving their individuality; H4 – foramina with a diameter larger than 2 mm linked into a trabecular structure. In this category, Hengen's grades 5 to 7, characterized by the outgrowth in trabecular form from the outer table, have been included.

Individuals with at least one orbit scored by grades H1 or H2 were assigned to individuals with mild *cribra orbitalia*. Similarly, individuals with at least one orbit classified by H3 or H4 degrees of intensity were termed as individuals with severe *cribra orbitalia* (*Figure 2*). In the total sample, only 16.5% of individuals exhibited unilateral occurrence of *cribra orbitalia*, and in addition, the severity of orbital lesions was found to be symmetrical in 76% of individuals. Therefore, in cases when only one orbit was observable, the same intensity of lesion has been assumed for the missing orbit.

Paleodemographic analysis has been based on composite life tables, as described by Acsádi and Nemeskéri (1970). Tables were constructed for individuals with and without orbital lesions separately.

RESULTS

In the Borovce sample, 167 (48.8%) individuals displayed *cribra orbitalia*. The ages of 10–14 years (85.7%) as well as 3–4 and 5–9 years (both, 83.3%) were found to be the most crucial periods with respect to the likelihood of displaying the orbital lesions (*Table 1*). The overall

TABLE 1. Prevalence of *cribra orbitalia* by age.

Age (Years)	Individuals with at least one observable orbit	Individuals with *cribra orbitalia*	
		Total	Severe
	N	n (%)	n (%)
0–1	20	10 (50.0)	1 (5.0)
1–2	16	13 (81.3)	3 (18.8)
3–4	24	20 (83.3)	6 (25.0)
5–9	30	25 (83.3)	5 (16.7)
10–14	14	12 (85.7)	5 (35.7)
15–19	13	9 (69.2)	4 (30.8)
20–29	34	11 (32.4)	2 (5.9)
30–39	44	15 (34.1)	3 (6.8)
40–49	60	23 (38.3)	5 (8.3)
50–59	63	23 (36.5)	4 (6.3)
60+	24	6 (25.0)	0 (0.0)
Total	342	167 (48.8)	38 (11.1)

frequency of the orbital lesions in subadults (0–19 years old) was found to be significantly higher (76.1%) than that of adults (34.7%) (χ^2=16.96, P=0.00). Females (37.4%) had a somewhat higher occurrence of *cribra orbitalia* than males (28.9%), but the difference was not statistically significant (Yates' χ^2=0.61, P=0.44).

In the total sample, 11.1% of the analysed individuals showed pronounced *cribra orbitalia*. Severe lesions were most commonly found in the 10–14-year-olds (35.7%) and 15–19-year-olds (30.8%). No pronounced orbital lesions were observed in individuals older than 60 years of age (*Figure 3*). The frequency of juveniles with severe lesions (20.5%) was significantly higher than that of adults (6.2 %) (Yates' χ^2=11.07, P=0.00). The difference between males (5.6%) and females (6.5%) was found to be non-significant (Yates' χ^2=0.00, P=0.98).

Spearman correlation coefficient was used to assess the relationship between the age of individuals and the intensity of occurrence of *cribra orbitalia*. Considering the total sample, the results show an indirect dependency between the increasing age of the individuals and the severity of lesions (R=–0.26, P=0.00). Thus, as age of the individuals increases, the intensity of lesions decreases. On the contrary, in the juvenile sample a direct dependency is observed, that is, the older the individuals get, the more severe orbital lesions are found (R=0.26, P=0.01).

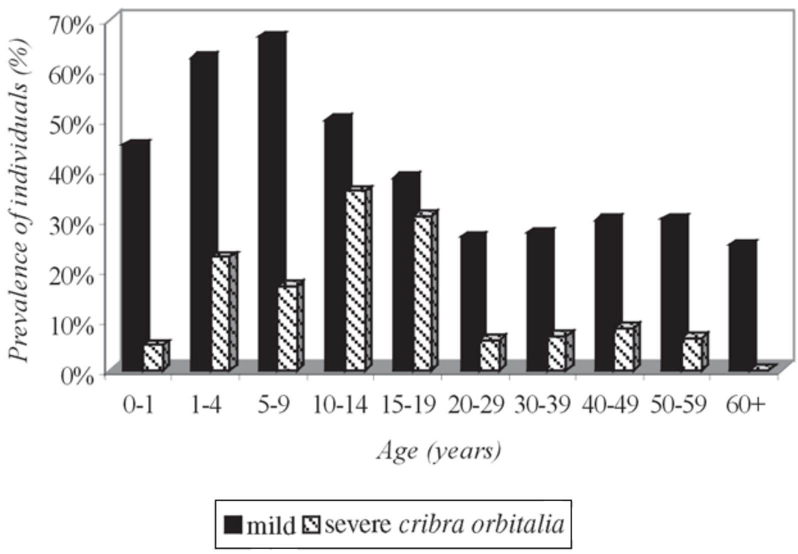

FIGURE 3. Intensity of expression of *cribra orbitalia* by age.

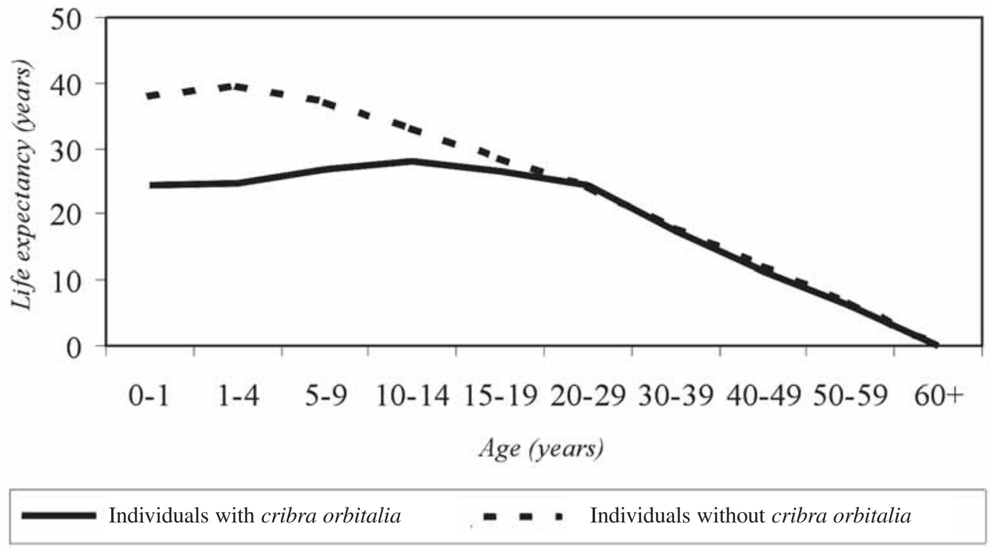

FIGURE 4. Life expectancy curves for individuals with and without *cribra orbitalia*.

The comparison of demographic parameters between the individuals with and without *cribra orbitalia* revealed some considerable differences. Life expectancy at birth and at the subsequent age groups (up to 5–9 years) was found to be lower for the individuals displaying *cribra orbitalia* (e_0 = 24.3 years) than for the unaffected sample (e_0 = 38.2 years) (*Figure 4*). The probability of death in the subadult sample was highest for the 0–1-year-olds in the unaffected series (5.7%), in contrast to the peak at 1–4 years (21.0%) for the affected individuals. In the sample without orbital lesions, 50% of the population managed to survive until 40–49 years, while individuals displaying *cribra orbitalia* reached 50% already at the age of 15–19 years.

Within both affected and unaffected samples, the life expectancy in 20–29-year-old males was higher than that of females. The probability of death was considerably higher for 30–39-year-old females, compared to their male counterparts. In the affected sample, the 20–29-year-old females had the probability of dying value almost twice as high as the males at this age.

DISCUSSION

Compared to other studies from the Early Medieval times in the present-day Slovak territory, the Borovce population showed similar prevalence of *cribra orbitalia* (48.8%) to that found at Šebastovce (50.0%) (Kráľová *et al.* 1997), but the value was more than twice as high as the 20.0% reported for the Devín site (Beňuš 1998). Individuals between the ages 10–14 years, 3–4 years and 5–9 years displayed the highest prevalence of *cribra orbitalia* (85.7% and 83.3% respectively). Similar percentages (85.7%) were found by Šlaus (2000) in the Nova Rača population for both 4–9-year-olds and 10–14-year-olds. He noted that in historical records from this era, periods of "great hunger and starvation" were mentioned.

Although emphasis has traditionally been on iron deficient diet as the primary cause of the anaemia underlying *cribra orbitalia* (El-Najjar *et al.* 1975), the aetiology of this condition is not that simple, and can be best understood in terms of synergistic interactions. It has been suggested that chronic hypoferremia was actually a primary adaptive response to disease and/or environmental pathogen load, followed by the development of iron deficiency anaemia as the threshold between hypoferremia and anaemia was surmounted (Kent *et al.* 1994). This would occur particularly when other factors such as physiological status (e.g., pregnancy), growth requirements, blood loss (as in parasitic infestation), or in rare cases diet, tipped the balance (Stuart-Macadam 1992).

Children would be particularly susceptible to iron deficiency anaemia at weaning because of increased pathogen exposure, low iron stores, and high growth demands (Kent 1986). High prevalence of the orbital lesions in 3–4 and 5–9-year-old individuals at Borovce correlates well with the probable stress connected to the weaning and post-weaning period.

As previously recognized, affected individuals will be most likely to appear in the mortality sample during periods of nutritional and/or disease stress. The highest frequency of individuals with orbital lesions dying between 10 and 14 years of age can be attributed to the fact that these individuals, probably exposed to stress also earlier in life, could not cope with stresses during the pubertal growth period, characterized by increased nutritional demands accompanied by greater susceptibility to environmental pathogens.

In consistency with most studies concerned with sex-related differences in the prevalence of *cribra orbitalia*

(Hengen 1971, Stuart-Macadam 1985, Walker 1986), no significant differences between males and females were found, although a slightly higher percentage of *cribra orbitalia* was detected in females. Where a higher prevalence of orbital lesions has been found in adult females compared with males, this has been interpreted as evidence of increased female susceptibility to iron deficiency anaemia resulting from their increased demands for iron in menstruation, pregnancies, and lactation (Larsen 1997).

Regardless of the presence of *cribra orbitalia*, females aged 30–39 years were at considerably higher risk of dying than their male counterparts, which may refer to a period of increased stress associated with childbearing and lactation. Interestingly, this is a relatively late age for an Early Medieval population. However, a slightly different pattern emerges, when females displaying *cribra orbitalia* are considered. The probability of dying value for these females refers to higher stress levels already at the age of 20–29 years. Thus, the unaffected females were probably able to handle the stress occurring at an earlier age, only to die somewhat later, possibly because of the stresses resulting from multiple pregnancies.

The Spearman correlation coefficient output supports previous suggestions (Stuart-Macadam 1985, Lovell 1998) that with increasing age of the individuals the orbital lesions become milder in expression, because after surviving the underlying stress period, partial or complete healing of the orbital porosities can appear. According to Stuart-Macadam (1985), *cribra orbitalia* seen in adults is most probably representative of an anaemia acquired during early childhood, that is, the result of growth period bone changes that have not undergone complete remodelling.

The underlying iron deficiency anaemia causing the development of *cribra orbitalia* appears to have had a significant effect on the life expectancy. In the analyzed sample, individuals with orbital lesions have a life expectancy by 14 years lower than individuals with no evidence of the disease.

CONCLUSIONS

The goal of the present research was to obtain information about the living conditions and environmental pathogen load by determining the prevalence of *cribra orbitalia* in the Early Medieval Slavic population at Borovce.

Considering the prevalence of the orbital lesions and the probability of dying values for affected infants (0–4-year-olds) and growing juveniles (10–14-year-olds) as well as for females at reproductive age, a pattern emerged suggestive of probable nutritional deficiencies and high pathogen load at Borovce. Further studies dealing with the prevalence of other paleopathological stress indicators (enamel hypoplasia, periostitis, etc.), and their interrelations will follow.

ACKNOWLEDGEMENTS

We wish to thank RNDr. Alena Šefčáková, PhD., head of the Department of Anthropology at the Slovak National Museum in Bratislava, for allowing access to the skeletal material upon which this study is based. We also would like to thank Martin Danišík for his support throughout the preparation of this paper, Michal Poljak for the photographic documentation, and Laura Niven for improving the language.

REFERENCES

ACSÁDI G., NEMESKÉRI J., 1970: *History of Human Life Span and Mortality.* Akadémiai Kiadó, Budapest. 347 pp.

BEŇUŠ R., 1998: *Antropologická analýza rannostredovekej populácie z pohrebiska Devín-Hrad datovaného do XI.–XII. storočia* (Diploma thesis). Katedra antropológie, PriF UK, Bratislava. 126 pp.

EL-NAJJAR M. Y., LOZOFF B., RYAN D. J., 1975: The paleoepidemiology of porotichyperostosis in the American Southwest: Radiological and ecological considerations. *Amer. J. of Roentgenology, Radium Therapy and Nuclear Medicine* 125, 4: 918–924.

HAUSER G., HEINRICH W., ROSSI S., GUIDOTTI A., 1983: Methodological aspects of classifying low and medium intensity of hyperostosis spongiosa orbitae. *Anatomischer Anzeiger* 154: 377–385.

HENGEN O. P., 1971: Cribra orbitalia: Pathogenesis and probable etiology. *Homo* 22: 57–75.

KENT S., 1986: The influence of sedentism and aggregation on porotic hyperostosis and anaemia: A case study. *Man* 21: 605–636.

KENT S., WEINBERG E. D., STUART-MACADAM P., 1994: The etiology of the anemia of chronic disease and infection. *J. of Clinical Epidemiology* 47, 1: 23–33.

KRÁĽOVÁ J., KRČMÁŘOVÁ M., LIETAVA J., THURZO M., 1997*: Porotic hyperostosis in Early Medieval Slavic population from Košice-Šebastovce (Eastern Slovakia).* Proceedings from international colloquium. Bratislava.

LARSEN C. S., 1997: *Bioarchaeology*. Cambridge University Press, Cambridge. 461 pp.

LOVELL N. C., 1998: The biocultural context of anemia in the ancient Indus Valley. *J. of Hum. Ecology* 9, 3: 205–219.

STAŠŠÍKOVÁ-ŠTUKOVSKÁ D., 2001: Vybrané nálezy z pohrebiska v Borovciach z pohľadu začiatkov kostrového pochovávania staromoravských a nitrianskych Slovanov. In: P. Kouřil, Z. Meřínský (Eds.): *Velká Morava mezi východem a západem.* Pp. 371–388. Spisy AÚ AV ČR, Brno.

STUART-MACADAM P., 1985: Porotic hyperostosis: Representative of a childhood condition. *Amer. J. of Phys. Anthrop.* 66, 4: 391–398.

STUART-MACADAM P., 1992: Porotic hyperostosis: A new perspective. *Amer. J. of Phys. Anthrop.* 87: 39–47.

ŠLAUS M., 2000: Biocultural analysis of sex differences in mortality profiles and stress levels in the Late Medieval population from Nova Rača, Croatia. *Amer. J. of Phys. Anthrop.* 111: 193–209.

ŠTEFANOVIČOVÁ T., 2002: Pohrebiská starých Slovanov. *Historická revue* XIII, 1: 6–7.

WALKER P. L., 1986: Porotic hyperostosis in a marine-dependent California Indian population. *Amer. J. of Phys. Anthrop.* 69, 3: 345–354.

WELCKER H., 1888: Cribra orbitalia, ein ethnologisch-diagnostisches Merkmal am Schädel mehrerer Menschenrassen. *Archiv für Anthropologie* 17: 1–18.

Zuzana Obertová
Osteologische Sammlung
Universität Tübingen
Wilhelmstrasse 27
D-72076 Tübingen, Germany
E-mail: zuzanaobertova@yahoo.com

Milan Thurzo
Department of Anthropology
Comenius University
Mlynská dolina B2
842 15 Bratislava, Slovakia
E-mail: thurzo@fns.uniba.sk