ANTHROPOLOGICAL REVIEW • Vol. 74, 57–68 (2011)
Available online at: https://doi.org/10.2478/v10044-010-0006-z

Analysis of cribra orbitalia in the earliest inhabitants of medieval Vilnius

Šarūnas Jatautis, Ieva Mitokaitė, Rimantas Jankauskas

Department of Anatomy, Histology and Anthropology, Faculty of Medicine, Vilnius University, Čiurlionio 21, Vilnius LT 03101, Lithuania; E-mail: rimantas.jankauskas@mf.vu.lt

ABSTRACT The purpose of this work is to present an analysis of cribra orbitalia (CO) from the population of a medieval cemetery in Vilnius, Lithuania, dated between the end of the 13th to the beginning of the 15th centuries. The sample consisted of 208 individuals with sufficiently preserved orbits: 82 subadults and 122 adults. CO was correlated with sex, age-at-death, and three skeletal indicators of biological health: linear enamel hypoplasia, periostitis, and adult femur length as a proxy value for stature. Siler's and Gompertz-Makeham's parametric models of mortality as well as $\chi 2$ statistics were used to evaluate these relationships. Almost one-third of all analyzed individuals had signs of CO, including approximately 60% of the subadults. There was a very strong relationship between the age-at-death and incidence of CO, i.e., individuals with the lesion were dying much younger. The frequency of CO among the sexes was not statistically significant. On the other hand, CO had a negative effect only on adult males, i.e., males who had the lesion died at a younger age. Furthermore, CO and linear enamel hypoplasia were positively related for subadults, whereas no significant relationships were found among adults of corresponding sex. Incidence of periostitis and adult stature were not related to CO.

KEY WORDS: mortality, health, Late Middle Ages, Lithuania

Cribra orbitalia (CO), which refers to porosity and hyperostosis of the superior wall of the orbit, is one of the most frequent lesions macroscopically found in archaeological skeletal collections and is frequently a topical subject of discussion in the bioarcheological literature.

Several explanations for the pathogenesis of CO have been given by previous researchers, including bone marrow hyperplasia, bone inflammatory processes, vestiges of hemorrhage, etc. [Stuart-Macadam 1985, 1987; Grupe 1995; Ortner & Ericksen 1997; Ortner *et al.* 1999, 2001; Schultz 2001; Ortner 2003; Wapler *et al.* 2004; Blom *et al.* 2005; Walker *et al*. 2009]. Nevertheless, traditionally this lesion is considered to be a response to long-term childhood anemia: in individuals suffering from anemia, hyperplastic marrow tissue

Received 20 October 2011; accepted 2 December 2011
DOI: 10.2478/v10044-010-0006-z

inside the diploic space protrudes through the external cortical bone, and manifests in the orbits as CO ([Steinbock 1976; Stuart-Macadam 1985, 1987, 1992, 1998; Mittler & Van Gerven 1994; Aufderheide & Rodriguez-Martin 1998; Blom *et al.* 2005]; however, see Sullivan [2005] concerning CO manifestation in adults). Anemia can be the result of genetic defects, acquired deficiencies and/or malabsorptions of iron and/or vitamin B12 or folic acid, due to chronic diseases or intestinal parasitism (e.g., diarrhea), blood loss due to trauma, etc. [Aster 2004]. Despite the fact that genetic forms of anemia may result in CO, non-genetic factors are considered to be mainly responsible for the vast majority of the CO cases in archaeological skeletal collections (with the exception of those of some specific regions) [Larsen 1997, Aufderheide & Rodriguez-Martin 1998, Piontek & Kozlowski 2002, Blom *et al*. 2005, Sullivan 2005]. In general, three main types of acquired anemia are thought to result in CO: dietary, megaloblastic, and pathogen load [Mensforth *et al*. 1978; Stuart-Macadam 1992, 1998; Larsen 1997; Goodman & Martin 2002; Holland & O'Brien 2002; Sullivan 2005; Walker *et al.* 2009]. Until recently, iron deficiency anemia was the most plausible cause of CO in the paleopathological literature [Hengen 1971; Steinbock 1976; Cybulski 1977; Stuart-Macadam 1985, 1992; Walker 1986; Goodman & Martin 2002, Benuš *et al.* 2010]. However, this hypothesis has been questioned [Walker *et al.* 2009]. Taken together, the exact causality of CO in archaeological skeletal collections is largely unclear. In addition, there is evidence that other causes, such as scurvy, infectious diseases or even post-mortem changes might produce similar changes in the skull, which are difficult to differentiate by macroscopic analysis [Larsen 1997; Ortner *et al.* 1999, 2001; Schultz 2001, Ortner 2003; Wapler *et al.* 2004]. Therefore, some authors suggest treating CO rather as a non-specific indicator of childhood stress [Lewis 2002]. Moreover, even supposing that it is possible to differentiate signs of anemia from other causes, the frequency of CO still reflects only a fraction of individuals who had had anemia: Firstly, archaeological skeletal samples mostly represent only the weakest and sickest individuals of a once living population [Milner *et al.* 2008]. Secondly, CO is a reflection of stressful events experienced in childhood. Thirdly, CO is most likely an indicator of chronic stress events. Those who had an acute anemia and died (or recovered) quickly, without leaving any clearly visible changes in the dry skeletons, will not be identified by macroscopic analysis. Fourthly, modern clinical evidence suggests that osseous changes do not always occur with the episodes of anemia, where only 50 – 75 % of individuals who have anemia show radiographic skeletal alterations [Stuart-Macadam 1985]. Finally, it is not clear whether the effect of remodeling affects the frequency of CO in adult individuals. If so, reconstructions of health experience during childhood and its influence on adults may be considerably distorted.

Despite the abovementioned considerations, CO in (pre)historical studies is very often considered as a general index of poor health as well as an indication of poor dietary and/or sanitary conditions and high incidence of infectious diseases (e.g., Cohen & Armelagos [1984], Steckel & Rose [2002]).

The aim of this paper is to analyze whether the distribution of CO in skeletal data from a medieval Vilnius cemetery can be related to the following factors: a) age at death, b) sex, c) three skeletal indicators

of biological health, i.e., periostitis, linear enamel hypoplasia, and stature. As the first comprehensive study of CO based on an archaeological skeletal collection from within current Lithuanian borders, it provides data from an original cultural environment and contributes to the discussion and assessment of an entity of considerable interest in bioarcheology.

Materials and methods

Vilnius, the capital of the Grand Duchy of Lithuania from the 14th until 18th centuries, was an eastern central European town, similar at least in some ways to large cities of the region such as Cracow, Prague, Bratislava and Budapest. Unfortunately, very scarce historical data about Vilnius in 13th to 15th centuries exists. The city was first mentioned in historical records in 1323 in the letters of Gediminas, the ruler of the Grand Duchy of Lithuania. The letters also document that Vilnius had recently became the capital of the country. Although archaeological data records that Vilnius already existed much earlier, historians argue that it fulfilled the typical attributes of a medieval town in the first half of 14th c. [Bumblauskas 2005]. From the very beginning of 14th c. it became a multinational and cosmopolitan town. Subsequently, in 1387, Vilnius was the first city in Lithuania to adopt the Magdeburg rights, or city rights [Kiaupa *et al.* 2000]. The period of interest is primarily characterized by frequent and severe fights with the Teutonic Order. To exemplify, in 1390 Vilnius had been under siege for a whole year [Kiaupa *et al.* 2000]. Moreover, the inhabitants were permanently plagued by fire due to the fact that the majority of buildings and even streets were made of wood and the buildings of simple townspeople positioned very close to each other. This also indicates that local dwellers lived in a crowded environment [Čaplinskas 2010]. Though little can be said about population size and sanitary conditions of this period, written sources from slightly later times testify that Vilnius was a messy town and that the local authorities did not seek to alter the situation significantly. Dirt was thrown directly onto the streets and drained to pools and rivers [Baronas 2001]. As a result, malnutrition, various diseases and high child mortality were characteristic of medieval Lithuanian towns [Čaplinskas 2010]. In taking this into account, it would follow that Vilnius provided a fertile environment for the causes of CO.

The graveyard which forms the material basis of this analysis was located in the area of the Bokšto street. Archaeological excavations were carried out in the years of 2006–2010. The cemetery is dated from the end of the 13th to the beginning of the 15th c.; the majority of material most likely coming from the 14th century [Mitokaitė 2011]. At that time the environs of Bokšto street belonged to the Orthodox community. It was the area of Vilnius named "Civitas Ruthenica", or Russian city [Jonaitis & Vėževičienė 2006, Katalynas 2006, Vaitkevičius 2010]. Human remains from the Bokšto street cemetery are relatively well preserved [Mitokaitė 2011] and therefore suitable for thorough analysis. On the other hand, the graves were sparse in archaeological artefacts. It is not known whether the rarity of grave inventory indicates something about the social position of the buried individuals or adherence to Christian rules. In this study, data from undisturbed graves in the sample were included in the analysis. All the data were collected according to our standard protocols. Sex and age at death were determined using conventional

Table 1. Palaeodemographical characteristics of cemetery from Bokšto Street

Variable	Value
Number of burials	320
Individuals under 20 years of age [%]	41
Juvenility index*	0.31
Sex ratio	1.10
Average newborn life expectancy [e^0_0]**	26.19
Average female life expectancy [e^0_{20}]**	17.01
Average male life excpectancy [e^0_{20}]**	20.16

* Calculated acc. to Bocquet-Appell & Masset [1977]
** Calculated acc. to Acsádi & Nemeskéri [1970]

morphological methods [Ferembach *et al.* 1980, Ubelaker 1989, Garmus & Jankauskas 1993, Maat *et al.* 2002, Bass 2005] by visual examination. The standard palaeodemographic characteristics of the sample are given in the Table 1.

CO was scored for presence and severity. The severity of cribra orbitalia was recorded on the basis of a three grade classification system described by Stuart-Macadam [1985]. Linear enamel hypoplasia (LEH) is defined as horizontal lines of decreased enamel thickness on the external surface of the tooth crown [Palubeckaitė *et al.* 2002] due to physiological perturbations of enamel-producing cells during teeth formation [Hillson 1996]. The analysis of LEH was performed by dr. Ž. Miliauskienė (Department of Anatomy, Histology and Anthropology, Vilnius University). LEH was recorded for all permanent teeth. Age at LEH formation was determined according to Massler *et al.* [1941]. The lesions of a periosteal reaction refer to an inflammation of the periosteum [Larsen 1997, Ortner 2003]. In this analysis, the periostitis was analyzed only on tibias, being the most often affected bone in most of archaeological skeletal collections [Ortner 2003, Weston 2008], and registered as a dichotomous variable (presence or absence). Length of femur was scored as a dichotomous variable only for adults. Males and females were divided into two groups, as follows: those whose length of femur was below one standard error of the mean of height; and those who had the femur longer than the first group for the corresponding sex.

In order to examine the effects of CO on mortality/survival, Siler's and Gompertz-Makeham's parametric models of mortality were used for all individuals and only for adults, respectively (see Wood *et al.* [1992, 2002], Milner *et al.* [2000, 2008] regarding the advances of the application of such type of mortality models instead of the traditional life- table approach). The analysis for adults was stratified by sex. This was done because of the very substantial differential susceptibility of the sexes to patterns of morbidity and mortality due both to cultural and biological factors [Grauer & Stuart-Macadam 1998, DeWitte 2010]. Maximum likelihood estimation was used to estimate parameters of mortality models. The log-likelihood ratio test (LR) was used to evaluate whether the effects of CO on survivorship were significant. The non-parametric Mann-Whitney statistical test was used to evaluate the differences in height among the sexes, whereas χ^2 statistics were used in all further statistical analyses. The α level was set at 0.05.

Results

From 208 skeletons with sufficiently preserved orbits, 67 (32.2%) had CO. There was a significant negative relationship between age at death and presence of CO. Individuals with the lesion had considerably greater risk of death than without it (LR=43.289, df=1, p=0.000), or, in other words, the probability of finding the lesion

in the skeleton decreased with increasing individuals' age at death (Fig. 1). Likewise, a similar pattern was also true for the distribution of the more severe form of cribra orbitalia (combined lesions of medium and severe degrees; LR=20.395, df=1, p=0,000). The peak of lesion formation was observed for individuals who died between 5 to 9 years of age, and only a few cases were found at and after 20 years of age at death (Fig. 2). Females had a higher percentage of CO than males (10 of 53

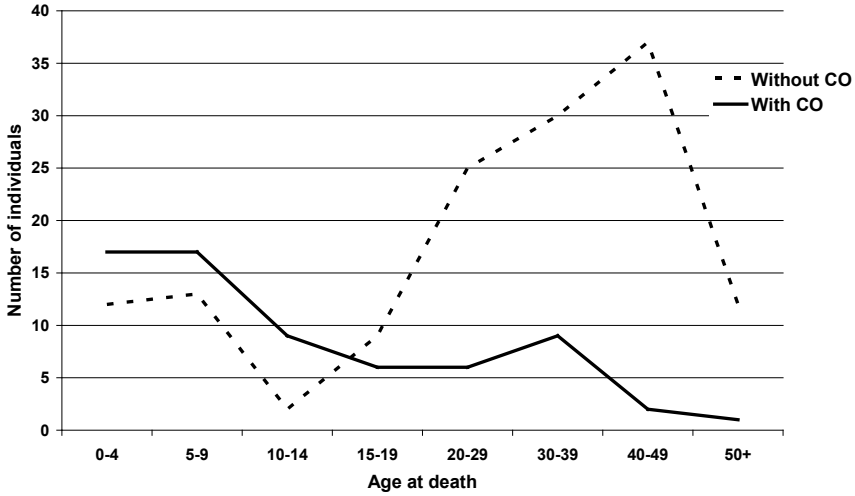

Fig. 1. Cribra orbitalia frequency in age-at-death groups

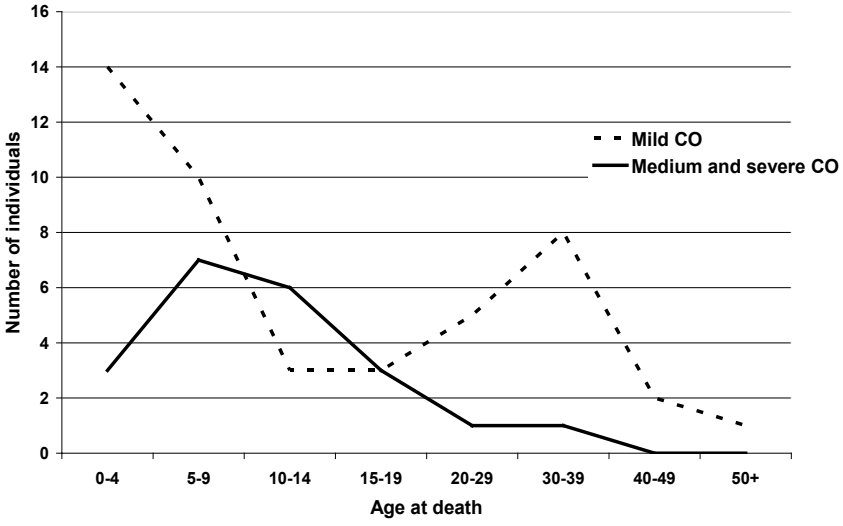

Fig.2. Frequency of cribra orbitalia in severity degrees in age-at-death groups

Table 2. Cribra orbitalia relationships with LEH, periostitis of tibia, and femur length for age and sex groups

Groups of interest	Cribra orbitalia relationship with		
	LEH	Periostitis (tibia)	Length of femur
Subadults (0-15 yrs)	χ^2 =9.545 (p=0.011*)	χ^2=0.548 (p=0.459*)	-
Males	χ^2=0.123 (p=0.659*)	χ^2=1.805 (p=0.320*)	χ^2=0.640 (p=0.451*)
Females	χ^2=0.072 (p=1.000*)	χ^2=0.760 (p=1.000*)	χ^2=0.451 (p=0.639*)
All individuals	χ^2=0.974 (p=0.386*)	χ^2=4.994 (p=0.039*)	-

*Fisher's exact test

(18.9%) and 8 of 69 (11.6%), respectively), though this difference was not statistically significant (χ^2=1.261, df=1, p=0.262). On the other hand, CO had a different effect on adult survival for sexes: males without the lesion lived apparently longer than with it (LR=7.118, df=1, p=0.008), while CO had no significant effect on female survival (LR=0.406, df=1, p=0.524).

Periostitis was identified in 22 of 215 individuals with at least one tibia preserved (10.2%). Only one individual with CO also had a periostitis out of 135 individuals who had retained at least one orbit and one tibia (0.7%). As a result, there was no significant relationship between these two lesions (Table 2).

88 of 108 (81.48%) individuals whose teeth were preserved well enough to be included in the study had imprints of LEH. The peak of the lesion formation was between 2 to 5 years of age. There were differences in distribution of CO among subadults affected and unaffected with LEH. In other words, individuals who had CO, and died before reaching adulthood, also had a higher probability for LEH. On the other hand, CO was equally distributed among adults affected or unaffected with LEH. Similarly, when all age at death groups were pooled together, there were no relationship between CO and LEH (Table 2).

As expected, males had significantly longer femurs than females (mean=451.3 cm, SE=2.9 cm, and mean=411.5 cm, SE=3.5 cm for males and females, respectively; Mann-Whitney test=47.179, p=0.000). However, an equal distribution of individuals affected and unaffected with cribra orbitalia in different femur length groups was found (Table 2), i.e., there was no significant relationship between length of femur and CO.

Discussion

In sum, age at death, sex, and LEH (only for subadults) were important factors accounting for the distribution of CO in the sample of interest. In contrast, adult length of femur was not related to CO, whereas periostitis was inversely associated with the lesion of interest.

In general, we found a significant negative relationship between the incidence of CO and age at death. Previous analyses of archaeological skeletal samples have shown the same pattern, i.e., individuals without CO had far better chances of surviving more years than affected individuals [e.g., Mittler & Van Gerven 1994, Šlaus 2000, Usher 2000, Blom *et al.* 2005, Steckel 2005, Obertová & Thurzo 2008, Redfern & DeWitte 2011]. A few possible explanations for this outcome can be sug-

gested. To begin with, it may confirm the notion that CO is a reflection of childhood stress, as concluded by many authors. This assumption is also supported by the fact that the vast majority of more severe lesions of CO in our sample were registered for subadults. It follows from the results that causes of CO either directly or indirectly had a deleterious influence on individuals' biological health, and contributed to the higher risk of mortality. In our skeletal sample more than half (41 of 68, or 60%) of the individuals who died between 0 to 15 years of age had signs of CO. That may suggest that anemia, as the most plausible explanation for this lesion, was an important factor for the increased risk of mortality for subadults buried in the cemetery of Bokšto Street. This proposal is also supported by the fact that the subadult period is free from confoundments, or at least much less confounded than may be expected for those who died in adulthood from the probable confounding effect of remodeling (see below).

The question as to whether causes of CO had an effect on the adult component of past populations is not straightforward. According to our results, there were no differences in frequency of CO between the sexes, though a slightly higher percentage of the lesion was recorded for females. This result was not unexpected and similar to other studies ([Walker 1986, Mittler & Van Gerven 1994, Arcini 1999, Fairgrieve & Molto 2000, Salvadei *et al.* 2001, Kozak & Krenz-Niedbala 2002, Yoder 2006], and many others). As an example, Stuart-Macadam provided a list of results from 28 analyses, and only 4 of them showed statistically significant differences among the sexes [Stuart-Macadam 1998]. On the other hand, we found that CO had different effects on adult males and females. Males who did not exhibit CO lived significantly longer, whereas CO had no significant effect on female life span. Supposing that remodeling was not an important factor for the patterns of CO distribution, the results may suggest that boys and girls were similarly exposed to the causes of cribra orbitalia in the population of interest, whereas the outcome was different: the effect was more severe and stronger for boys, at least for those who survived until 20 years of age. Such results may imply that males were more susceptible to the causes of CO than females – as they are with many other biofactors. A similar interpretation is proposed elsewhere [Stuart-Macadam 1998, DeWitte 2010], suggesting that females have a more efficient immune system [Ortner 1998]. An alternative opinion would be that the most vulnerable girls had died before reaching maturity. However, due to imprecise methods of sex estimation for subadults by traditional osteological methods, it is not possible to verify this hypothesis. In addition, the results of this analysis may testify to a significant impact of childhood health on adult survival. This hypothesis has both a theoretical and empirical basis [Crews & Bogin 2010, Montez & Hayward 2011], including research on archaeological skeletal collections [Steckel 2005].

However, the issue of remodeling could significantly alter the abovementioned interpretations. In the majority of studies, as previously mentioned, CO is generally thought to indicate childhood stress events, mostly anemia, which had not been completely overcome. Hence, the analysis of effects of CO on adult survival/mortality is validated if, and only if, the lesions do not completely remodel; even inmates survived for many years after the stressful events producing CO. Unfortunately, there is no consensus concerning this issue. If

CO remodeled without leaving any clearly visible alterations in the bones, the lesion's relationship to life span could be significantly distorted. Nevertheless, although it is yet not proven, it would be unreasonable to abandon CO analyses in adult skeletons [Sullivan 2005].

Clues for the interpretation of CO could be also provided by the analysis of relationships with other skeletal indicators of biological health. All three indicators examined here have a theoretical basis for possible links with CO and its associated causes. However, our analysis confirmed that only LEH was related to the lesion of interest.

A few studies consider the relationship between two childhood stress-related indicators, CO and LEH. There is no clear agreement regarding the magnitude of the link. Some of researchers [Stuart-Macadam 1985, Repetto 1988, Stodder 1997, Obertová & Thurzo 2008] argue that the connection is reliable, while others disagree [Kozak & Krenz-Niedbala 2002] (see Obertová and Thurzo [2008] for more comprehensive review of references regarding this issue). We calculated a statistically significant co-occurrence between these two lesions for subadults. That is to say that young and weak individuals who had CO also had a high probability to develop LEH. Furthermore, the peak of LEH formation was between 2 to 5 years of age. This period corresponds to the critical time for susceptibility to anemia [Stuart-Macadam 1985]. Additionally, although these indicators are rather non-specific indicators of childhood stress, both of them are mainly thought to be related with the similar causality, i.e., malnutrition, pathogen load, poor hygiene, etc. Therefore, it may suggest that the causes of both lesions interacted with and plagued the life of young individuals. Yet, the nature of association is still not clear, and it may be either direct or indirect.

Variation in body height, especially in early childhood, renders an individual particularly susceptible to agencies of the external environment [Stinson 2000]. Therefore, the relationship between CO and length of femur is expected. Moreover, there are empirical bases for this relationship, which suggests a link between anemia and reduced height [Mensforth 1985]. However, our analysis failed to demonstrate this link.

A similar situation exists with periostitis. Although periostitis could be caused by many factors [Weston 2008, Waldron 2009], some authorities argue that it is produced mostly by infectious diseases [Ortner 1998, 2003]. Given the strong relationship between anemia and infectious diseases [Lallo *et al.* 1977, Mensforth *et al.* 1978], a relationship between periostitis and CO was believed to exist. However, contrary to expectation, there was only one individual who had both of these conditions in our sample. This indicates that the causes of periostitis did not increase risk of CO.

Finally, to ascertain what particular causes may have created the conditions that resulted in CO in the local population is complicated for several reasons. Until now there has not been agreement on what the exact causes of CO are: Even the most current prevailing idea of iron deficiency anemia has been challenged [Walker *et al.* 2009]. Secondly, the archeological and historical context of the cemetery and early medieval Vilnius in terms of everyday life activities, pathogen load, etc. have until the present been poorly studied. Nevertheless, further research on this sample has recently begun, and we hope it will be possible to treat to the abovementioned issues much more thoroughly in the near future.

Final remarks

1. It is not clear how much the cemetery sample is representative of a previously existing living population [Waldron 2007, Milner *et al.* 2008]. However, we can conclude that, at least for the subadults, factors that produced cribra orbitalia (anemia?) significantly burdened their biological health and were likely associated with their early death.
2. Cribra orbitalia was strongly and positively correlated with the risk of dying. If not a matter of remodeling, then it not only confirms above mentioned idea but may also suggest that stressful events in childhood impacted negatively, either directly or indirectly, on adult survival.
3. Although there were no significant differences in frequency of cribra orbitalia between males and females, sex, as a separate factor, was important in accounting for the association between cribra orbitalia and age at death. Males with the lesion lived for a significantly shorter time. This tendency was not significant for females.
4. Cribra orbitalia was significantly and positively related with LEH for individuals who died at a young age (0 to 15 years) – young and weak individuals with cribra orbitalia also had a high probability for LEH. This link was insignificant for older individuals.
5. Periostitis and stature, as separate factors, were not related with increased risk for cribra orbitalia.

Notes

Acknowledgements The authors would like to express their gratitude to anonymous reviewers, remarks and suggestions of whom substantially helped to improve the manuscript.

References

Acsádi G.Y., J. Nemeskéri, 1970, *History of Human Life Span and Mortality*, Akadémiai Kiadò, Budapest

Arcini C., 1999, *Health and Disease in Early Lund*, Phd Dissertation, Lund University, Lund

Aster J.C., 2004, *Red blood cell and bleeding disorders*, [in:] *Robbins & Cotrain Pathological Basis of Diseases, Seventh Edition*, V. Kumar, N. Fausto, A. Abbas (eds.), Saunders, 619–60

Aufderheide A.C., C. Rodriguez-Martin, 1998, *The Cambridge Encyclopedia of Human Paleopathology*, Cambridge University Press, Cambridge

Bass W.M., 2005, *Human Osteology: A Laboratory and Field Manual*, Missouri Archaeological Society, Columbia

Baronas D., 2001, *Ligos ir epidemijos* [*Diseases and epidemics*], [in:] *Lietuvos Didžiosios Kunigaikštystės kultūra. Tyrinėjimai ir vaizdai* [*Culture of the Grand Duchy of Lithuania. Investigations and imagery*], V. Ališauskas *et al*. (eds.), Aidai, Vilnius, 293–303

Benuš R., Z. Obertová, S. Masnicová, 2010, *Demographic, temporal and environmental effects on the frequency of cribra orbitalia in three early medieval populations from western Slovakia*, J. Comp. Hum. Biol., **61**, 178–90

Blom D.E., J.E. Buikstra, *et al.*, 2005, *Anemia and childhood mortality: Latitudinal patterning along the coast of pre-Columbian Peru*, Am. J. Phys. Anthropol., **127**, 152–69

Bocquet J.P., C.L. Masset, 1977, *Estimateurs en Paléodémographie*, L'Homme, **18**, 65–90

Bumblauskas A., 2005, *Senosios Lietuvos istorija, 1009-1795* [*History of ancient Lithuania, 1009-1795*], R. Paknio leidykla, Vilnius

Cybulski J.S., 1977, *Cribra orbitalia, a possible sign of early historic native populations of the British Columbia coast*, Am. J. Phys. Anthropol., **47**, 31–40

Cohen M.N., G.J. Armelagos, 1984, *Paleopathology at the Origins of Agriculture*, Academic Press, New York

Crews D.E., B. Bogin, 2010, *Growth, development, senescence, and aging: A life history perspective*, [in:] *A Companion to Biological Anthropology*, C.S. Larsen (ed.), Wiley-Blackwell, Chicester, 124–52

Čaplinskas A.R., 2010, *Vilniaus istorijos legendos ir tikrovė* [*Legends and reality of Vilnius history*], Charibdė, Vilnius

DeWitte S.N., 2010, *Sex Differentials in Frailty in Medieval England*, Am. J. Phys. Anthropol., **143**, 285–97

Fairgrieve S.I., J.E. Molto, 2000, *Cribra orbitalia in two temporally disjunct population samples from Dakhleh Oasis, Egypt*, Am. Phys. Anthropol., **111**, 319–31

Ferembach D., I. Schwidetzky, M. Stloukal, 1980, *Recommendations for age and sex diagnoses of skeletons*, J. Hum. Evol., **9**, 517–49

Garmus A., R. Jankauskas, 1993, *Methods of Person's Identification from the Skeleton in Lithuania*, Medicina Legalis Baltica, **3-4**, 5–23

Grauer A.L., P. Stuart-Macadam (ed.), 1998, *Sex and Gender in Paleopathological Perspective*, Cambridge University Press, Cambridge

Grupe, G., 1995, *Etiology of cribra orbitalia: Effect of amino acid profile in bone collagen and the iron content of bone minerals*, Z. Morphol. Anthropol., **81**, 125–37

Goodman A.H., D.L. Martin, 2002, *Reconstructing health profiles from skeletal remains*, [in:] *The Backbone of History: Health and Nutrition in the Western Hemisphere*, R.H. Steckel, J.C. Rose (eds.), Cambridge University Press, Cambridge, 11–60

Hengen O.P., 1971, *Cribra orbitalia, pathogenesis and probable etiology*, Homo, **22**, 57–75

Hillson S., 1996, *Dental Anthropology*, Cambridge University Press, Cambridge

Holland T.D., M.J. O'Brien, 2002, *Parasites, porotic hyperostosis, and the implications of changing perspectives*, American Antiquity, **62**, 183–93

Yoder C.J., 2006, *The Late Medieval Agrarian Crisis and Black Death Plague Epidemic in Medieval Denmark: A Paleoapathalogical and Paleodietary Perspective*, PhD Dissertation, Texas A&M University, Houston

Jonaitis R. Vėževičienė V., 2006, Istorinis rusų miestas senajame Vilniuje XIV– XV a., *Arkheologia i istoria Litvy i Severo-Zapada Rossii (materialy mezhdunarodnogo simpoziuma)* [*Historical Russian town in Vilnius in 14th-15th centuries, Archaeology and history of Lithuania and North-West Russia (materials of international symposium)*]. Sankt-Peterburg, December 4-8, 2006

Katalynas K., 2006, *Vilniaus plėtra XIV – XVII a.* [*Development of Vilnius in 14th-17th centuries*], Diemedžio leidykla, Vilnius

Kiaupa Z., J. Kiaupienė, A. Kuncevičius, 2000, *Lietuvos Istorija iki 1795 metų* [*History of Lithuania till 1795*], A. Varnas, Vilnius

Kozak J., M. Krenz-Niedbala, 2002, *The occurrence of cribra orbitalia and its association with enamel hypoplasia in a medieval population from Kołobrzeg, Poland*, Variability and Evolution, **10**, 75–82

Lallo J., G.J. Armelagos, J.C. Rose, 1977, *Paleoepidemiology of infectious disease in the Dickson Mounds population*, Medical College of Virginia Quarterly, **14**, 17–23

Larsen C.S., 1997, *Bioarchaeology: Interpreting Behaviour from the Human Skeleton*, Cambridge University Press, Cambridge

Lewis M.E., 2002, *The Bioarchaeology of Children: Perspectives from Biological and Forensic Anthropology*, Cambridge University Press, Cambridge

Maat G.J.R., R.G. Panhuysen, R.W. Mastwijk, 2002, *Manual for the Physical Anthropological Report*, Barge's Anthropologica No. 6, Leiden

Massler M., I. Schour, H.G. Poncher, 1941, *Developmental pattern of the child as reflected in the calcification pattern of the teeth*, Am. J. Dis. Child, **62**, 33–67

Mensforth R.P., 1985, *Relative tibia long bone growth in the Libben and Bt-5 prehistoric skeletal populations*. Am. J. Phys. Anthropol., **68**, 247–62

Mensforth R.P., C.O. Lovejoy, J.W. Lallo, G.J. Armelagos, 1978, *The role of constitutional factors, diet, and infectious disease in the etiology of porotic hyperostosis and periosteal reactions in prehistoric infants and children*, Med. Antropol., **2**, 1–59

Milner G.R., J.W. Wood, J.L. Boldsen, 2000, *Paleodemography*, [in:] *Skeletal Biology of Past People: Research Methods*, S.R. Saunders, M.A. Katzenberg (eds.). Wiley-Liss, New York, 467–97

Milner G.R., J.W. Wood, J.L. Boldsen, 2008, *Advances in paleodemography*, [in:] *Biological Anthropology of the Human Skeleton, Second Edition*, M.A. Katzenberg, S.R. Saunders (eds.), Wiley-Liss, New York, 561–600

Mitokaitė I., 2011, *Seniausių Vilniaus gyventojų bioarcheologinė charakteristika, 2006-2010 m. archeologinių tyrimų Bokšto g. 6 duomenimis* [*Bioarchaeological charateristics in Vilnius oldest inhabitants according to archaeological data from Bokšto street*

2006-2010], Master thesis, Vilnius University, Vilnius

Mittler D.M., D.P. Van Gerven, 1994, *Developmental, diachronic, and demographic analysis of cribra orbitalia in the medieval christian population of Kulubnarti*, Am. J. Phys. Anthropol., **93**, 287–97

Montez J.K., M.D. Hayward, 2011, *Early life conditions and later life mortality*, [in:] *International Handbook of Adult Mortality*, R.G. Rogers, E.M. Crimmins (eds.), Springer, Dordrecht, 187–206

Obertová Z., M. Thurzo, 2008, *Relationship between cribra orbitalia and enamel hypoplasia in the early medieval Slavic population at Borovce, Slovakia*, Int. J. Ostearchaeol., **18**, 280–92

Ortner D.J., 1998, *Male-female immune reactivity and its implications for interpreting evidence in human skeletal paleopathology*, [in:] *Sex and Gender in Paleopathological Perspective*, A.L. Grauer, P. Stuart-Macadam (eds.), Cambridge University Press, Cambridge, 79–92

Ortner D.J., 2003, *Identification of Pathological Conditions in Human Skeletal Remains, Second Ed.*, Academic Press, London

Ortner D.J., M.F. Ericksen, 1997, *Bone changes in the human skull probably resulting from scurvy in infancy and childhood*, Int. J. Osteoarchaeol., **7**, 212–20

Ortner D. J., E.H. Kimmerle, M. Diez, 1999, *Prabable evidence of scurvy in subadults from archaeological sites in Per*u, Am. J. Phys. Anthropol., **108**, 321–31

Ortner D.J., W. Butler, J. Cafarella, L. Milligan, 2001, *Evidences of probable scurvy in subadults from archaeological sites in North America*, Am. J. Phys. Anthropol., **114**, 343–51

Palubeckaitė Ž., R. Jankauskas, J. Boldsen, 2002, *Enamel hypoplasia in Danish and Lithuanian late medieval/early modern samples: A possible reflection of child morbidity and mortality patterns*, Int. J. Osteoarchaeol., **12**, 189–201

Piontek J., T. Kozlowski, 2002, *Frequency of cribra orbitalia in the subadult medieval population from Gruczno, Poland*, Int. J. Ostearchaeol., **12**, 202–208

Redfern R.C., S.N. DeWitte, 2011, *A new approach to the study of romanization in Britain: A regional perspective of cultural change in late iron age and roman Dorset using the Siler and Gompertz-Makeham models of mortality*, Am. J. Phys. Anthropol., **144**, 269–85

Repetto E., A. Cancini, M. Borgognini-Tarli, 1988, *Skeletal indicators of health conditions in the Bronze Age sample from Toppo Daguzzo (Basilicata, Southern Italy)*, Anthropologie, **XXVI**, 173–82

Salvadei L., F. Ricci, G. Manzi, 2001, *Porotic hyperostosis as a marker of health and nutritional conditions during childhood: Studies at the transition between imperial Rome and the Early Middle Ages*, Am. J. Hum. Biol., **13**, 709–17

Schultz M., 2001, *Paleohistopathology of bone: A new approach to the study of ancient diseases*, Yrbk. Phys. Anthropol., **44**, 106–47

Steckel R.H., 2005, *Young adult mortality following severe physiological stress in childhood: Skeletal evidence*, Econ Hum Biol, **3**, 314–28

Steckel R.H., J.C. Rose, 2002, *The Backbone of History: Health and Nutrition in the Western Hemisphere*, Cambridge University Press, Cambridge

Steinbock T.R., 1976, *Paleopathological Diagnosis and Interpretation*, Charles C. Thomas, Springfield, Ill.

Stinson S., 2000, *Growth variation: biological and cultural factors*, [in:] Human *biology: An evolutionary and biocultural approach*, S. Stinson *et al*. (eds.), Wiley-Liss, New York, 425–63

Stodder A.L.W., 1997, *Subadult stress, morbidity, and longevity in Latte Period populations on Guam, Mariana Islands*, Am. Phys. Anthropol., **104**, 363–80

Stuart-Macadam P., 1985, *Porotic hyperostosis: Representative of a childhood condition*, Am. J. Phys. Anthropol., **66**, 391–98

Stuart-Macadam P., 1987, *A radiographic study of porotic hyperostosis*, Am. J. Phys. Anthropol., **74**, 511–20

Stuart-Macadam P., 1992, *Porotic hyperostosis: A new perspective*, Am. J. Phys. Anthropol., **87**, 39–47

Stuart-Macadam P., 1998, *Iron deficiency anemia: exploring the difference*, [in:] *Sex and Gender in Paleopathological Perspective*, A.L. Grauer, P. Stuart-Macadam (eds.), Cambridge University Press, Cambridge, 45–63

Sullivan A., 2005*, Prevalence and etiology of acquired anemia in medieval York, England*, Am. J. Phys. Anthropol., **128**, 252–72

Šlaus, M., 2000, *Biocultural analysis of sex differences in mortality profiles and stress levels in the late medieval population from Nova*

Rača, Croatia, Am. J. Phys. Anthropol., **111**, 193–209

Ubelaker D.H., 1989, *Human Skeletal Remains. Excavations, Analysis, Interpretation. Manuals of Archaeology*, *Second Ed.*, Taraxacum, Washington

Usher B.M., 2000, *A Multistate Model of Health and Mortality for Paleodemography*, PhD Dissertation, Pennsylvania State University, University Park

Vaitkevičius G., 2010, *Vilniaus įkūrimas* [*Foundation of Vilnius*], Lietuvos nacionalinis muziejus, Vilnius

Waldron T., 2007, *Paleoepidemiology. The Measure of Diseases in the Human Past*, Left Coast Press, Inc., Walnut Creek, California

Waldron T., 2009, *Paleopathology*, Cambridge University Press, Cambridge

Walker P., 1986, *Porotic hyperostosis in a marine-dependent California Indian population*, Am. J. Phys. Anthropol., **69**, 345–54

Walker P.L., R.R. Bathurst, R. Richman, T. Gjerdrum, V.A. Andrushko, 2009, *The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis*, Am. J. Phys. Anthropol., **139**, 109–25

Wapler U., E. Crubězy, M. Schultz, 2004, *Is cribra orbitalia synonymous with anemia? Analysis and interpretation of cranial pathology in Sudan*, Am. J. Phys. Anthropol., **123**, 333–39

Weston D.A., 2008, *Investingating the Specificity of Periosteal Reactions in Pathology Museum Specimens*, Am. Phys. Anthropol., **137**, 48–59

Wood J.W., D.J. Holman, K.M. Weiss, A.V. Buchanan, B. LeFor, 1992, *Hazards models for human population biology*. Yrbk. Phys. Anthropol. **39**, 99–135

Wood J.W., D.J. Holman, K.A. O'Connor, R.J. Ferrell, 2002, *Mortality models for paleodemography*, [in:] *Paleodemography: Age Distributions from Skeletal Samples*, R.D. Hoppa, J.W. Vaupel (eds.), Cambridge University Press, Cambridge, 129–68

Streszczenie

Celem tej pracy była analiza *cribra orbitalia* (CO) w populacji ze średniowiecznego Wilna (Litwa), zbadanej na podstawie próby szkieletów z cmentarzyska datowanego od końca XIII do początków XV wieku. Podstawowe charakterystyki paleodemograficzne tej próby (208 osobników, w tym 82 młodocianych) zawiera tabela 1. Zbadano korelację CO z płcią, wiekiem w chwili śmierci i trzema kostnymi wyznacznikami zdrowia – hipoplazją szkliwa zębowego (LEH), śladami zapalenia okostnej i wysokością ciała (dorosłych). Do oceny zależności wykorzystano parametryczne modele umieralności Silera i Gompertz-Makehama oraz statystykę χ^2.

Prawie 1/3 badanych osobników (32%)wykazywała CO, w tym 60% osobników młodocianych (zmarłych przed 15 rokiem życia). Ponadto analiza wykazała wysoką zależność między tą cechą a wiekiem w chwili śmierci – osoby ze śladami CO umierały znacznie młodziej (Fig. 1, 2). Może to sugerować, ze ważnym czynnikiem podnoszącym ryzyko zgonu wśród osobników młodocianych była anemia. Co więcej, jeśli nie są to ślady remodelowania, mogą one sugerować, że stresujące wydarzenia z dzieciństwa wpłynęły także pośrednio lub bezpośrednio na przeżywalność osób dorosłych. Choć u dorosłych kobiet CO występowały nieco częściej niż u mężczyzn, różnica nie była istotna. Z drugiej strony, CO miały negatywny wpływ tylko na dorosłych mężczyzn (umierali oni młodziej). Być może kobiety miały więc sprawniejszy układ odpornościowy. Innym wyjaśnieniem mogłaby być śmierć bardziej wrażliwych na ten czynnik dziewcząt w wieku młodocianym. CO pozytywnie korelowały z LEH u młodocianych, podczas gdy istotnych korelacji u dorosłych nie stwierdzono (tab. 2). Można sądzić, że młodociane i słabe osobniki z cechą CO, z większym prawdopodobieństwem miały LEH. Tak więc interakcje obu czynników sygnalizowanych obecnością cech CO i LEH mogły być odpowiedzialne za skracanie życia młodych osobników. *Periostitis* i wysokość ciała w badanej próbie nie wykazywały związku z CO (tab. 2).