Comparative osteoarchaeological perspectives on health and lifestyle of Neolithic, Chalcolithic and Early Bronze Age populations from Slovakia, Moravia and Bohemia

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Abstract

Despite the potential of a biocultural methodology, osteology and archaeology are often approached separately in some parts of Central Europe. This osteoarchaeological thesis presents a rare comparative study of populations occupying modern-day Slovakia, Moravia, and Bohemia from the Neolithic to the Early Bronze Age (EBA). By examining skeletal indicators of health and lifestyle, it aims to contribute to bioarchaeological research within the study region. It also provides new insights into a series of important sites where no osteological evaluation of skeletal remains have previously been performed. Human remains from thirty-four sites in Slovakia, Moravia and Bohemia, 152 adults and 136 subadults, were analysed. Demographic, pathological and metric data were recorded and evaluated, and compared with previously published data for contemporaneous populations in order to create a more comprehensive representation of the populations in the area.

The results suggest several differences between the Neolithic and the following periods, mostly as regards health status. Higher dietary and environmental stress was indicated in the Neolithic period, as suggested by lower mortality peak (especially of females and subadults) and about 5cm shorter stature, and generally worse health status of Neolithic population when compared to the Chalcolithic and EBA individuals. The Neolithic is also the only period where females were more numerous than males. Such a trend is quite common in the Neolithic of the study region. This may be a result of increased migration of Neolithic females, as raids for wives are suggested to have been practiced. As indicated by both the osteological and archaeological record, one of the sites examined, Svodín, could have been a site of contemporary elites and their family members. Chalcolithic populations revealed differences in cranial shape, being mesocephalic (medium-headed) or brachycephalic (short-headed), whereas both the Neolithic and the EBA populations were dolichocephalic (long-headed). Differences in male and female cranial features suggest a possible mixing of indigenous and incoming populations. Such results may contribute to the ongoing discussion about the ‘foreignness‘ of Chalcolithic Bell Beaker people in the area. Traumatic lesions suggest that males were more physically active than females in all three periods, including violent encounters. Even though violence was recorded in all three periods, especially in the western part of the region, and the intensity and brutality of the assaults appears to increase in the Chalcolithic and culminating in the EBA. In addition, poorer health status of EBA children was recorded, possibly related to more marked social differentiation in the period. In general, poorer health was implied for the prehistoric populations of today's Slovakia. The results of this study can serve as the basis for future research and contribute to a more comprehensive image of lifestyle and development of prehistoric populations in the study area.

Lay Summary

The study compares health and lifestyle of prehistoric populations in Slovakia, Moravia and Bohemia, from the Late Neolithic to the Early Bronze Age. The time span covered by the analysis ranges from about 4800 to 1700/1600 BC. By examining health and lifestyle indicators on human skeletal remains within their archaeological contexts, the thesis provides one of a few comparative osteological studies of archaeological populations in the area in the studied period. Moreover, it presents a new insight into sites where no osteological evaluation of skeletal remains has previously been performed. The significance of the study also lies in the fact that, despite the potential of an osteoarchaeological approach, the two disciplines – osteology (the study of human skeletal remains) and archaeology – have traditionally been pursued separately in Central Europe. The study should therefore significantly contribute to bioarchaeological research within the study region.

I hereby declare that:

a) this thesis has been composed by myself
b) this work is my own
c) the work has not been submitted for any other degree or professional qualification
d) any included publications are my own work, except where indicated throughout the thesis and summarised and clearly identified on the declarations page of the thesis.

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Chapter 1:

INTRODUCTION

1.1. Rationale

Reconstruction of the behaviour and lifestyle of past populations can benefit considerably from osteological and bioarchaeological studies, which are capable of addressing topics such as palaeodemography, palaeopathology, burial rites and social organisation, daily activities and the division of labour, genetic relationships, metric studies of normal variation, diet and disease (Larsen 1997; Buikstra and Beck 2006; Sofaer 2006: xvi). Owing to the fact that skeletal and dental tissues can reveal a broad range of individual patterns of behaviour, osteoarchaeology can contribute enormously to the study of past societies. Additionally, the study of human remains offers the possibility of investigating traces of interpersonal violence (Boylston 2000; Walker 2001), childbirth (Cox 2000; Malgosa *et al.* 2004), or how people dealt with disabled individuals (Hawkey 1998, Roberts 2000). The advantage of using the osteological data also lies in the possibility of at least partial theory verification using contemporary remains (Sofaer 2006: 24).

In some parts of Central Europe such as Slovakia, Moravia and Bohemia, despite the potential of the osteoarchaeological approach, the two disciplines – osteology and archaeology – are often approached separately, with a relatively small percentage of archaeological human remains evaluated properly within their archaeological contexts. Even though co-operation between archaeologists and biological anthropologists is increasing, especially in Moravia and Bohemia, there is still a vast amount of skeletal material that remains bioarchaeologically unprocessed. Moreover, often due to a lack of financial support, bioarchaeological research in the region focuses primarily on the more archaeologically interesting assemblages (Lukes *et al.* 2008; Castex *et al.* 2011; Drozdová 2011; Bickle *et al.* 2014), or on smaller collections (for example, Horňák *et al.* 2010), frequently neglecting the data obtainable from other anthropological collections, whereas there have been only few comparisons between individual sites and studies. All of the above-mentioned problems have contributed to the failure to create a more complex image of the prehistoric populations living in the area of present-day Slovakia, Moravia and Bohemia.

The majority of the skeletal remains examined for this thesis come from sites excavated decades ago. Through the evaluation of such material within a single bioarchaeological project, this thesis aims to establish a sound basis for more complex bioarchaeological research within the study region of Slovakia, Moravia and Bohemia. Moreover, it provides new insights into a series of important sites where no osteological evaluation of skeletal remains was previously performed – including collections from Slovakia that are the key 'representatives' of their respective periods in the area, both of them consisting of a settlement and burial ground (Němejcová-Pavúková 1995; Olexa 2003; Olexa and Nováček 2013). The Slovak Neolithic assemblage from Svodín represents one of the very few well-preserved skeletal collections from the region, while the site at Nižná Myšľa is believed to be one of the most important Early Bronze Age centres in eastern Slovakia, and its burial ground is the largest in the area (*cf*. Kovács 1992; Olexa and Nováček 2013: 30). Even if studied separately, these two sites would yield extraordinary bioarchaeological information. Unfortunately, only a few publications using the material from the graves have been produced, and even those are mostly archaeologically focused (Olexa 2003; Demján 2010; Nováček 2010). This is yet another respect in which the present study can contribute to knowledge of the lives of both the Neolithic and the Bronze Age populations in Central Europe.

The results of the present study will hopefully serve as the basis for further research in the area, possibly supplemented by chemical or other analyses, which, for various reasons, could not be undertaken as part of the PhD research. Bioarchaeological research, including chemical and isotope analyses, shall be performed in the case of the two Slovak sites of Svodín and Nižná Myšľa in the near future, with the cooperation of foreign researchers (Anett Osztás from the Hungarian Academy of Sciences, and Dalia Pokutta from the Stockholm University) and, together with this thesis, a more comprehensive study should emerge.

1.2. Temporal and geographical focus

Human remains from thirty-four sites in Slovakia, Moravia and Bohemia[1] were selected for the study (Figure 1). Altogether, 288 human skeletons were examined, 152 adults and 136 juveniles. The Slovak material comprises two assemblages - the Late Neolithic skeletons discovered at Svodín in western Slovakia, and the Early Bronze Age remains from Nižná Myšľa

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[1] Moravia and Bohemia forming the modern day Czech Republic

in eastern Slovakia. Based on recent ^{14}C analyses, the Late Neolithic can be dated between *c.* 4800 and 4100 cal BC (Stadler and Ruttkay 2007: 130), and the Early Bronze Age to *c.* 1850 – 1700/1600 cal BC (Bátora 2000a; Bárta 2001; Podborský 1993: 237). In addition to the Slovak sites, the Moravian Chalcolithic Bell Beaker collection discovered at Hulín, dated to the late Chalcolithic period, *c.* 2400-2200 cal BC (Turek 2006; Buchvaldek *et al.* 2007: 103), was examined. Human remains from Bohemia consist of older material, excavated from the 1950s to 1980s at nineteen Chalcolithic and thirteen Early Bronze Age sites (see Chapter 4, section 1), the latter being dated to 2200-1700/1600 cal BC (Buchvaldek *et al.* 2007: 104-5). Overall, the thesis covers the time range from about 4800 to 1700/1600 cal BC.

[redacted]

Figure 1. Location of study region and main study sites. a – Germany; b – Poland; c – Switzerland; d – Austria; e – Hungary; f – Slovenia. 1 – Nižná Myšľa; 2 – Svodín; 3 – Hulín; 4 – Prague (Free World Maps 2015; adapted by author).

1.3. Study aims and objectives

Shedding more light on the lives of Neolithic, Chalcolithic and Early Bronze Age populations in the area of present-day Slovakia, Moravia, and Bohemia is the main aim of the present study. By employing macroscopic osteological techniques and addressing both the archaeological and historical contexts of the examined remains, the present study aims to reveal more about Neolithic, Chalcolithic and Early Bronze Age populations in the study region, focusing mostly on their health and lifestyles. Answers to the following questions were sought:

- Did general health and living conditions vary between the periods? Is there any indication of different subsistence practices and, if so, did they have an impact on the health of the populations? Did the incidence of any pathological conditions vary significantly between the periods?

- Are there any skeletal indicators pointing to sex, age or social differentiation?
- Did the level of violence and injuries increase from the Neolithic to the Early Bronze Age?
- Was the allegedly foreign Bell Beaker population of the Chalcolithic skeletally different from the Neolithic and the Bronze Age populations? Are there any indications of migrations?
- Would any aspect of the present research be worth pursuing on a more extensive level, covering more skeletal material from the area?

Shifting from hunting and gathering to the adoption of agriculture makes the Neolithic period one of the most important turning points in the history of mankind. Although not happenning within a short period of time, such a big change in subsistence certainly required high degree of physical adaptation, affecting health and living conditions of human populations into a great extent. In terms of subsistence, transformations between the Neolithic and the Chalcolithic, and between the Chalcolithic and the Bronze Age were not accompanied by such big changes. What was changing, however, were the tools and technologies available in the following periods, leading to, e.g., higher crop yields or different food preparation techniques (Točík 1970; Pleinerová 1981; Peške 1985). Increased consumption of meat and softer foods has been suggested for the Chalcolithic and the EBA (Jarošová 2008; 2012; Smrčka *et al.* 2008b; Horňák *et al.* 2010; for discussion see also Kolář *et al.* 2012), most likely having impact on human skeletal and dental health. General health can thus be expected to have varied between the periods.

The above-mentioned changes have an impact on much more than health of past populations. Engagements in more physically-demanding activities such as ploughing, mining or hunting, as well as the protection of the family, are believed to determine the role of the man as the main food provider or a protector. In addition, the use of new material in the Early Bronze Age (EBA) probably contributed to the development of specialised professions as well as crafts. In addition to farmers, a new class of craftsmen – metallurgists – probably emerged (Jiráň 2008: 11; Jaeger and Olexa 2014). Similar trend can be presumed in other fields. Sex, age and social differentiation are therefore suggested by archaeological record, and skeletal manifestations of different lifestyles determined by sex, age, or various social positions can also be expected.

New possibilities of foods and goods accumulation can be expected to have resulted in increased violence, as there was much more to be defended. The existence of violent encounters is probably reflected in establishments of fortified hilltop settlements that emerged in the Chalcolithic and EBA (Točík 1970: 184–185; Podborský 1993: 192–200; Neustupný 2008: 98–102). The improvement of material and techniques was also reflected in tools and weapons refinement. The level of violence and severity of the injuries can thus be expected to have increased from the Neolithic to the EBA.

Much and more has been written about the Bell Beaker population accross the Europe. However, the origin of the Bell Beaker group is still a hotly debated topic. Moravian-Slovak Bell Beakers are considered the east-most oikumene of the group. Different shape of this population's crania, when compared to populations from previous and following periods, has already been noticed by local authors (for example, Podborský 1993: 230–232; 2006a). However, only little attention has been paid to other skeletal markers, which is why this topic is one of the main study aims of the present thesis.

In order to answer the above-mentioned questions, skeletal and dental data from the better-preserved individuals from the Slovak, Moravian and Bohemian Neolithic, Chalcolithic and Early Bronze Age were gathered. Physical, social, economic and other lifestyle-related transformations between the individual periods in the study region were investigated by comparing and contrasting any variations between the individuals from different periods. Another objective was to determine which of these differences, if any, were statistically significant, meriting further research. The data were then compared with previously published data from the same region and archaeological periods. All the results are discussed with reference to environmental, biological and cultural contexts, and the remains interpreted in terms of the archaeological and historical contexts in which they occurred.

1.4. Significance and structure of the thesis

This thesis presents the first detailed comparative study of populations occupying Slovakia, Moravia, and Bohemia from the Neolithic to the Early Bronze Age.

Chapter 2 introduces a number of topics addressed in the thesis. The study region, its location and climate are reviewed, followed by a general description of the archaeological and historical backgrounds. A general overview of bioarchaeological research in the study region is provided in Chapter 3, including a literature review for all three studied periods.

Chapter 4 presents the materials and the methodology used in the study, a justification for the approach taken, as well as some comments on the drawbacks of the different techniques used.

The results are presented in Chapter 5, while Chapter 6 provides a full discussion and analysis of the findings with the osteological data interpreted with respect to the archaeological record and are further compared to other collections from the region.

The concluding chapter summarises the main findings, highlights the limitations of the research and offers suggestions for future research. Additional archaeological information and tables are presented in the Appendix. Furthermore, Excel database, including all osteological data, and a photographic inventory are provided on the enclosed DVD.

Chapter 2:

ARCHAEOLOGICAL SETTINGS

2.1. The study region

The thesis focuses on Central Europe and specifically the countries of Slovakia and the Czech Republic, the latter being further subdivided into two regions: Bohemia in the west and Moravia in the east (Figure 2). It is this tripartite regional division - Slovakia, Moravia, Bohemia – that is used throughout the thesis.

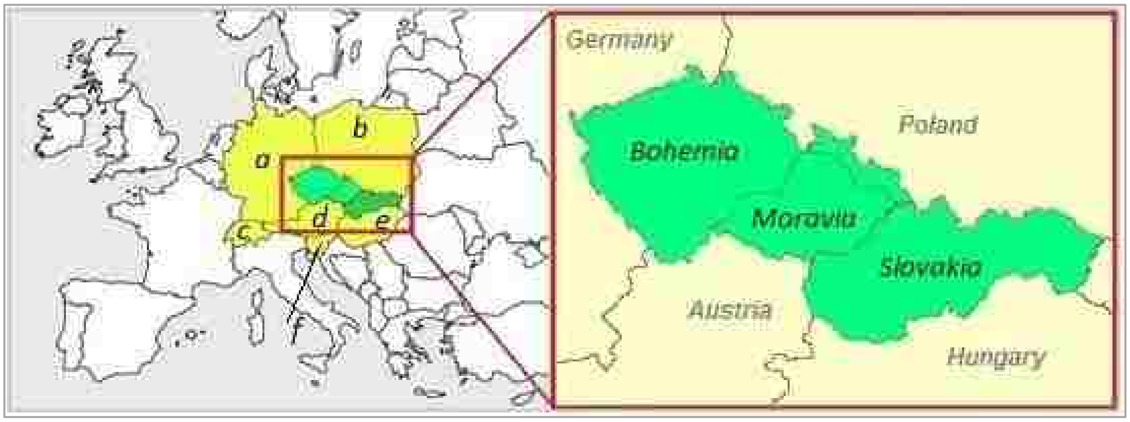

Figure 2. Central Europe and the location of Slovakia, Moravia and Bohemia (Free World Maps 2015, adapted by author). a – Germany; b – Poland; c – Switzerland; d – Austria; e – Hungary; f – Slovenia.

Throughout the Holocene, humans became an increasingly important agent of environmental change in the region, including the period from the Neolithic to the Early Bronze Age (*c*. 5600 to 1500 cal BC). Owing to limitations of space, details of archaeological features such as settlements and material culture can be found in Appendix 1. Below, a short summary of the absolute and relative chronologies used in Slovakia, Moravia, and Bohemia is provided for each of the periods, including the major cultural groups. Additionally, aspects of the archaeology of the region relevant to the interpretation of human remains, i.e. subsistence, burial rites and social organisation, are briefly described below.

2.2. Absolute and relative chronologies

2.2.1. The Neolithic

The beginnings of the Central European Neolithic were in the sixth millennium cal BC (Stadler *et al.* 2005/2006; Lenneis 2008; Pettitt and Hedges 2008), the earliest Neolithic in the study region being dated to *c.* 5700–5500 cal BC (Pleiner and Rybová 1978; Podborský 1993). A summary chronology is provided in Table 1, including the main Neolithic cultures by geographical area. The dating of different phases is approximate, as the transition between periods is a continuous process and cannot be delimited precisely. Local cultural groups have been identified in various parts of the study region, but are not described here for reasons of space.

2.2.2. The Chalcolithic

Several terms are applied to the period following the Neolithic – 'Chalcolithic'[2], '[A]eneolithic'[3], 'Copper Age' – indicating that the production of the first metal objects is one of the key features of the period. In the study region, this period represents a transition between the Neolithic and the Bronze Age. For practical reasons, the term 'Chalcolithic' will be used throughout this thesis, as it is commonly used in the English literature. The Chalcolithic of the study region is divided into several phases as shown in Table 2. However, the dates should be considered as approximations. As the increased number of cultures suggests, the development of the region became more dynamic, reflecting not only the shorter duration of archaeological cultures but also their co-existence (Buchvaldek *et al.* 2007; Sosna 2007: 52).

2.2.3. The Early Bronze Age (EBA)

The Bronze Age in Slovakia, Moravia and Bohemia lasted for over a millennium, and is usually subdivided into four stages – Early, Middle, Late and Post Bronze Age[4]. The Early Bronze Age lasted from about 2000 to 1500 cal BC (Bátora 2000a; Bárta 2001; Podborský 1993: 237), and is primarily represented by the Únětice, Nitra and Otomani cultures (for example, Podborský 2006a) (Table 3).

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[2] *khalkós*= 'copper'in Greek

[3] *aeneus*= 'copper' in Latin

[4] transition period between the Bronze and the Iron Age

PERIOD	APPROXIMATE DATING	CULTURES		
		Slovakia	**Moravia**	**Bohemia**
Early Neolithic	**From** 5700/5500 BC **To** 5100/4900 BC	▪ Linear Pottery (LBK) (W Slovakia) ▪ Eastern Slovak Linear Pottery (ES LBK) (E Slovakia)	▪ Linear Pottery (LBK)	▪ Linear Pottery (LBK)
Transition period		▪ Želiezovce group	▪ Šárka stage of LBK ▪ Želiezovce group	▪ Šárka stage of LBK
Middle Neolithic	**From** 5100/4900 BC **To** 4800/4500 BC	▪ Želiezovce group (W Slovakia) ▪ Eastern Slovak Linear Pottery (E Slovakia) ▪ Bükk Culture (E Slovakia) ▪ Tisza Culture (TK) (E Slovakia)	▪ Stroked Pottery (STK)	▪ Stroked Pottery (STK)
Late Neolithic	**From** 4800/4500 BC **To** 3700/3500 BC	▪ Lengyel Culture (LgK) (W Slovakia) ▪ Tisza Culture (TK) (E Slovakia) ▪ Polgár Complex Cultures (E Slovakia)	▪ Moravian Painted Pottery (MPP) ▪ Jordanow Culture	+ influence of: ▪ Moravian Painted Pottery (MPP) ▪ Jordanow Culture

Table 1. The main stages of the Neolithic in Slovakia, Moravia, and Bohemia (after Točík 1970; Pleiner and Rybová 1978; Podborský 1993; Pavlů and Zápotocká 2007).

PERIOD	APPROXIMATE DATING	CULTURES		
		Slovakia	**Moravia**	**Bohemia**
Proto Chalcolithic [EpiLengyel]	4 200 BC 3 500 BC	▪ post Lengyel development with local groups [*e.g., Brodzany, Ludanice, Retz*] (W Slovakia) ▪ Polgár Complex Cultures (E Slovakia)	▪ Moravian Painted Pottery (MPP) ▪ Jordanow Culture and local groups [*Retz*]	▪ post Lengyel development with local groups ▪ Michelsberg Culture ▪ Jordanow Culture
Early Chalcolithic	3 000 BC	▪ Funnel Beaker Culture (TRB) (W Slovakia) ▪ Polgár Complex Cultures (E Slovakia)	▪ Funnel Beaker Culture (TRB)	▪ Funnel Beaker Culture (TRB)
Middle Chalcolithic	2 600 BC	▪ Baden Culture [grooved ware] (W and E Slovakia) ▪ Bošáca group (W Slovakia)	▪ Baden Culture [grooved ware] ▪ Globular Amphora Culture (KAK) ▪ Jevišovice Culture ▪ Bošáca group	▪ Baden Culture [grooved ware] ▪ Globular Amphora Culture (KAK) ▪ Řivnáč Culture ▪ Cham Culture
Late Chalcolithic	2 300 BC	▪ Vučedol complex groups [*e.g., Makó-Kosihy- Čaka, Chlopice-Veselé (W Slovakia) or Nyirszég-Zatín (E Slovakia)*]	▪ Corded Ware Culture (CW) ▪ Bell Beaker Culture (BB)	▪ Corded Ware Culture (CW) ▪ Bell Beaker Culture (BB)
Post Chalcolithic	2 000 BC	▪ Corded Ware and Bell Beaker Culture penetration (W Slovakia) ▪ Nitra Culture (NK) (W Slovakia) ▪ East Slovak Tumulus (E Slovakia)	▪ Chlopice-Veselé ▪ Proto-únětice Culture (PUK)	▪ Proto-únětice Culture (PUK)

Table 2. The main stages of the Chalcolithic in Slovakia, Moravia, and Bohemia (after Točík 1970; Pleiner and Rybová 1978; Podborský 1993; Neustupný 2008a; Šmíd 2008).

PERIOD	DATING	CULTURES		
		Slovakia	**Moravia**	**Bohemia**
Early Bronze Age	2 000 1 500	▪ Nitra Culture (NK) ▪ Únětice Culture (UK) (W Slovakia) ▪ Otomani Culture (E Slovakia)	▪ Nitra Culture (NK ▪ Únětice Culture (UK)	▪ Únětice Culture (UK)
Middle Bronze Age	1 300	▪ Maďarovce Culture [SE influence] (W Slovakia) ▪ Middle Danubian Tumulus Culture (W SVK)	▪ Věteřov Group [SE influence] ▪ Middle Danubian Tumulus Culture	▪ Věteřov Group [SE influence] ▪ Middle Danubian Tumulus Culture
Late Bronze Age	1 000	▪ Middle Danubian Urnfield Culture *[Velatice stage]* ▪ Lusatian Urnfield Culture *[Lausitz stage]* ▪ SE Urnfield Cultures	▪ Middle Danubian Urnfield Culture *[Velatice stage]* (southern Moravia) ▪ Lusatian Urnfield Culture *[Lausitz stage]* (northern Moravia)	▪ Urnfield Cultures: Knovíz Culture Milaveč Culture Lusatian Culture
Post Bronze Age	750	▪ Middle Danubian Urnfield Culture *[Podolí stage]* ▪ Lusatian Urnfield Culture *[Lausitz stage]* ▪ SE Urnfield Cultures	▪ Middle Danubian Urnfield Culture *[Podolí stage]* (southern Moravia) ▪ Lusatian Urnfield Culture *[Silesian stage]* (northern Moravia)	Štítary Culture Nynice Culture Silesian-Platěnice Culture

Table 3. Bronze Age stages and related cultures in Slovakia, Moravia, and Bohemia (after Podborský 1993; Jiráň 2008). Curved lines indicate continuity of cultures.

2.3. Subsistence, settlement organization and climate

2.3.1. The Neolithic

As elsewhere, the Neolithic in the study region commences with the transition from hunting and gathering to a sedentary life characterised by plant cultivation and animal husbandry, pottery production and polished and drilled stone tools, and the transition to a more sedentary lifestyle (Champion *et al*. 1984; Podboský 1993; Çilingiroğlu 2005; Pavlů and Zápotocká 2007).

Central Europe is characterised by a tradition of building long Neolithic houses[5] (Pavlů and Zápotocká 2007; Čižmář 2008b), with the length of a house proportional to the number of hearths found in the house. Findings at the Bohemian site of Postoloprty imply that the length of the house may have been related to the number of 'households' living in the house (Jelínek 2006). Much smaller houses of eastern Slovakia may be the result of southeastern influence, as implied by similar houses found in Hungary (Kalicz and Makkay 1977; Kalicz and Ratzky 1982), as well as by a more mountainous local environment.

Based on the findings of plant remains and seed impressions, plants grown included wheat (Tempír 1968; Bogaard 2004; Pavlů and Zápotocká 2007: 63), but various forest fruits and seeds remained part of diet (for example, Vencl 1985; see also Chapter 3). In the Early Neolithic, domesticated species prevailed over wild animal species, while at the end of the period the proportions of wild and domesticated animals vary by site (for example, Peške 1986; Rulf 1991; Podborský 1993: 149; Němejcová-Pavúková 1995). Pavlů and Zápotocká (2007) ascribe these differences to local climatic changes and periods of crop failure. Tóth *et al.* (2011) monitored the locations and distribution of Neolithic and Chalcolithic settlements in present-day western Slovakia. They found evidence of temporal changes in settlement locations, which they interpreted as a consequence of frequent climatic fluctuations in the Late Neolithic, followed by a long period of dry climate prevailing until the Early Chalcolithic. Moreover, as Pavúk (1982) and Dreslerová (2006) suggest, animal proteins may have been used to compensate for the shortage of plant proteins, and so the increased proportion of animal bones found during the presumed periods of drought may in fact point to climate deterioration in the area. Similar trends are observed at a number of sites in the surrounding area in the same periods (Ambros 1986; Dreslerová 2006). The above-mentioned hypotheses are also supported by rare climatic

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[5] *c.* 5–6m wide and 10–40m long

proxy data based on the calcareous tufa[6] formations in the Bohemian Karst near Prague (Žák *et al.* 2002). Žák *et al.* (2002) also indicate a dramatic climatic change in the end of the Neolithic (*c.* 6500 cal BP [4550 cal BC]), with short-term alterations of dry and humid periods. The weakness of their study seemingly lies in the fact that only a single site was used for the study. However, as shown by Ložek (1992), the geological bedrock is similar in the most of the sites from the region, so no significant differences should occur. Unfortunately, the reconstruction of local climate and its oscillations in prehistory is a complex and problematic issue, especially in regions such as Slovakia, Moravia and Bohemia where there is a general lack of regional proxy-based analyses (for discussion see D. Dreslerová 2010).

2.3.2. The Chalcolithic

In spite of the undeniable importance of the appearance of the first metal objects and the development of metallurgy in the Chalcolithic, arguably the most significant feature of the new era, is the shift to plough-based agriculture, resulting in an increase in yields and expansion into new ecological niches (Točík 1970: 186, 189; Pleinerová 1981; Peške 1985; Kruk and Milisaukas 1999: 166–170). In addition, new socio-economic characteristics appear, including an increase in the use of domestic animals for labour, new craft specializations, more advanced exchange, private ownership and fortified hilltop settlements with administrative and power functions (Neustupný 1967, 2008b: 11, 18; Točík 1970: 135–138; Šmíd 2008: 248). The horse is also believed to have been in use (for example, Anthony 2007: 203–204), probably both as a draught and as a riding animal, although finds of horse harnesses from neighbouring countries imply that riding was more important (Kruk 1973; Hüttel 1981: 18, 20; Kruszynski 1991; Anthony 2007: 221). Stone tools are believed to have been used as weapons more often than in the Neolithic (Neustupný and Neustupný 1960: 135; Neustupný 2008: 24). Additionally, the use of bows in the Late Chalcolithic is indicated by the presence of arrowheads and wristguards, as well as bow-shaped bone pendants (Turek 2006; Růžičková 2008; Olivík 2009, 2012). Generally, the Chalcolithic period in Central Europe is often regarded as the final stage of the Neolithic ‘revolution’ (Točík 1970: 138; Podborský 1993: 161).

There is a lack of subterranean structures in the Late Chalcolithic settlements (Turek *et al.* 2003), previously ascribed to the nomadic/pastoral lifestyle of the cultural groups (Buchvaldek 1986; Vencl 1994). Nevertheless, evidence of farming in the Corded Ware culture

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[6] a type of limestone

has been recorded (for example, Turek 1995) and the topography of Moravian settlements revealed a relatively dense network of sites similar to that of the EBA, including sunken features (Geislerová *et al.* 1992; Matějíčková 1995; Turek and Peška 2001). Excavations at Moravian sites such as Olomouc-Slavonín or Žádovice indicate small clusters of subterranean structures rather sparsely distributed (Turek and Peška 2001). As the authors suggest, this may point to the existence of small villages inhabited by a few families. Other sites also show smaller conglomerations of structures distributed 50 to 250 m from each other (Turek 1998; Turek *et al.* 2003). Basing his presumption on the graves found within the Late Chalcolithic graveyards, Neustupný (1983, 2001a: 121–122) also suggests two to six families of, on average, four members living at a settlement at the same time.

2.3.3. The Early Bronze Age (EBA)

No dramatic change in subsistence is presumed to have occurred in the EBA (for a summary see Podborský 1993; Jiráň 2008), although a higher meat intake in the period has been suggested, e.g., by the amount of selenium and zinc in bone tissues (for example, Smrčka *et al.* 2011c) or dental microstriations (Horňák *et al.* 2010) (see also Harding *et al.* 2007). The changes introduced in the Bronze Age are mostly associated with mass production and more frequent use of a new material – bronze. The softness of copper was compensated for by adding an alloying element, usually tin, making bronze more usable than copper (Harding 2000: 202–205; Copper Development Association Inc. 2015). Stone tools were gradually replaced by those of bronze (Podborský 1993: 233; Jiráň 2008), increasing the effectiveness of work, thereby enabling the creation of larger surpluses and advancing exchange, leading to specialisation of crafts, including metallurgy (Williamson 1990: 72–73, 82–116; Sosna 2007: 232–233). Such an overall boost in production is also believed to have resulted in the number and variety of imported goods, and more advanced hierarchisation of society (see Jiráň 2008; Podborský 1993).

The character and structure of the EBA settlements are still unclear, probably because of the small number of excavated sites (Peška 1994: 147; Jiráň 2008: 72). However, according to Stuchlík (2000), EBA houses were generally smaller than those of the Neolithic, although long EBA houses have been excavated in Bohemia (Pleinerová 2002). However, long EBA houses are not numerous, which, according to Kruťová and Turek (2004), may have been caused by shallow subterranean remains having been damaged by modern activity. Judging by the smaller clustered cemeteries from the period, Neústupný (1986: 323) and Jiráň (2008: 72) estimate that the average settlement area may have been inhabited by two to four families. The eastern part of the study region was dominated by the Otomani culture, characterised by fortified settlements of pre-urban structure with smaller dwelling structures and production areas (such as in Barca at Košice, Spišský Štvrtok, Nižná Myšľa; see Novotný 1986: 648–649; Olexa 2003; Podborský 2006a).

2.4. Mortuary customs

2.4.1. The Neolithic

Different forms of burial appear during the Neolithic, ranging from formal and casual, single and group inhumations within settlements, to cave burials and cemeteries (Horáková-Jansová 1931; Točík 1970: 26; Pavúk 1972; Šiška 1986; Podborský 1993: 87–8; Zápotocká 1998; Dočkalová and Čižmář 2008a, 2008b; Pavlů and Zápotocká 2007: 83). Neolithic burials in Slovakia, Moravia and Bohemia are mainly inhumations, although cremations also occur, especially in the Bohemian Stroke Pottery culture (Vokolek and Zápotocká 1997; Zápotocká 1998: 44; Šmíd 2008). The first regular, designated burial grounds appear in the Early Neolithic (Horáková-Jansová 1931; Pavúk 1972; Vokolek and Zápotocká 1997; Podborský *et al.* 2002). In general, Neolithic inhumations were usually placed in individual graves in an east–west direction[7], in flexed/crouched positions, lying mostly on the left side (Točík 1970: 26; Podborský 1993: 88; Pavlů and Zápotocká 2007: 83). Occasionally, individuals were discovered in bizarre positions and/or in collective graves (see Kazdová and Lorencová 1985; Podborský 1993: 105–107; Rulf 1997). The uniformity of such a grave orientation changed later in the period, when individuals were also placed on their right side (Pleiner and Rybová 1978: 210; Podborský 1993: 88, 134). In his work, Podborský (1993: 132–134) mentions numerous Late Neolithic sites with non-ritual burials of adults as well as juveniles, including remains where the skulls had been separated from the rest of the skeletons (also Podborský 1988: pic. 87), or interments of skulls with no postcranial skeleton at all (Geisler and Kovárník 1983). Moreover, the end of the Neolithic, especially the Moravian Painted Pottery culture, is associated with mass graves involving animal burials (Čižmářová *et al.* 1996: 24; for references see also Podborský 1993: 133–135). In comparison to Moravia and Bohemia,

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[7] the position of the head is indicated first

south-western Slovak sites such as Svodín were part of the eastern Lengyel complex with more extensive designated cemeteries (for example, Němejcová-Pavúková 1998).

The Lengyel burial rite in the study region was characterised by inhumations, with individuals being buried in the crouched position on the right side. Such customs were also applied to juveniles. The grave inventories comprise pottery, stone or bone/antler tools, weapons and jewellery. In addition, the presence of animal bones suggests that foods were also a part of burial customs. Large cemeteries from the period such as Aszód, Zengövárkony, Móragy (Hungary) or Svodín (Slovakia) yielded extraordinarily rich graves of males (Dombay 1960; Kalicz 1985; Zalai-Gaál 2007; Demján 2010), equipped with boar tusks and axes or battle-axes. In addition, richly equipped graves of children were discovered. However, graves of boys seldom contained the items typical of male burials, but valuable jewellery typical for adult females was frequently found in the graves of infant girls (Němejcová-Pavúková 1995). Despite that the sub-adults were sexed only by grave inventories, all these imply that Late Neolithic society was already differentiated (see also Demján 2015).

2.4.2. The Chalcolithic

Mortuary patterns in the Chalcolithic range from interments in isolated long mounds, to large tumuli, single-grave cemeteries, and isolated simple graves (Prudká 1978; Podborský 1993; 2006a; Neustupný 2008b: 25; Šmíd 2008: 248–257). More commonly, burial grounds were separated from the settlement areas and in most cases one type of burial rite, either cremation or inhumation, was practised (Šmíd 2008: 249, 251). Rites in Early Chalcolithic eastern Slovakia seem to have been strict also in terms of gender differentiation whereby the graves of male individuals were often more richly equipped than those of females (for example, see Točík 1970). Later in the period, a similar trend can be observed in the rest of the study region (Podborský 1993: 226) and a more unified rite is found in the Late Chalcolithic. Like in the Late Neolithic, non-cremated remains were usually interred in the crouched/flexed position, but on the right side and oriented mostly in an east–west direction, although other orientations occur (Točík 1970: 142; Podborský 1993: 173; Šmíd 2008: 249, 251).

Bell Beaker burials in the study region are typically inhumations, although in Moravia the proportion of cremations is quite high – more than 20% (Turek 2006). Differentiation between male and female burials is reflected in the position of the skeletons, whereby male individuals are placed on their left side with their heads facing north, and females on their right side with their heads to the south. Such a custom was applied to children as well (Turek 2000a). Gender differentiation is also evident in grave equipment. Graves of male individuals often involve wrist-guards, arrowheads, and probably also bows, copper daggers, boar tusks and bow-shaped bone pendants. Female burials usually include v-shaped buttons and pots, the richer burials also containing metal jewellery made of gold, silver or copper (for a summary see Turek 2006). Like in the Corded Ware culture, there are encircled burial pits and unusually richly equipped graves, sometimes with a wooden lining (Knor 1966; Dvořák 1992: 226–228, obr. 142), possibly evidence of social differentiation. Some such burials belong to females buried by a rite typical for males (Turek 2011b). Cemeteries with predominantly buried subadults were discovered (Moucha 1966: 107; Černý 2000; Skružný *et al.* 2000), although as Turek (2006) suggests, this may be a reflection of the state of research (see also Kytlicová 1960).

2.4.3. The Early Bronze Age (EBA)

EBA cemeteries were usually placed in the vicinity of settlements, and could be almost generally characterised as ‘flat-grave cemeteries’ (see Podborský 1993: 236; Fridrichová 1995: 133; Olexa 2003; Jiráň 2008: 235). Burial rites are represented mostly by inhumation, with bodies placed in flexed positions (Furmánek *et al.* 1991: 283–284; Podborský 1993: 242; Olexa 2003: 66). Strict rules regarding sexual differentiation applied (Appendix 1, Table 51). Burials in southern and western Bohemia are characterised by mound cemeteries with both cremations and inhumations, a custom more common in the Middle Bronze Age (for example, Havlice 2001). In the Únětice culture, especially in Moravia where people were often interred in coffins made from hollowed tree trunks, *baumsargs*, stone lining of burial pits, often occurred (Ondráček 1962; Podborský 1994: 85). Similar customs were common in Slovakia, where the dead were placed in graves with wooden linings or at least wrapped in organic material (Vladár 1973: 125; Machnik 1977: 63; Olexa and Nováček 2013: 13–15). Many graves bear traces of being re-opened to add further burials. The majority of these graves were also robbed, especially in areas where valuable items had been placed, indicating that the robberies may have been performed rather shortly after the burial (Lorencová *et al*. 1987; Podborský 1993: 248). The number of skeletons with traces of evidence of unconventional intervention indicating ritual or cult-related activities seems to have increased in comparison to previous periods (Demeterová 1988; Salaš 1990; Podborský 1994: 85; Jiráň 2008: 238).

Únětician burial grounds are located near the settlements, with the spatial distribution of the graves being much tighter and more organized than in the previous period (Sklenář *et al.* 2002; Kruťová 2003). Clusters of graves are often found (Kruťová and Turek 2004; Lutovský and Smejtek 2005), presumably representing family relationships of the buried individuals (Jiráň 2008: 65). Cremations are rare in Únětician necropolises, especially in Bohemia (for example, Sklenář *et al.* 2002). The main features of the burial rite are similar and quite strictly followed in most of the Únětician graves, regardless of gender or age. The deceased were usually placed in a crouched position on their right side, with their heads to the south, facing east (summarized in Jiráň 2008). However, as Podborský (1993) mentions in connection with the easternmost Únětician *oecumene*, female skeletons were sometimes placed on the left side, which was probably caused by the influence of the Nitra culture (Ondráček 1967). Grave goods usually comprise pottery, metal items such as bronze pins, bracelets and other jewellery, spiral armlets, weapons such as axes or daggers, and tools (Moucha 1954, 1963; Novotný 1986). Rarely, extremely rich burials occur (Stuchlík 1980, 1987). The use of coffins is also frequent in the Únětice culture, especially in Moravia (Pleinerová 1960: 21; Ondráček 1962; Lorencová *et al.* 1987: 107; Stuchlík 1987: 38–39; Sklenář *et al.* 2002). In the Moravian site of Rebešovice, coffins occurred in 62.5% of the graves (Ondráček 1962). Children were sometimes buried in vessels (for example, Tihelka 1963), a common custom in the region of today's Bulgaria, the Aegean region, and Anatolia (Podborský 1993: 247; Mcgeorge 2013).

Information about the burial rites of the Otomani population in the study region comes almost exclusively from Nižná Myšľa, Slovakia (Olexa 1983, 1988, 2003). The graves were organised in rows, although separated groups of burial pits have been discovered. Currently, these graves are interpreted as burials of individuals belonging to the settlement, but not living directly in it, e.g., miners, suppliers, etc. (Nováček 2010). The classic phase of the Otomani culture in the study region is dominated by inhumation, with the body being placed in a crouched position, similar to the Únětice culture. Males were buried on their right side, with their heads to the south, females on their left side, with their heads to the north. Both males and females faced east. The pattern was strictly also followed in subadults (Novotný 1986; Nováček 2010). Grave goods comprised the usual inventory – pottery, jewellery, weapons, boar tusks, and work tools. The funerary equipment was also gender-related, with weapons, boar tusks and tools found almost exclusively in male burials, and pottery and certain types of tools in those of females. Grave inventories differed in number as well, and the space around the rich burial pits was larger than that around most graves. Some male burials were especially rich, often containing boar tusks and other equipment related to hunting, or tools used for metalworking (Nováček 2010). As in the Únětice culture, coffin traces were discovered, and were also found almost exclusively in the rich graves (Olexa 2003; Olexa and Nováček 2013). As reported by Nováček (2010), the depths of the rich burial pits were greater than depths of commonly equipped graves.

Secondary burials are more frequent in the period in both the west and the east of the study region, as are the secondary openings of burial pits (Olexa 1988; Ernée 2000). For instance, in the Moravian site of Rebešovice, secondary openings were recorded in 80% (Ondráček 1962: 65–68), and at the Austrian site of Gemeinlebarn in 94% of the pits (Neugebauer 1991: 113–129). In Nižná Myšľa, secondary intervention was confirmed in 50 (17%) of 300 excavated graves (Nováček 2010). Some authors suggest ritual reasons or re-burial of human remains (Olexa 1988; Kruťová and Turek 2004), although others simply ascribe it to grave robberies (Peška 2011; Sosna *et al.* 2011: 103). Secondary interments were documented (Matoušek 1982; Peška 2009), and re-use of a burial pit was also recorded (Stuchlík and Stuchlíková 1996: 85), suggesting mortuary rituals were the more probable cause of secondary openings of the graves. Moreover, as suggested by Nováček (2010), such intense invasions would not have been easy so close to the settlements, if it was not accepted by the society. However, a combination of the two is the most probable cause.

2.5. Society

2.5.1. *Social structure*

2.5.1.1. The Neolithic

Social differentiation, social status, property and crafts in the study region are still hotly debated topics (for discussion, see Whittle *et al.* 2013), owing largely to highly variable burial rites (Appendix 1, Table 49). Based on the archaeological finds from large Neolithic houses with presumably social and meeting functions, including a large fenced-off area nearby, it can be presumed that basic resources, such as land or herds, might have been the common property of a clan/tribe (Plainer and Rybová 1978: 226; Jelínek 2006: 149). In the Late Neolithic, similar meeting and social functions seem to have been associated with a large fenced–off area, or ‘roundel’, the construction of which was sufficiently demanding as to require cooperation of several settlements in the area, suggesting a structured society (Podborský 1994: 42–44;

Pavlů and Zápotocká 2007: 99). Unfortunately, roundels do not yield much information about the economy of the Late Neolithic society, or about the distribution of goods. Nevertheless, certain craft specialisations can be presumed and individuals of privileged status may thus have existed, especially in the areas with access to special raw material (Vencl 1986; Pavlů and Zápotocká 2007). In other words, private ownership gained by individual abilities might have been respected, and was probably the domain of males (Lüning 1991; Podborský 2002a). On the other hand, it is frequently believed that the society was matrilineal (Podborský 2002a; Květina 2004: 387). Podborský (2002b) concedes different yet equally important social roles of males and females. Arguing on the basis of mortuary practices in the LBK population of Nitra, Slovakia, Pavúk (1972) advocates the dominance of males, challenging the egalitarian hypothesis. As regards Late Neolithic society, Demján (2015) points to the social complexity of the period, owing to new cultural influences from the south. Challenging the commonly used richness of burials as indicators of individuals of higher/different status, he introduces the concept of exceptionality. This is based on the composition and spatial distribution of grave inventories rather than on presumed items of prestige. Studying the Lengyel site of Svodín, Slovakia, the author argues for higher status of middle-aged men and the existence of different kinships within the settlement, suggesting the emergence of elites (Demján 2015). Demján's conclusions are similar to those of Jeunesse (1997: 121) who suggests that Neolithic society was egalitarian in the beginning of the period while that of the late Neolithic was more strongly differentiated. If the social position of an individual is indicated by the number of grave goods, Lengyel society would certainly have been stratified (Dombay 1960; Kalicz 1985; Zalai-Gaál 2007; Demján 2010). Moreover, studies by Hungarian authors (Zalai-Gaál 1988; Siklósi 2007) also imply social differentiation not only on the individual, but also the family level (Zalai-Gaál 2002).

2.5.1.2. The Chalcolithic

Engagements in more physically-demanding activities such as ploughing, mining or hunting, as well as the protection of the family, are believed to determine the role of the man as the main food provider or a protector in the Chalcolithic. Sosna (2006) cites evidence from the Bell Beaker site of Šlapanice, Moravia, where gender and social identity are clearly seen. Here, subadult individuals were clearly differentiated from adults, their graves being shallow and poorly equipped. Adult gender differentiation was shown to be a complicated topic in this culture, reaching beyond the binary perception of male and female gender. A similar conclusion was reached by Turek (2011b, 2013) who mentions several sites where biological females were buried as males (also Vaňharová 2011), although the opposite tendency is only rarely documented (Turek 2006). Turek (2006) also mentions that 'mixed' equipment is mostly found in rich female graves, suggesting that they may have been a part of a social 'elite'. However, in his later work, Turek (2013) admits that females may have been also engaged in male activities such as hunting, as often seen in Native American tribes (Devereux 1937; Lang 1990; Ramet 2004).

Many of the rich male graves included clusters of working tools (Moucha 1989; Turek 2003), suggesting the privileged position of craftsmen (Bátora 2002; Turek 2006). The generally high position of males is possibly also indicated by statuettes with emphasised masculine attributes and the phallic shape of Chalcolithic axe-hammers. Such symbolism falls within a more complex picture where axe-hammers act as a prestigious masculine sign of social power and the patriarchal nature of society, whereas social and age differentiations are suggested also by richly equipped graves (Hájek 1961; Neustupný 1967; Šebela 1999; Turek and Daněček 2000). The aforementioned artefacts can be also interpreted as weapons or symbols of warfare (Vencl 1984; Zápotocký 1992), believed to have been a growing phenomenon since the Chalcolithic (for example, Turek 2007). The existence of violent encounters is probably reflected in the numerous fortified hilltop settlements that emerged, especially in the middle to late Chalcolithic (Točík 1970: 184–185; Podborský 1993: 192–200; Neustupný 2008: 98–102). What is interesting is that although there are numerous finds of weapons found in late Chalcolithic Corded Ware or Bell Beaker graves, there are no known fortifications in sites belonging to these cultures (Neustupný J. 1968; Turek 2007). However, this may be a consequence of the generally low number of settlements known for Chalcolithic cultures.

2.5.1.3. The Early Bronze Age

The use of new material in the Early Bronze Age (EBA) probably contributed to the development of specialised professions as well as crafts. In addition to farmers, a new class of craftsmen – metallurgists – probably emerged (Jiráň 2008: 11; Jaeger and Olexa 2014), and a similar trend can be presumed in other fields such as pottery, bone manufacturing, or trade (Podborský 2006a). What also supports the hypothesis of specialized production is the increasing number of hoards of raw materials or items from the period (see Jiráň 2008; Chvojka *et al.* 2009; Vladár and Oravkinová 2015). As suggested, e.g., by Vladár (2012) this may also point to wealth accumulation and the existence of social differentiation. Slovakia's mountainous character and rich metal deposits contributed to the formation of fortified settlements of urban character, specialised in metallurgy (Vavák *et al.* 2015), also documented at Nižná Myšľa, one of the sites from which the human remains studied in this thesis come (Olexa 2003; Jaeger and Olexa 2014). A trend of pre-urban fortified settlements with craft specialization is recorded in the western part of the region, suggesting a progressively differentiated and hierarchical society (for example, Vavák *et al.* 2015). Given its demand on physical power, metalworking was probably dominated by male members of the society (Jaeger 2014; Jaeger and Olexa 2014), whereas activities such as pottery-making probably fell within the competence of women (Mogielnicka-Urban 1984; Bouzek 2001: 26; Jaeger and Olexa 2014). However, as Sosna *et al.* (2008) observed, EBA society was not necessarily dominated by males, as frequently believed (Neustupný 1967, 1978; Bátora 1991; Furmánek *et al*. 1991; Neugebauer 1994). Based on mortuary variability evaluated by computer-intensive resampling methods, the equal importance of both sexes is indicated, although they do not disprove gender-related occupations (Sosna *et al.* 2008). Rich graves of female individuals in the area also support these findings (Shennan 1975, 1982; Dornheim *et al.* 2005). However, secondary manipulations and grave robbery may distort the general interpretation. Moreover, social stratification among females has been observed (for example, Sosna *et al.* 2008), and the same can be expected for males, as indicated by rich graves of metallurgists from Nižná Myšľa (Nováček 2010; Jaeger and Olexa 2014).

2.5.2. Long-distance contacts

2.5.2.1. The Neolithic

As far as the spread of agriculture is concerned, the issue of Central European neolithisation remains unsolved, although DNA-based research indicates that the first farmers were not descendants of the local Mesolithic population (Chikhi *et al*. 2002; Bramanti *et al.* 2009; Haak *et al*. 2010). However, isotope-based studies suggest probable intermarriage between foragers and farming communities (Price *et al.* 2001; Bentley *et al.* 2003), and so the possibility of some kind of a dual model cannot be rejected (see also Bentley *et al.* 2002; Sampietro *et al.* 2007). The distribution of extra-local materials such as obsidian or *Spondylus* shell indicates long-distance exchange (Točík 1970; Hladilová 2002; Zvelebil and Pettitt 2008: 213).

2.5.2.2. The Chalcolithic

Based on pottery shapes and the findings of whole pottery sets, contacts with the southeast continued in the Chalcolithic. In addition, the influence of North European cultures is reflected in pottery shapes and burial rites, e.g., in the Middle Neolithic Globular Amphora culture, probably brought by merchants from the north (for details see Podborský 2006a). Finds of a distinctive type of flint prove contacts with the regions north of the Carpathians (Pelisiak 2006, 2008; Soják 2013). The existence of barter via the network of merchant paths continued to the end of the period (Harrison 1977). At the end of Central European Chalcolithic, several culturally and anthropologically distinct groups appear, especially the Corded Ware and Bell Beaker populations (see Podborský 1993: 230–232; 2006a). However, in spite of the foreign origin of some cultural elements, Turek and Peška (2001) argue that the Bell Beaker culture is more a result of local development, and they support their hypothesis by the continuity of burial rites and areas settled. But traces of Corded Ware and Bell Beaker settlements are generally scanty or remain unpublished (Müller *et al.* 2009; Turek and Peška 2001), complicating the research into these cultural groups. The origin of these cultures, especially the Bell Beaker group, is still a hotly debated topic, which lies outside the scope of the present study.

2.5.2.3. The Early Bronze Age

Owing to the use of bronze, metallurgy and metallurgy-related barter intensified contacts among cultural groups, also at the supra-regional level (Harding 2000; Parkinson 2002; Kristiansen and Larsson 2005; Jiráň 2008: 11). Copper and tin deposits do not occur close to one another, suggesting that long-distance routes existed (Rowlands 1973: 596). The spread of the Únětice culture across more or less the whole of Central Europe (from Germany, Poland, south to the Danube, and east of the Ipeľ River[8] (Buchvaldek *et al.* 2007) suggests intensive contacts in the EBA, especially with the west and/or along the so-called 'Amber Road' (Schliemann 1966; Hulínek and Furmánek 2006). In eastern Slovakia, the Otomani culture developed as a part of the widespread Otomani-Füzeszabony group in the southeast (Gimbutas

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[8] creating the west-middle southern boundary between Slovakia and Hungary

1965: 200–218; Ponting 2001: 178). Contacts with other regions, especially the Achaean area (Greece), are also indicated by pottery shapes and imported goods (Venclová 1990: 39–40; Frána *et al*. 1997: 52–55; Bátora 2006: 223; Bartík, as cited in Hulínek and Furmánek 2006).

Chapter 3:

BIOARCHAEOLOGY OF SLOVAKIA, MORAVIA AND BOHEMIA

Human bones and teeth are extremely responsive to environment. They also respond well to repeated long-lasting activity. Therefore, systemic disruption caused by a compromised environment, in other words 'stress', can result in extensive bone modification (Wolff 1986; Ruff *et al.* 2006; Lerwick 2009), indicating the health and lifestyle of individuals. Such stress can manifest in, for example, lower average population height, slow subadult growth rate, lower life expectancy, or as disease (for a summary see Larsen 1997). A review of state of bioarchaeological research in the study region is provided below.

3.1. History and state of bioarchaeology research in the region

In former Czechoslovakia, the beginnings of anthropology are rooted in the nineteenth century. As a scientific field, it was always closely related to archaeology. However, in comparison to American and British anthropology, which aims to place human remains within their cultural and social contexts, Central-European anthropology is mostly regarded as a natural science studying the human body and its physical morphology (Malina 2009). As a result, the research of Czech/Slovak anthropologists often lacks interpretations with regards to the (pre)historical and archaeological contexts. It is important to understand why archaeology and anthropology had such a different development in the study region. The potential of the progressive Czecho-Slovak anthropology, represented by, for example, Karel Absolon or Aleš Hrdlička, was halted first by the German occupation of the Bohemian part of the country, and later by the communist regime. Both intervened in the field of anthropology, dictating its course. Firstly, the field was influenced by German racist anthropology and the authors of anti-racist works were strictly persecuted (see, for example, Hampl and Stella 2009). The communist regime did not support multidisciplinary approach to anthropology either, as it potentially revealed problems inconsistent with the ideology of "scientific communism" and "historical materialism" of the Marxism-Leninism (Malina 2009; see also Seligman 1901). As a result, instead of bio-socio-cultural interpretations, anthropological works were often limited to the physical attributes of skeletal remains. Although Malina (2009) mentions close cooperation of anthropology and archaeology, this was limited for a long time. Interdisciplinary collaboration in archaeology is not as well established as, for example, in Germany or Poland (Beneš and Pokorný 2008) and bioarchaeology is still not a mainstream discipline in Slovakia, Moravia, and Bohemia, with only rare comprehensive works appearing, such as that by Beneš and Pokorný (2008). Even these studies are more archaeobotanically oriented, covering bioarchaeological topics as defined by Mays (2010b), only marginally. According to Beneš and Pokorný (2008), bioarchaeology is a discipline covering all the biological sciences used in archaeology, not only those specifically connected to human skeletal remains. This perspective is slightly different from that in Western Europe where bioarchaeology is usually solely associated with human remains (for example, Mays 2010b). In the study region, this approach is covered by so-called archaeological anthropology.

Therefore, until quite recently, human remains played only a minor role in archaeological research (for example, Stocký and Matiegka 1925; Chochol 1964; Jelínek 1964). Despite the multi-factorial nature of these works, there are several limitations that make them osteoarchaeologically inadequate and obsolete. Firstly, the authors refer to methodologies that, despite being based on European populations and thus being anthropologically closer to the studied remains, are no longer in use, or which have been replaced by more accurate and widely applicable methods (Bello *et al.* 2006). These studies still predominantly focus on metric attributes of bones, while skeletal pathologies and their interpretations are almost entirely ignored. Due to the fact that the evaluations were made a half a century ago, a lack of supplementary methods, such as chemical analyses, is not unexpected. In addition, the published results were based on assemblages of rather small sizes. Nowadays, there are many more comparative skeletal assemblages both from the study region and from all over Europe. Therefore, the conclusions of the older works should be challenged and supplemented by new findings, using more modern approaches.

Until recently only few anthropologists considered human remains within their historical and archaeological contexts, as for instance Stloukal (1979, 1999). However, even Stloukal offers a discussion of methods and bioarchaeological approaches rather than a specific study. Nevertheless, the importance of his work lies in the fact that it demonstrates that archaeology and anthropology should not act as two unconnected fields and that collaboration between them is indeed beneficial. There has been huge progress in bioarchaeology in past few years, especially in the Czech Republic. However, bioarchaeological research is still mostly performed by anthropologists or medical researchers, who provide basic skeletal reports to archaeologists, specialising in individual (pre)historical periods. Yet, despite an increasing number of osteoarchaeological studies using modern methodology and a multidisciplinary approach (Beneš and Pokorný 2008; Dočkalová and Čižmář 2008a, 2008b; Smrčka *et al.* 2008a, 2008b; Zvelebil and Pettitt 2008; Horňák *et al.* 2010; Drozdová 2011; Havelková *et al.* 2013), in comparison to Moravian and Bohemian material, the majority of Slovak assemblages remain largely neglected, eagerly calling for bioarchaeological research. The number of Slovak anthropologists applying a multidisciplinary approach to the interpretation of osteological data is particularly limited. In addition, it is almost exclusively the western Slovak sites that are being bioarchaeologically processed (see discussion below), with the rest of the country being largely overlooked. This is caused by two main factors. First, the majority of western Slovakia comprises of fertile lowlands (Danubian Lowland), very favoured in the prehistoric era. In comparison, the rest of the country has a more mountainous character, the only larger lowland being located far to the east of the republic. What is more, the Eastern Slovakian lowland is only about a third of the size of Danubian Lowland (Figure 3). The second problem affecting the state of the research in Slovakia is related to the distribution of, mostly financial, resources. Owing to the more frequent and larger archaeological finds in western part of the country, more attention is paid to this region. In addition, the headquarters of the main archaeological institution, the Slovak Academy of Sciences, is located in the west, including many leading researchers.

Figure 3. Location and size of lowlands in Slovakia (original map from wikimedia.com 2017, adapted by author). a – Austria; b – Ukraine.

3.2. Bioarchaeology of the Neolithic, Chalcolithic, and the Early Bronze Age

On the whole, four main bioarchaeological themes suggested by Mays (2010b) – palaeodemography, palaeopathology, bone chemistry, and metric and non-metric variation – are all pursued in the region. However, in each of the studied periods different topics get differing amounts of attention, as discussed below.

3.2.1. The Neolithic

Larger collections of evaluated Neolithic remains come from a few designated early-Neolithic cemeteries such as Vedrovice (Moravia) or Nitra (Slovakia) (Pavúk 1982; Podborský 2002; Podborský and Kazdová 2005a, 2005b, 2005c; Zvelebil and Pettitt 2008; Whittle *et al.* 2013). Although focused mostly on the Linear Pottery culture, the scope of bioarchaeological research focusing on the Neolithic is, nevertheless, quite broad. A comprehensive study of the Vedrovice population was performed by Zvelebil and Pettitt (2008). Among others, the work includes demographic evaluation by Lillie (2008a) who also provides life tables and describes mortality rates by age. Like Vedrovice, Nitra cemetery was analysed in more detail within the international project focused on the Linear Culture (LBK) (Bickle and Whittle 2013). In addition to preliminary assessments of sex and age provided by Pavúk (1982), Whittle *et al.* (2013) have analysed proportions of subadults and adults, provided a comparison with Moravian sites, and also discussed the differences between them. Despite that Svodín is one of the few sites with preserved human remains coming from a single cemetery in the region, the skeletal material had remained practically unevaluated until today. Jakab (1986) had previously assessed the remains; however, as has emerged from the present study, not all of the assessments were accurate and re-evaluation of the remains had to be conducted. Moreover, a re-analysis showed that only some of the Svodín graves could be dated to the Lengyel period with higher degree of certainty, although no ^{14}C analyses were undertaken (a list of graves dated to the Lengyel period was provided by Demján in 2011). A full review of Moravian child burials, including their anthropological evaluation as well as a discussion and interpretation of the results, is provided by Dočkalová and Čižmář (2008a). In other studies, attention has been also paid to burials within the house/settlement areas often perceived as ‘building sacrifices’ (for example, Jelínek 2007; for a literature review see Gardelková 2009). The majority of these burials were children (for example, Humpola 2007; Gardelková 2009).

However, a more complex osteoarchaeological approach has been applied only in some of the studies (Dočkalová and Čižmář 2007; Jelínek 2007; Gardelková 2009).

In the region, bone chemistry, covering topics such as stable isotope analyses and DNA tests, is a relatively new field as in the rest of Europe. Owing to the destructive nature and costs of the analyses, the number of such studies is generally limited. From the Neolithic period, a large project, in cooperation with Sheffield University focused on the Vedrovice population, as mentioned above (Zvelebil and Pettitt 2008). The study included carbon, nitrogen, and strontium analyses, relating to both diet and migration. A similar approach was adopted by Bickle and Whittle (2013) in their LBK *Lifeways* project, where the authors focused on isotope analyses (primarily carbon, nitrogen, and strontium), as well as the osteological examination of the remains from Central Europe. The results obtained from the Vedrovice population revealed that the Early Neolithic populations probably had a mostly vegetarian, plant-food diet, with a focus on grains. This was suggested by both dental micro-wear (Jarošová 2008) and isotope analyses (Richards *et al.* 2008; Smrčka *et al.* 2008a). Richards *et al.* (2008) also indicate that animal proteins, either meat or milk, contributed to a large part of the diet. By examining the kill-off patterns of domestic animals, Kovačiková *et al.* (2012) came to the conclusion that livestock were exploited for both meat and milk during the LBK. However, as for instance Burger *et al.* (2007) mention, the consumption of significant amounts of fresh milk would probably not have been possible in the Neolithic, due to lactase persistence. Yet, as suggested, e.g., by Tresset and Vigne (2011), processed milk could have been digested by adults. The consumption of milk products in this period is also suggested by studies from nearby countries, based on lipid residues in pottery (Bogucki 1984; Craig *et al.* 2005; Evershed *et al.* 2008; Salque *et al.* 2013). Bioarchaeological research by Whittle *et al.* (2013) combined the Vedrovice data with that obtained from other Moravian sites (Těšetice – Kyjovice and Brno – Starý Lískovec) and the western-Slovak sites of Nitra and Krškany. The results indicate clear similarities in dietary practices, although due to the low carbon isotope values recorded at Nitra, the authors suggest that the Slovak population may have been obtaining food from a different, more wooded, environment (Whittle *et al.* 2013). All in all, overall research indicates that, regardless the environment, it is very probable that besides plant food playing a key role in the Neolithic diet, meat and milk were also consumed.

Considering the higher average δ^{15}N values detected in Vedrovice, Whittle *et al.* (2013) point to the possibility that freshwater fish were consumed. However, freshwater fish are rather difficult to recognise as dietary components in stable isotope analysis, especially if they did not contribute to a large part of the diet (Hedges and Reynard 2007). In the study region, the consumption of fish is implied only by archaeological finds of small net-weights or fishing hooks, or by fish bones themselves (Pleiner and Rybová 1978: 256-257; Kuna 1991; Podborský 1993: 146-147; Kyselý 2008, 2010; Dobeš *et al*. 2011; Nývltová-Fišáková 2011). However, a study from Hungary suggests that fish were consumed along the Danube in prehistory, possibly also including the Slovak part of the river (Bartosziewicz and Bonsall 2004). Nevertheless, in order to determine if and what amount of fish was consumed, further research and more precise excavation focused on obtaining fish remains would be needed (Dobeš *et al.* 2011).

Jarošová and Dočkalová (2008) studied dental remains from Moravia in different stages of the Neolithic and found that cariosity was higher in the beginning of the Neolithic than in its later phases. Based on dental wear, they also suggest that the coarseness of foods decreased later in the Neolithic. These findings imply a slight change in diet over time, not only from more carbohydrate-based to protein-based foods, but also from coarse to more refined prepared food. However, that these conclusions were made only by macroscopic osteological analysis needs to be borne in mind and more isotope-based research is needed.

Although the preservation of DNA molecules in the remains from Vedrovice was poor, Bramanti's (2008) analysis indicates an Eastern-European ancestry. These results are similar to those of Kráčmarová *et al.* (2006) who studied Y-chromosome haplogroups, revealing a predominantly Palaeolithic origin for today's Czech population (for further discussion see Zvelebil and Pettitt 2006). Individuals studied by Richards *et al.* (2008) also suggest a local origin for the majority of the population, with only a small percentage living elsewhere in childhood or over the previous ten/twenty years. The same conclusion was reached by Whittle *et al.* (2013) after an additional sample from Vedrovice was used.

Strontium isotope analyses suggest the migration of Early Neolithic females from the region (Price *et al.* 2001; Bentley *et al.* 2002; Whittle *et al.* 2013). Finding differences between the diets of males and females, Bickle *et al.* (2013) also suggest higher mobility of women in the period, ascribing it to patrilocality. In other words, women may have moved, for marriage to the location of their husbands (also Bentley 2007, 2013; Bickle *et al.* 2011; Bentley *et al.* 2012). Such a custom seems to have been widely practiced by the LBK people, possibly contributing to the spread of the culture (Price *et al*. 2001). In spite of this, Bentley (2007) indicates reducing mobility over the duration of LBK, but the lack of research for the Late Neolithic makes it difficult to confirm such a trend.

As discussed above, palaeopathological research is still not very well established in the study region, probably because it does not have strong tradition. Although progressing, the amount of attention given to individual pathologies varies. Studies examining larger skeletal assemblages are probably the most common works in the field of palaeopathology in the region. Some of these are focused on collections from single sites (for example, Dočkalová 2008; Whittle *et al.* 2013); other authors evaluated remains collected from a variety of small sites (Dočkalová and Čižmář 2007, 2008a; Smrčka and Tvrdý 2009). Palaeopathology of the Vedrovice population was comprehensively assessed by Dočkalová (2008) and Lillie (2008) within the above-mentioned Vedrovice project (Zvelebil and Pettitt 2008). However, even though detailed descriptions of skeletal remains and pathological lesions were provided by Dočkalová (2008), she does not provide specific prevalence rates for the pathologies. Given the size of the skeletal assemblage, prevalence rates would have been expected. Such ommisions are quite common in the study region. Considering complex studies of Neolithic populations from small Neolithic sites, Moravian finds from single graves and/or small sites have been comprehensively evaluated, e.g., by Smrčka and Tvrdý (2009) or Dočkalová and Čižmář (2007; 2008a). Smrčka and Tvrdý (2009) examined and compared 122 skeletons from thirty sites dated to different stages of the Neolithic. Similar research was performed on Neolithic dental remains of fifty-five subadults and forty-nine adults from the Neolithic (Jarošová and Dočkalová 2008). Studies dealing with a specific type of pathology are less numerous, dental evaluations being the most frequently researched. Besides the study by Jarošová and Dočkalová (2008), dental health has been examined in detail for LBK individuals from Vedrovice (Nystrom 2008), and Frayer (2004) compared the size and dental health of LBK populations from Vedrovice and Krškany, Slovakia, with a Mesolithic sample. The Slovak LBK population from Nitra was also analysed by Whittle *et al.* (2013) as a part of the project by Bickle and Whittle (2013). Dental evaluations focused on Late Neolithic remains are scarce and are often included as a part of primarily archaeological articles (for example, Trampota *et al.* 2012). Attention has been paid to trauma, especially in relation to discussions on Neolithic warfare (Jakab 1995; Vencl 1999), and Smrčka and Tvrdý (2009) also recorded trauma in their study. However, the authors do not include many details about the lesions.

As mentioned above, together with the evaluation of sex and age at death, metric analysis has quite a long tradition in the study region. However, despite numerous measurements being taken, only few are used for further research, with estimations of height being the most commonly evaluated and interpreted (Černý and Velemínský 1998; Vančata and Charvátová 2001; Brůžek *et al.* 2005; Dočkalová 2008; Ehler and Vančata 2009; Smrčka and Tvrdý 2009). The disadvantage of these studies is that they either use different methodologies for stature estimation, or the methodology is not mentioned at all. Therefore, no accurate comparison or firm conclusions between the study samples can be made. In addition to stature, craniometric data have been analysed for the Early Neolithic (Černý and Velemínský 1998; Stloukal 1999; Dočkalová 2008), as well as Late Neolithic populations (Stloukal 1999). As regards the Lengyel skeletal remains, it is Hungarian authors who deal with human remains into a greater extent, comparing them also with the Central-European data (Zoffmann 2000; Köhler 2012).

3.2.2. The Chalcolithic

Despite the fact that numerous cultures inhabited the region of Slovakia, Moravia, and Bohemia in the Chalcolithic, the best-preserved skeletal material comes from only two cultures: Corded Ware and Bell Beaker (Jakab 1986; Černý and Velemínský 1998; Farkaš 2002; Kasperová 2012; Gabulová *et al.* 2013; *Databáze LKP*). However, there are several limitations regarding Chalcolithic skeletal material - it usually comes from smaller sites (Černý 2000; Drozdová 2001; Drozdová 2005; Dobisíková and Havelková 2009), is not numerous (Lorencová 1961), or is very badly preserved (Stloukal 1980; 1985). Moreover, the human remains from even more extensive Chalcolithic burial grounds such as Brno – Holásky (Dvořák 1991), Blažovice II, Slavkov, Kobylnice, Němčice za Hanou or Old Břeclav (Podborský 1993), have not been anthropologically evaluated until now (Drozdová 2011: 7). Other collections such as Němčice, Šlapanice or Prosiměřice were analysed decades ago (Jelínek 1964; Lorencová 1961). Until the discovery of the Moravian site of Hoštice I za Hanou in 2002, the largest anthropologically assessed assemblage from a single burial ground was the Pavlov-Horní Pole, analysed by Dobisíková (Dobisíková and Langová 1996). Nonetheless, only the most basic anthropological descriptions of the bones were provided, with no discussion or further analysis. Anthropological evaluations of Chalcolithic skeletal material have been provided for several smaller sites (Stloukal 1985, Dobisíková and Langová 1996, Černý 2000, Drozdová 2001, 2005, 2011), none of them representing multi-bioarchaeological studies such as that by Drozdová (2011). Despite certain imperfections in the research, the multidisciplinary study by Drozdová (2011) provides a good basis for further research regarding the period. The only problem with the study is that the osteological methodologies suggested by local authors are used instead of international standards, and thus the results are less comparable with those from other countries.

The bioarchaeological study focused on the Hoštice population addressed several topics, including demographic analysis (Drozdová 2011), determination of sex of subadult remains using aDNA analysis (Vaňharová 2011), mobility of randomly-selected individuals and dietary analysis based on isotope analyses (Smrčka *et al.* 2011a, 2011b), palaeopathology evaluation (Smrčka and Drozdová 2011), as well as metric analysis of both the adults and subadults (Drozdová 2011). In many areas, the study goes beyond the basics. As regards demographic composition, in addition to evaluation of sex and age at death, Drozdová (2011) also provides life tables and discusses the results, as she does for the age composition at the site. Moreover, the author also compares her results with those available from several other sites, which is one of the key contributions of the study. A very rare study was undertaken by Ovesná *et al.* (2011) who examined blood types of the Hoštice population. The authors used a modified absorption-inhibitory serological method (AI) suggested by Lengyel (1975). In spite of the advantages of this technique, such as the requirement to use only a minimum of bone for analysis, it is only rarely used in archaeological remains (for example, Masnicová a Hanulík 1999; Drozdová 2006). In addition to the reconstruction of diet of the Hoštice population using the stable isotopes, Smrčka *et al.* (2011a, b) also analysed contents of trace elements present in bone tissues (i.e., phosphorus, calcium, zinc, iron, strontium, sodium, potassium, copper, chromium, selenium, and lead). A similar study on Chalcolithic remains was conducted by Smrčka *et al.* (2005b), using a collection of Bohemian Bell Beaker individuals.

So far, the work by Drozdová (2011) represents the most detailed bioarchaeological study of Chalcolithic skeletal material from the study region. Remains from multicultural sites are usually published in local articles, often being in the form of osteological descriptions with no osteoarchaeological interpretations (for example, Drozdová 2011). Palaeopathological studies suffer from similar limitations. The only fairly comprehensive study focused on health and skeletal pathology of Chalcolithic populations was conducted by Shbat *et al.* (2009). The authors studied pathology in 257 Corded Ware and Bell Beaker individuals and also compared their results with Neolithic remains, as well as between Chalcolithic cultures.

The authors also calculated health index values and determined weight and BMI of the individuals, which are rare in the study region. This study, although involving only Bohemian remains, thus represents a key contribution regarding the evaluation of health and skeletal pathology of Chalcolithic populations. The evaluation of pathology is sometimes comprised of studies focused on single types of pathology and its incidence during the prehistory, e.g., trepanations (Malyková 2002) or tumours (Strouhal and Němečková 2008).

Regardless of the bone analyses undertaken for the Hoštice project, it is mostly the work of Václav Smrčka which focuses on chemical analyses such as stable isotopes and trace elements analyses, including the Chalcolithic remains (Smrčka 2005; Smrčka and Jambor 2000; Smrčka *et al.* 2005, 2006, 2008a, 2008b, 2011a, 2011c). A recent article dealing with the presence of selenium in human skeletal remains provides a comparison of Chalcolithic and Bronze Age populations, including a rather extensive discussion of dietary differences between the periods (Smrčka *et al.* 2011c). A contribution to the knowledge of a regional Bell Beaker population is represented also by the comprehensive study by Price *et al.* (2004) who tried to shed light on the migration of the Bell Beaker people by using stable isotopes of strontium. However, because of the wide geographical focus of the research, only two samples from Bohemia were used.

The metric analysis of Chalcolithic remains, especially of skulls, has drawn considerable attention owing to the alleged foreignness of the Bell Beaker population. A detailed study on the metrics of the Bell Beaker population was produced at the beginning of the twentieth century by Stocký and Matiegka (1925). Different shapes of Bell Beaker crania have been further discussed in a number of additional works (Lorencová 1961, Jelínek 1964, Dobisíková and Langová 1996, Černý 2000, Drozdová 2001). In addition to cranial measurements, Sládek *et al.* (2006) focused on femoral midshaft geometry in order to assess the mobility of Chalcolithic populations. The sample comprised of 151 individuals from five Chalcolithic and EBA cultures from Moravia, Bohemia, and Lower Austria. Unfortunately, no Slovak samples were involved. The drawback of the study, regarding the presumed Bell Beaker migration, lies in the methodology used, as the Bell Beaker sample was pooled with Corded Ware remains (Sládek *et al.* 2006). Nevertheless, the study contributes greatly to bioarchaeological research in the study region, providing yet another perspective to the issue of population migrations. By comparing humeral bilateral asymmetry, Sládek *et al.* (2007)

prove that osteology can shed light on topics where archaeology cannot, e.g., in revealing gender-specific activities.

3.2.3. The Early Bronze Age

In spite of the existence of several assemblages suitable for extensive bioarchaeological research, given both by their size and preservation (for example, Nižná Myšľa, Jelšovce, Branč, Výčapy-Opatovce; Holešov, Rebešovice, Vliněves, Praha – Dolní Počernice[9] and more), only one broad study touching upon numerous bioarchaeology topics has recently emerged (Ernée 2015). Several bioarchaeological topics have been addressed in evaluation of the Únětice population from Prague – Miškovice, including palaeodemographic and palaeopathological analyses, and bone chemistry analyses (analysis of mitochondrial DNA [MtDNA], histological examination of human bones, and strontium and oxygen isotope analyses)[10].

In addition to the recent publication mentioned above, only material from Jelšovce, Slovakia, has been evaluated in more detail, although individual topics are dealt with through several studies. A detailed palaeodemography of the site has been produced by Jakab (2007), who evaluated 660 individuals from three EBA cultures (213 individuals of the Nitra culture, 126 of the Únětice culture, and 321 individuals of the Maďarovce culture). The author provides data on sex, age at death[11] and stature[12], and includes life tables and estimates of the number of social groups within individual cultures[13] (Jakab 2007). A much more detailed study on Jelšovce has been produced by Koel (2011), although the author focused solely on the adult population of the Nitra and the Únětice cultures. However, the study provides a detailed skeletal analysis of the remains, including palaeopathological evaluations, using both the macro- and microscopic methods. Having access to X-ray[14], micro-CT technology[15] as well as histological analyses, Koel's study (2011) contains rare evaluations of diseases not necessarily visible to a naked eye, such as leprosy, or treponemal diseases. As a result, the value of Koel's work

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[9] Ondráček 1972; Vladár 1973; Ondráček and Šebela 1985; Bátora 1999; 2000; Olexa 2003; Olexa and Nováček 2013

[10] unfortunately, I was not able to get access to the book, only the detailed contents (ARUP 2016)

[11] the population average age (31-32 years) seems to be stable during the almost seven centuries of burying at the site

[12] in all three groups the average age of men was higher than that of women

[13] If assuming the stationary population, numbers of burying groups could represent almost 24-25 inhabitants of the Nitra culture, 22 inhabitants of the Únětice culture and 55 inhabitants of the Maďarovce culture.

[14] examining, e.g., skull fractures, Harris lines

[15] examining bony microstructures, tissue samples

(2011) is incalculable as regards our knowledge of EBA populations in the study region. Jelšovce burials have also been dated by ^{14}C method, based on thirteen samples of bone collagen (Bátora 2000b). Traumatic lesions and violence in Jelšovce have been discussed in detail by Hårde (2005, 2006), who collected anthropological data for a number of large Slovak and Moravian EBA sites and discussed them within their archaeological and (pre)historical contexts. However, as mentioned also by Hårde (2005), not all skeletal material from EBA sites in the area has been also osteologically evaluated (such as Mýtna Nová Ves). Despite the above-mentioned limitations, it can be stated that Hårde (2005, 2006) provides the first osteoarchaeological works regarding violence in Slovak and Moravian EBA. In spite of the emphasis on this site, only migration of the Jelšovce population was examined, using stable isotopes of strontium[16] (Reiter 2013, 2014; Reiter and Frei 2015). Apart from Koel's works, no chemical bone analyses focused on diet or relationships within the Jelšovce populations were undertaken, and the potential of the site has not yet been exploited to the full.

Several osteoarchaeological studies have also emerged in Slovakia, although they are usually limited by low sample size. For instance, Horňák *et al.* (2012) produced quite an exhaustive osteological study on the EBA population from Melčice, comprising of thirty-two individuals. However, in addition to the rather small size of the collection, preservation of the remains was also quite bad (Horňák *et al.* 2012). Nevertheless, the authors addressed a variety of topics, including life expectancies, pathological assessment, as well as diet reconstruction using dental microwear patterns. In spite of sample size limitations, the demographic results are similar to those obtained by Jakab (2007) for Jelšovce. Similar results regarding demographic data and stature were indicated by Šefčáková (2014) in the population from Zohor. She also provides a list of pathologies observed on the remains (such as *cribra orbitalia*, dental caries, dental enamel hypoplasia, spondylarthrosis, cranial trauma, or arthroses) although no differential diagnoses or deeper discussions are discussed. In general, the author gives a description of the remains but does not discuss the topics much further. Like Horňák *et al.* (2012), Šefčáková's (2014) collection was too small for any conclusions to be made, comprising only of twenty-three graves. Prevalence rates of a variety of pathological lesions are provided also by Pankowská (2009) and Pankowská and Monik (2009), although the authors focused on archaeological topics such as social status and thus only the general health status

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[16] population buried at the EBA cemetery of Jelšovce on the other side of the Carpathians was subjected to only moderate in-migration rates on a regional level

of the studied individuals. On the other hand, their study represents one of a few works also dealing with metabolic diseases, although detailed analyses are missing (Pankowská 2009).

Bone chemistry studies are still quite rare also as regards EBA skeletal material from the study region. Diet composition has been recently studied by Smrčka *et al.* (2011c) also as a part of the comparison of Chalcolithic and EBA populations (see section *The Chalcolithic* above), using the contents of selenium in human skeletal remains. In addition, the composition of EBA diet was studied by Pankowská *et al.* (2014). In order to reconstruct diet, the authors used the ratio of Ba/Ca and Sr/Ca isotopes with the application of 'Laser Ablation Inductively Coupled Plasma Mass Spectrometry' (LA-ICP-MS). However, their work represented only a pilot study whose primary aim was to test the application of the methodology in dietary reconstruction. As Pankowská *et al.* (2014) concluded, the technique was only useful in the case of dental enamel, and not bone.

In general, skeletal material from quite a number of archaeological sites has been osteologically evaluated, although there are many limitations to the works. First of all, a great number of anthropological assessments of larger samples date to more than forty years ago (Hanáková *et al.* 1973; Hanáková 1978; Stloukal 1978), many of which are unpublished dissertations (Kordovaníková 1967; Michnáčová 1967; Hanulík 1970; Kollárová 1970). Moreover, the majority of the older studies focus on metrics and the morphological variation of skeletons (for example, Chochol 1964; Jelínek 1978), or basic evaluation of sex and age at death (for example, Strouhal 1978). Like the older research, newly-excavated remains are also assessed as parts of bachelor degree dissertations of varying quality (for example, Velebová 2016; Kalášková 2016). Quite often, osteological evaluations form only attachments to archaeological reports (for example, Chochol 1968b; 1982c), or are published in periodicals, which are often difficult to access (for example Stloukal 1979). As regards more recent publications, metric data for EBA populations are quite commonly incorporated in studies comparing populations from different periods. For instance, Černý (1996) provides a quantitative comparison of cranial variation of the Chalcolithic and EBA populations in Bohemia, also using statistical analysis of variance (ANOVA), and Vančata and Charvátová (2001) studied body size and robusticity of Neolithic and EBA populations from across Central Europe. Moreover, their sample of 662 individuals was also compared with data from the Mesolithic period, finding similarities between the EBA and Mesolithic individuals. Other than cranial measurements and stature, Sládek *et al.* (2007) studied bilateral asymmetry of the humeri, in order to reveal evidence of a change in subsistence from the Chalcolithic to the EBA, as well as differences between males and females from these periods. Previously, Sládek *et al.* (2006) had conducted a similar study on the femora of populations from the same periods, searching for any indications of differences in mobility. Their results did not confirm any differences between the two populations, indicating quite low level of mobility.

Chapter 4:

MATERIAL AND METHODOLOGY

This chapter lays out the osteological collections that have been assessed in this thesis, and explains the methods that have been used in their assessment, recording, and data processing. The last section focuses on the limitations of bioarchaeological research, and possible weaknesses in the presented study.

4.1. Material

Altogether, 288 available skeletons from the Neolithic, Chalcolithic and the Early Bronze Age were macroscopically evaluated: 152 adults and 136 subadults. The cultures to which the skeletal remains belong include the Neolithic Lengyel culture, the Chalcolithic Bell Beaker culture, and the Early Bronze Age Únětice and Otomani cultures, coming from the sites of Svodín and Nižná Myšľa (Slovakia), Hulín 1 (Moravia), Brandýsek, Kněževes, Lochenice, Mochov, Praha – Malá Ohrada (Bohemia), and a number of other Bohemian sites located mostly within the Prague district or its vicinity (Figure 4, Table 4).

Figure 4. Location of sites where the study material comes from. blue dot – Neolithic site; red dot – Chalcolithic site; green dot – EBA site. 1 - Praha (Prague); 2 - Brandýsek; 3 - Březno u Loun; 4 - Čičovice; Kněževes; Stehelčeves; Tuchoměřice; 5 - Kozly; Malé Březno; 6 - Libochovice; Sulejovice; Žabovřesky; Židovice; 7 - Lochenice; 8 - Klučov; Mochov; 9 - Plotiště nad Labem; 10 - Tišice; 11 - Velké Přílepy; 12 - Želenice; 13 - Brodce; 14 - Polepy; 15 - Stekník; 16 - Svojšice; 17 - Vraný.

Period	Culture	Site	Region	NI	NA	NJ	M	F
NEO			**TOTAL:**	**62**	**33**	**29**	**14**	**19**
	Lengyel	Svodin	Slovakia	62	33	29	14	19
CHAL			**TOTAL:**	**94**	**43**	**51**	**25**	**18**
	Bell Beaker	Brandysek, Kladno	Bohemia	12	5	7	4	1
	Bell Beaker	Brezno, Louny	Bohemia	1	1	0	0	1
	Bell Beaker	Hulin 1	Moravia	18	9	9	5	4
	Bell Beaker	Knezeves	Bohemia	14	5	9	2	3
	Bell Beaker	Kozly	Bohemia	1	0	1	0	0
	Bell Beaker	Libochovice	Bohemia	2	1	1	1	0
	Bell Beaker	Lochenice	Bohemia	7	3	4	2	1
	Bell Beaker	Male Brezno	Bohemia	1	1	0	0	1
	Bell Beaker	Mochov	Bohemia	20	2	18	1	1
	Bell Beaker	Plotiste nad Labem	Bohemia	1	1	0	1	0
	Bell Beaker	Praha Kobylisy	Bohemia	1	1	0	1	0
	Bell Beaker	Praha Mala Ohrada	Bohemia	1	1	0	0	1
	Bell Beaker	Stehelceves	Bohemia	2	2	0	1	1
	Bell Beaker	Sulejovice, Litomerice	Bohemia	2	2	0	2	0
	Bell Beaker	Tisice	Bohemia	2	1	1	1	0
	Bell Beaker	Tuchomerice	Bohemia	1	1	0	1	0
	Bell Beaker	Velke Prilepy	Bohemia	3	3	0	1	2
	Bell Beaker	Zabovresky, Litomerice	Bohemia	1	1	0	1	0
	Bell Beaker	Zelenice, Most	Bohemia	1	0	1	0	0
	Bell Beaker	Zelesice	Moravia	1	1	0	1	0
	Bell Beaker	Zidovice, Litomerice	Bohemia	2	2	0	0	2
EBA			**TOTAL:**	**132**	**76**	**56**	**44**	**32**
	Unetice	Brodce	Bohemia	1	1	0	1	0
	Unetice	Cicovice	Bohemia	2	1	1	1	0
	Unetice	Klucov	Bohemia	2	0	2	0	0
	Unetice	Mochov	Bohemia	1	1	0	0	1
	Otomani	Nizna Mysla	Slovakia	97	45	49	23	22
	Unetice	Polepy	Bohemia	1	1	0	1	0
	Unetice	Praha Bubenec	Bohemia	2	0	2	0	0
	Unetice	Praha Cimice	Bohemia	2	1	1	0	1
	Unetice	Praha Liben	Bohemia	1	1	0	1	0
	Unetice	Praha Mala Ohrada	Bohemia	19	19	0	14	5
	Unetice	Praha Podhori	Bohemia	1	0	1	0	0
	Unetice	Steknik	Bohemia	1	1	0	0	1
	Unetice	Svojsice	Bohemia	1	1	0	0	1
	Unetice	Tuchomerice	Bohemia	1	1	0	0	1
	Unetice	Vrany	Bohemia	3	3	0	3	0

Table 4. Sizes of study samples by period. NI - number of evaluated individuals; NA - number of adults; NJ - number of juveniles; M – males; F - females.

More details about individual sites and the context in which the studied human remains were found are provided below. In addition, the overall population sizes from individual sites[17] as well as number of skeletons studied within this thesis are also mentioned.

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[17] as indicated by archaeological record

4.1.1. The Neolithic

4.1.1.1. Svodín, Slovakia

Modern-day Svodín is located within the Nové Zámky district in south-western Slovakia. It is situated in the undulated terrain of the southern Danubian Hills, between the lower River Hron basin to the east and the Danube to the south. The Lengyel excavation site is placed on a high loess terrace, in the vicinity of water streams, and it is so far the southern-most situated early-Lengyel settlement in Slovakia (Demján 2009).

Although preliminary excavations at Lengyel were conducted in the 1930s, 1950s and 1960s (Točík and Lichardus 1966), fully systematic research was only conducted from 1971 to 1983 by Viera Němejcová-Pavúková (Němejcová-Pavúková 1995). An area of about 3 ha was uncovered and revealed occupation during almost all prehistoric periods. However, it is in the Late Neolithic Lengyel stage when the occupation of the site appears to be the most intense. Besides the settlement, two roundels (circular compounds demarcated by concentric circles of ditches and palisades) located on the top of the terrace were discovered, with groups of graves placed within the area. The skeletal remains assessed in this present study originate from this Late Neolithic stage.

Groups of graves were distributed all over the settlement, with a clear chronology. However, individual graves seem to lack any obvious chronology (Němejcová-Pavúková 1995). Altogether, 184 graves were unearthed, 111 of which were dated to the Lengyel period (4900-4700 cal BC) (Němejcová-Pavúková 1995: 217; Demján 2012). The position in which individual skeletons had been placed could only be determined in a hundred graves, ninety-four of which were placed on the right side, four on left side, and two on their backs (Němejcová-Pavúková 1986). The preferred orientation of the grave pits is SW-NE, with 69% of the graves being oriented in this direction. A W-E orientation[18] was detected in 15% of the pits, with the numbers of burials in other directions being insignificant. Double burials were rare (only two double burials occurred). With its more than a hundred graves, Svodín population represents larger Late Neolithic community. In general, Late Neolithic cemeteries in the region vary in size, the largest being located in Hungary (Table 5).

Only a brief evaluation of sex and age at death had been performed by Július Jakab (Jakab 1986). However, as was discovered, his conclusions were not always accurate and a re-evaluation was needed (also concluded by Dr Jakab, personal communication, June 2013).

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[18] position of head is mentioned first

The re-assessment of more than a half of the skeletal remains from Svodín was carried out by the author for this thesis, as was further osteological evaluation. Skeletons excluded from the examination were either extremely incomplete,they could not be properly cleaned (many bones were covered by calcified accretions), or were not available (could not be found in the depository).

Site	**NI**	**References**
HUNGARY		
Alsónyék-Bátaszék	862	Köhler (2013)
Aszód-Papi földek	204	Zoffmann (2013)
Csabdi-Télizöldes	34	Köhler (2004)
Esztergályhorváti	38	Zoffmann (2007)
Mórágy-Tűzkődomb	108	Zoffmann (2004; 2014)
Zengővárkony	64	Zoffmann (1969-1970)
AUSTRIA		
Friebritz-Süd	12	Neugebauer-Maresch and Teschler-Nicola (2006)
Mauer	7	Strouhal and Jungwirth (1970)
Poigen	5	Ehgartner and Jungwirth (1956)
CZECH REPUBLIC		
Těšetice-Kyjovice (MOR)	6	Kazdová (1984); Podborský (1988); Golec (2003); Kazdová *et al.* (2005)
Střelice u Jevišovic (MOR)	6	Databazelkp

Table 5. Examples of other Late Neolithic sites in the region and sizes of related skeletal assemblages (NI).

4.1.2. The Chalcolithic

Like Neolithic cemeteries, Late Chalcolithic sites from different parts of the region also indicate different population sizes. The largest cemeteries were discovered in Hungary, while the numbers of graves are much lower in the western part of the region (Table 6). However, it is difficult to estimate specific population sizes, as the large cemeteries may have just been used longer. Overall sizes of the populations from which the studied remains came from, as well as specific numbers of examined individuals, are also provided below as a part of individual sites' descriptions.

Site	**NI**	**References**
HUNGARY		
Békásmegyer	154	Kalicz-Schreiber and Kalicz (1998/2000)
Budakalász	1070	Czene (2008; 2011)
Csepel-Szennyvíztisztító	150	Horváth *et al.* (2007)
Szigetszentmiklós-Felsö-Ürgehegyi dülö	216	Patay (2011)
Szigetszentmiklós-Üdülösor	155	Endrödi *et al.* (2010; 2011)
AUSTRIA		
Oberbierbaum	7	Neugebauer-Maresch and Neugebauer (1994)
Zwingendorf	21	Kern (1984; 2000/2001)
CZECH REPUBLIC		
Dolni Vestonice III (MOR)	16	Dobisíková and Langová (1996)
Hoštice za Hanou (MOR)	143	Drozdová (2011)
Pavlov-Horní Pole (MOR)	44	Dobisíková and Langová (1996)
Stříbrnice-Lopaty (MOR)	65	Pankowská (2008)
Čachovice (BOH)	21	Neustupný and Smrž (1989)
Kolín (BOH)	20	Dvořák (1936); Hájek (1968)
Neratovice (BOH)	23	Hájek (1968)
Praha 6 - Lysolaje (BOH)	25	Hájek (1968)

Table 6. Examples of other Chalcolithic (Bell Beaker) sites in the region and sizes of related skeletal assemblages (NI).

4.1.2.1. Hulín 1, Moravia

The site is located to the north-west of present-day Hulín village, falling within the Kroměříž district, Moravia (Berkovec 2007). It is situated on a hillock, at an altitude of 192 metres above sea level, in the vicinity of the Morava River.

The site was excavated by the Olomouc Archaeology Centre (ACO) in 2004 and 2005, in advance of motorway construction. During this excavation a layer containing Bell Beaker graves was excavated (Daňhel 2010).

The site was inhabited from the Late Neolithic period, continuing into the Chalcolithic, and included the Bell Beaker cemetery, the human remains from which were examined for this thesis. The evidence of several EBA cultures vouches for continuous occupancy of the site until the last centuries BC when the site was inhabited by the Celts (Daňhel 2010).

The Bell Beaker cemetery, located in southern part of the site, yielded twenty-four burials. The inventory of the graves was entirely typical for the Bell Beaker culture, including mostly pottery, but also wrist guards, beads and arrowheads. The dating of the site was based on these assemblages (Berkovec 2007). The graves were oriented mostly in an NE-SW direction, although four burials did not follow this pattern. The majority of the skeletons were incomplete or only partially preserved; only eight were well preserved and one skeleton were not preserved at all. Out of twenty-four graves, two contained cremated remains, while all the others were inhumations. All individuals that could be were buried in a crouched position. Eleven individuals lay on their left side, eight on the right side, two lay on the back, and one on stomach. Out of fifteen skeletons where the face direction could be assessed, fourteen were facing south or south-east. The face of one individual was facing the bottom of the burial pit. However, the bones of this individual had moved after death, probably by rodents, and so the position may not correspond with the original position in the pit.

Preliminary demographical evaluation of the skeletons from Hulín 1 was performed as a part of a diploma thesis by Zuzana Koldínská (2007). However, it has emerged that the evaluations were frequently incorrect (Tvrdý, personal communication, May 2011) and a new analysis was vital. For the present study, eighteen individuals whose skeletons included more than 50% of all bones were evaluated: nine adults and nine juveniles. The degree of completion and preservation of the majority of the evaluated skeletons were good, with only a few of the remains damaged.

4.1.2.2. Brandýsek, Bohemia

The site lies about 30 km northwest of Prague, in an undulated forest-free terrain. Research, conducted in several stages, yielded finds from multiple periods. Besides Neolithic occupation, Corded Ware and Bell Beaker culture graves were also unearthed, as well as Roman and early medieval interments (Kytlicová 1960).

Twenty-one Bell Beaker graves with twenty-two individuals were retrieved by Kytlicová (1960) between 1956 and 1957. Grave orientation was uniform, strictly in a N-S direction. The faces of all the individuals were turned to the east; all were in a crouched position, males on the left side, females on the right. Juvenile remains were more common than those of adults. Some graves had probably been lined by wood or stone (Kytlicová 1960).

Preliminary anthropological evaluation was performed by Blajerová (1960) more than half a century ago but the evaluation techniques were either not clearly described or not mentioned at all, for instance, in the case of age at death and stature. Moreover, the description of pathological lesions is for the most part very ambiguous and vague. For these reasons a complete re-evaluation of the skeletal material was required. Twelve of these individuals (more than a half of the skeletons unearthed at Brandýsek) were selected for this thesis, five adults and seven subadults.

4.1.2.3. Kněževes, Bohemia

The site is located to the north-west of Prague, in the south-eastern part of the village of Kněževes, lying on the terrace of the Únětice stream (Kytlicová 1956). Several seasons of archaeological research indicated that the occupation of the site was exceptionally intense, dating from the Neolithic to the medieval age, as suggested by numerous archaeological finds (Smejtek 2011). The excavations of Bell Beaker graves studied for the present thesis took place during rescue excavations in 1953-1954, under the supervision of Kytlicová.

Altogether, fourteen Bell Beaker graves were uncovered; twelve of them were inhumations, and two were cremations (Kytlicová 1956). More than a half of the remains were oriented in a N-S direction, with heads to the north, lying on their left side. The rest of the bodies were placed in the opposite direction, lying on the right side. In both cases the faces were turned to the east. No relation between the position in a grave and sex or age was detected. Kytlicová (1956) also points to the prevalence of juvenile graves.

For the purposes of this research, all fourteen skeletons, five adults and nine subadults, from the site were evaluated.

4.1.2.4. Lochenice, Bohemia

The site is located in eastern Bohemia, near Hradec Králové. Several stages of excavations have been conducted since the1950s. The occupation of the site during prehistory was detected to have been quite intense, as suggested by numerous archaeological finds dated to the Neolithic, Chalcolithic, Bronze Age, and the Migration period. The site remained occupied until the Early Medieval and in modern times (Zeman 1978; 1986).

With its twenty-four Bell Beaker graves, the site belongs to those larger burial grounds from the period in Bohemia (Buchvaldek 1990). The graves were excavated during a 1953-1954 rescue excavation and as a part of systematic research conducted between 1978 and 1983 (Zeman 1986). The graves were irregularly distributed, with large distances between them (8-10 m) (Zeman 1978). The inventory of the graves was typical for the Bell Beaker culture, and included beakers and wrist-guards. Preliminary evaluation of basic anthropological features was performed by Chochol (1983). However, his evaluation does not include the methodology used and is provided only in a form of a basic written report. Owing to the generally bad preservation of skeletal remains from Lochenice, only skeletons with at least 50% of bones with moderate and good bone-surface preservation were selected for the analysis - three adults and four subadults.

4.1.2.5. Mochov, Bohemia

Mochov is situated about 30 kilometres northwest of Prague and belongs to one of the better explored burial grounds in Bohemia. Despite this, the documentation regarding this site is scarce.

Considering Bell Beaker remains, the site yielded twenty-eight graves with inhumations, with a prevalence of subadult graves. Only five graves are believed to contained adult individuals. The majority of the remains were oriented in N-S direction, eleven skeletons lying in a crouched position on their left side with the head oriented to the north (presumed to be males); thirteen skeletons were placed on their right side, with head to the south (presumed to be females) (Moucha 1966).

Twenty skeletons from the twenty-eight graves are involved in the present study, two adults and eighteen subadults.

4.1.2.6. Other Chalcolithic sites

Each of the sites listed below yielded a limited number of Bell Beaker individuals, usually single inhumations, as most were not primarily occupied by Bell Beaker populations. Documentation of the sites, where it existed, is only in the form of site reports. The situation was exacerbated by the major Prague flood in 2002 when a lot of the National Museum’s archive documentation was destroyed. Together, twenty-three skeletons from these sites were examined for this thesis, nineteen adults and four subadults (Table 4, Figure 4). Bibliographical references for these sites are provided below (Table 7).

Site	Region	References
Březno, Louny	Bohemia	Chochol (1975); Pleinerová (1980; 1981)
Kozly	Bohemia	NA
Libochovice	Bohemia	Blažek and Kotyza (1990)
Malé Březno	Bohemia	Černá and Velímský (1991)
Plotiště nad Labem	Bohemia	Rybová and Vokolek (1972); Chochol (1978); Vokolek and Zápotocká (1997)
Praha - Kobylisy	Bohemia	Chochol (1980a)
Praha - Malá Ohrada	Bohemia	Kovářík (1979-1981); Petriščáková (2011)
Stehelčeves	Bohemia	Hájek (1961); Knor (1962; 1966); Chochol (1968a)
Sulejovice, Litoměřice	Bohemia	Blajerová (1957)
Tišice	Bohemia	Hájek (1968)
Tuchoměrice	Bohemia	Šneidrová (1957)
Velké Přílepy	Bohemia	Černý (2000); Skružný *et al.*(2000)
Žabovřesky, Litoměřice	Bohemia	NA
Želenice, Most	Bohemia	Chochol (1977)
Želešice	Moravia	Šebela (1981); Chochol (1982a, b)
Židovice, Litoměřice	Bohemia	NA

Table 7. List of other Chalcolithic sites where the studied remains come from, and related bibliography.

4.1.3. The Early Bronze Age

Population sizes in the Early Bronze Age vary on both the micro- and macro-regional levels, although the numbers are strongly affected by the period of time during which a specific burial ground was in use. Slovak and Lower-Austrian sites usually yield much higher numbers of skeletal remains than sites located in Moravia and Bohemia (Table 8). Overall sizes of the populations from which the studied remains came from, as well as specific numbers of examined individuals, are provided in the descriptions of individual sites.

Site	NI	References
SLOVAKIA		
Branč	237	Vladár (1973b)
Jelšovce	660	Jakab (2007); Koel (2011)
Vráble	*c.* 1000	Tóth (2013)
AUSTRIA		
Franzhausen	714	Teschler-Nicola (1988); Neugebauer-Maresch and Neugebauer (1997); Spatzier (2007)
Gemeinlebarn	258	Wohlschlager (2011)
Hainburg	*c.* 350	Schultz (2001a); Novotný *et al.* (2010); Krenn-Leeb (2011)
CZECH REPUBLIC		
Holešov (MOR)	355	Ondráček (1972); Ondráček and Šebela (1985); Stloukal (1985)
Hulín 3 - U potůčku (MOR)	82	Pankowská (2007)
Prušánky (MOR)	27	Meduna (1959)
Rebešovice (MOR)	86	Jelínek (1959); Ondráček (1962)
Slatinice na Hané (MOR)	23	Šmíd (2003; 2006); Dočkalová (2006)
Slavkov u Brna (MOR)	58	Dočkalová and Svenssonová (2000) Horálková-Enderová and Štrof (2001)
Vyškov (MOR)	22	Tihelka (1953)
Blšany (BOH)	40	Pleinerová (1960b)
Praha - Dolní Počernice (BOH)	77	Lutovský and Smejtek *et al.* (2005: 429-430)
Kněževes (BOH)	24	Smejtek (2001) Lutovský and Smejtek *et al.* (2005: 356)
Liběšovice (BOH)	44	Moucha and Pleinerová (1966) Pleiner and Rybová (1978)
Polepy (BOH)	142	Dvořák (1926); Moucha (1954); Bartelheim (1998); Sklenář *et al.* (2002: 273-274)
Praha - Bubeneč (BOH)	14	Lutovský and Smejtek *et al.* (2005: 417)
Praha - Čakovice (BOH)	21	Chochol (1980c) Lutovský and Smejtek *et al.* (2005: 422-424)
Praha - Miškovice (BOH)	44	Erneé (2000) Lutovský and Smejtek *et al.* (2005: 446-447)
Velké Žernoseky (BOH)	48	Moucha (1961)
Vliněves (BOH)	350	Křivánek (2003); Pleinerová *et al.* (2003)

Table 8. Examples of other EBA sites in the region and sizes of related skeletal assemblages (NI).

4.1.3.1. Nižná Myšľa, Slovakia

Nižná Myšľa is situated in the southern part of the Košice basin, at the foot of the Slanské Hills, close to the junction of three rivers – Hornád, Torysa and Olšava. The site is located 217 meters above sea level (Olexa 2003).

The first graves were discovered in 1948, although these were rather poorly equipped and no follow-up research was conducted. It was not until after thirty years that systematic research under the Slovak Academy of Sciences (SAS) was launched in 1977. Excavations continue until the present under the supervision of Ladislav Olexa.

Currently, about a third of an estimated area of 10 ha has been excavated (Olexa 2003). The site comprises of a fortified settlement (settlement I), its agricultural surroundings, and a cemetery. The beginning of the settlement is dated to about 1700 BC when the settlement and the necropolis were established on a local ‘Várhegy’ hillock. The cemetery includes almost 800 interments, and is estimated to have been in use for almost 300 years. It is one of the largest Early Bronze Age necropoleis in the Carpathian Basin (Olexa 2003). Analyses date the cemetery to about 1866 ± 61 cal BC (Olexa and Nováček 2013; Jaeger and Olexa 2014).

Individual interments seem to have been distributed in chronological order in several rows. Given the fact that none of the graves disturbed each other, it can be presumed that the graves were marked on the surface (Olexa 2003). The strict burial rite does not seem to have changed throughout the centuries. With the exception of a few graves, burials were oriented in N-S direction, occasionally with a slight deflection to the east. The majority of the burials included single individuals, occasionally double, and very rarely multiple burials. Double graves usually consisted of a skeleton of a female and a child (Olexa 2003). The deceased were placed in flexed positions with their face to the east, females lying on their left side and oriented in N-S direction, males on the right and oriented in the opposite direction. As no anthropological evaluations had been conducted until now, it is not clear whether this tradition also applied to children. Traces of large pieces of thick textile and leather were found in many graves and Olexa (2003: 74) suggests that the dead might have been buried wrapped in bags or blankets. Unfortunately, such a presumption was not yet supported by any form of scientific analysis.

For the purposes of this thesis, a collection of ninety-seven human remains from Nižná Myšľa was examined, forty-nine subadults and forty-five adults. The selection was made from the 310 excavated between 1977 and 1985. These graves are believed to represent the first stage of the occupation of the site; moreover, the graves had already been archaeologically evaluated, with a detailed catalogue of the finds (Olexa and Nováček 2013). An osteological evaluation of these remains is thus a welcome contribution, enabling the creation of a complete set of information for more than a third of the necropolis. Unfortunately, the remains were stored in an open-air depository in paper bags and boxes, easily accessible to small animals. In addition, bones of multiple individuals had been placed in one box. As a result, the bones were often commingled and, because individual bones were not labelled, some of the remains could not be associated with the individual they belonged to.

4.1.3.2. Praha – Malá Ohrada

The burial ground is located in the west of the present day Prague. The site spreads over an area of almost 11 ha (Kovářík 1979-1981). The cemetery was dated according to the archaeological inventories found in the graves. Although a more precise method would be preferred, the inventory is very similar to that found within the Únětice graves in Kněževes, which was radiocarbon dated to the Early Bronze Age (Smejtek 2005: 234; Smejtek 2011). The burial pits were disturbed by features from later periods (Kovářík 1979-1981).

Altogether, forty graves with sixty individuals were excavated, eleven graves containing more than one individual (Chochol 1987). According to archaeological documentation, there were no cremations at the site (Kovářík 1979-1981). Male graves were more numerous than those of females, and almost 50% of the burial pits did not include any grave goods. The graves were quite shallow, being from 10 to 45 cm deep. More than 80% of the graves were oriented in a S-N direction. All individuals from the twenty-four graves, for which the positions of skeletons could be assessed, were buried on their right side, facing east. Where the exact position could be established, all were buried in a crouched position. Preliminary evaluation of the remains from Malá Ohrada was made by Chochol (1987), although though no discussion was provided. The lack of detailed documentation meant that new osteological analysis was vital. Owing to the poor preservation of skeletal remains from the site, only nineteen adult individuals from Praha – Malá Ohrada are included in the present study.

4.1.3.3. Other Early Bronze Age sites

Similar to Chalcolithic assemblages, the remains from Early Bronze Age (EBA) sites below come either from smaller sites, not primarily Únětician, or poorly studied sites. Together, nineteen individuals from various sites (Figure 4, Table 4) were examined, twelve adults and seven subadults. Bibliographical references for these sites are provided in Table 9.

Site	Region	References
Brodce	Bohemia	Knor (1955)
Cicovice	Bohemia	NA
Klucov	Bohemia	Kudrnáč (1955)
Mochov	Bohemia	Moucha (1966); Chochol (1968b)
Polepy	Bohemia	Moucha (1954)
Praha Bubenec	Bohemia	Jíra (1923; 1924); Kostka (2014)
Praha Cimice	Bohemia	Huml (1980); Chochol (1980b)
Praha Liben	Bohemia	NA
Praha Podhori	Bohemia	Fridrichová (1977)
Steknik	Bohemia	NA
Svojsice	Bohemia	Chochol (1982c)
Tuchomerice	Bohemia	Pleiner and Rybová (1978)
Vrany	Bohemia	Knor (1957)

Table 9. List of other Early Bronze Age sites where the studied remains come from, and related bibliography.

4.2. Methodology

4.2.1. Osteological analysis of human remains

All the remains were assessed macroscopically and a database including data for all the remains was created. In summary, following were evaluated:

- Preservation of the remains
- Sex of adult individuals
- Age at death
- Stature of adult individuals
- Anthropometric data
- Health indicators
- Developmental anomalies and non-metric variation

4.2.1.1. Preservation

Two main categories for assessing skeletal preservation were used – quantitative (completeness) and qualitative (bone surface preservation). In addition, the survival rate of individual bones was assessed for adults but not for subadults, as subadult bones were too poorly preserved. All the preservation data are available in the enclosed MS Excel database.

Completeness as a quantitative indicator represents the ratio of the number of present bones to the total number of bones found in a complete skeleton. In the case of juvenile remains, only the diaphyses and primary bone elements were taken into consideration. Four degrees of skeletal completeness were considered, based on the categories suggested by Mays *et al.* (2002, Table 1):

- <25% (nearly incomplete)
- 25-50% (quite incomplete)
- 50-75% (quite complete)
- ≥75% (nearly complete)

A qualitative marker refers to how well the surface of the bone was preserved. Bone surface can be disturbed by numerous agents, such as heat, weather, plant roots, micro- and macro-fauna, soil composition, or human activity (Ubelaker 1989; White and Folkens 1991; Ortner and Puschar 1985; Behrensmeyer 1978). A system of bone weathering stages, including cracking and flanking, have been created by Behrensmeyer (1978), although his system is not entirely applicable to the erosion/abrasion caused by soil composition, plant activity, or re-deposition of human remains. More recently, McKinley (2004) introduced a more general system for scoring the level of surface damage, including five grades of erosion/abrasion. McKinley's system showed to be unnecessarily detailed for the material from Slovakia, Moravia and Bohemia, and so only three modified categories have been used:

- Good

  (surface with little or no post-mortem damage, any pathological lesions would be clearly visible)
- Moderate

  (surface with some post-mortem damage, but any surface pathological lesions would be visible, if present)
- Poor

  (surface with apparent post-mortem/taphonomic damage [such as weathering, animal or plant-related destruction, etc.]. Pathological lesions, other than severe changes, such as fractures, would be difficult to assess)

Each preserved bone has been evaluated, but since the condition frequently varied from bone to bone in a single skeleton, an average condition for the whole skeleton was used.

4.2.1.2. Evaluation of sex

The sex of an individual refers to a person's biological identity rather than to one's social identity. Sex was evaluated only for adult individuals, as the osteological determination of sex is inaccurate in subadult remains. The main problem is that until late adolescence the bones of males and females are not sufficiently differentiated. This is mostly because male-sex-indicating features on bones are dependent on testosterone levels that develop only during puberty (Walker 2005). To date, molecular sexing methods have been shown to be quite reliable in evaluating the sex of juvenile remains (Cappellini *et al*. 2004; De La Cruz *et al*. 2008; Daskalaki *et al*. 2011), but they were not used in this study owing to funding limitations. As for macroscopic evaluation, some techniques have been suggested to determine the sex of juvenile skeletons, such as those based on differences in the greater sciatic notch and mandible (Schutkowski 1993; Loth and Henneberg 2001), or comparison of pelvic and femoral measurements (Fazekas and Kósa 1978). However, various studies testing these methods produced varying degrees of accuracy (Schutkowski 1987; Scheuer 2002), lowering their overall usability. Moreover, only Schutkowski's (1993) method covers all the subadult age categories, and that with ambiguous results. Despite the potential of some methods, such as those based on the angle of greater sciatic notch[19] (Schutkowski 1993; Holcomb and Konigsberg 1995) or that based on the size and morphology[20] of the deciduous dentition (Cardoso 2008), these techniques are very dependent on the observer's expertise (Scheuer and Black 2004: 20), do not consider differences between populations, or require good skeletal preservation.

The sex of adult individuals was determined using methods based on morphological features and bone dimensions. Sex-determination methods based on the morphology of the skull and pelvis are considered to be the most accurate. When only skull features are considered, the accuracy of sex identification can be as high as 80-90% if the mandible is present (Meindl *et al*. 1985a; Lovell 1989; Maat *et al.* 1997; Cox and Mays 2000; Byers 2002; Walker 2005;

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[19] reaching the accuracy up to 95% in some studies (e.g., Wilson *et al.* 2008)
[20] reaching the accuracy of 75-85% (e.g., DeVito and Saunders 1990; Cardoso 2008)

Williams and Rogers 2006). The accuracy of estimation is believed to be considerably higher with the presence of the pelvis, 90-95% (Meindl *et al.* 1985a; Lovell 1989; Byers 2002; Walker 2005). A range of features was used in both the skulls and the pelves, so that sexing was possible also in less well-preserved skeletons. However, given that the majority of the material used in this research was quite well preserved, it can be presumed that overall sex estimation based on skull and pelvis is accurate. Table 10 summarises features that were used to evaluate the sex of adults.

Sex was also determined using the dimensions of bones of the post-cranial skeleton (Table 11). These methods are based on the assumption that male bones are more robust and larger than those of females (Brothwell 1981), mostly as a result of hormonal changes occurring at puberty (St Hoyme and Isçan 1989: 54, 59). Section points suggested by Dwight (1894)[21], Thieme (1957)[22], Black (1978)[23], Stewart (1979)[24], and Symes and Jantz (1983)[25], listed in Bass's (2005), were used as additional method of sexing adult remains, as they are frequently used in osteological studies. However, other factors such as lifestyle or genetics can significantly contribute to bone development, and so sexual dimorphism can vary between populations. For this reason the overall sex estimation was derived from a combination of the above-mentioned methods, with most weight being placed on pelvic morphology, followed by the morphology of skull, and lastly on postcranial bone measurements. Bone dimensions were helpful mostly in cases where sex could not be clearly assessed from skull or pelvic morphologies.

Sex of adult individuals was categorised according to a system suggested by Buikstra and Ubelaker (1994). In all skeletons, sufficient data were available for sex determination, and so sex was determined either as: female (F), probably female (F?), probably male (M?), male (M), or ambiguous sex (?).

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[21] scapula length

[22] glenoid cavity length, clavicle length, length of humerus, epicondylar width

[23] femoral midshaft circumference

[24] vertical diameter of humeral head, femoral head

[25] tibial proximal and distal breadths, circumference at nutrient foramen

FEATURE	FEMALE	MALE	References
Cranium			
Forehead slope	Vertical	Sloping	Acsádi and Nemeskéri (1970) Walker in Buikstra and Ubelaker (1994) Graw *et al.* (1999) Brickley and McKinley (2004)
Glabella	Undistinguished	Large	
Orbital margin	Sharp	Thick and rounded	
Supraorbital ridge	Small	Large	
Nuchal crest	Smooth	Rugged	
Occipital process	Absent or small	Large	
Mastoid process	Small, non-projecting	Large, projecting	
Mental eminence	Small, pointed	Large, broad	
Mandibular angle	>125°	<125°	
Pelvis			
Pelvic inlet shape	Wide, round	Narrower, heart-shaped	Phenice (1969) Rogers and Saunders (1994) Walker in Buikstra and Ubelaker (1994) Brickley and McKinley (2004)
Greater sciatic notch	Wide, shallow, U-shaped	Small, close, J or V-shaped	
Preauricular sulcus	Large, circular	Absent or very small	
Ventral arc	Present	Absent	
Sub-pubic concavity	Inferior border concave	Inferior border absent or convex	
Ischio-pubic ramus ridge	Present crest-like ridge	Absent	
Sub-pubic angle	U-shaped, >90° wide	V-shaped, <90° wide	
Obturator foramen	Triangular, small	Ovoid, large	
Sacrum			
Shape	Short, broad, flatter	Long, narrow, curved	Schwartz (1995)
Dimensions of 1st body	Equal to width of each ala	Greater than width of each ala	

Table 10. Morphological features of the skull and pelvis used to evaluate sex of adult individuals.

Measurement	Female	Female?	Unknown	Male?	Male
Scapula length	<129		140-159		>160
Glenoid cavity length[26]	<34		34-46		>37
Clavicle length[25]	140.28				158.24
Vertical diameter head - humerus	<43	43-44	44-46	46-47	>47
Humerus length[25]	305.89				338.98
Epicondylar width – humerus[25]	56.77				63.89
Diameter head – femur [27]	<42.5	42.5-43.5	43.5-46.5	46.5-47.5	>47.5
Midshaft circumference – femur	<81				>81
Proximal breadth – tibia[28]	70.66		75.11		79.56
Distal breadth – tibia[27]	46.24		49.24		52.23
Circumference at nutrient foramen – tibia[27]	84.34		90.16		95.97

Table 11. Sectioning points indicating the sex of an adult individual (after Dwight (1894), Thieme (1957), Black (1978), Stewart (1979), and Symes and Jantz (1983) as listed in Bass (2005)).

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[26] based on American Negro population

[27] mean

[28] racial variation, information for Whites given

4.2.1.3. Evaluation of age at death

4.2.1.3.1. Subadult remains

Ageing subadult skeletons, especially infants, is much more precise than estimating age of the adults, mainly because the formation and the eruption of teeth "seems to be under tighter genetic control" (White and Folkens 2005: 364; also Cardoso 2007). The times of formation and the eruption of teeth do not vary from population to population to such a great extent as, for instance, the length of bones. The chronology of deciduous dentition development is also quite well documented and, using available tables for individual teeth formation and eruption, makes tooth development quite a reliable aging method in juvenile remains (Saunders *et al.* 1993; Liversidge 1994; Cox and Mays 2000; Cardoso 2007).

Multiple techniques based on juvenile dentition development are available for determination of age at death in juvenile remains (Demirjian *et al.* 1973; Gustafson and Koch 1974; Liversidge and Molleson 1999). Teeth development stages based on American Indian sample by Ubelaker (1989) were chosen for the present study, as it showed to be effective also for European samples (Smith 1999). Ubelaker (1989)also provides a composite visual image depicting teeth development in individual ages, which makes the age estimation easier. The estimation of age was performed separately for each assessable tooth, and then an overall age range was recorded for each individual.

If dental remains are unavailable, age can be estimated using bone dimensions (Buikstra and Ubelaker 1994; Rissech *et al.* 2008). However, children are especially sensitive to environmental stressors (Black *et al.* 2003; Pelletier and Frongillo 2003; Müller and Krawinkel 2005; Liu *et al.* 2012) and this method may thus be less accurate when applied alone.In the case of adolescent subadults, the method based on times of appearance of secondary ossification centres and their fusion with individual bones can also be used (Schwartz 1995; Scheuer and Black 2004; Schaefer *et al.* 2009). One drawback lies in the dependence of the technique on the sex of an individual, as epiphyseal fusion occurs earlier in females than in males, and so in unsexed adolescents the final age range can be wide.

For ageing juvenile remains from Central Europe, Buikstra and Ubelaker's (1994) scoring system was used as a complementary method. The list of measured bones is listed in Table 12. The dimensions were associated with certain age ranges, using age tables provided by Stloukal and Hanáková (1978) and Fazekas and Kósa (1978). Both works were chosen because the values were obtained from local populations, the former for children aged six months to fourteen years, the latter for subadults of foetal age. In addition, dimensions of femur (especially diaphyseal length and femoral head diameter) showed to be accurate indicators of subadult age when using equations suggested by Rissech *et al.* (2008). The method worked very well for the mixed European sample. However, only 26% of subadult remains examined in this thesis could be evaluated by this method. Final assessments of age at death of juvenile individuals were, therefore, primarily based on dental development.

Bone	Measurement
Pars petrosis	Length
Zygomatic bone	Length, width
Humerus	Length
Radius	Length
Ulna	Length
Clavicle	Length
Scapula	Length, width
Ilium	Length, width
Ischium	Length, width
Pubis	Length
Femur	Length
Tibia	Length
Fibula	Length

Table 12. List of bones measured in juvenile remains.

While bone size is useful in age estimation of younger subadults, the range of bone lengths increases with age and is dependent on sex and population (Ubelaker 2010). In the case of adolescents older than fourteen, fusion of secondary ossification centres with individual bones represents the key method for age assessment in adolescents and early adults (for example, Lewis and Garn 1960; Krogman 1962; Cundy *et al.* 1988), although this technique is also limited by the fact that females mature earlier than males (Lewis and Garn 1960; Krogman 1962) and the range of differences between the sexes can be as large as two years (Ubelaker 2010). As a result, if the sex of the individual is unknown, the evaluated age range can be very broad. In addition, fusion times have been proven to vary between populations (Crowder and Austin 2005; Schaefer and Black 2005). On the other hand, a recent research by Schaefer *et al.* (2015) has demonstrated that the appearance and union times of the ossification centres in shoulder (proximal humerus epiphysis, and acromial and coracoid apophyses) can contribute to a more accurate age estimation in adolescents, although the sex still needs to be known. When the sex of an adolescent could not be estimated, the lowest and highest age values were recorded (based on morphological summaries by Schaefer *et al.* 2009), the lower value being the lowest age for a female individual, the higher value being the maximum age estimate for a male. The overall age of adolescents in the present work was assessed by a combination of bone measurements (where possible) and the timing of epiphyseal union (after Schaefer *et al.* 2009).

4.2.1.3.2. Adult remains

Age-at-death estimation in adult individuals is less precise mostly because once the development of bones is complete, degenerative processes are the only changes to occur in a bone, and the rate of degeneration in individuals varies. Moreover, until today, there are no international standards for the determination of age at death of adult individuals. In addition, not all ageing standards are necessarily suitable for archaeological populations (Usher 2002: 29, 40-41), and age ranges are not consistent between individual studies (Falys and Lewis 2011). Despite such inconsistencies, the only option is to use those methods that are the most applicable to a studied population.

The most commonly used methods are those based on the morphology of the pubic symphysis (Todd 1930; Meindl *et al.* 1985b; Brooks and Suchey 1990), the auricular surface (Lovejoy *et al.* 1985; Buckberry and Chamberlain 2002), sternal rib end ossification (İsçan *et al*. 1984a; 1984b; 1985; İsçan and Loth 1986; Yoder *et al.* 2001; Kurki 2005; DiGangi *et al.* 2009), the extent of dental wear (Scott 1979; Brothwell 1981; Lovejoy 1985; Miles 2001; Gilmore and Grote 2012), and cranial suture closure (Meindl and Lovejoy 1985; Mann *et al.* 1987). In a review of age-determining methodology, Falys and Lewis (2011) suggest, dental attrition and cranial suture closure are the least accurate methods, especially if they are the only ones that can be used. In comparison, the authors established that the technique using the morphology of auricular surface suggested by Lovejoy *et al.* (1985) can be precise for individuals between twenty and forty-nine years. Other methods that have been shown to be quite reliable for older adults are those based on pubic symphysis morphology and sternal rib ends (Falys and Lewis 2011).

As for pubic symphysis, evaluation of age at death suffers several limitations, for instance, bilateral asymmetry (Overbury *et al.* 2009) or different rate and pattern of symphyseal changes within a single population (Hoppa 2000). Methods based on auricular surface are restricted by similar limitations. As Nagaoka and Hirata (2008) have discovered, Buckberry and Chamberlain’s (2002) method working with the features of the auricular surface, the evaluated ages were usually older than using methodology by Lovejoy *et al.* (1985). Buckberry and Chamberlain's (2002) technique may thus be more realistic as regards archaeological samples, but it is still not widely applied method. Moreover, using equations, Samworth and Gowland (2007) studied a large sample of modern-day skeletons of known age and created tables with amended age estimates as well as prediction age intervals based on eight-phase system by Suchey and Brooks (1990). Their age estimates for both the pubic symphysis and auricular surface are thus rather essentially unbiased, and were proven to perform well also for other samples (for example, Passalacqua 2010). However, Suchey's and Brooks's system (1990), and Todd's categories (Todd 1930) are still more frequently employed worldwide, so ariss the method by Lovejoy *et al.* (1985), and so their original scoring systems were used for the assemblage studied in this thesis. In all cases, minimum and maximum ages suggested by the individual methods were recorded. The minimum value of the final age range was set as a mean of the minimum values, and the same procedure was applied in considering the maximum age value.

The sternal rib end morphology technique belongs to those perceived as less reliable (O'Connell 2004: 20), mainly because the original research was based on the fourth rib (İşcan and Loth 1986; İşcan *et al.* 1984a; 1984b; 1985), which is often difficult to identify (for example, Cox 2000b). However, Yoder *et al.* (2001) have found that the age at death can be equally estimated using most of the other ribs, and that a score based on several ribs might be the same as when using the fourth rib alone. Therefore, for the present study, all the available sternal rib ends were used when assessing the age at death, following the system by İşcan and Loth (1984a; 1984b; 1986).

As dentition tends to survive well in archaeological contexts, it is still used for indicating the age of adult individuals (*cf.* Whittaker 2000). However, dental wear depends on many factors such as tooth size, shape, diet, the use of teeth as work tools, ante-mortem tooth loss, etc. (Mays *et al.* 1995: 668; Mays 2002; Lev-Tov Chattah and Smith 2006; Molnar 2008; Bartletta *et al.* 2011). Hence the whole age at death estimation is much more imprecise than it is in the case of subadult remains (for example, Cox 2000b). For this reason, age estimations based on dental wear needs to be regarded with caution. A combination of the three most used techniques (Brothwell 1981; Lovejoy 1985; Miles 2001) has been deployed for ageing the adult skeletons in this study. The minimum value of the age range was set as a mean of the minimum ages, the maximum as the mean of maximum ages that were established based on individual methods.

Age estimation based on cranial suture closure is probably the least accurate of all ageing techniques (Key *et al.* 1994; Falys and Lewis 2011), mainly because the factors influencing suture closure are still not fully understood (for discussion see Cox 2000). In the present study, the most widely used cranial-suture-closure method, originally suggested by Meindl and Lovejoy (1985), has been employed in adult skeletons whose skulls were at least 75% complete, but the results are purely informative.

There are many limitations to the methods used for determining age at death and there is still a hot debate on which of the methods can provide the most accurate results. The majority of techniques are highly dependent on the person evaluating the skeleton, and thus are prone to inter-observer error. Moreover, the methods are not necessarily applicable to all the populations or both sexes to the same extent (Key *et al.* 1994; Hershkovitz *et al.* 1997; Cox and Mays 2000; Falys and Lewis 2011). A multifactorial approach may minimise the errors, although some authors (for example, Jackes 1992) still consider this too unreliable because of the above-mentioned problems. However, certain methods, such as that by Samworth and Gowland (2007), combining pelvic morphologies, has worked well for other samples (for example, Passalacqua 2010). Moreover, several other studies indicate that the utilisation of multiple age indicators correlate better with real age than if a single marker is used (Lovejoy *et al.* 1985b; Bedford 1993). Therefore, in the present study, a multifactorial approach was applied, relying predominantly on pelvic and sternal rib end morphology.

4.2.1.3.3. Age-at-death categories

Applying the above-mentioned ageing techniques, age categories based on Buikstra and Ubelaker (1994) were used (see below), although modifications to their system were made, especially as regards juvenile remains. The reason is that the categories should represent individual life stages of an individual. “Perinate” rather than “foetal (<birth)” category was used, as it covers a whole dangerous period for a child related to birth. “Infant” group represents still a rather weak individuals, but who are affected also by environment in which they live. Other juvenile age categories try to correspond with: an early childhood, represented by “young child” category associated with weaning and in which a child is learning through observing, experimenting and playing, while still requiring high degree of supervision by parents; middle

childhood (“older child”) refers to a time when a child develops mostly socially and mentally, and gets more independent; and adolescence, including physical changes and adoption of a role in a given society. Similar approach was adopted for adults. In addition to Buikstra and Ubelaker’s (1994) system, in the present thesis “young adult” category (20-35) was split into two – young (18-24) and prime (25-35) adults. The reason for such a division is that young adulthood, as suggested by the author of this thesis, probably represents the period of culminating reproduction among the prehistoric populations and may thus have an impact on, e.g., higher mortality of young females related with parturition. Prime adults then represent adults at the peak of physical strength; “mature” age (35-50) refers to a period during which the ageing of the body begins, e.g., muscle mass reduction, etc. Old adults represent a group where the effects of significant biological changes such as menopause or bone loss are expected. In summary, following age categories were used:

1. Perinate (foetal – *c.*1 month)
2. Infant (*c.* 1 month – 11.9 months)
3. Young child (1 – 5 years)
4. Older child (6 – 11 years)
5. Adolescent (12 – 17 years)
6. Young adults (18 – 24 years)
7. Prime adults (25 – 35 years)
8. Mature adults (36 – 49 years)
9. Old adults (50 years +)

4.2.1.3.4. Dental vs. skeletal age

In both subadults and adults dental and skeletal ages were collated. In juveniles, differences may point to retarded/accelerated growth and stress factors connected with living conditions, socio-economic status, nutrition or disease (Rudney 1983; Goodman *et al.* 1984; Bennike *et al.* 2005; Pinhasi *et al.* 2006). This is because extrinsic factors such as malnutrition or infection might affect the growth rate of bones, and the dimensions of individual bones might not correspond with the actual age of a juvenile as indicated by the dentition (Black *et al.* 2003; Pelletier and Frongillo 2003; Müller and Krawinkel 2005; Liu *et al.* 2012). In adolescence, dental age is evaluated by the level of attrition rather than tooth development, since the process is already almost complete (Gustafson and Koch 1974; Ubelaker 1999). This is why only juveniles of pre-adolescent age (younger than twelve) were used in the analysis. Due to the fact that dental age can be evaluated quite accurately in juveniles, retardation/acceleration of growth was scored as present if the difference between dental and skeletal age was greater than two years.

In adults, great differences between dental and skeletal ages may be caused by several factors, from diet to (not) using teeth as tools (Molleson and Jones 1991; Lubell *et al.* 1994; Hattab and Yassin 2000; Turner and Anderson 2003). On the other hand, a difference may also indicate more extensive stress on age-indicating bones. Due to the lowered accuracy of adult-ageing techniques, the difference was scored as considerable only if it was greater than five years.

4.2.1.4. Stature of adult individuals

Each individual has a certain genetic predisposition for a certain height, but it depends on various external and internal factors whether a person reaches this potential or not (Eveleth and Tanner 1990:176). As indicated by multiple studies, both adult and subadult remains can be affected by external environmental and cultural factors and general standards of living (Steckel 1995; Silventoinen *et al.* 1999; Vančata and Charvátová 2001; Checkley *et al.* 2003; Maat 2005; Shetty 2006). A study by DeWitte and Hughes-Morey (2012) even suggests that the risk of mortality increases with short stature, especially during epidemics. Stature can hence point to general health status as well as poor living conditions caused by factors such as malnutrition, disease, etc. There are several methods used for estimating adult stature. These are predominantly based on the lengths of long bones, but most of the formulae rely on modern population data (Fully 1956; Trotter 1970; Meadows and Jantz 1992; Jason and Taylor 1995). Moreover, the use of stature equations may be also limited by differences between populations (see, for example, Ruff *et al.* 2012).

The most accurate method is probably that devised by Fully (1956; further examined by Raxter *et al.* 2006 and Raxter *et al.* 2007), since it adds the dimensions of skeletal elements from the calcaneus to the skull, in calculating overall stature. However, the presence of the majority of the bones is required, which is unlikely in archaeological remains.

Calculations based on lower limb bones are believed to provide the best estimates of stature (Brothwell and Zakrzewski 2004). Therefore, in the present work, equations using dimensions of complete long bones of Caucasian populations have been applied, based on formulae suggested by Trotter and Gleser (1952; 1958; 1977). Despite the fact that the formulae were derived from US samples and may not always be entirely suitable for European samples (Brothwell and Zakrzewski 2004: 33), they are widely used, making the gathered data more comparable to other collections evaluated by the same method. Stature calculated from complete metacarpals (Meadows and Jantz 1992) and metatarsals (Byers *et al.* 1989) was also used. However, the standard errors are usually larger than that based on the lengths of long bones, but were used where long bones were missing. The same is true for long bone length values calculated from fragmentary long bones (Byers 2002: 247-250). The deviations in such cases were often too broad, so, wherever possible, calculations based on complete limb bones were preferred. Table 52 in Appendix 2 summarises the formulae[29] used for stature calculations.

Final stature was calculated from the lengths of lower long bones, as they provide smaller associated errors (Brothwell and Zakrzewski 2004). If no complete lower limb bones were preserved, preference was given to complete upper limb bones. Final stature range always represents mean values of minimum and maximum calculated values. If there was no measurable complete long bones, formulae based on the lengths of metacarpals and metatarsals were used. Only if both methods were impossible to use, stature was calculated from the values gained from incomplete bones, with the final stature range obtained in a similar way as that using the lengths of complete limb bones.

4.2.1.5. Subadult growth curves

In skeletal remains, retarded or advanced growth of subadult individuals can be investigated by establishing growth curves. These are based on the comparison of age suggested by long bone lengths and that indicated by dental development (Humphrey 2000). Some studies have found that growth in stressed subadults was retarded (Fernald and Grantham-McGregor 2002; Pinhasi *et al.* 2006), although others have not entirely supported such a hypothesis (Schillaci *et al.* 2011). Even though no firm conclusion about the relation of growth and stress can be drawn owing to the complexity of the issue, age based on femoral dimension was compared to the average dental age value in order to see any anomaly in growth rates. Femoral

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[29] based on Terry collection (Trotter 1970; Meadows and Jantz 1992), individuals from the Maxwell's Museum of the University of New Mexico (Byers *et al.* 1989), the Forensic Data Bank at the University of Tennessee, Knoxville (Jantz 1992), and modern individuals from the Regional Forensic Center in Memphis, Tennessee (Meadows and Jantz 1992)

shafts only were chosen because they are considered to be the most precise indicators and growth rates tend to be different for individual bones (Humphrey 1998).

4.2.1.6. Metric data

Metric analysis was performed for all the examined skeletons. All measurements were taken using a digital sliding calliper, an osteometric board, and a fabric measuring tape, all the values were recorded in millimetres. Dental metrics were not applied in this study. For adult remains, a number of skeletal indices were calculated. The list of measurements taken and resulting indices can be found in Tables 53-54 in Appendix 2. Cranial indices and body mass values are further discussed in the thesis. The reason for this is that cranial indices are particularly important in association with the key questions that this thesis aims to answer, i.e. the foreignness of the Chalcolithic Bell Beaker culture, and because body mass can be an important factor in the emergence of some pathologies such as osteoarthritis. Body mass was estimated using the calculations suggested by Ruff *et al.* (2012). The calculations were based on large skeletal assemblages from the whole of Europe and from numerous historical periods[30], and so the accuracy of their method is superior to that of previously suggested methods. Mean cranial indices and body mass values are provided in Chapter 5; other measurements were recorded in an MS Excel database and are included in the Appendix 8 that accompanies this thesis.

General preservation of juvenile remains was poorer than that of adult skeletons, especially in skulls. For this reason, in the case of juvenile remains, only nineteen (four cranial and fifteen postcranial) measurements were taken, mostly for the purposes of age estimation and growth-retardation analysis, following the standards by Schaefer *et al.* (2009). More measurements were taken on adult bones, amounting to thirty-one cranial and fifty-nine post-cranial measurements (Appendix 2, Tables 53-54), following the *Standards for Data Collection from Human Skeletal Remains* by Buikstra and Ubelaker (1994).

4.2.1.7. Pathology assessment

In this thesis, the term ‘pathology’ relates to all possible manifestations of disease and trauma. Each skeleton was macroscopically evaluated for the presence of any atypical lesion and, when possible, a diagnosis has been suggested. Lesions were divided into three main

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[30] from the Mesolithic to the twentieth century

categories: pathological, traumatic injuries, and non-pathological lesions. Such a division was used purely for the purposes of clearer arrangement, since trauma and violence represent one of the main topics of the present thesis, and developmental anomalies/non-metric traits are not primarily related with pathological processes or medical conditions. Pathological lesions were further categorised as: dental disease, infectious disease and non-specific health indicators, metabolic disease, joint disease, and miscellaneous pathologies, sub-categories used in numerous palaeopathology-related works (for example, Roberts and Manchester 1995; Aufderheide and Rodríguez-Martín 1998; Ortner 2003; Waldron 2009). Traumatic lesions were divided into fractures, dislocations, and *osteochondritis dissecans* (OD). In all types of trauma, ante-, peri-, and post-mortem injuries were distinguished. Non-pathological lesions were further classified as developmental, or ascribed to morphological variation (non-metric traits) (Table 13).

Pathological	Trauma	Non-pathological
• Dental disease • Infectious disease and non-specific stress indicators • Metabolic disease • Joint disease • Miscellaneous pathologies	• Fractures • Dislocations • Osteochondritis dissecans (OD)	• Developmental anomalies • Non-metric traits

Table 13. Classification system of pathologies used in the study.

Definitions of individual conditions provided by Waldron (2009) were used as a primary source of reference, as he describes the basic characteristics, preventing over-diagnosis. However, in addition, sources such as Roberts and Manchester (1995), Aufderheide and Rodríguez-Martín (1998), Ortner (2003), and Pinhasi and Mays (2008) were consulted, as were specific articles dealing with individual conditions. The following section specifies methods of pathological evaluation of individual disease categories.

4.2.1.7.1. Dental disease

Dental pathology is one of the most observable pathologies in skeletal remains. It can be indicative of dental hygiene as well as dietary habits and occupations of past populations (for example, Freeth 2000). For dental remains, both the crude prevalence rate (CPR[31]) and total prevalence rate (TPR[32]) were evaluated, as it is mostly TPRs that are provided in the published

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[31] percentage of affected individuals calculated from all individuals in the category (e.g., males, females)
[32] calculated only from individuals with preserved dentitions

studies from the region. The most frequently present dental pathological lesions, observable by a naked eye, are represented by:

- Caries
- Abscess
- Ante-mortem tooth loss
- Periodontal disease

Caries is characterised as a hole or a cavity caused by progressive decalcification of enamel or dentine, caused by organic acids produced by bacterial fermentation of carbohydrates (Hillson 1996; Waldron 2009: 237). The aetiology of dental caries is not straightforward, as they can be affected by other factors such as enamel defects and composition, fluoride level, hygiene, food texture, or by the use of teeth as tools (Molnar and Molnar 1985; Hillson 1996: 278; Ismail and Hasson 2008; for discussion see also Larsen 1997: 65-67). Caries can affect crowns and exposed roots of both deciduous and permanent teeth and their occurrence has a tendency to increase with age (Waldron, 2009: 238; Larsen 1997: 65). In this study, caries were identified macroscopically. The presence/absence of caries was recorded for individual teeth, and can be consulted in the enclosed database.

Peri-apical lesions (abscesses) are cavities created by the destruction of tissues, filled with localised collection of pus, and are associated with infection of the pulp cavity. Abscesses are commonly found at the root apices of teeth (Roberts and Manchester 1995: 50-51; Dias *et al.* 2007; Waldron 2009: 241-243). The lesions can be formed as a consequence of periodontal disease, caries and other dental impactions (Roberts and Manchester 1995: 50; Waldron 2009). The cavity may develop into the alveolar bone and also lead to ante-mortem tooth loss (e.g. Schwartz 1995: 255). In skeletal remains, dental abscesses manifest mostly as sinuses in alveolar bone, with the tips of the roots visible through them (Dias *et al*. 2007; Waldron 2009: 241-242). As with caries, only the presence/absence of abscesses was evaluated and the location by tooth recorded.

Antemortem tooth loss (AMTL) can occur as a result of several conditions, including caries, scurvy, trauma, and periodontal disease (Al-Shammari *et al*. 2005; Lukacs 2007; for a discussion on the topic see Larsen 1997). The prevalence of AMTL often increases with age (Gilmore and Grote 2012). Once a tooth is lost, the tooth socket starts remodelling and closing, and where a tooth was lost long before death, the socket can be completely closed (Larsen 1997: 78; Waldron 2009: 239). Because of this remodelling, it might be difficult to assess the cause of antemortem tooth loss, unless there is clear evidence, for example in the case of trauma, periodontal disease, etc. Post-mortem and ante-mortem tooth loss were distinguished by the level of tooth socket remodelling (Waldron 2009: 239). If at least one tooth was lost antemortem, AMTL was recorded as present, although tooth position was not taken into consideration.

Periodontal disease is a condition that affects the tissues surrounding a tooth, the ‘periodontium’. In its early stage it is known as ‘gingivitis’, and both periodontal disease and gingivitis have a common aetiology as they are mostly believed to be caused by pathogenic bacteria present in dental plaque. However, it takes more than the presence of bacteria for periodontal disease to develop. Bleeding and weakened gums in combination with the presence of bacteria can result in inflammation, leading to alveolar bone destruction and consequently to tooth loss (Page 1998: 108-120; Hillson 2005; Waldron 2009: 239). It is this alveolar bone damage that can be recognised on skeletal remains, mostly displayed as a recession of the margin around the teeth and inter-dental processes, accompanied by the signs of inflammation – darkened bone with pitting and/or remodelling, and horizontal lowering of the alveolar margin (Roberts and Manchester 1995: 56; Larsen 1997: 77; Waldron 2009: 240). Often, when periodontal disease is scored, calculus is also present, as gums can get disturbed by the condition, making it easier for bacteria to cause harm (Littleton and Frohlich 1993). Mechanical demands such as excessive masticatory loading can also result in periodontal disease and/or following tooth loss, so can poor oral hygiene, malocclusion, even pregnancy or mental stress (Clarke and Hirsch 1991; Hildebolt and Molnar 1991; Enwonwu 1995; Hillson 2005). Diagnosing and recording periodontal disease in archaeological remains is rather complicated, as the preservation of alveolar margins is not always ideal. Moreover, the process of eruption of human teeth does not stop with reaching certain age (Roberts and Connell 2004: 39), meaning that the cemento-enamel junction (CEJ) of teeth shifts further from the alveolar margin by continuous eruption. Therefore, periodontal disease is confirmed only if alveolar recession is accompanied also by infection of the alveolar bone. Considering skeletal collections examined in the present study, the scoring system after Roberts and Connell (2004: 39) was applied. If the resorption was greater than 2 mm, and porosity, darker colouration, recession of inter-dental processes, and the signs of horizontal remodelling of alveolar margin were observed, periodontal disease was scored as present.

4.2.1.7.2. Infectious diseases and non-specific stress indicators

Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi, and can be spread from person to person (Larsen 1997: 64; Ortner 2003: 179-181). In times before antibiotics, infectious diseases could cause many deaths, including what are today rather mild conditions such as flu, more severe conditions such as pneumonia, or rapid epidemic diseases (Roberts and Manchester 1995: 124-125). A pathogen does not necessarily result in disease, and even those which do, are not automatically manifested on bones (Waldron 2009: 83-84). The reason for this is that many infectious diseases are acute and are either cured earlier than they can display on the bones, or result in death soon after infection (Roberts and Manchester 1995: 125; Larsen 1997: 64). Such diseases are very difficult to record macroscopically in archaeological remains, often only by some general, non-specific signs of infectious disease. On the other hand, chronic infections often leave skeletal evidence, especially if the body was affected for a long time (for example, Larsen 1997: 64). These specific infections include mostly diseases such as tuberculosis, brucellosis, leprosy, treponematoses, or parasitic diseases (Ortner 2003: 227-342; Roberts and Manchester 1995: 125). In some cases, although skeletal changes are present, it is not possible to determine a particular cause. Such lesions are included under the term ‘non-specific health indicators’. Four main types of non-specific stress indicators were taken into account in the presented study: periostitis, dental enamel hypoplasia (DEH), *cribra orbitalia* (CO), and porotic hyperostosis and non-specific cranial vault porosity.

Periostitis refers to new bone formation, usually formed within the top-most layer of the bone – the periosteum, and represents a process launched by bone-forming cells in this surface layer. Such newly formed bone is also known as ‘woven bone’, because of its non-organised appearance and is usually brown in colour. The formation of such a layer is believed to be indicative of inflammation of the periosteum and systemic infection, especially when found on juvenile bones (Waldron 2009: 115). However, the causes of periosteal new bone formation are multiple, including non-inflammatory and non-infectious origins (Ortner 2003; *cf.* Waldron 2009: 116). Given its multifactorial aetiology, the condition is considered more descriptive than diagnostic. A major problem when identifying periosteal reactions is that the layers of new bone are easily destroyed by natural processes or during post-excavation treatment of the bones.

Furthermore, the multifactorial aetiology of periosteal new bone formation[33] complicates comparisons between populations, as the condition cannot be considered diagnostic. Finally, in infants and young children, the presence of woven bone may be a normal manifestation of growth (Lewis and Roberts 1997; Weston 2012), which is why some authors think that juveniles should not be included in prevalence rate calculations at the population level (Ribot and Roberts 1996). On the other hand, scurvy and rickets are possible causes of juvenile periosteal lesions (Ortner 2003); hence the issue of involvement of subadult remains in overall prevalence rates remains one of the major limitations. Additionally, macroscopically observable infection-related changes may indicate long-term survival with the condition, and thus point to good immunity in the individual. Therefore, infectious disease alone is a poor indicator of general health and additional markers need to be considered (Ortner 2003).

Periostitis was identified where a layer of brownish woven bone formation was present on the surface of the bone. The location on individual bones was also recorded, in order to distinguish between a localised infection and more systemic conditions. If the lesion was clearly associated with a specific condition such as metabolic disease or trauma, it was not evaluated under the non-specific health indicators. The stage of healing was not evaluated.

Dental enamel hypoplasia can be recognised by the presence of transverse lines, pits and grooves on the tooth surface (Hillson 2005: 168). These hypoplastic defects are for the most part the result of disruptions during the formation of the tooth. Because of the known times of individual tooth mineralisation, if a tooth is not too worn, the location of the defect can point to the age at which the insult occurred (Hillson 2005: 172). The aetiology of the defect is believed to be multifactorial (Goodman 1989; King *et al.* 2005; Starling and Stock 2007), yet it is predominantly related to a metabolic disturbance and thus dietary or disease stress (Hillson 2005: 175).

Hypoplasia was evaluated macroscopically. If at least one tooth was affected, the feature was recorded as present. The age of the formation of the hypoplastic defect was assessed as a mean of values obtained from individual teeth according to the method suggested by Goodman and Rose (1990).

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[33] including non-inflammatory and non-infectious origins such as poor blood circulation, local injury of soft tissues, skin ulcers, cancer, or irritation of the lower respiratory track (Roberts and Manchester 1997; Bruce *et al.* 2000; Riojas-Rodriguez *et al.* 2001; Ortner 2003; Nicholls 2005; Santos and Roberts 2006; Weston 2008; *cf.* Waldron 2009: 116; Nicklisch *et al.* 2012; Weston 2012)

Cribra orbitalia (CO) and porotic hyperostosis (PH) both manifest as porotic lesions. CO refers to pitting of the orbital roofs, usually located in antero-lateral part of the orbit (Aufderheide and Rodríguez-Martín 1998). PH manifests as intense pitting of various size penetrating the external table of the cranium. In addition, the middle table of the skull, the diploë, is thicker than normal. If examined under a microscope, sometimes a ‘hair on end’ pattern of the bone can be observed (Ortner 2003: 102). PH is often bilaterally symmetrical, occurring on the parietals or occipital bone (Aufderheide and Rodríguez-Martín 1998). Both lesions are usually a manifestation of a condition rather than conditions themselves. They have been frequently associated with anaemias, mostly with iron-deficiency anaemia (for example, Goodman and Armelagos 1989), but such a conclusion seems to lack clinical validity and the cause of such bony reactions is speculated. For instance, Walker (1986) points out that nutrient loss can be also associated with diarrhoeal disease, and thus PH may not necessarily be a result of diet as such. Similarly, Lewis (2007) concludes that it may be the mal-absorption of iron that is responsible for the condition. In her study, Stuart-Macadam (1992) also suggests that PH is a reaction of the human body to adapt to the pathogen load in the environment rather than a response to nutrition as such. At present, several authors agree that PH might be a result of multiple factors associated with an anaemia related to a low intake of vitamin B12 and folic acid, as well as improper absorption of nutrients in the intestines, e.g., via diarrhoea (Dupras and Tocheri 2007; Walker *et al.* 2009).

If at least one orbit was affected, the lesion was recorded as present. The stage of healing process was not evaluated. PH was scored if thickening of the diploë was also present (Waldron 2009: 137). Non-specific vault porosity without cranial thickening was also recorded, as the pitting may be indicative of healed PH[34]. The comparative studies used in this study do not distinguish between the lesions with and without the thickening of the diploë, and to be able to compare the data with that from the study collections, both conditions were also assessed together as ‘cranial vault porosity’.

4.2.1.7.3. Metabolic diseases

Metabolic diseases are disorders linked to nutritional and/or hormonal defects (Ortner 2003: 383). Among others, they include conditions such as bone loss (osteopenia/osteoporosis), scurvy, rickets and osteomalacia.

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[34] porosity without the thickening of the diploë may also be indicative of other conditions, e.g., scurvy (Ortner 2003: 389)

Osteoporosis may be caused by a dietary problem or some systemic disorders, but it is mostly associated with age-related endocrine changes. However, based on the skeletal remains from Nubia, Dewey *et al.* (1969) discovered that females started to suffer from the condition much earlier than in modern females. The authors came to the conclusion that, instead hormonal changes, extended lactation and accompanied by insufficient calcium intake may be responsible. This would also imply the importance of diet as a factor influencing the onset of osteoporosis. The diagnosis of osteopenia/osteoporosis in skeletal remains is rather subjective and difficult to assess. The reason is that dry bone data does not compare well with the values gained from living individuals (Weaver 1998: 29). What is more, some studies have shown that the pattern of loss of cancellous bone differs between individuals (for example, Agarwal *et al.* 2004). Primarily, it affects the spongy bone of the ribs, vertebrae, os coxae, and femoral neck; at a later stage, the limb bones can also become affected (Schwartz 1995: 20; Ortner 2003: 412). The lightness of bones or fractures of the affected sites can be indicative of the condition (Weaver 1998: 29). This is why, in the present study, bone loss was suspected only if the bone was very light and the structure sparse, and when fractures at the most frequently affected sites were observed.

Vitamin deficiency diseases can be rather difficult to determine, especially in cases where more than one occur together, however rare the combinations might be (for example, Cheadle 1882; Ortner *et al.* 2001). Vitamin C cannot be produced by the human body, and so people are dependent on its intake from diet (Waldron 2009: 131). The manifestation of long-term vitamin C deficiency include haemorrhaging, bleeding and swollen gums, tooth loss, or subperiosteal bleeding, accompanied by increased pitting and sometimes by periosteal new bone formation in the affected area. Due to its contribution to collagen synthesis, the lack of vitamin C can also result in increased bone resorption and osteoporosis (Roberts and Manchester 1995: 173; Waldron 2009: 132). Scurvy is usually more marked in children. This is because vitamin C is essential for the formation of collagen (for example, Libby and Aikawa 2002), and so scurvy most commonly manifests in the most rapidly growing bones such as costochondral junctions of ribs, distal femur, ulna and radius, and proximal humerus (Ortner 2003: 383). In scurvy, new bone formation on the skull (especially at the orbits, mandibular foramen, infraorbital foramina on the maxillae, maxillar alveolar margins and sphenoid) or enlarged and porous epiphyses can be considered as symptomatic of the condition (for example, Waldron 2009: 132-133; Brickley and Ives 2008: 56-62; Ortner 2003: 383-393).

It was these changes that were looked for when evaluating the condition. Only if more than three lesions indicated scurvy, was the condition scored as present.

Vitamin D deficiency results in the reduction of bone mineralisation and, especially during growth, might lead to bone deformation (Ortner 2003: 393). Unlike vitamin C, the human body is able to synthesise vitamin D if exposed to sunlight, which is the main source of the vitamin. It can be also diet-obtained, but the amount of vitamin D gained via sunlight exposure is much higher than dietary gain (Waldron 2009: 127; Desai *et al.* 2012). Its lack is therefore more likely to be caused by insufficient exposure to sunlight rather than diet (see also Dawodu *et al.* 1998). On the other hand, diarrhoea and other conditions resulting in low vitamin D intake may also be responsible (for example, Pitt 1995: 1896; Agarwal *et al.* 2012). In juvenile remains, the bowing of long bones carrying the weight of a body may occur (Waldron 2009: 127-128). If the condition was severe, it can be noted later on adult skeleton in form of bowed femurs or tibiae (Waldron 2009: 129). The condition affects mostly cancellous bone, and so it can be frequently observed on ribs, sternum, vertebrae, or pelvis, and is thus difficult to distinguish from osteoporosis. In severe cases, the ribs can become curved, as can the sternum, which can be additionally pushed forward. Vertebrae might be flattened with cupping, and the pelvis deformed (Ortner 2003: 399).

In the case of juvenile remains, rickets was diagnosed if deformation of the long bones, mandibular ramus, ribs or ilium was present. In addition, enlarged and porous epiphyses were also looked for (Brickley and Ives 2008: 90-1, 101; Waldron 2009: 129). Adult skeletons were examined for the signs of osteomalacia, the adult form of the condition, including cranial porosity, fractures and cupping of the vertebrae, and the deformation of the sternum, and pelvis with the sacrum (Ortner 2003: 398-401; Brickley and Ives 2008: 85, 127-29).

4.2.1.7.4. Joint diseases

Joint diseases are the most common pathologies identified on skeletal remains (Roberts and Connell 2004: 38), and are most frequently associated with age-related degenerative changes. The most frequently affected joints are the synovial ones, joints with a membrane-lined cavity filled with synovial fluid, such as the knee, elbow, etc. (Roberts and Manchester 1995: 101; Waldron 2009: 25-6). In synovial joints, the changes are often related to lifestyle and activity performed during life. Other joint conditions can be related to inflammation (such as septic arthritis), metabolic changes (such as gouty arthritis), or the endocrine system (such as ankylosing spondylitis) (Roberts and Manchester 1995: 99-101; Ortner 2003: 561-588). Many joint diseases share symptoms, although the distribution of joints affected by individual diseases may be different for each condition (Roberts and Manchester 1995: 100; Ortner 2003: 561). Therefore, accurate diagnosis requires preservation of as many joints as possible. The most common joint diseases observable on archaeological remains include osteoarthritis (OA), vertebral osteophytosis, and Schmorl's nodes (SN) (Ortner 2003: 545; Waldron 2009: 26, 40-5).

Osteoarthritis (OA) is a common as well as rather well recognisable joint disease when found in archaeological remains (Roberts and Manchester 1995: 105). It is characterised by the destruction of the cartilage of synovial joints and the bone formation around the edges of the adjacent bone. Due to the lack of cartilage, the bones of a joint rub against each other and often a polished lesion called 'eburnation' develops. Bony spicules around the edges of the bone, formed as a response to excessive friction, are known as 'osteophytes' and are a secondary indicator of OA. In severe cases, marginal osteophytes might unite, especially in the spine (Larsen 1997: 166; Ortner 2003; Waldron 2009: 28). Most frequently, the causes of the condition are mechanical, and the changes therefore tend to affect the most loaded joints. Diagnosis of the condition dwells in the combination of numerous indicators, because, individually, they might be indicative of several other conditions. OA was diagnosed if the presence of the ultimate indication of OA, eburnation, was scored. If this phenomenon was not present, then at least two other signs associated with the disease had to be present: osteophytes/marginal lipping, new bone on the joint surface, porous joint surface, or the deformation of joint contour (Waldron 2009: 27-28, 33-34). The sites included in the analysis were: the temporo-mandibular joint, sterno-clavicular joint, gleno-humeral joint, elbow, and wrist, apophyseal and costo-vertebral joints of the vertebrae, hip joint, knee, and ankle. Primary OA was evaluated separately, while secondary OA (that had developed as secondary to another disease) was evaluated together with its cause, for example, trauma.

Vertebral osteophytosis is a condition where bony spicules are formed at the insertion sites of intervertebral ligaments, creating the effect of lipping (Bick 1956). It is thus often accompanied by degenerative changes to the intervertebral discs or articulations (see, for example, Lindblom 1951). Where bone formation is intense and/or the joint does not move enough, ankylosis may occur (Roberts and Manchester 1995: 103). Several aetiological factors are associated with the onset of the condition, namely the compressive forces on vertebral endplates (Nathan and Islael 1962), bone density (Kinoshita *et al.* 1998), obesity (O'Neill *et al.* 1999) and genetic factors (Sambrook *et al.* 1999). However, it is probably a combination of several factors that contribute to the development of vertebral osteophytosis (Harada *et al.* 1998). Osteophytosis can accompany numerous spinal diseases, including spinal OA, intervertebral disc disease, ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH), inflammations in the spinal column, or conditions such as scoliosis or compression fracture of the vertebrae, etc. (Bick 1954; 1956; Waldron 2009). Sometimes, especially in archaeological remains when a great portion of vertebrae may be damaged or missing, it is very problematic to assess the condition that osteophytosis is related to. Therefore, in the present thesis, only the presence of osteophytosis was recorded. Only if a strong indication of a more specific disease was found, was it evaluated as a part of that disease rather than separately. The level and severity of osteophytosis was not scored, and its presence was only recorded if at least three vertebrae showed signs of marginal osteophytes.

Schmorl's nodes are depressions found on vertebral bodies, which form as a result of the *nucleus pulposus* (the substance in the middle of the disc) protruding through the surface of the vertebral body (Ortner 2003: 464, 549; Waldron 2009: 45; Mann and Hunt 2005: 95). The shape and size of the nodes vary and the edges of the depressions usually show some degree of remodelling. The aetiology of the condition is still debated, as it can accompany almost any disease that causes weakening of the cartilaginous endplate or vertebral body. Possible causes involve trauma (Burke 2012), excessive loading (Dar *et al.* 2010), or heredity (Kyere *et al.* 2012). However, the lesions are especially common in the lower thoracic and lumbar areas (Waldron 2009: 45; Burke 2012; Dar *et al.* 2010), which may indicate that the anatomy of the spine and its use plays a role in the development of Schmorl's nodes. A similar conclusion has been reached by studies on elite athletes (Hellstrom *et al.* 1990; Sward *et al.* 1991; Sward 1992). Quite often the lesions are recorded in individuals of increased age (Mann and Hunt 2005: 95; Ortner 2003: 549), although such a connection is not fully proven (Üstündağ 2009). The condition was recorded as present if at least one vertebral surface was affected. The presence of Schmorl's nodes was recorded in any assessable vertebra, but only CPRs were calculated.

4.2.1.7.5. Trauma

Trauma is a broad term referring to any injury or wound. It involves fractures, bone dislocations, disruption in nerve and blood supplies, and artificial bone modifications such as trepanations (Roberts and Manchester 1995: 65). All traumatic lesions were divided into ante-, peri- or post-mortem injuries, according to Lovell (1997). The location and the type of the injury were evaluated. Three categories of trauma were assessed: fractures, dislocations, and osteochondritis dissecans (OD).

Fractures may result as a consequence of repeated stress or pathology (Lovell 1997). Broken bone starts to heal immediately after the trauma occurs, a callus being formed at about second or third week after the injury. For perimortem and antemortem fractures the type of injury was suggested (e.g., blunt-force trauma, pathology-related, stress-related trauma, etc.) (Lovell 1997: 141-142).

Dislocations were distinguished as they are also quite common, but it should be remembered that they are clearly visible on skeletal remains only when the condition was long-lasting or congenital (Roberts and Manchester 1995: 87; Waldron 2009: 155). Trauma is most likely to be visible in joints where spontaneous healing is obstructed by the range of movements of the joint and the multiple bones creating the joint (such as the shoulder or wrist) (Ortner 2003). Dislocations are most commonly caused by trauma, although congenital anomalies may contribute to higher chance of dislocation (Ortner 2003). Skeletally, a dislocation can be accompanied by a fracture (especially in the shoulder area), disorganised bone remodelling (caused by injury to the soft tissues), and possibly also osteoarthritis. In severe cases, the blood supply to the joint may be disrupted and tissue death may occur; in addition, the formation of a secondary articular surface may develop if reduction fails (Ortner 2003). In this study, dislocation was scored only if at least two of the above-mentioned signs (fracture, extensive bone remodelling, secondary articular facet, joint socket reduction) were present together in at least two bones of the affected joint.

Osteochondritis dissecans (OD) refers to a tear or fracture of the cartilage covering the bone(s) of joints (Schenck *et al.* 1996). The necrotic fragment of the bone is separated, and it can either fuse back and heal or remain loose. Unlike many skeletal lesions, OD is easily recognisable in skeletal remains. The lesion manifests as a depression in the bone, is usually circular, with well-defined contours, and porosity in the defect (Roberts and Manchester 1995: 87). The exact aetiology is not clear, but trauma is one of the most probable causes of the condition (Edge and Porter 2011), and it is common in people engaged in strenuous activity (see, for example, Orava and Virtanen 1982). The most affected joints include the knee, elbow, and ankle (Waldron 2009: 154). OD was recognised according to the description provided above and its location was recorded in the database.

4.2.1.7.6. Miscellaneous lesions

Skeletal lesions that could not be classified in any of the above-mentioned categories were scored as ‘miscellaneous lesions’. CPRs, detailed descriptions and differential diagnoses of individual lesions are provided in Chapter 5.

4.2.1.7.7. Developmental anomalies and non-metric traits

Developmental anomalies and non-metric traits were recorded, but not further analysed. The CPRs of individual variations are provided in the Appendix 3 (Table 55, Figures 101-103) and the occurrences of individual anomalies are also recorded in the enclosed Excel database.

4.2.2. Data presentation and statistics

Age at death and stature of individuals were compared between and within the populations from individual periods, using SPSS. For the comparison of mean ages and statures between the three periods one-way analysis of variance (One-Way ANOVA) was used. When mean values of only two samples (e.g., males and females) were compared, a T-Test was performed on the normally distributed data.

The differences in variable distributions between and within the samples were determined using Chi-square statistics (χ^2). The significance level was set to 5%, meaning that the p value was less than 0.05 if the result was significant.

Principal component analysis (PCA) was applied on the adult metric data. In order to eliminate the effect of missing data, only the variables available for more than eighty individuals were used (see Table 43 in Chapter 5). The remaining missing values were replaced by means and varimax rotation was applied.

Using SPSS, the frequencies of individual pathologies are expressed as the percentage of affected individuals, in the form of a crude prevalence rate (CPR). In the thesis, CPR refers to a proportion of affected individuals from all the individuals in the category (which means that if 5 of 100 Neolithic female skeletons showed the signs of cranial trauma, the CPR would be 5%). Total prevalence rates (TPRs) were not used for all pathologies. This is because only a very small number of skeletons were badly preserved and thus the differences of individual pathologies between the periods would be minimal. However, TPRs are more frequently provided for dental pathologies from the study region so, in addition to CPR, also TPRs are provided for comparative reasons[35].

In order to establish whether any conclusions can be applied more generally, the results of the study were also compared and evaluated in combination with published data from other sites in the area. The same statistical tests as those used for the study collection were applied to the combined sample, i.e., the sample including the data obtained in this study and those from published record, although because of incompatible methodologies or missing data not all the features could be evaluated. The results are discussed in Chapter 6.

4.3. Problems and limitations of osteoarchaeology

Regardless of the numerous possibilities offered by bioarchaeological studies, the discipline suffers from several limitations, mostly caused by the inadequate preservation of skeletal remains, sample bias, inter-observer error, indiscernibility of many diseases, limits of diagnosis, or the destructive nature of methods such as stable isotope analysis, DNA analysis and radiocarbon dating (Wood *et al*. 1992; Mays 2010a; Ortner 2012). In addition, as discussed by Gowland (2016), health of past populations should not be considered purely on the basis of immediate environment. The author points to the importance of the heritability of health and criticises the fact that only little attention is paid to foetal and infant metrics as indicators of health stress of a population, especially women/mothers (Gowland 2016). In addition to all the above-mentioned problems, a phenomenon known as the 'osteological paradox', limitations, that can significantly affect the interpretation of archaeological skeletal data (Wood *et al*. 1992).

First of all, Wood *et al.* (1992) mention that the health of an individual, suggested solely by skeletal remains, may not reflect the true health status of the individual. This is because the time needed for development of many pathological lesions can be slow (Roberts and Manchester 1995), and only chronic diseases may manifest osteologically. Susceptibility to different health stressors, be they pathogens or living conditions, varies between individuals and a frail individual may die before the disease manifests on the bone. The skeletal remains of such an individual would therefore appear as healthy, while those of an individual with better survival adaptability would display lesions, owing to the fact that the individual survived the disease longer than the frail individual. Consequently, frequencies of numerous pathological conditions suggested by skeletal remains may not reflect true rates. Another problem suggested

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[35] TPRs were calculated from preserved dentitions, not by tooth

by Wood *et al.* (1992) is represented by so called 'selective mortality'. This refers to the fact that archaeological skeletal samples represent only a subset of the total number of individuals in individual age categories. In other words, the deceased represent only a fraction of individuals of a specific age, whereas the number of those who survived to and after that age cannot be estimated. As a result, the rates of pathologies in individual age categories, as suggested by osteological material, may be higher than in reality. A third problem mentioned by Wood *et al.* (1992) relates to the demography of past populations. The authors state that populations are rarely stationarity because of repeated migrations (see also De Witte and Stojanowski 2015), and that high numbers of infants in archaeological populations may actually reflect increased fertility rather than poor health because of the immigration of fertile women. However, this is difficult to establish because a higher number of buried subadults may point to either of the two.

Even though the issues of the 'osteological paradox' certainly represent key limitations to bioarchaeological research, some authors have challenged the total validity of the 'osteological paradox' and proposed how these limitations can be overcome. As Goodman (1993) points out, it is necessary to consider all health indicators, such as stature or dental problems, which may refer to conditions at both death and during life. Moreover, conditions such as trauma are not affected by the phenomenon. Goodman (1993) also argues that there are additional factors that would affect whether an individual lives or dies, for instance, a person's immunity or available medical care. Cohen (1994) and Ortner (2008) also point out that the causes and reasons of death may vary in a population, or that there may be more than one condition affecting a skeleton, thus lowering the impact of the 'osteological paradox'. In their recent review of the topic, DeWitte and Stojanowski (2015) found that researchers address the issues of the osteological paradox in "more informed ways" (DeWitte and Stojanowski 2015). The authors also mention progress in four main areas of bioarchaeology that significantly helps to eradicate the problems introduced by Wood *et al.* (1992). These comprise the increased emphasis on the archaeological context, more detailed research on subadult remains, the relationship between skeletal stress markers and demographic phenomena, and elaborated research on the aetiology of skeletal lesions (DeWitte and Stojanowski 2015; see also Wright and Yoder 2003). However, even if the issues of the 'osteological paradox' may not be as restricting in an overall bioarchaeological interpretation as claimed by Wood *et al.* (1992), they need to be borne in mind in palaeopathological interpretations.

5.1. Preservation

5.1.1. Skeletal completeness

As far as possible, well-preserved individuals were selected for the study. The majority of the remains (70%) were more than 50% complete, adults more than subadults and male individuals more than females. Similar results were obtained when each period was evaluated separately (Figures 5 and 6).

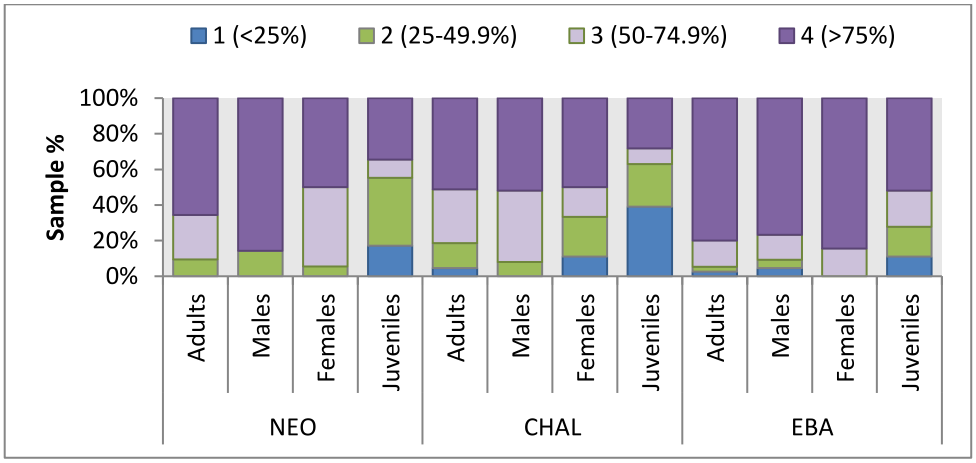

Figure 5. Skeletal completeness of adult and subadult skeletons by period.

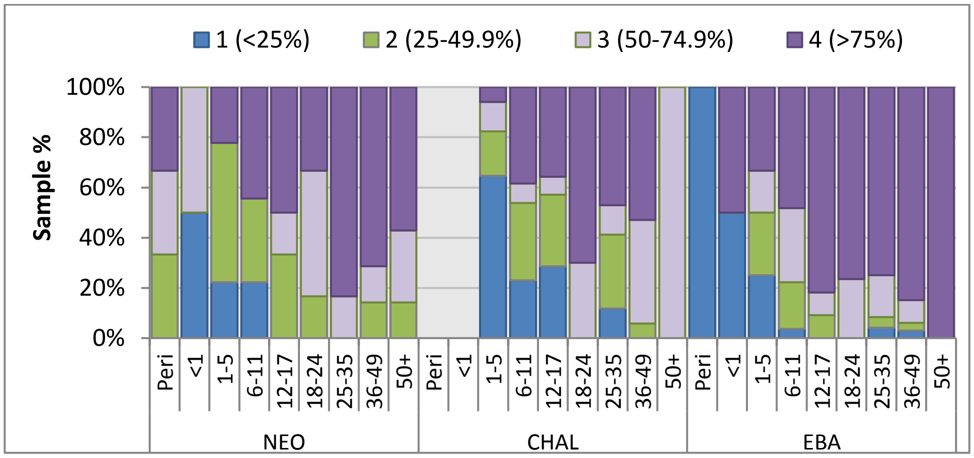

Figure 6. Skeletal completeness of adult and subadult skeletons by age and period.

5.1.2. Bone surface preservation

Bone surface preservation of 50% of the remains was evaluated as moderate, 38% as good and 12% as poor. This means that in the majority of the skeletons, despite some post-mortem damage, any surface lesion would be visible if present.

Like skeletal completeness, there was a relationship between the level of bone surface preservation and the period, the worst being in the Neolithic and the best preserved in the EBA. The differences between the bone surface preservation of males and females were small. However, when individual periods were evaluated separately, there was a considerable difference between males and females in the EBA, males being better preserved than females (Figure 7).

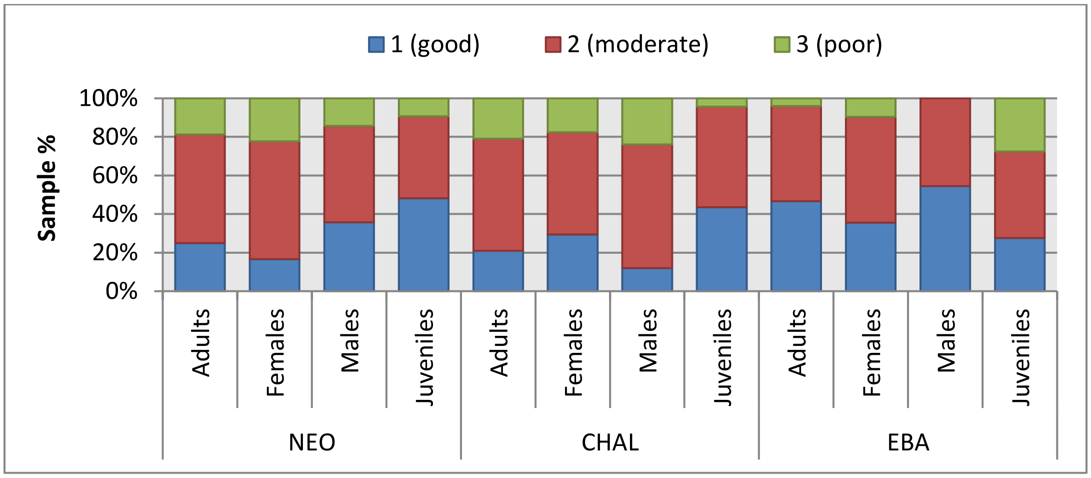

Figure 7. Bone surface preservation of adult and subadult skeletons by period.

No correlation between bone surface preservation and overall bone completeness was recorded. In other words, worse bone surface preservation did not also mean poor bone completeness.

5.1.3. Survival rate of individual bones in adults

The best preserved bones were those with a higher ratio of cortical to cancellous bone. These include mainly the limb bones, clavicles and some bones of the skull, such as the frontal and occipital bones and mandible (Figure 8). The degree of preservation for pelves and scapulae was also rather high; both bones were scored as present if at least 50% of each were preserved.

In the case of scapulae, at least the shoulder joint was usually preserved, while in pelves it was mostly the acetabular area and ischium. Small bones and bones with higher proportions of cancellous bone tended to be more poorly preserved, including carpals and phalanges or thinner bones of the skull (e.g., nasals, sphenoid).

The differences between the survival rates of the bones of males and females did not vary to a great extent. For males and females in individual periods, certain differences were indicated, especially in the case of cranial bones (the poorest preservation being scored in Chalcolithic females), radii, and vertebrae (especially low in Chalcolithic males). Otherwise, the pattern of the survival rate curves was very similar in all three samples, being generally highest in the Bronze Age and the lowest in the Chalcolithic (Figures 9 and 10).

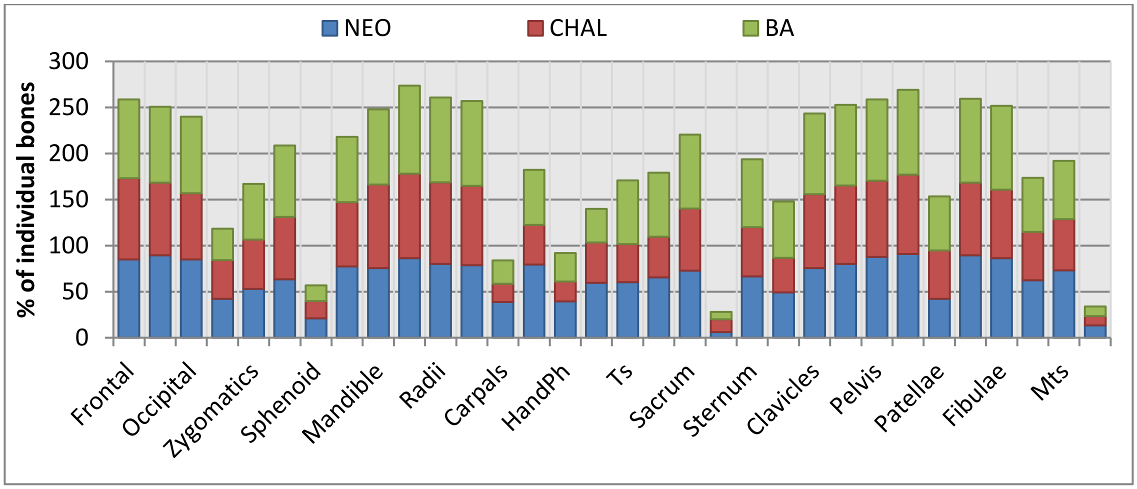

Figure 8. Survival rates of individual bones of all adult individuals by period.

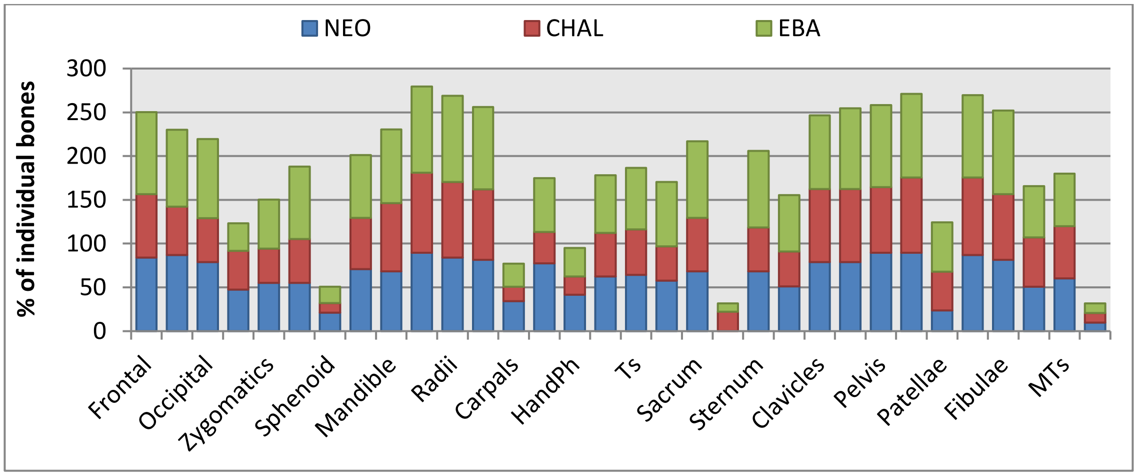

Figure 9. Survival rates of individual bones of females by period.

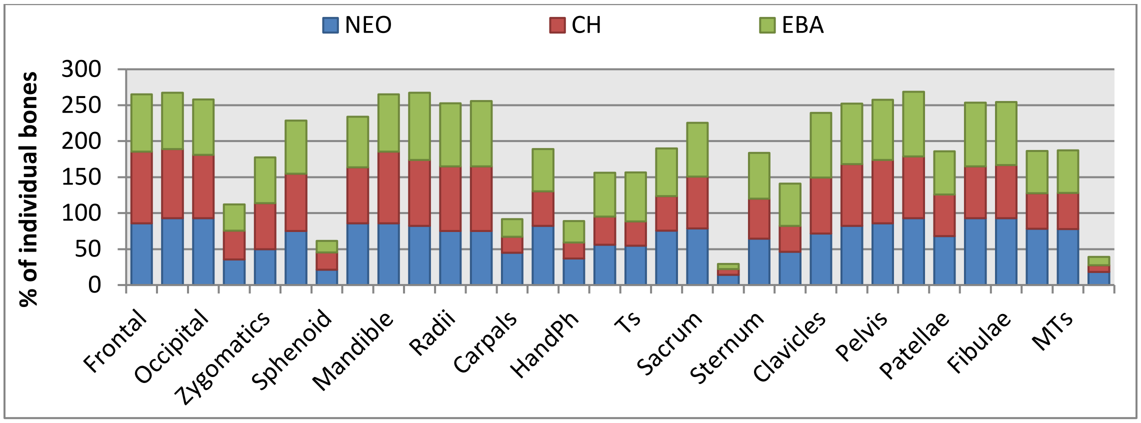

Figure 10. Survival rates of individual bones of males by period.

5.2. Sex and age-at-death

Table 14 summarises sex and age-at-death composition in individual periods. In the whole assemblage, males outnumber females. The only period where the number of females was higher than males was the Neolithic. Adults usually outnumber subadults; the only assemblage where the number of juvenile remains was greater than the number of adults was in the Chalcolithic sample (Figure 11).

	Age	NEO NI	%	CHAL NI	%	EBA NI	%	All
Subadults	**All**	29	100.0	51	100.0	56	100.0	**136**
	Perinate	3	10.3	0	0.0	1	1.8	4
	<1	2	6.9	0	0.0	2	3.6	4
	1-5	9	31.0	18	35.3	14	25.0	41
	6-11	9	31.0	17	33.3	27	48.2	53
	12-17	6	20.7	16	31.4	12	21.4	34
Females	**From adults**	19	57.6	18	41.9	32	42.1	**69**
	18-24 (young)	5	26.3	5	27.8	9	28.1	19
	25-35 (prime)	7	36.8	8	44.4	11	34.4	26
	36-50 (mature)	3	15.8	5	27.8	12	37.5	20
	50+ (old)	4	21.1	0	0.0	0	0.0	4
Males	**From adults**	14	42.4	25	58.1	44	57.9	**83**
	18-24 (young)	1	7.1	3	12.0	7	15.9	11
	25-35 (prime)	5	35.7	9	36.0	14	31.8	28
	36-50 (mature)	4	28.6	12	48.0	21	47.7	37
	50+ (old)	4	28.6	1	4.0	2	4.5	7
Adults	**All**	33	100.0	43	100.0	76	100.0	**152**
	18-24 (young)	6	18.2	8	18.6	16	21.1	30
	25-35 (prime)	12	36.4	17	39.5	25	32.9	54
	36-50 (mature)	7	21.2	17	39.5	33	43.4	57
	50+ (old)	8	24.2	1	2.3	2	2.6	11

Table 14. Sex and age composition by period. NI = number of individuals; % = sample percentage.

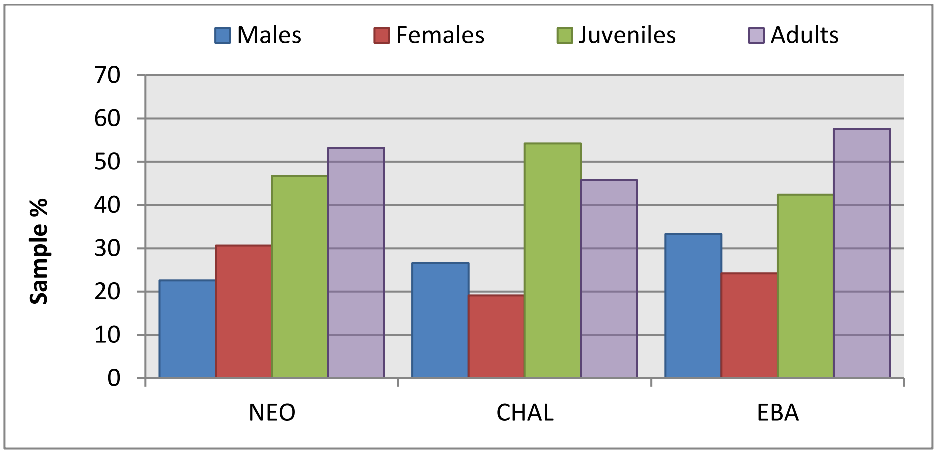

Figure 11. Proportion of males, females and juveniles by period.

The overall peak in subadult mortality was reached between the sixth and the eleventh years of age. The greatest number of children up to one year was detected in the Neolithic, but no clear peak was recorded as children between the first and the eleventh year of age were dying in equal proportions. The situation was similar in the Chalcolithic although a slightly higher mortality of subadults between the ages of one and five was observed. The subadult mortality peak in the EBA falls clearly between the age of six and eleven (Figure 12). Considering adults, the most numerous group is represented by mature adults, closely followed by prime adults. When divided into individual periods, Neolithic adults were dying mostly in their prime age, while the peak of mortality in other two periods was reached later in life.

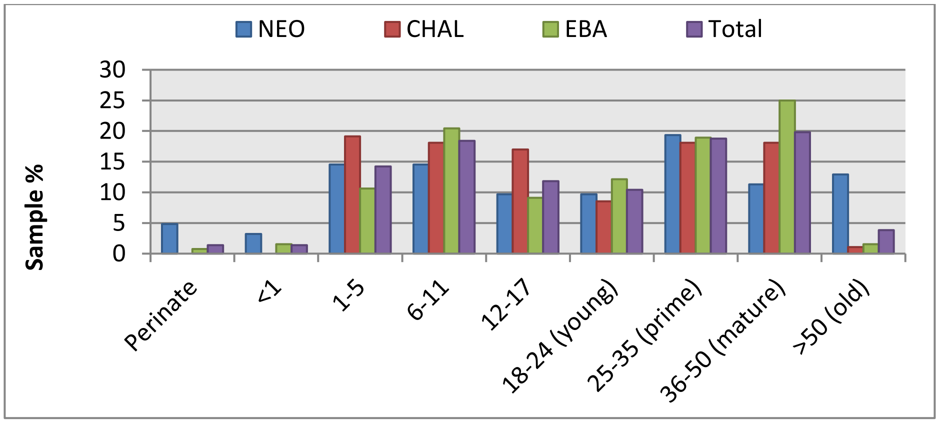

Figure 12. Mortality peaks in individual periods (calculated from the total sample).

Mortality rates suggest that males were dying at an older age than females. In the Neolithic, both sexes were dying earlier in life than in the other two periods. Most of the Neolithic males died in their prime age, whereas mature males were the most numerous in the following periods. The mortality of female individuals was the highest in the prime age group in all periods but the EBA where mature females were more numerous (Figure 13).

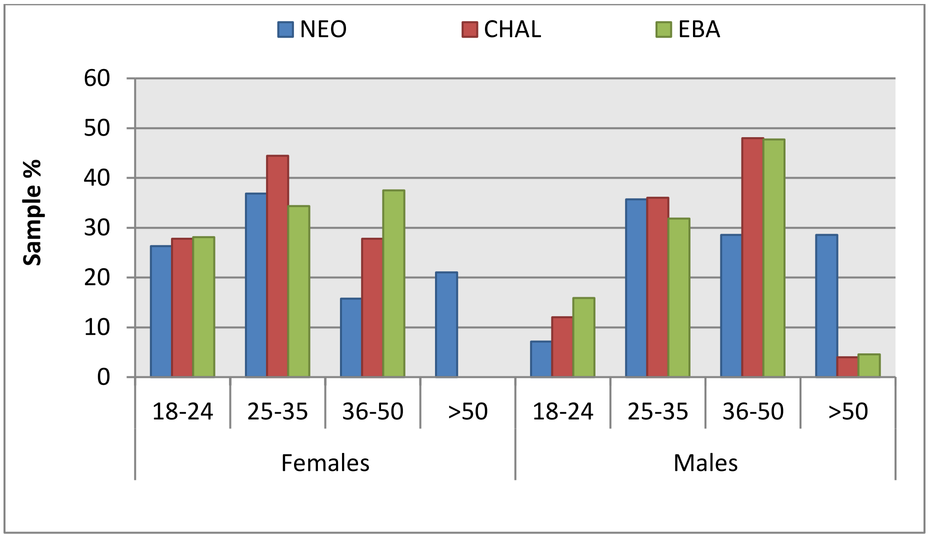

Figure 13. Mortality peaks for females and males by period.

5.2.1. Dental *vs.* skeletal age

Both dental and skeletal ages were available for 201 remains: 89 subadults, 50 females and 62 males (see enclosed database). From all assessable subadults, only 64 individuals younger than eleven years were present. Adolescents were not included in the analysis because dental age in this period tends to vary more than in younger children. No significant differences between the periods were detected. In six subadults, dental age was considerably higher than skeletal age - one Neolithic, two Chalcolithic, and three EBA children. The opposite situation, with higher skeletal than dental age, was recorded in ten subadults - one Neolithic, three Chalcolithic, and six EBA individuals (Figures 14, 15, and 16).

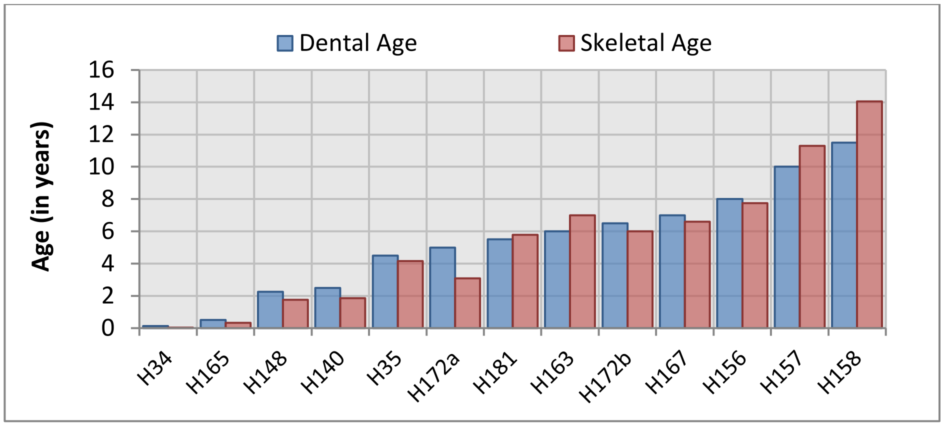

Figure 14. Comparison of dental and skeletal ages of Neolithic juveniles.

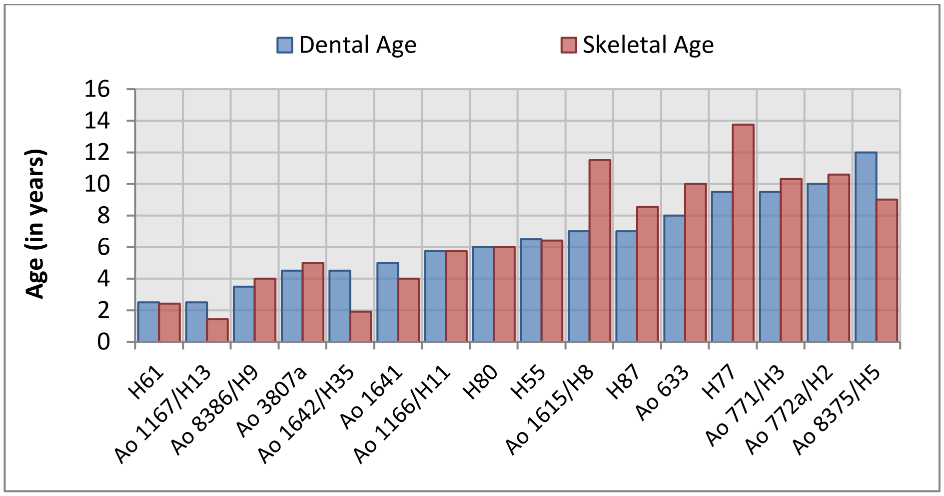

Figure 15. Comparison of dental and skeletal ages of Chalcolithic juveniles.

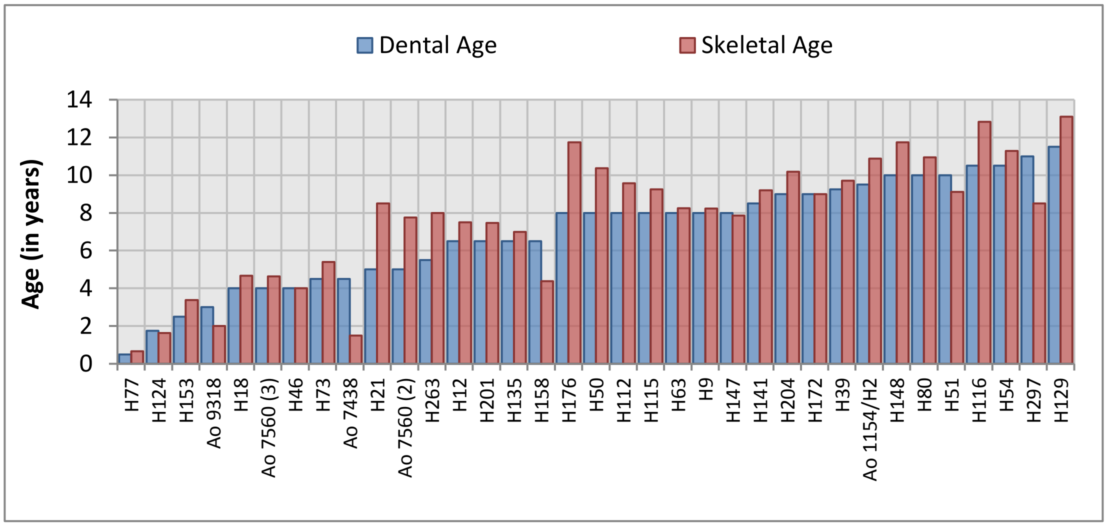

Figure 16. Comparison of dental and skeletal ages of EBA juveniles.

In adults, there were fourteen cases with a much higher dental than skeletal age, four Neolithic, five Chalcolithic and five EBA individuals (Figures 17, 18, and 19). Eleven individuals had higher skeletal than dental age, seven of them being females and four males[36].

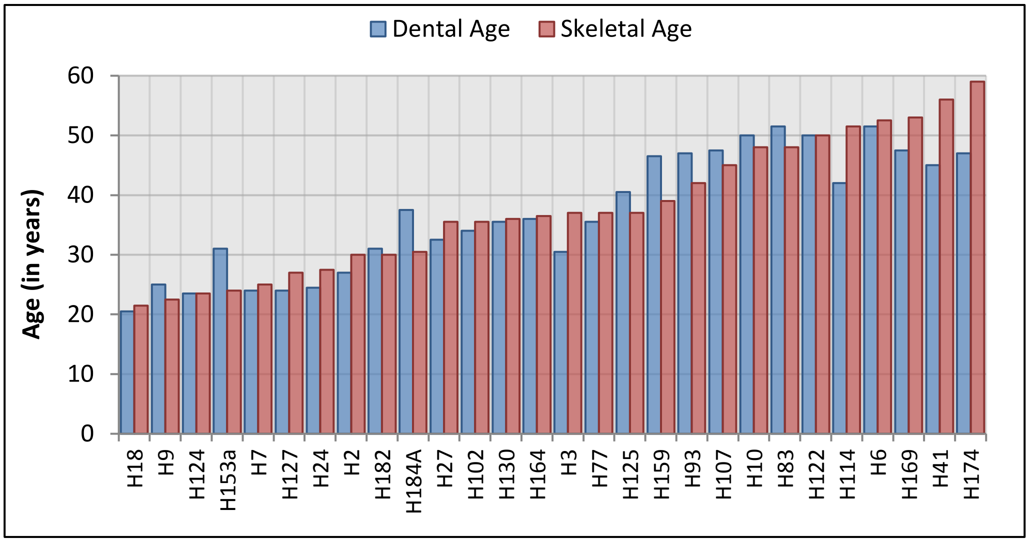

Figure 17. Comparison of dental and skeletal ages of Neolithic adults.

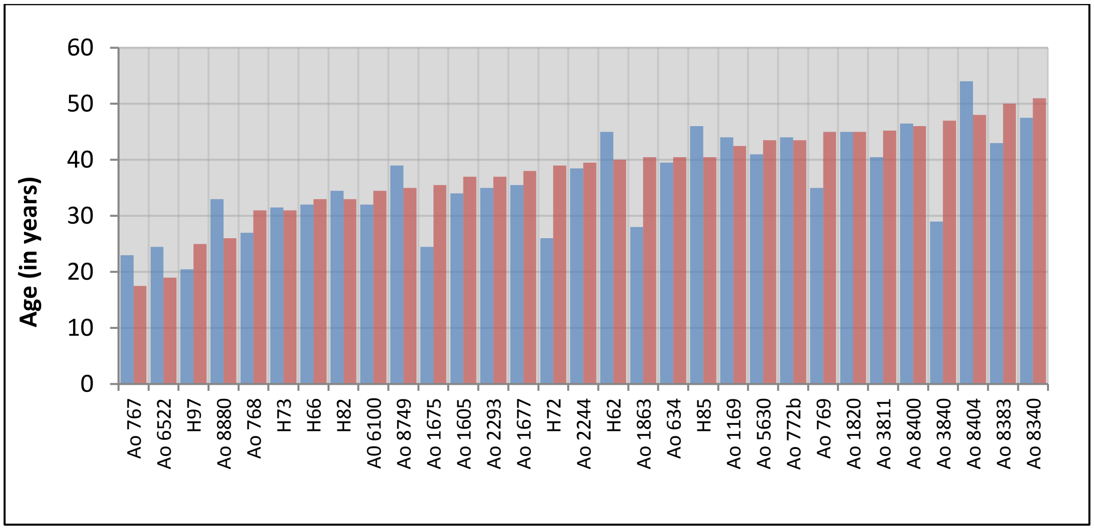

Figure 18. Comparison of dental and skeletal ages of Chalcolithic adults.

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[36] Neolithic: two females, one male
Chalcolithic: three females, two males
EBA: two females, one male

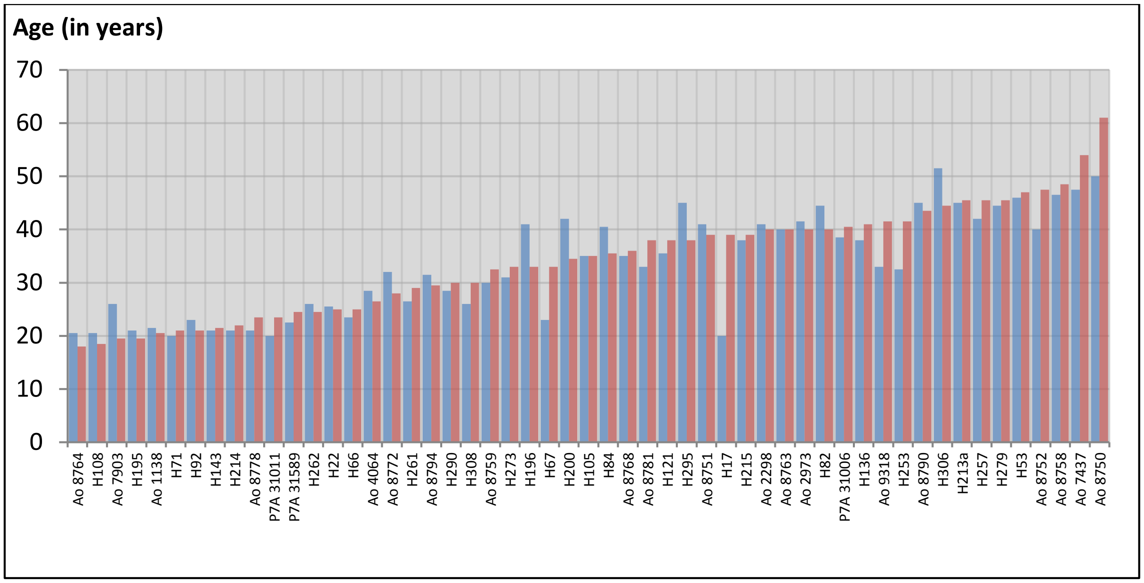

Figure 19. Comparison of dental and skeletal ages of EBA adults.

5.3. Stature and growth

5.3.1. Stature of adult individuals

Stature was calculated for 148 adults. A summary is provided in Table 15. When compared to the Neolithic, Chalcolithic and EBA individuals were about 5 cm taller. The greatest range of statures was observed in the EBA sample (Figure 20). The differences between mean statures in individual periods are also statistically significant, as regards the whole samples as well as individual sexes (Appendix 5, Tests 1-3), whereas the data were normally distributed.

	SEX	NI	MIN	MAX	Mean	SD
NEO	Females	19	147.30	165.00	156.0105	6.04804
	Males	14	156.40	180.30	167.8643	5.74478
	Together	33	147.30	180.30	161.0394	8.32928
CHAL	Females	17	152.60	167.60	160.7588	4.31017
	Males	24	166.20	182.50	173.1500	5.04251
	Together	41	152.60	182.50	168.0122	7.76206
EBA	Females	32	149.30	170.60	161.8219	5.32382
	Males	42	157.00	182.20	172.9214	4.67737
	Together	74	149.30	182.20	168.1216	7.41454

Table 15. Average stature of males and females by period. NI = number of individuals; MIN = minimum stature; MAX = maximum stature; SD = standard deviation.

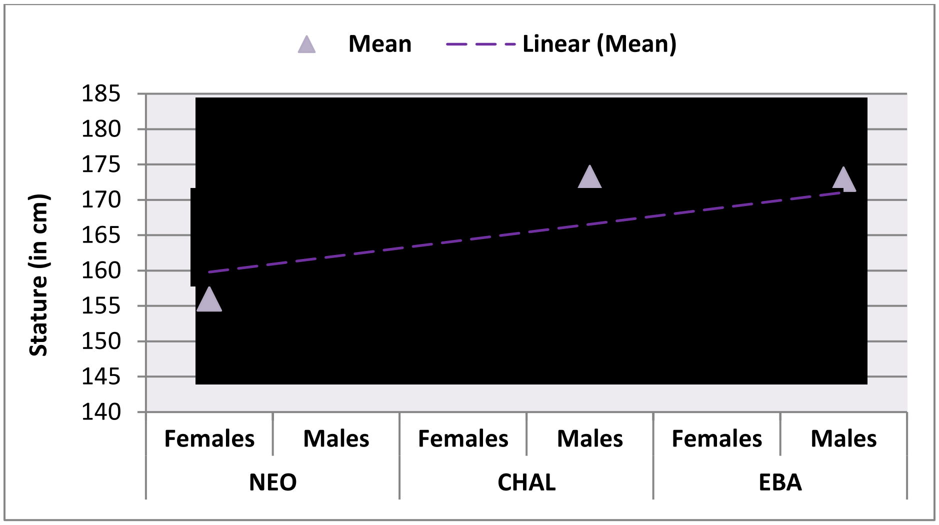

Figure 20. Stature of males and females by period.

5.3.2. Subadult growth curves

The total number of subadult individuals with both dental age and the length of either of the femora was thirty-eight. When compared with the Neolithic population, growth was slightly retarded from the age of four in the Chalcolithic and from about the age of six in the EBA (Figure 21).

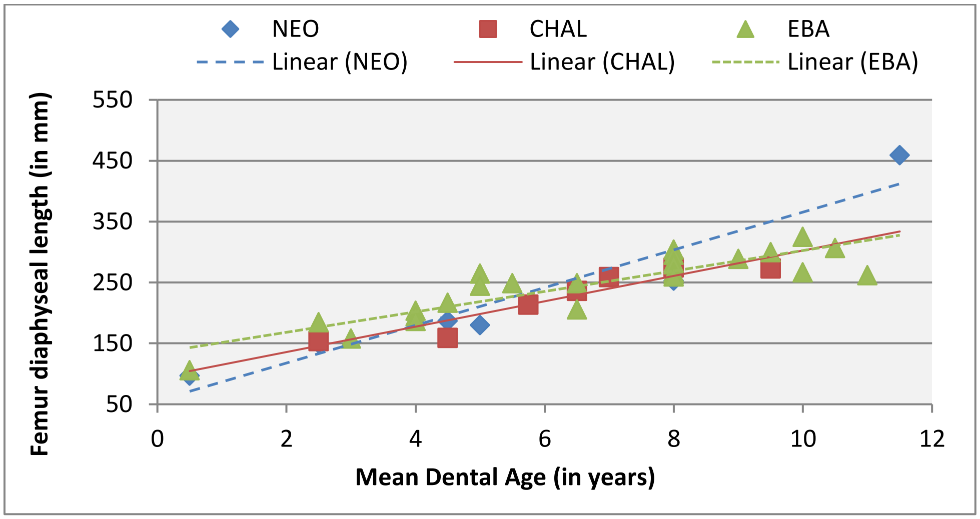

Figure 21. Subadult growth curves by period, based on diaphyseal length of femur. Data points represent mean bone lengths of a single individual against its mean dental age.

5.4. Metric data

5.4.1. Cephalic index

The cranial index was calculated for forty-nine adults, thirteen Neolithic, fourteen Chalcolithic, and twenty-three EBA. Both the Neolithic and the EBA populations are dolichocephalic (long-headed), especially the latter. On the contrary, the Chalcolithic population was clearly brachycephalic (short-headed), although the index of female skulls was close to mesocephalic (medium-headed) (Table 16, Figures 22, 23, and 24). When mean indices were compared by One-Way ANOVA, the Chalcolithic population was significantly different from the populations of the other two periods (Appendix 5, Test 4). All data were normally distributed.

		Min	Max	Mean	Cephalism
NEO	**Males**	71.4	76.9	75.2	Dolichocephalic
	Females	66.0	77.3	73.5	Dolichocephalic
	Together	66.0	77.3	73.7	Dolichocephalic
CHAL	**Males**	77.8	88.2	82.5	Brachycephalic
	Females	79.1	86.0	82.6	Mesocephalic[37]
	Together	77.8	88.2	82.8	Brachycephalic
EBA	**Males**	62.9	81.8	72.4	Dolichocephalic
	Females	65.4	79.1	71.4	Dolichocephalic
	Together	62.9	81.8	69.2	Dolichocephalic

Table 16. Cranial indices by sex and period.

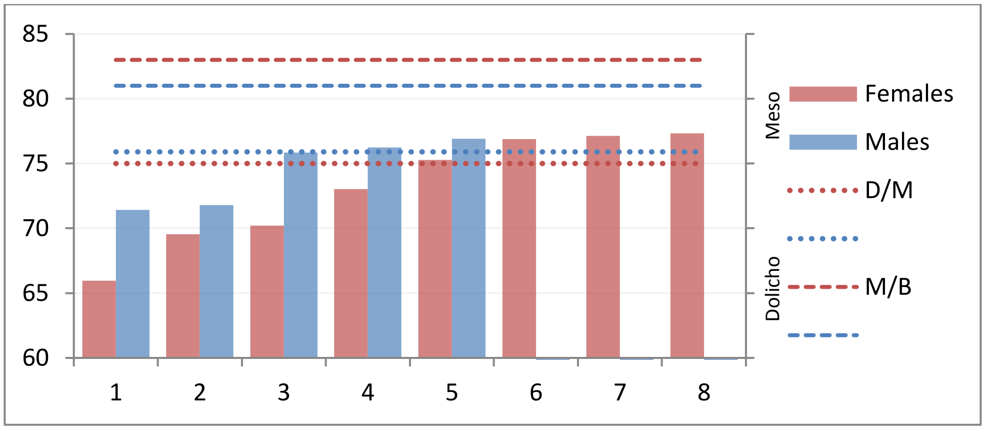

Figure 22. Cranial index of Neolithic males and females. D/M – section point between dolichocephalism and mesocephalism; M/B - section point between mesocephalism and brachycephalism; red – females; blue – males.

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[37] if the values were rounded, the females would also fall into the brachycephalic category

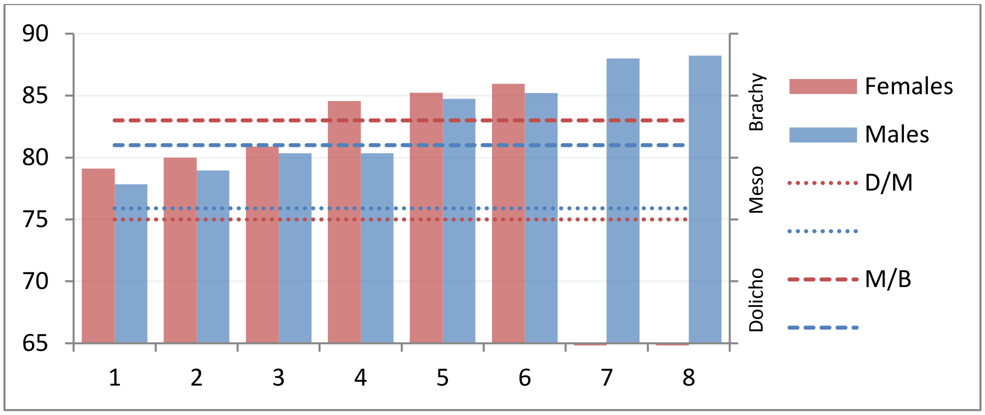

Figure 23. Cranial index of Chalcolithic males and females. D/M – section point between dolichocephalism and mesocephalism; M/B - section point between mesocephalism and brachycephalism; red – females; blue – males.

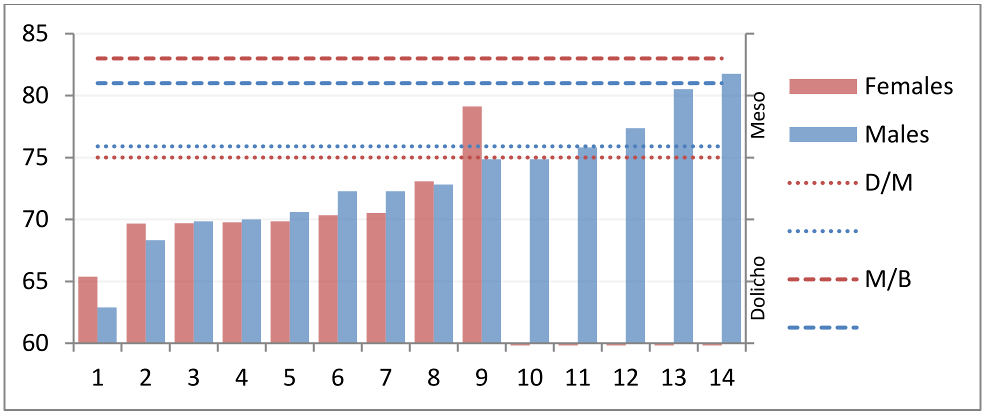

Figure 24. Cranial index of EBA males and females. D/M – section point between dolichocephalism and mesocephalism; M/B - section point between mesocephalism and brachycephalism; red – females; blue – males.

5.4.2. Body mass (BM)

Body mass, estimated using the calculations suggested by Ruff *et al.* (2012), could be calculated for more than 75% of all adult individuals, fifty-six females and sixty-three males. The Neolithic population had the lowest BM of all. The data were normally distributed and the difference is also statistically significant (Appendix 5, Test 5). The same showed to be true for the females and males when evaluated separately, although the data for EBA males were not normally distributed[38] (Appendix 5, Test 6). Differences between the body mass of males and females from the same period were similar in all three periods (Table 17; Figure 25).

		NI	%	Min	Max	Mean
All periods	**All**	119	78.3	49.2	87.5	64.2
	Females	56	81.2	49.2	73.2	59.9
	Males	63	75.9	54.2	87.5	68.1
NEO	**All**	29	87.9	50.3	71.5	60.2
	Females	18	94.7	50.3	64.5	57.4
	Males	11	78.6	54.2	71.5	64.7
CHAL	**All**	27	62.8	53.6	78.9	65.9
	Females	11	61.1	53.6	71.0	60.6
	Males	16	64.0	61.6	78.9	69.5
EBA	**All**	63	82.9	49.2	87.5	65.3
	Females	27	84.4	49.2	73.2	61.2
	Males	36	81.8	57.9	87.5	68.5

Table 17. Body mass (BM) of the individuals by sex and period; NI – number of individuals for which the BM could be evaluated; % - percentage of individuals for which the BM could be evaluated; Min – minimum BM value in the category; Max – maximum BM in the category; Mean – mean of all the BM values in the category.

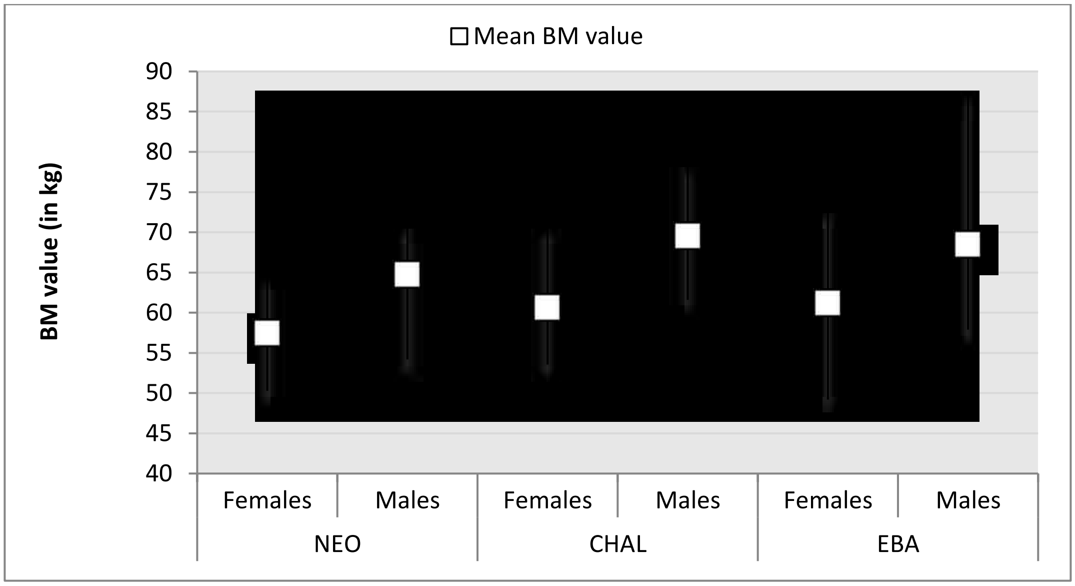

Figure 25. Body mass (BM) of males and females by period.

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[38] one male from Malá Ohrada (8772) showed to be much heavier than other EBA males

5.5. Pathology assessment

5.5.1. Dental diseases

No marked differences between caries CPRs and TPRs were recorded, probably owing to the good preservation of the remains. Hence, only the results based on CPRs are analysed below, whereas TPRs are provided in tables.

5.5.1.1. Caries

In total, caries were present in 19.1% of all studied individuals, including both subadults and adults. However, when adults and subadults were evaluated separately, caries were significantly more frequent in adults (Table 18).

The CPR of caries in subadults increases with period, which may also be a result of the smaller size of the Neolithic sample of juvenile remains and/or bad preservation and state of dentitions among these subadults. From all the juvenile individuals affected by caries, 4.4% of lesions are observed on deciduous and 2.9% on permanent dentitions (see enclosed database). Only one EBA juvenile, aged six to eleven years, (H148) exhibited caries on both deciduous and permanent teeth. Because of the small number of subadults with caries, no statistical test was performed.

	NEO		**CHAL**		**EBA**		**Together**	
CPR[39]	**NI**	**%**	**NI**	**%**	**NI**	**%**	**NI**	**%**
Females	4	21.1	5	27.8	10	31.3	19	27.5
Males	6	42.9	9	36.0	11	25.0	26	31.3
Adults	10	30.3	14	32.6	21	27.6	45	29.6
Juveniles	0	0.0	3	5.9	7	12.5	10	7.4
Total	10	16.1	17	18.1	28	21.2	55	19.1
TPR[40]								
Females	4	25.0	5	33.3	10	35.7	19	32.2
Males	6	50.0	9	36.0	11	27.5	26	33.8
Adults	10	35.7	14	35.0	21	30.9	45	33.1
Juveniles	0	0.0	3	6.4	7	14.6	10	8.5
Total	10	20.0	17	19.5	28	24.1	55	21.7

Table 18. CPRs and TPRs of dental caries in individual periods. Both permanent and deciduous dentitions are involved. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

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[39] calculated from all individuals in the category

[40] calculated from individuals with at least one preserved tooth

In the adult population, the prevalence rates of caries do not vary much between the periods (Table 18). In the total sample, slightly more males than females suffered from dental caries. The same tendency was observed in the Neolithic and the Chalcolithic, although the situation was the opposite in the EBA, where the CPR was higher in females. However, while the proportion of affected males decreases from the Neolithic, the number of affected females slightly increases (Figure 26).

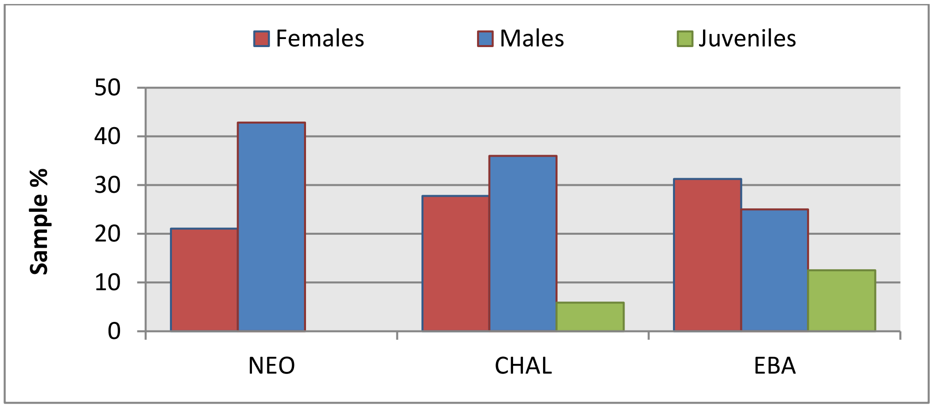

Figure 26. Caries CPRs in males and females by period.

As mentioned above, none of the Neolithic subadults suffered from caries. In Chalcolithic subadult remains caries occurred mainly between the ages of six and eleven years, whereas EBA juveniles were more affected in adolescence (Figure 27). While the CPR among Neolithic and Chalcolithic adults increases with age, caries are equally frequent in all age categories in the EBA population. The prevalence rates of old adults may be misleading, owing to the generally low number of elderly individuals. Excluding the elderly, caries are greater in mature adults (Figure 28). Considering males and females in individual periods, the frequency of caries in Neolithic males increases with age, while females were affected earlier in life. The trend is similar in the Chalcolithic. In the EBA, caries are especially common in young females (Figure 28).

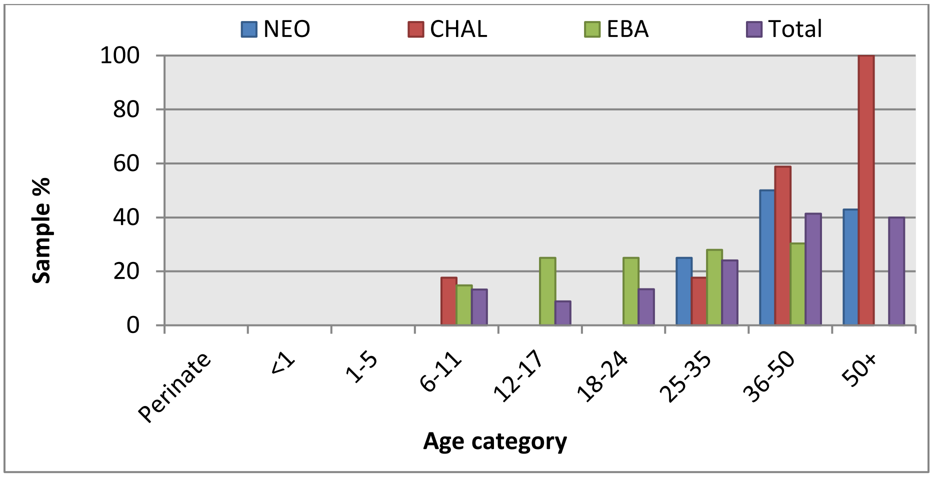

Figure 27. CPRs of caries in permanent dentitions by age.

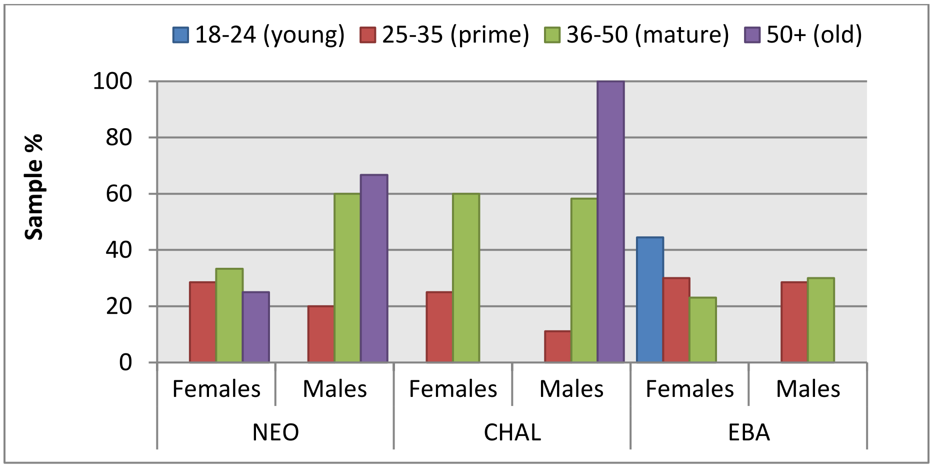

Figure 28. CPRs of caries in males and females by age and period.

In general, posterior teeth were the most affected of all teeth. In the deciduous dentition, carious lesions were present only on molars, especially the second molars. Considering the permanent dentition of subadults, only four out of 136 individuals suffered from caries, all older than nine. Altogether, five subadult permanent dentitions were affected. Four subadults had caries on molars and one on an incisor (see enclosed database). It is also posterior teeth that were affected the most in adults in all three periods, especially the first molars (Figure 29). Only a minimum of lesions were observed on canines and incisors. However, in the case of EBA individuals, caries were also detected on the anterior teeth to greater extent than in the earlier periods (Figure 30).

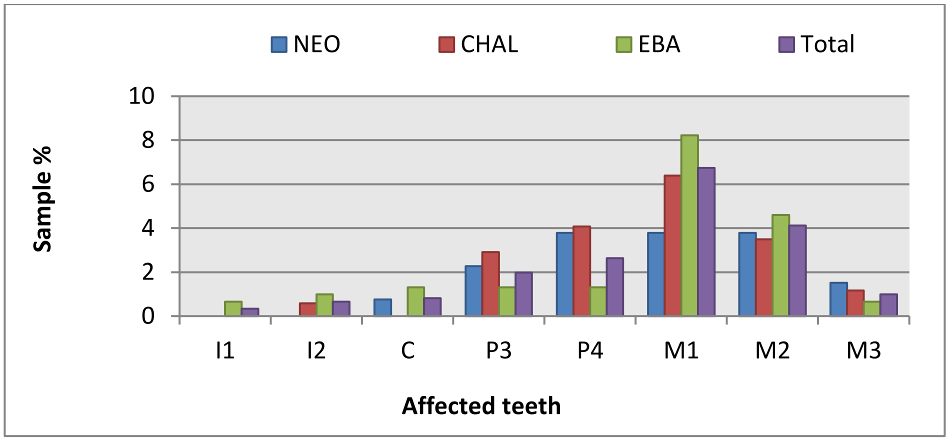

Figure 29. CPRs of caries in adults by tooth.

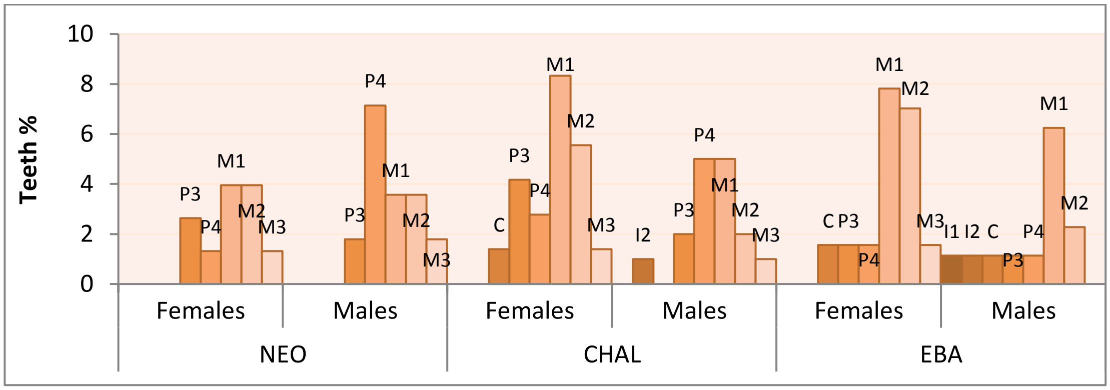

Figure 30. CPRs of caries in males and females by tooth.

5.5.1.2. Periapical lesions (abscesses)

The CPR of dental abscesses is 11% when all individuals, including juveniles, are considered, and maxillae were generally more affected than mandibles (see enclosed database). However, only one subadult jaw showed the condition - an EBA child aged six to eleven (H39). When only adult individuals were considered, about a fifth of all individuals exhibited periapical lesions (Table 19). The overall rate was greatest in the Neolithic, especially in males. The Chalcolithic was the only period where more females than males suffered from the condition (Figure 31). Nevertheless, as suggested by Pearson’s Chi-squared test, the number of abscesses in adults is not dependent on period (Appendix 5, Test 6). Because quite a low number of individuals were affected no statistical tests for males and females were individually performed.

	NEO		CHAL		EBA		Together	
CPR[41]	**NI**	**%**	**NI**	**%**	**NI**	**%**	**NI**	**%**
Females	3	15.8	4	22.2	5	15.6	12	17.4
Males	6	42.9	4	16.0	9	20.5	19	22.9
Total	9	27.3	8	18.6	14	18.4	31	20.4
TPR[42]								
Females	3	18.8	4	23.5	5	17.9	12	19.7
Males	6	46.2	4	16.7	9	23.7	19	25.3
Total	9	31.0	8	19.5	14	21.2	31	22.8

Table 19. CPRs and TPRs of abscesses by period. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

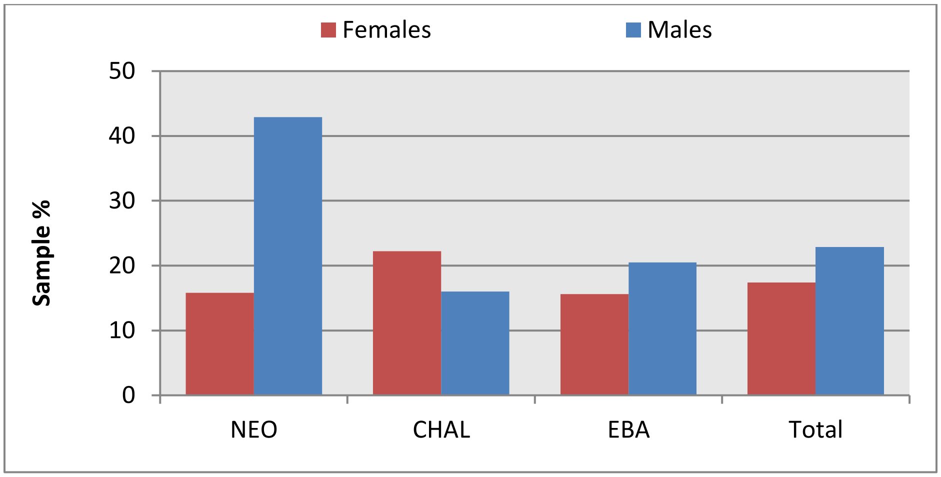

Figure 31. Abscess CPRs in males and females by period.

The CPR of abscesses generally rises with age, even though the peak of abscess occurrence was achieved in mature adulthood in the Neolithic (Figure 32). When evaluated by sex, Neolithic women suffered from abscesses in their old age, while the lesion prevailed in mature females in the other two periods (Figure 33). However, it is important to remember, that the Neolithic sample was the only assemblage where old females were represented. On the contrary, Neolithic males were the only ones whose peak of abscess occurrence was not reached in old but in mature age (Figure 33).

Like caries, abscesses also prevailed in posterior teeth, especially first molars and premolars. However, anterior teeth were affected more frequently by abscesses than they were by caries, especially in the Neolithic females and EBA males (Figures 34 and 35).

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[41] calculated from all individuals in the category

[42] calculated from individuals with at least one preserved tooth

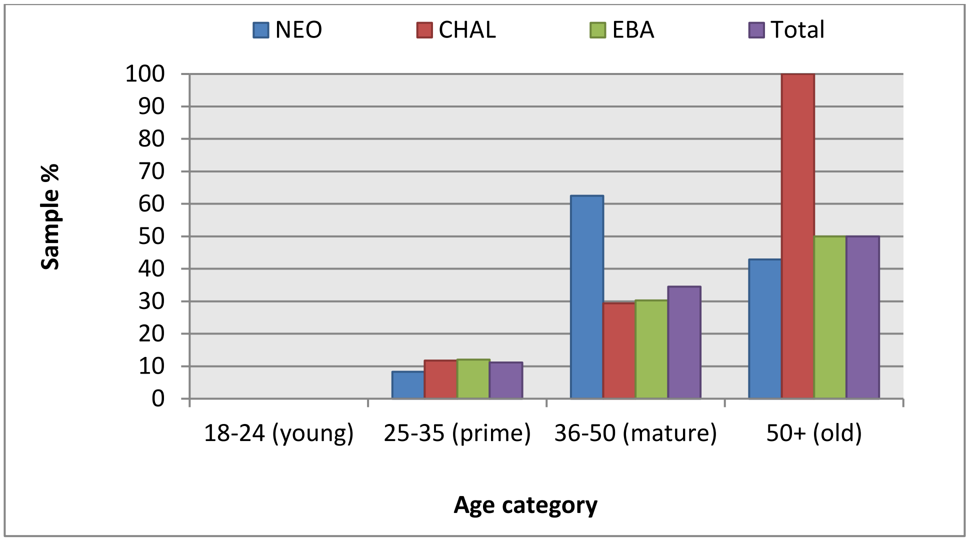

Figure 32. CPRs of abscesses in individual periods by age.

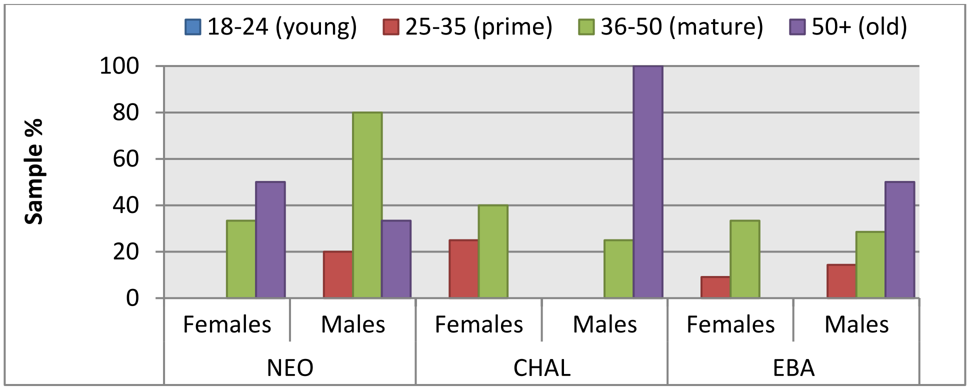

Figure 33. CPRs of abscesses in males and females in individual periods by age.

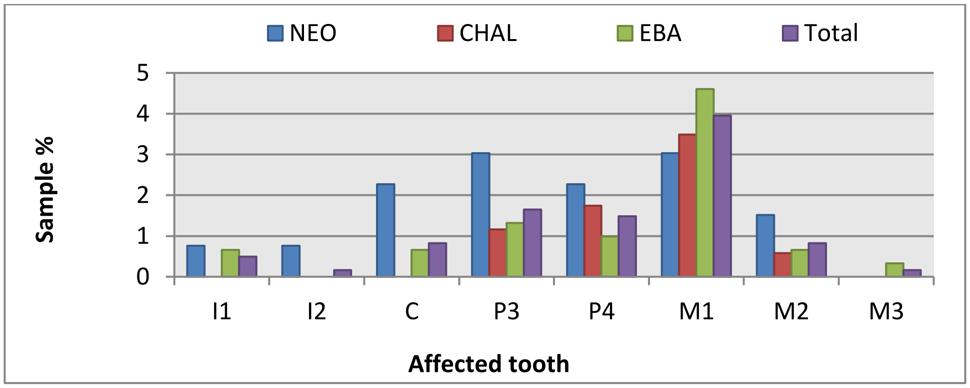

Figure 34. CPRs of abscesses by tooth.

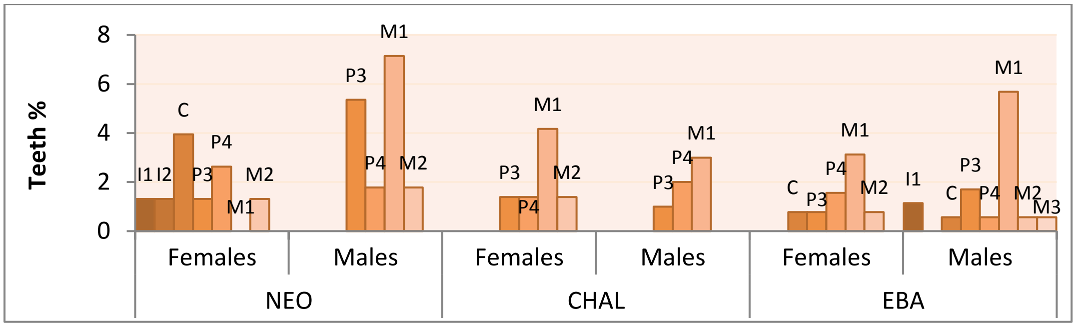

Figure 35. CPRs of abscesses in males and females by tooth.

5.5.1.3. Antemortem tooth loss (AMTL)

AMTL was evaluated only in adults. Altogether, 36.8% of all individuals exhibited the condition, and the number of affected individuals decreased from the Neolithic to the EBA (Table 20). This difference is not statistically significant (Appendix 5, Test 8). In general, AMTL was more common among males than females. The Neolithic was the only period with no CPR difference between males and females. The rates vary greatly between Chalcolithic males and females. Of all females, Neolithic women were affected the most, whereas AMTL was most common among Chalcolithic males when compared to their counterparts from the other two periods (Figure 36). The CPR of AMTL increases significantly with age in all three periods (Figure 37). It is Neolithic females who suffered from AMTL to the greatest extent already by their prime age. All of the other adults with AMTL are most numerous in the mature age category (Figure 38). The lack of old females affected by AMTL in the Chalcolithic and EBA is probably a consequence of generally low number of old individuals in the two samples.

	NEO		**CHAL**		**EBA**		**Together**	
CPR[43]	**NI**	**%**	**NI**	**%**	**NI**	**%**	**NI**	**%**
Females	8	42.1	4	22.2	8	25.0	20	29.0
Males	6	42.9	14	56.0	16	36.4	36	43.4
Total	14	42.4	18	41.9	24	31.6	56	36.8
TPR[44]								
Females	8	50.0	4	23.5	8	28.6	20	32.8
Males	6	46.2	14	58.3	16	42.1	36	48.0
Total	14	48.3	18	43.9	24	36.4	56	41.2

Table 20. CPRs and TPRs of AMTL in individual periods. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

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[43] calculated from all individuals in the category

[44] calculated from individuals with at least one preserved tooth

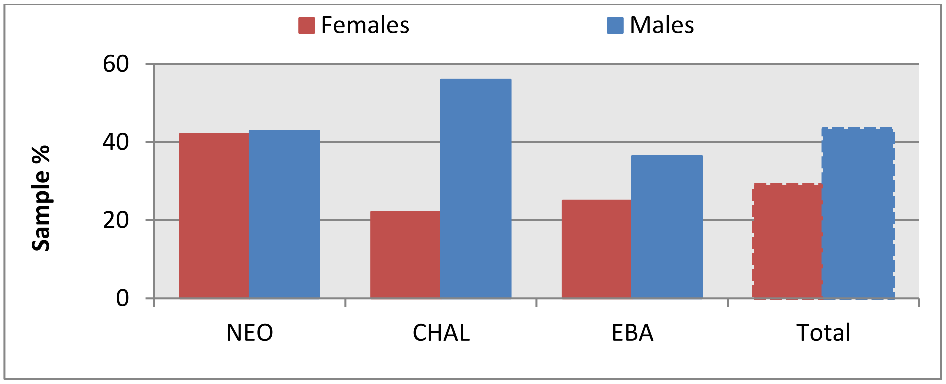

Figure 36. CPRs of AMTL in males and females by period.

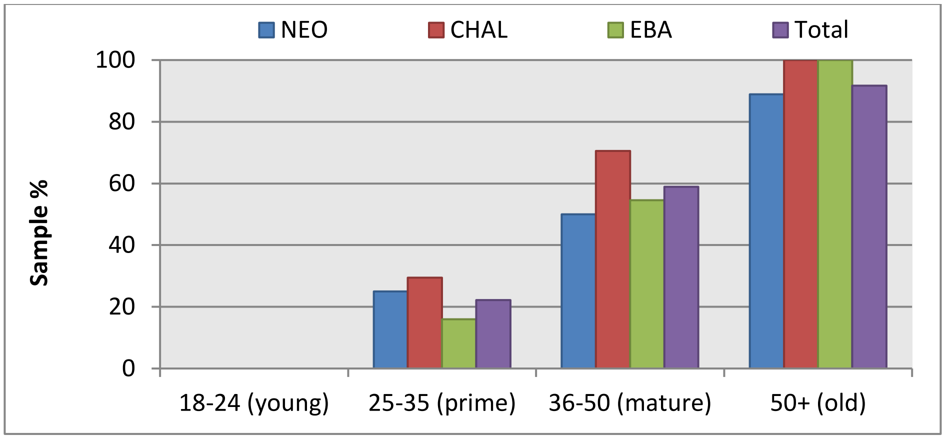

Figure 37. CPRs of AMTL in individual periods by age.

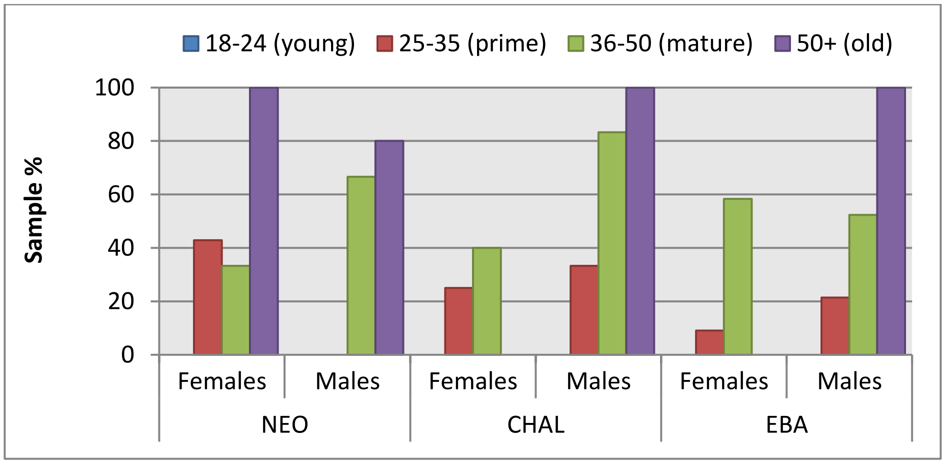

Figure 38. CPRs of AMTL in males and females by age and period.

Molars were the teeth most frequently lost prior to death (Figure 39). In comparison to other dental diseases, AMTL was commoner in the anterior dentition. Differences between males and females were not statistically evaluated owing to the low number of affected individuals. In the EBA, males were losing their anterior teeth much more often than females from the same period who had not lost any anterior teeth (Figure 40).

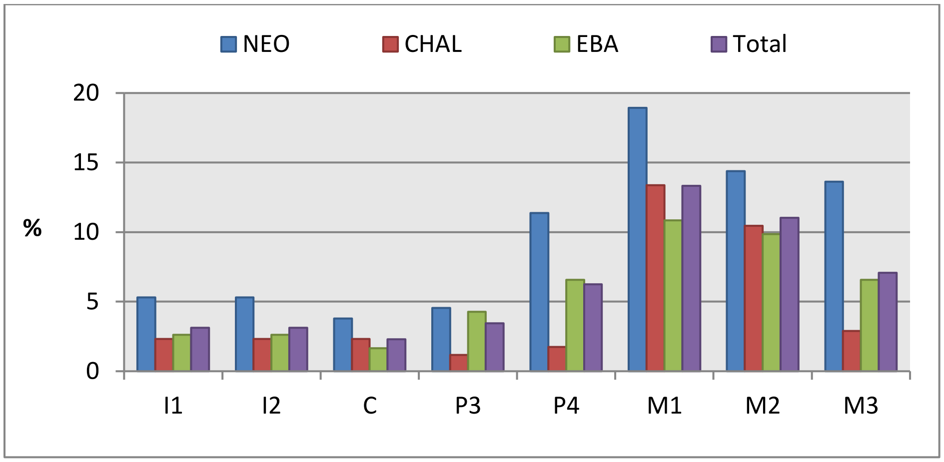

Figure 39. Percentage of teeth lost antemortem by period.

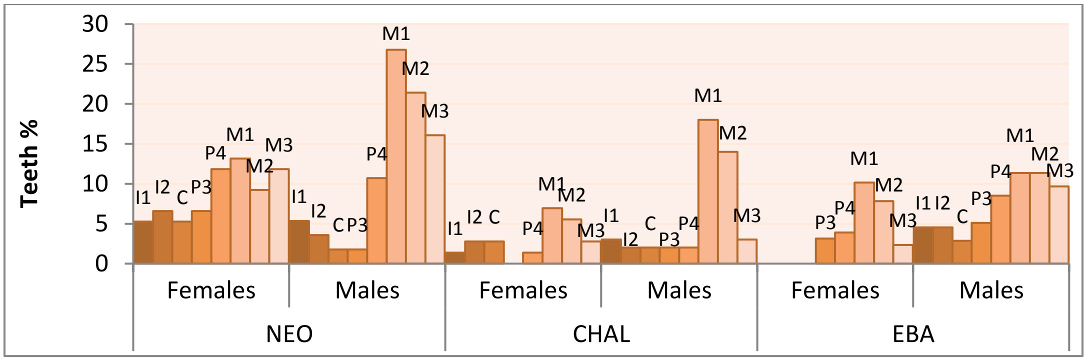

Figure 40. Percentage of teeth lost antemortem in males and females by tooth.

5.5.1.4. *Periodontal disease*

No traces of periodontal disease were detected on subadult remains. In adults, the number of cases of periodontal disease decreased from the Neolithic to the EBA, although statistical tests could not be performed because of the low number of affected adults in individual periods (Table 21). In comparison to the Neolithic with almost 25% individuals suffering from the condition, there were almost no EBA individuals with periodontal disease.

The disease was especially widespread among the Neolithic females and Chalcolithic males (Figure 41).

	NEO		CHAL		EBA		Together	
CPR	**NI**	**%**	**NI**	**%**	**NI**	**%**	**NI**	**%**
Females	6	31.6	1	5.6	0	0.0	7	10.1
Males	2	14.3	6	24.0	2	4.5	10	12.0
Total	8	24.2	7	16.3	2	2.6	17	11.2
TPR								
Females	6	37.5	1	5.9	0	0.0	7	11.5
Males	2	15.4	6	25.0	2	5.3	10	13.3
Total	8	27.6	7	17.1	2	3.0	17	12.5

Table 21. CPRs of periodontal disease in individual periods. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

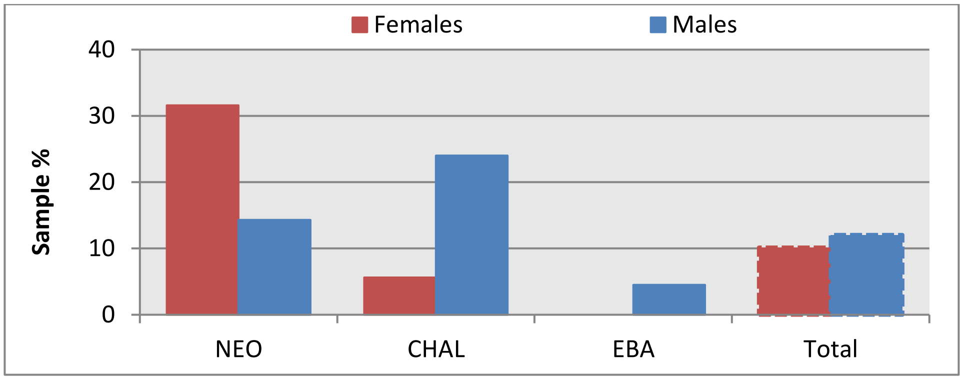

Figure 41. CPRs of periodontal disease in males and females by period.

The higher the age, the more frequent periodontal disease was (Figure 42). In young adulthood, only Neolithic females showed signs of periodontal disease, otherwise the condition prevailed in individuals older than thirty-six (Figure 43).

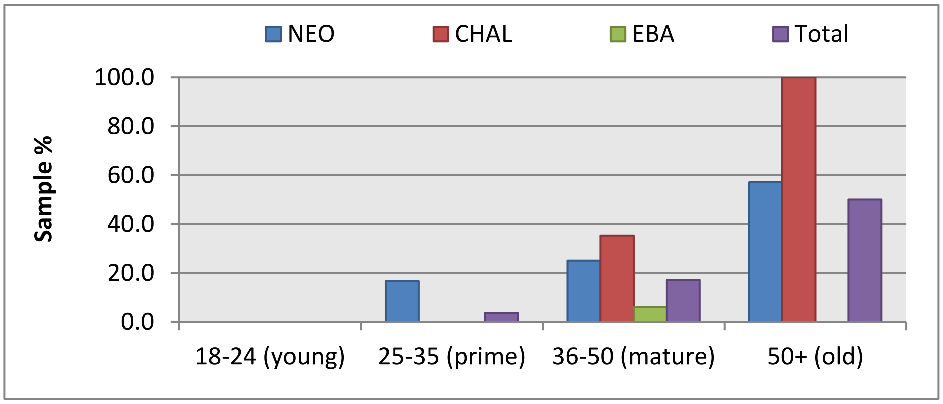

Figure 42. CPRs of periodontal disease in individual periods by age.

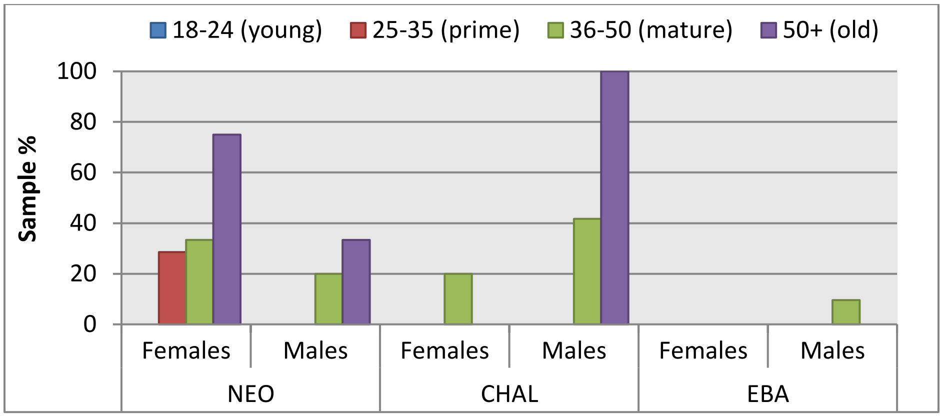

Figure 43. CPRs of periodontal disease in males and females by age and period.

In summary, dental diseases, namely periapical lesions (abscesses), AMTL and periodontal disease, were the most frequent in the Neolithic, with anterior teeth being most commonly affected (especially by AMTL). Moreover, Neolithic males suffered from caries the most of all males in all the periods, whereas the CPR of caries in Neolithic females was the lowest of all females. On the other hand, Neolithic females were the most affected by AMTL and periodontal disease compared to both Neolithic males and the females in the following periods. Moreover, periodontal disease seems to have developed earlier in life in Neolithic females than males. Also, lesions such as abscesses and AMTL were more common in the anterior than posterior teeth in Neolithic females when compared to the males from the same period.

None of the dental pathologies were strikingly frequent in the Chalcolithic, although when the sexes were evaluated separately, AMTL was much more frequent among Chalcolithic males than in males or females from other periods. Also, the percentage of Chalcolithic males affected by periodontal disease was the highest of all males. So, after Neolithic females, Chalcolithic males suffered the condition most frequently of all individuals in the total sample. Considering only the Chalcolithic population, abscesses showed to be more common in females than males.

The EBA population had the least CPR of AMTL, but at the same time the CPR of caries was the highest among the EBA females and juveniles. EBA females were also the only females where caries were common also at a young age. The anterior teeth of EBA males were more frequently affected by all dental pathologies than the anterior dentitions of females.

From seventeen individuals with signs of periodontal disease, fifteen (88%) suffered also from antemortem tooth loss – seven from the Neolithic, seven from the Chalcolithic, and one from EBA. All but two of the individuals with this combination were older than thirty-six years. Two individuals with periodontal disease from Svodín also exhibited signs of a systemic condition, as suggested by periostitis affecting multiple bones, mostly ribs and legs (H77, H164). A similar case was observed in a male from Nižná Myšľa (H213a), affected by both periodontal disease and antemortem tooth loss, whose tibiae and fibulae were also affected by periostitis. A combination of periodontal disease with abscess, AMTL and caries occurred in six cases (35% of individuals with periodontal disease), three Neolithic and three Chalcolithic individuals. The co-occurrence of periodontal disease with caries was recorded in nine cases (53% of individuals with periodontal disease).

5.5.2. Non-specific stress indicators

Several conditions were considered under this category: dental enamel hypoplasia, periostitis that could not be related to any specific condition, *cribra orbitalia*, and cranial vault porosity including both porotic hyperostosis (PH with expansion of the diploë), and increased vault porosity with no thickening of the diploë [45].

5.5.2.1. Dental enamel hypoplasia (DEH)

Both CPRs and TPRs for DEH are provided in Table 22. The proportions of affected individuals do not vary considerably between the CPR and TPR. The overall CPR of the condition is 40.3% when individuals of the whole assemblage are considered. In general, adults were slightly more affected than children, especially in the Neolithic[46]. Males were slightly more affected than females in all three periods, although the TPRs for Chalcolithic males and females are equal. Chalcolithic adults were the least affected by the condition and Neolithic adults were the most affected. The number of affected children is highest in the EBA (Figure 44). Despite the above mentioned variations, no statistically significant differences were detected (Appendix 5, Tests 9-14).

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[45] It is necessary to mention that increased vault porosity with no thickening of the diploë may indicate healed PH, but as it is rather difficult to distinguish, it is evaluated separately.

[46] possibly because of the better preservation of adult dentitions as well as not fully developed juvenile dentitions.

	NEO		CHAL		EBA	
CPR	**NI**	**%**	**NI**	**%**	**NI**	**%**
Females	9	47.4	6	33.3	13	40.6
Males	7	50.0	10	40.0	19	43.2
Adults	16	48.5	16	37.2	32	42.1
Juveniles	8	27.6	19	37.3	25	44.6
Total	24	38.7	35	37.2	57	43.2
TPR						
Females	9	56.3	6	40.0	13	46.4
Males	7	58.3	10	40.0	19	47.5
Adults	16	57.1	16	40.0	32	47.1
Juveniles	8	36.4	19	40.4	25	52.1
Total	24	48.0	35	40.2	57	49.1

Table 22. CPRs and TPRs of DEH by period.

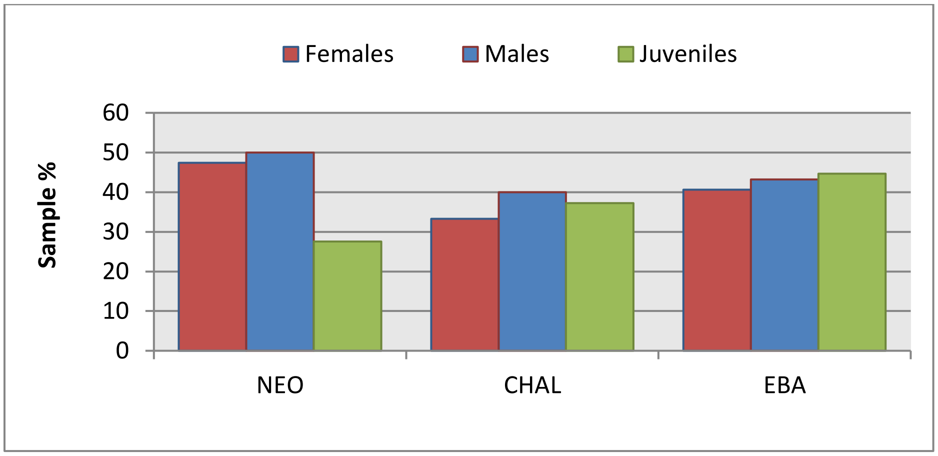

Figure 44. CPRs of DEH by sex and period.

The average age range of the occurrence of DEH is very similar in all three periods, the absolute peak being observed between the third and fourth years of age (Figure 45). Considering females, in the Neolithic, the peak occurs between ages three and five, while in the other two periods it is earlier, from two to four years. In the case of males, the peak is the same in all three periods, between ages two and four, although in the Neolithic the peak tends to be achieved slightly later, between three and four years (Figures 46 and 47).

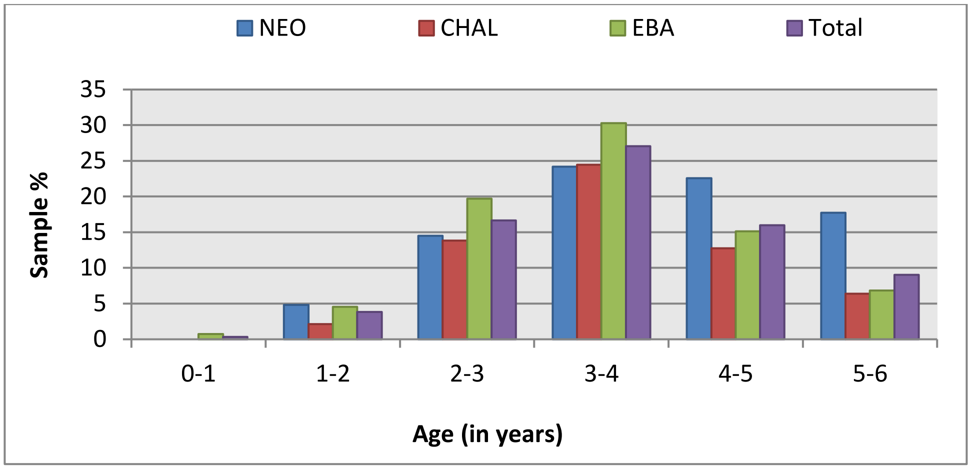

Figure 45. Age of occurrence of DEH in both juveniles and adults by period.

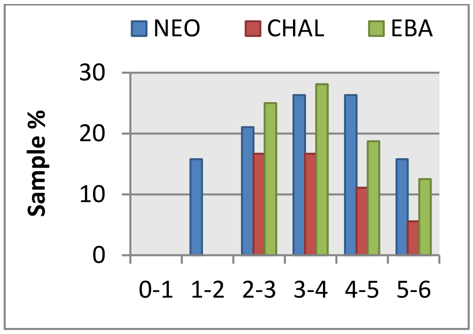

Figure 46. Age of occurrence of DEH in females.

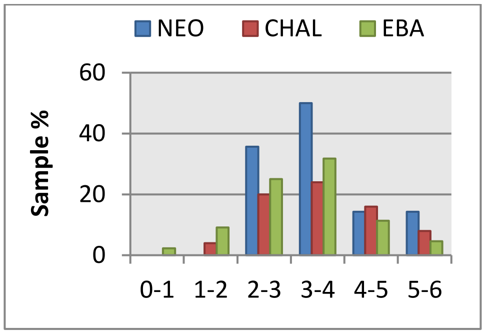

Figure 47. Age of occurrence of DEH in males.

5.5.2.2. Periostitis

Periosteal lesions other than those clearly related to trauma or a metabolic disease were present in thirty-six individuals (12.5%), including adults and subadults from all periods. The CPR is higher among the juveniles (17.6%), with only 7.9% of all adults being affected. The subadult CPR is lowest in the Chalcolithic (11.8%), whereas the same rates are indicated for Neolithic and EBA juveniles (20.7% and 21.4% respectively), with no statistical significance (χ^2=1,950; df=2; p=0,377). The adult CPRs are much higher in the Neolithic sample than it is in the following periods (15.2% *vs.* 2.3% *vs.* 7.9%, respectively). There is no difference in CPRs between the sexes of the total sample. In individual periods, periostitis is more frequent among Neolithic females than males, the trend being the opposite in the EBA. Chalcolithic males were not affected at all (Figure 48). No statistical test was performed because of the low number of affected adults. Data for non-specific periostitis are provided in Table 23.

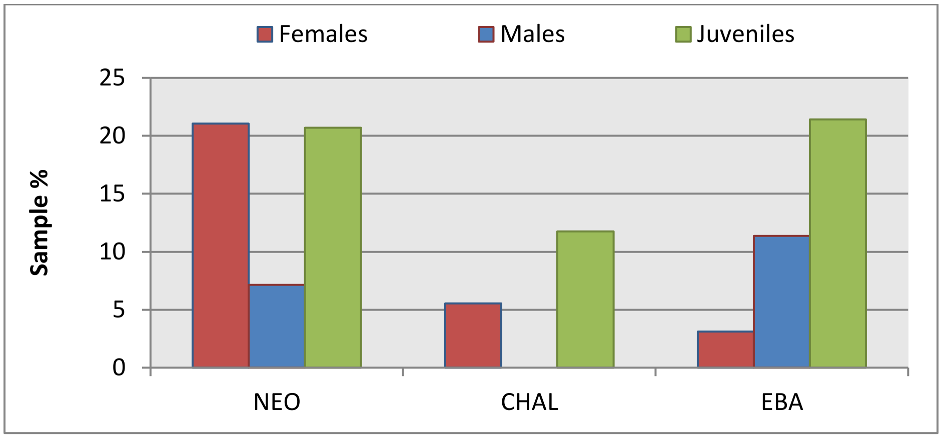

Figure 48. Overall CPRs of periostitis by sex and period.

		Females	%	Males	%	All	%
NEO	Subadults	-	-	-	-	6	20.7
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	2	22.2
	6-11	-	-	-	-	2	22.2
	12-17	-	-	-	-	2	33.3
	Adults	4	21.1	1	7.1	5	15.2
	18-24 (young)	2	40.0	0	0.0	2	33.3
	25-35 (prime)	2	28.6	1	20.0	3	25.0
	36-50 (mature)	0	0.0	0	0.0	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0
CHAL	Subadults	-	-	-	-	6	11.8
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	2	11.1
	6-11	-	-	-	-	3	17.6
	12-17	-	-	-	-	1	6.3
	Adults	1	5.6	0	0.0	1	2.3
	18-24 (young)	1	20.0	0	0.0	1	12.5
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	0	0.0	0	0.0	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0
EBA	Subadults	-	-	-	-	12	21.4
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	1	50.0
	1-5	-	-	-	-	2	14.3
	6-11	-	-	-	-	7	25.9
	12-17	-	-	-	-	2	16.7
	Adults	1	3.1	5	11.4	6	7.9
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	9.1	2	14.3	3	12.0
	36-50 (mature)	0	0.0	3	14.3	3	9.1
	50+ (old)	0	0.0	0	0.0	0	0.0

Table 23. Overall CPRs of periostitis.

5.5.2.2.1. Periostitis as an indicator of systemic conditions

Periosteal lesions located on multiple bones were recorded on twenty-seven out of thirty-six cases with periostitis, and was observed mostly on the long bones of the lower extremities (fifteen cases) or on the internal surface of ribs, indicating lung problems (five cases). More than one skeletal area was affected in seven individuals, ribs being affected almost in all of these cases (see Appendix 8). As no specific conditions could be diagnosed, these periostitis cases were considered under non-specific stress indicators. Table 24 provides CPRs for periostitis indicating systemic conditions; Figure 49 presents the most affected bones by period. Owing to the small number of affected individuals, no statistical tests were performed.

		Females	**%**	**Males**	**%**	**All**	**%**
NEO	Subadults	-	-	-	-	2	6.9
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	2	22.2
	12-17	-	-	-	-	0	0.0
	Adults	4	21.1	1	7.1	5	15.2
	18-24 (young)	2	40.0	0	0.0	0	0.0
	25-35 (prime)	2	28.6	1	20.0	0	0.0
	36-50 (mature)	0	0.0	0	0.0	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0
CHAL	Subadults	-	-	-	-	5	9.8
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	1	5.6
	6-11	-	-	-	-	3	17.6
	12-17	-	-	-	-	1	6.3
	Adults	1	5.6	0	0.0	1	2.3
	18-24 (young)	1	20.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	0	0.0	0	0.0	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0
EBA	Subadults	-	-	-	-	10	17.9
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	1	50.0
	1-5	-	-	-	-	2	14.3
	6-11	-	-	-	-	5	18.5
	12-17	-	-	-	-	2	16.7
	Adults	0	0.0	4	9.1	4	5.3
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	2	14.3	0	0.0
	36-50 (mature)	0	0.0	2	9.5	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0

Table 24. CPRs of periostitis indicating systemic conditions.

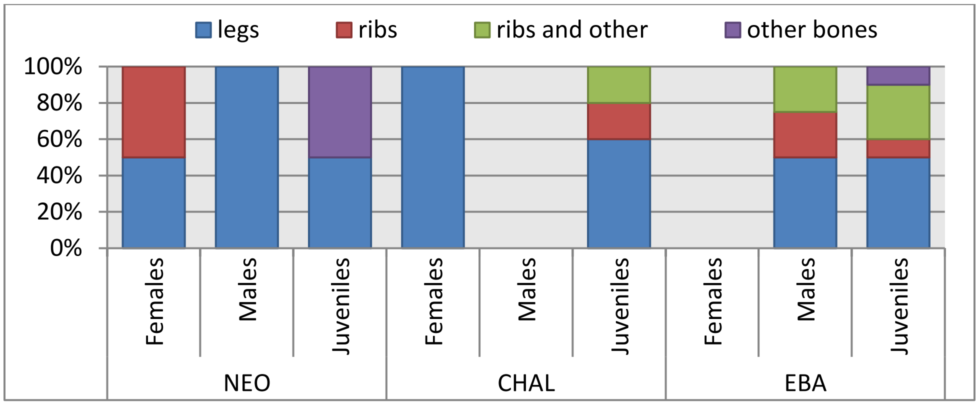

Figure 49. Skeletal areas affected by periostitis indicating systemic conditions by sex and period.

5.5.2.2.2. Periostitis as an indicator of localised infection

Non-specific periosteal lesions on single bones were noted in only three EBA adult individuals; all lesions were located on tibiae. Six more individuals – all subadults – exhibit the lesion only on one bone (see enclosed database). However, skeletal and/or bone surface preservation did not allow for more accurate estimations of the condition.

5.5.2.3. Cribra orbitalia and vault porosity

Table 25 presents CPRs for *cribra orbitalia* (CO) and cranial vault porosity with vault expansion (porotic hyperostosis) and without thickening (referred to as 'non-specific vault porosity). Apart from DEH, *cribra orbitalia* (CO) was the most frequent non-specific stress indicator (31.3%), its level being similar in all three periods. CO was most common in the Neolithic, especially among females and juveniles. The Neolithic is the only period in which females with CO were affected more frequently than males; in the other two periods more males than females were affected. Considering males, the CPRs are similar for all three periods. The CPR for EBA subadults is higher than in the previous periods (Figure 50).

The CPR of cranial vault porosity (including both PH and non-specific porosity) was significantly higher in the Neolithic (Figure 51). Adult individuals were much more frequently affected by non-specific vault porosity. The differences between males and females in individual periods are not too large, except for the Chalcolithic where porosity was much more common in males than females. As in adults, the CPR of non-specific vault porosity is the highest among Neolithic subadults.

Genuine porotic hyperostosis (PH), including the expansion of the diploë, was not a common finding. It occurs only in four Neolithic and three EBA individuals; no case was recorded in the Chalcolithic or among the subadults of any period (Table 23).

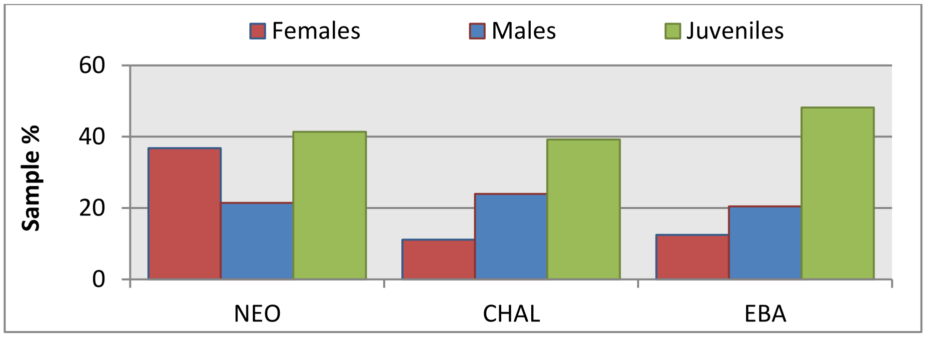

Figure 50. CPRs of CO in males, females and juveniles by period.

		Together		Females		Males		All adults		Juveniles	
		NI	%	NI	%	NI	%	NI	%	NI	%
NEO	CO	22	35.5	7	36.8	3	21.4	10	30.3	12	41.4
	PH	4	6.5	2	10.5	2	14.3	4	12.1	0	0.0
	NS vault porosity	22	35.5	10	52.6	7	50.0	17	51.5	5	17.2
	Both porosities	26	41.9	12	63.2	9	64.3	21	63.6	5	17.2
CHAL	CO	28	29.8	2	11.1	6	24.0	8	18.6	20	39.2
	PH	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	NS vault porosity	13	13.8	1	5.6	7	28.0	8	18.6	5	9.8
	Both porosities	13	13.8	1	5.6	7	28.0	8	18.6	5	9.8
EBA	CO	40	30.3	4	12.5	9	20.5	13	17.1	27	48.2
	PH	3	2.3	2	6.3	1	2.3	3	3.9	0	0.0
	NS vault porosity	20	15.2	8	25.0	11	25.0	19	25.0	1	1.8
	Both porosities	23	17.4	10	31.3	12	27.3	22	28.9	1	1.8

Table 25. CPRs of CO and cranial vault porosities (both types).

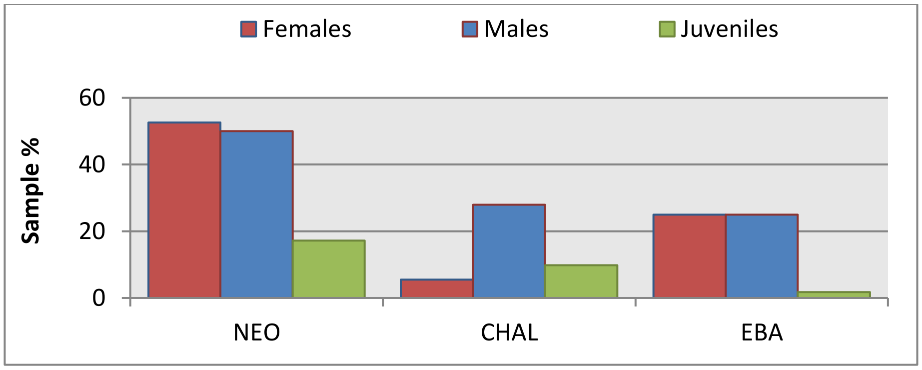

Figure 51. CPRs of non-specific vault porosity by sex and period.

Cribra orbitalia (CO) were the most frequent non-specific skeletal stress indicator in the Chalcolithic and the EBA. In these periods, vault porosity was the second most commonly recorded trait. In contrast, in the Neolithic, the frequency of vault porosity was slightly greater than CO (Figure 52). It is Neolithic adults in general who are affected by all stress indicators most frequently. Non-specific vault porosity was observed in more than a half of all Neolithic adults, while the adults of the other two periods were affected to a much lesser extent (Figure 53). CO was more common in juveniles than adults, whereas the reverse situation was detected in the case of PH and non-specific cranial porosity (Figure 53). No case of PH was recorded in subadults. There are only slight differences between males and females in individual periods, except for the Chalcolithic where non-specific vault porosity was much more common in males than females. When females are compared by period, the higher occurrence of CO and non-specific vault porosity in the Neolithic is clear. The CPR of CO among males was similar in all three periods, whereas all other stress indicators were more common in the Neolithic (Figure 53).

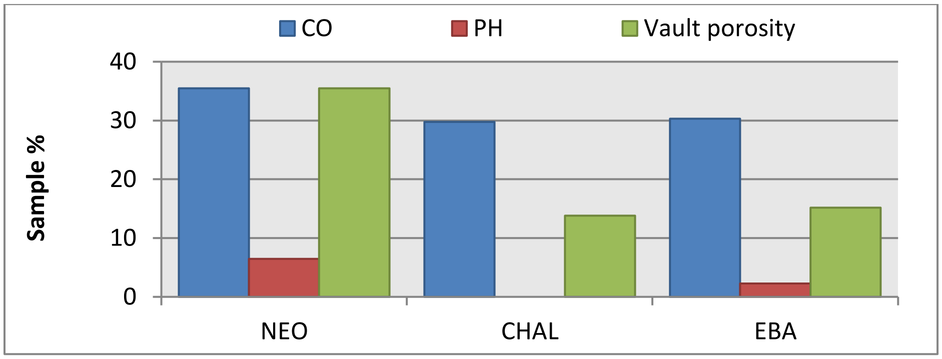

Figure 52. CPRs of individual non-specific stress indicators by period.

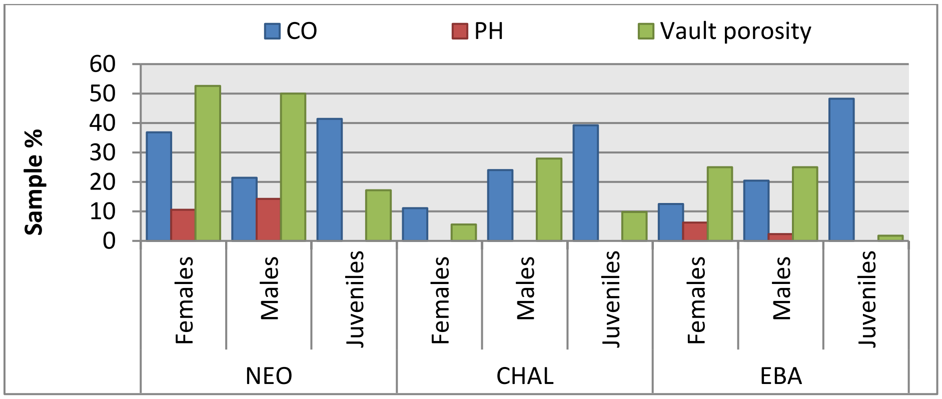

Figure 53. CPRs of individual non-specific stress indicators in males, females, and juveniles by period.

In subadults, CO was found to an equal extent in all individuals older than one year, and this is the case in all the periods. In the Neolithic and the Chalcolithic, non-specific vault porosity increases with age, whereas in the EBA only a small number of children aged one to five were affected. On the other hand, the EBA is also the only period where children younger than one year show the signs of periostitis, while in previous periods only the individuals within other age categories were affected (Figure 54).

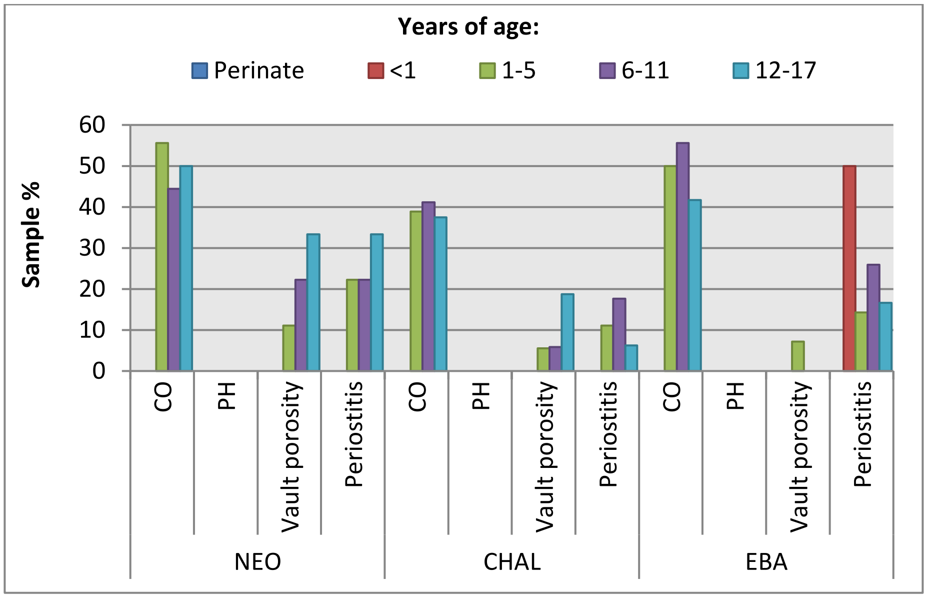

Figure 54. Age distribution of all non-specific stress indicators in subadults.

The Neolithic is the only period where young adults did not show traces of CO. On the other hand, the occurrence of the feature among those aged twenty-five to thirty-five years was the highest of all the periods. No old individuals were affected in the EBA (Figure 55). PH occurred almost exclusively in the Neolithic, and was present in all but prime adults. The only other period where the signs of PH were observed was the EBA, the majority of the cases falling into the prime age category (Figure 55). Non-specific vault porosity was fairly common in the young adult age, especially in the Neolithic and the Chalcolithic. Only a small number of EBA individuals were affected. Generally, the proportion of affected individuals in all the age categories was quite balanced in the EBA. The same situation was observed in the Neolithic, although the condition was much more common in this period, and was entirely missing among the mature individuals. In the Chalcolithic, it was mainly the young and old individuals that suffered from the condition and the number of affected individuals in other age categories was not as numerous as in the other periods (Figure 55). In the Neolithic, isolated lesions of periostitis were present in all but the mature age categories, whereas only a small number of individuals in the young adult age were affected in the Chalcolithic. No young or old adults were affected in the EBA either, the number of prime and mature individuals with the feature being also quite small in comparison to the Neolithic (Figure 55).

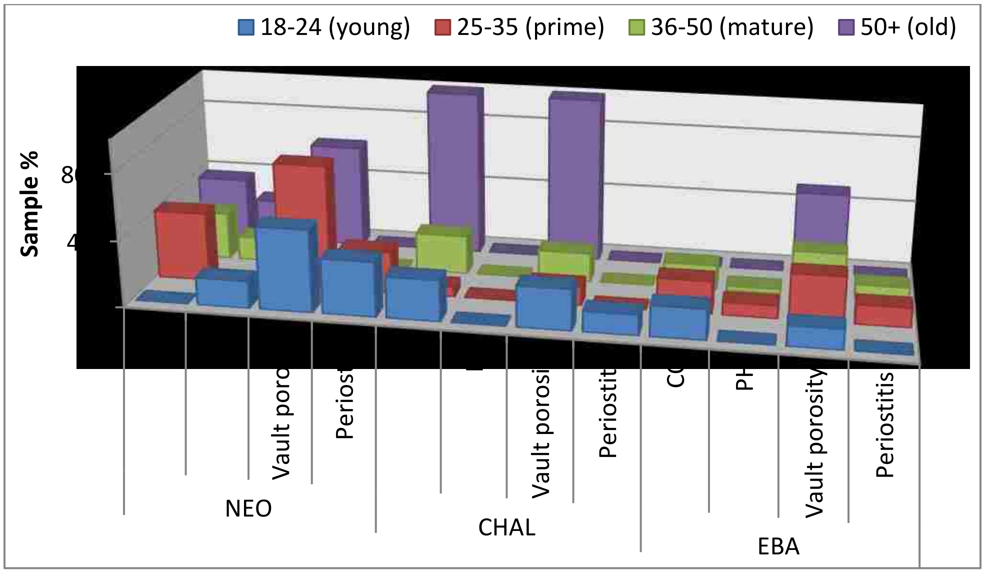

Figure 55. Age distribution of all non-specific stress indicators in adults by period.

All non-specific stress indicators among females were more frequent in younger females in the Neolithic; among males the rate was higher in those of older age. Similarly, in the Chalcolithic, among females, only young females were affected by all of the indicators, whereas among males it was mostly mature and old males that showed the signs of CO and vault porosity, the only features observed in Chalcolithic males. The differences between the distributions of the conditions by age were not large when EBA males and females were considered. Considering females, it was mostly young and prime aged females who were affected by all the traits in the Neolithic and the Chalcolithic, whereas in the EBA the general number of affected females was rather low and the conditions were found in all but the old age category (Figure 56).In males the trend seems to be rather the opposite, with no males suffering from any of the conditions in their young age in the Neolithic, but more young males being affected by vault porosity in the Chalcolithic, and by vault porosity and CO in the EBA. On the other hand, the number of affected mature and old males was higher in the first two periods, their numbers decreasing in the EBA when individuals in individual age categories were affected into a similar extent (Figure 57).

These indicators suggest that health was worst in the Neolithic period. In this period, the non-specific stress indicators prevailed in all adults, more so in females. What is more, females were also highly affected from a young age. In comparison to the Neolithic, it was the subadults whose bones showed the majority of the non-specific stress indicators in the Chalcolithic and the EBA. Neolithic adolescents were the most numerous of all the adolescents with the non-specific stress indicators. The EBA was the only period where children under one year were affected.

Six individuals with periosteal lesions indicating systemic stress were accompanied by dental pathologies such as periodontal disease, abscesses, advanced AMTL or a combination of the three (Svodín H77, H124, H164, Nižná Myšľa H98, H213a, H261). Of these, additional pathologies were observed only in two males from Nižná Myšľa (H98 and H213a, both older than thirty-six years), not all necessarily related to the occurrence of periostitis. In addition to advanced AMTL and caries, vault porosity and a calcified cyst on the right parietal roof were observed on the skeleton of the male, H98. Moreover, he also suffered from probable rotator cuff disease on both humeri, a labrum tear of the right acetabulum, and a possible spinal deformation suggested by a slightly laterally tilted sacrum. The man was robust, with obvious enthesopathies at the costo-clavicular ligament insertion and at the elbows. The male, H213 a suffered mostly from dental diseases (severe AMTL, abscess, periodontal disease), and in addition, his fifth lumbar vertebra was unilaterally fused to the sacrum, possibly caused by a trauma. He also exhibited other signs of trauma, such as a healed fracture of the left femur. With the exception of Schmorl’s nodes and a perimortem cut on one of his ribs, a prime male from Praha – Malá Ohrada (8783b) was affected only by periostitis. However, a thick layer of woven bone was observed on multiple bones of the postcranial skeleton, namely the ribs, right clavicle, left os coxa, and the shins.

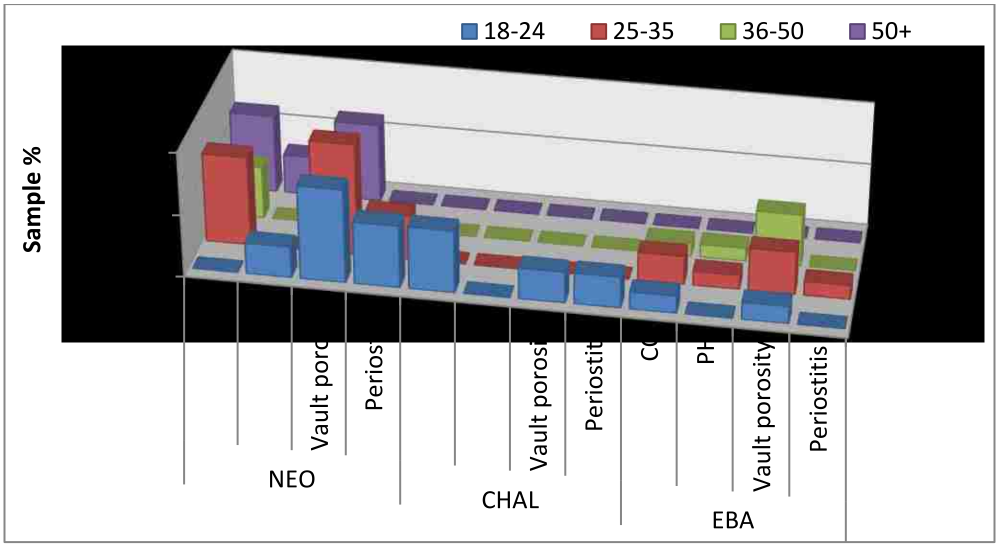

Figure 56. Age distribution of all non-specific stress indicators in females by period.

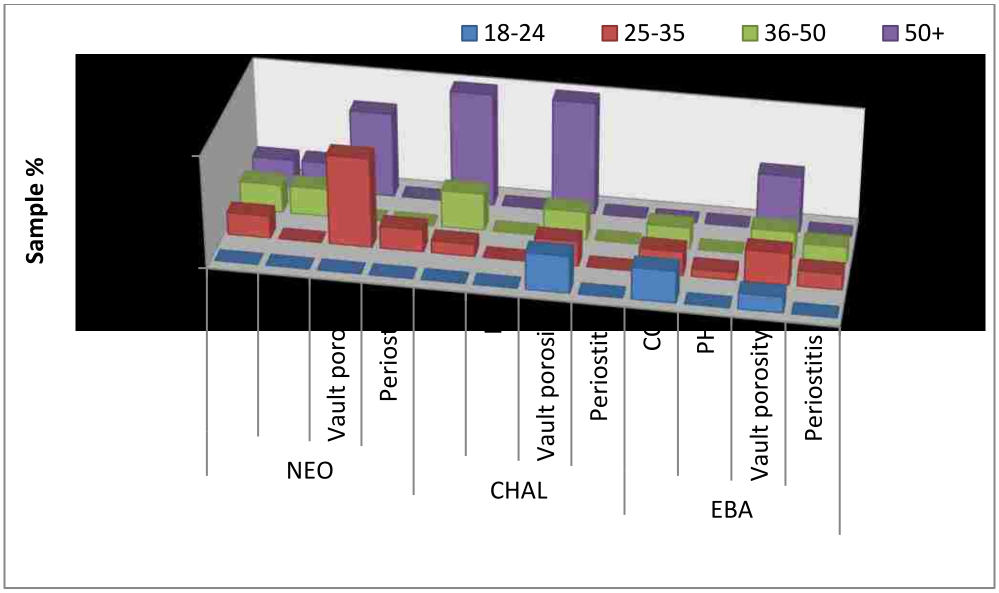

Figure 57. Age distribution of all non-specific stress indicators in males by period.

5.5.3. Metabolic diseases

Lesions suggestive of metabolic diseases such as osteopenia/osteoporosis, scurvy, and rickets/osteomalacia were observed. All of the cases mentioned below are probable cases of the individual conditions. The number of individuals affected by all metabolic diseases was rather low and thus not statistically evaluated.

Only 9% of individuals showed traces of metabolic diseases, the greatest proportion being affected by bone loss (Table 26). The occurrence of metabolic diseases seems to decrease from the Neolithic to the EBA, with the Neolithic adult population suffering considerably more often than individuals from the later periods. In general, metabolic diseases prevailed in adults, and more so in males than females. The smallest differences between both sexes and the juveniles were detected in the EBA (Figure 58).

Period	Together		Females		Males		All adults		Juveniles	
	NI	%	NI	%	NI	%	NI	%	NI	%
NEO	11	17.7	4	21.1	5	35.7	9	27.3	2	6.9
Osteop	6	9.7	3	15.8	3	21.4	6	18.2	0	0.0
Scurvy	3	4.8	1	5.3	2	14.3	3	9.1	0	0.0
Rickets	2	3.2	0	0.0	0	0.0	0	0.0	2	6.9
CHAL	7	7.4	2	11.1	4	16.0	6	14.0	1	2.0
Osteop	3	3.2	0	0.0	3	12.0	3	7.0	0	0.0
Scurvy	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Rickets	4	4.3	2	11.1	1	4.0	3	7.0	1	2.0
EBA	8	6.1	2	6.3	3	6.8	5	6.6	3	5.4
Osteop	1	0.8	0	0.0	1	2.3	1	1.3	0	0.0
Scurvy	6	4.5	1	3.1	2	4.5	3	3.9	3	5.4
Rickets	1	0.8	1	3.1	0	0.0	1	1.3	0	0.0
All periods	26	9.0	8	11.6	12	14.5	20	13.2	6	4.4
Osteop	10	3.5	3	4.3	7	8.4	10	6.6	0	0.0
Scurvy	9	3.1	2	2.9	4	4.8	6	3.9	3	2.2
Rickets	7	2.4	3	4.3	1	1.2	4	2.6	3	2.2

Table 26. CPRs of metabolic diseases by period. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

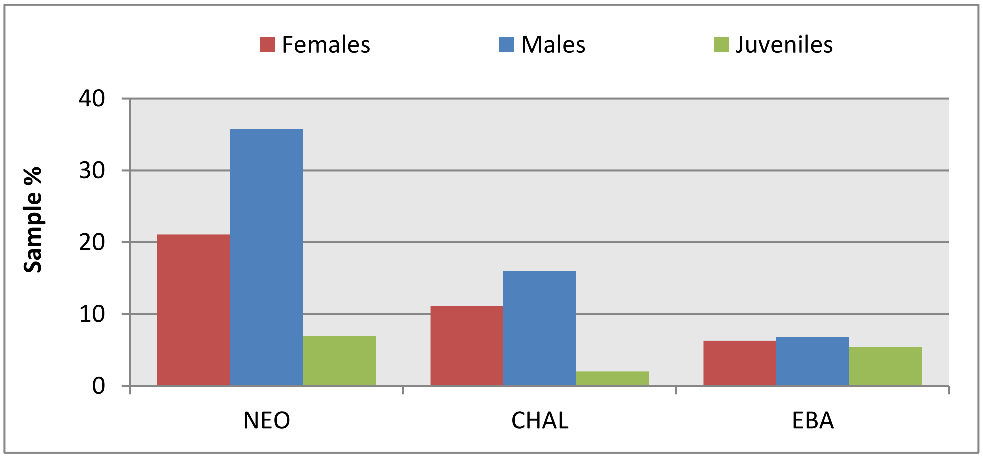

Figure 58. CPRs of metabolic diseases in males, females and juveniles by period.

Among juveniles, children younger than one year did not show any signs of metabolic disease, the highest prevalence rate of metabolic diseases were detected between the ages of one to five years, and then in adolescents. The number of affected subadults was very small, so the situation in individual periods could not be assessed accurately. However, the percentage of affected Neolithic and EBA juveniles was highest in adolescents, while in the Chalcolithic only one child, aged one to five years, was affected (Figure 59).

In adults, it was mostly old individuals that show signs of metabolic diseases. The level of occurrence is similar in young and mature adults, the lowest rate being recorded in the prime age category. Similar to subadult remains, the overall number of adult individuals with a metabolic disease is rather small, thus the results for individual periods are only informative rather than strongly indicative. The prevalence of the conditions was higher in older individuals of the Neolithic and the EBA, individuals in the Chalcolithic being affected equally in the young and mature age categories (Figure 59).

In the Neolithic, only young and old females were affected by a metabolic disease, in contrast to males who showed the signs of metabolic disease quite significantly after the age of twenty-five. Despite the fact that metabolic diseases are more common in Chalcolithic males rather than females, both sexes were affected in the young and mature age categories. At the same time, Chalcolithic individuals were the only ones where both sexes were affected in young adulthood. The only period when neither young males nor young females suffered from a metabolic disease is in the EBA, the diseases notably prevailing in old males (Figure 60).

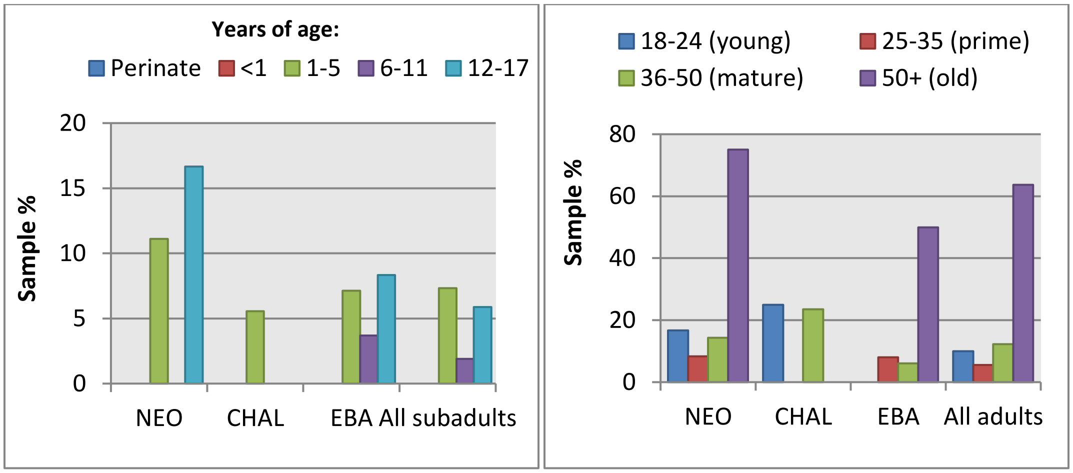

Figure 59. Percentages of juvenile (left) and adult (right) individuals with signs of metabolic disease by age.

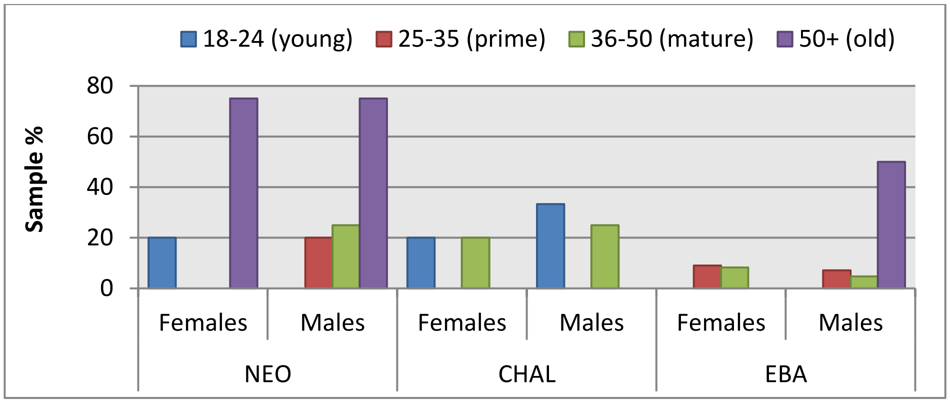

Figure 60. Percentages of male and female individuals with evidence of a metabolic disease by age.

Osteopenia/osteoporosis were the commonest metabolic conditions in the overall sample, although it was only the adult population that was affected (Figure 61). Altogether, ten individuals showed the signs of osteopenia/osteoporosis. Scurvy was the next most frequent metabolic disease and was found in nine skeletons, three subadults and six adults. Signs of rickets/osteomalacia were present on seven individuals, four adults and three juveniles. The occurrence of individual diseases in individual periods differed, osteopenia/osteoporosis being the most frequent in the Neolithic, rickets being most common in the Chalcolithic, and scurvy in the EBA. All in all, it is the Neolithic population that suffered most from all the metabolic diseases in general (Figure 62).

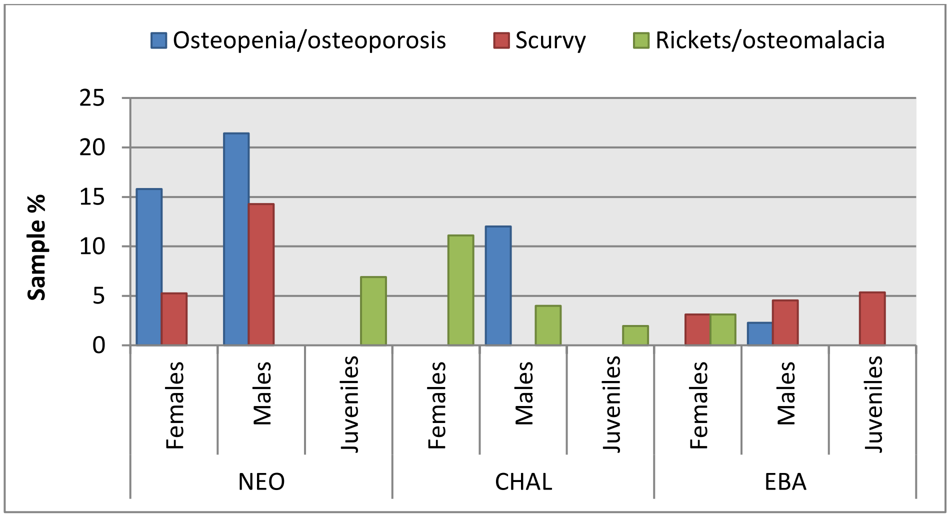

Figure 61. Percentage prevalence rates of all metabolic diseases in males, females, and juveniles by period.

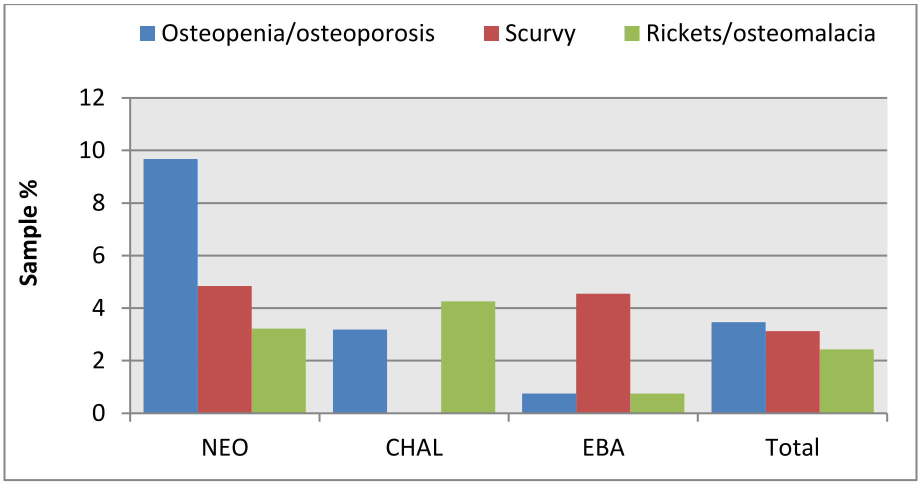

Figure 62. Percentage prevalence rates of all metabolic diseases by period.

The metabolic diseases of subadults include only scurvy and rickets. However, it is only in the EBA period when scurvy occurred. At the same time, no signs of rickets were detected in the EBA juvenile population. On the contrary, Neolithic subadults seem to have been affected only by rickets, as were the subadults in the Chalcolithic, even though there were fewer cases in the later period (Figure 61). In the Neolithic and Chalcolithic, signs of rickets were recorded predominantly in juveniles aged one to five years, although only in the Neolithic does it also occur in adolescents quite significantly. Juvenile scurvy was recorded only in the EBA when children of all ages were affected (Figure 63). However, small number of affected individuals needs to be borne in mind.

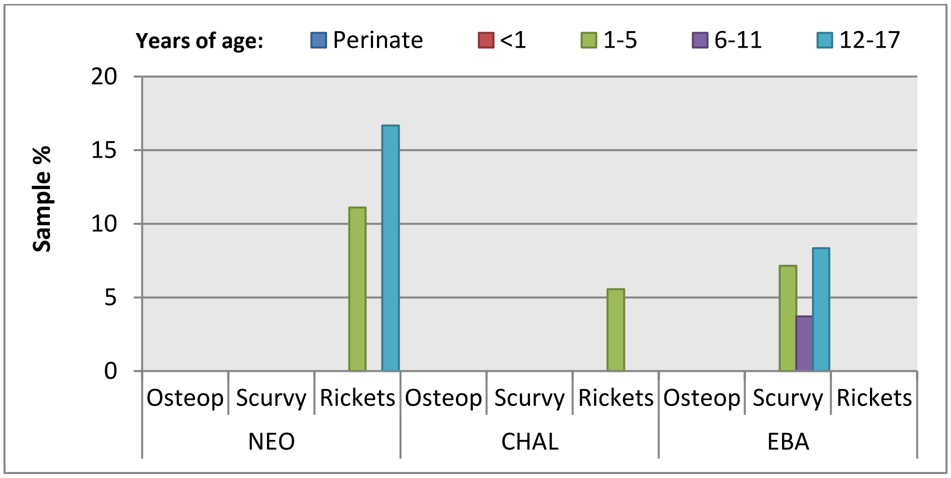

Figure 63. Percentage occurrences of individual metabolic diseases in subadults by age. Osteop = osteoporosis/osteopenia.

The most frequent metabolic disease in adult individuals was osteopenia/osteoporosis, followed by scurvy, and healed rickets. Most cases of osteopenia were detected in the Neolithic and the least in the EBA. In the Neolithic and Chalcolithic, osteopenia was commoner in male individuals. Scurvy in adult individuals is most frequently indicated in the Neolithic, then in the EBA, Chalcolithic individuals being unaffected by this condition. Males are, again, more affected than females. Signs of healed rickets are the most frequent in the Chalcolithic, affecting mostly females. In the EBA it is only female individuals who show the signs of healed rickets, with no males suffering from the condition (Figure 61). In adults, osteoporosis is commonest in old age, in both sexes in the Neolithic, and in EBA males, Chalcolithic males suffering from the condition earlier in life. From females, only Neolithic women were affected by the condition (Figure 64). In the case of scurvy, it is the individuals in the earlier stages of adulthood that show the signs of scurvy more frequently than those in old age. Considering females, in the Neolithic, only young females were affected, whereas scurvy is commoner in mature EBA females. Affected males in both periods where scurvy was recorded (the Neolithic and EBA) were in their prime or mature stages of adulthood, the condition being commoner in the Neolithic (Figure 64). Similar to scurvy, signs of healed rickets were recorded mostly in young adults, especially in the Chalcolithic, males being affected more than females. This was the only age category where males were affected, while mature females were also affected. No individuals suffered from the condition in the Neolithic, and it is only a few females of prime age who show the signs of this metabolic disease in the EBA (Figure 64).

Three out of nine (33%) individuals with possible scurvy also suffered from healed fractures. In Svodín, a young female (H113) exhibited a healed fracture of the humeral shaft (Appendix 6, Figure 107), and a mature male (H27) had a fractured shaft of the fibula and also had evidence of porotic hyperostosis (Appendix 6, Figure 106). A mature female from Nižná Myšľa (H253) had a healed rib fracture and signs of spinal deformation. In addition to these three individuals, a prime male from Svodín had suffered from possible scurvy (H3), and cysts of unknown origin were observed on his femoral and metatarsal necks (Appendix 6, Figure 109). Individuals suffering from probable osteopenia/osteoporosis also suffered from other bone degenerative or age-related changes such as ossification of tendons (Sulejovice 1820; Appendix 6, Figure 108), osteoarthritis (for example, Svodín H122, H169; Appendix 6, Figure 109), possible ankylosing spondylitis (Stehelceves 3839, Nižná Myšľa H19; Appendix 6, Figure 110), or periodontal disease (Svodín H6, H41; Appendix 6, Figure 111).

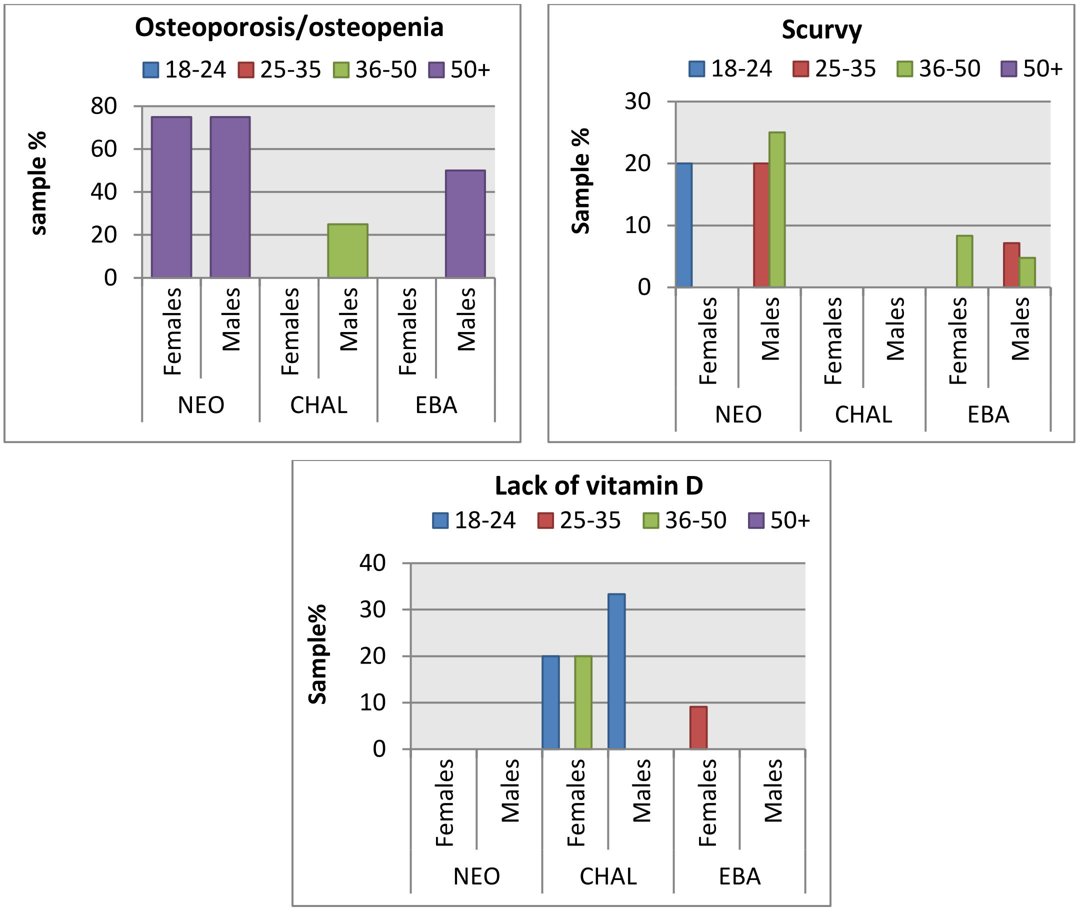

Figure 64. Percentage occurrences of individual metabolic diseases in adults by age and sex.

5.5.4. Joint diseases

5.5.4.1. Spinal joint diseases

Three main conditions were considered within the spinal joint disease category: osteoarthritis (OA), osteophytosis, and Schmorl's nodes. None of the conditions was discovered on subadult remains, and the CPRs provided below refer solely to adult populations from individual periods. Cases of OA secondary to trauma are not included here, but are considered within the trauma section.

Spinal joint disease is very frequent in the overall sample, detected in more than a half of all adults (Table 27). The Neolithic population suffered from spinal joint disease the least, the EBA population the most, but the difference is not statistically significant (although χ^2=5.333; df=2; p=0.069). Males were more affected than females in all three periods

(Figure 65). However, the difference between CPRs obtained for males and females were not statistically significant in any of the three periods (Appendix 5, Tests 15-17).

		Females	%	Males	%	Total	%
NEO	Together	6	31.6	7	50.0	13	39.4
	18-24 (young)	1	20.0	0	0.0	1	16.7
	25-35 (prime)	2	28.6	1	20.0	3	25.0
	36-50 (mature)	1	33.3	3	60.0	4	50.0
	50+ (old)	2	50.0	3	100.0	5	71.4
CHAL	Together	5	27.8	14	56.0	19	44.2
	18-24 (young)	1	20.0	1	33.3	2	25.0
	25-35 (prime)	2	25.0	3	33.3	5	29.4
	36-50 (mature)	2	40.0	9	75.0	11	64.7
	50+ (old)	0	0.0	1	100.0	1	100.0
EBA	Together	17	53.1	29	65.9	46	60.5
	18-24 (young)	2	22.2	3	42.9	5	31.3
	25-35 (prime)	4	36.4	9	64.3	13	52.0
	36-50 (mature)	11	91.7	15	71.4	26	78.8
	50+ (old)	0	0.0	2	100.0	2	100.0
All periods	Together	28	40.6	50	60.2	78	51.3
	18-24 (young)	4	21.1	4	36.4	8	26.7
	25-35 (prime)	8	30.8	13	46.4	21	38.9
	36-50 (mature)	14	70.0	27	71.1	41	70.7
	50+ (old)	2	50.0	6	100.0	8	80.0

Table 27. CPRs of spinal joint disease in adults. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

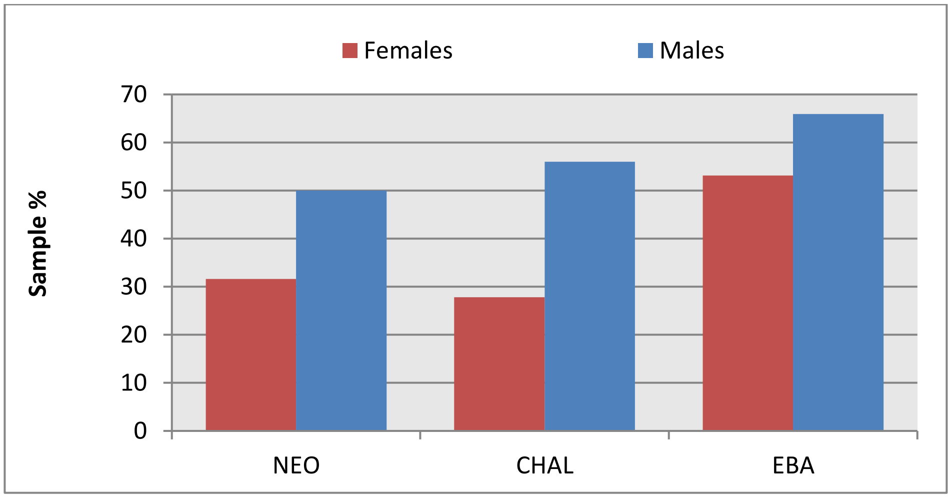

Figure 65. CPRs of spinal joint disease in males and females by period.

The prevalence of overall spinal disease is age-dependent in all three periods. This trend is the same when individual sexes are considered separately. The highest difference between the number of affected females and males was recorded in individuals older than fifty, males being affected more than females. However, this may a result of the low numbers of old females in the sample. In the Neolithic, females were more frequently affected in the young adult age category, whereas males of mature and old age dominate. In the other two periods, both females and males exhibited spinal lesions from young adult age. As in the Neolithic, CPRs of spinal joint disease in mature and old age categories are higher in males than females. When females of individual periods are compared, it is only in the Neolithic when old females were found to suffer from spinal joint disease. However, as suggested above, this is probably influenced by the low numbers of old females in the Chalcolithic and the EBA samples. Young adult Neolithic males did not show any signs of spinal joint disease, unlike the Chalcolithic and EBA when the CPRs of males were generally higher. This is also the case in the prime age category (Figure 66).

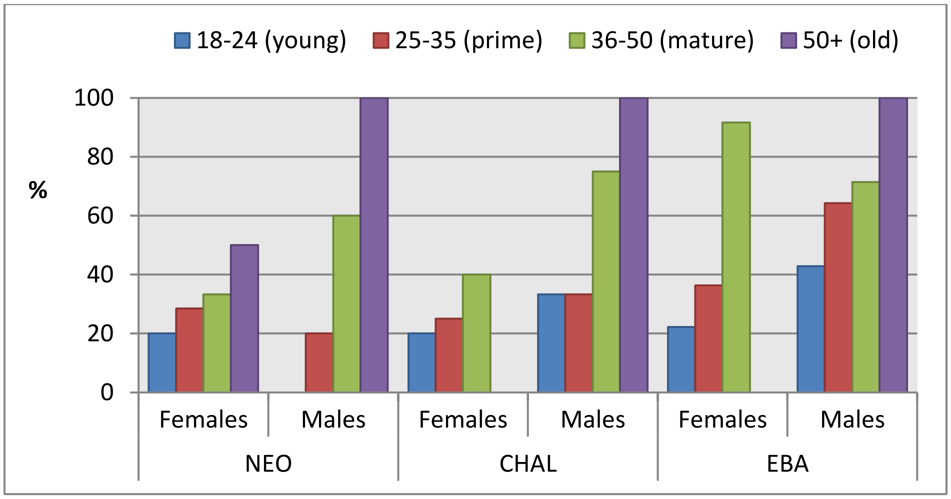

Figure 66. CPRs of spinal joint diseases in males and females by age category.

5.5.4.1.1 Spinal osteoarthritis

Altogether, eighteen individuals, 11.8% of the whole sample, were affected by spinal osteoarthritis[47]: twelve males (14.5%) and six females (8.7%). The lowest number of affected individuals comes from the Chalcolithic, whereas CPRs for the Neolithic and EBA samples are similar (Table 28). In the Neolithic, only males were affected. In the other two periods,

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[47] In this thesis, spinal osteoarthritis refers to osteoarthritis of the facet joints.

the CPRs for males and females are similar, although more males were affected in the Chalcolithic, and more females in the EBA. In other words, while in females the CPRs increase proportionally from the Neolithic to the EBA, Neolithic males were affected far more frequently than their counterparts from the other two periods (Figure 67). Owing to the small number of individuals with the condition, no statistical tests were performed.

		Females	%	Males	%	Total	%
NEO	Together	0	0.0	4	28.6	4	12.1
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	0	0.0	2	40.0	2	25.0
	50+ (old)	0	0.0	2	66.7	2	28.6
CHAL	Together	1	5.6	2	8.0	3	7.0
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	1	20.0	1	8.3	2	11.8
	50+ (old)	0	0.0	1	100.0	1	100.0
EBA	Together	5	15.6	6	13.6	11	14.5
	18-24 (young)	1	11.1	0	0.0	1	6.3
	25-35 (prime)	2	18.2	0	0.0	2	8.0
	36-50 (mature)	2	16.7	5	23.8	7	21.2
	50+ (old)	0	0.0	1	50.0	1	50.0
All periods	Together	6	8.7	12	14.5	18	11.8
	18-24 (young)	1	5.3	0	0.0	1	3.3
	25-35 (prime)	2	7.7	0	0.0	2	3.7
	36-50 (mature)	3	15.0	8	21.1	11	19.0
	50+ (old)	0	0.0	4	66.7	4	40.0

Table 28. CPRs of spinal osteoarthritis. % = percentage of individuals in a given category.

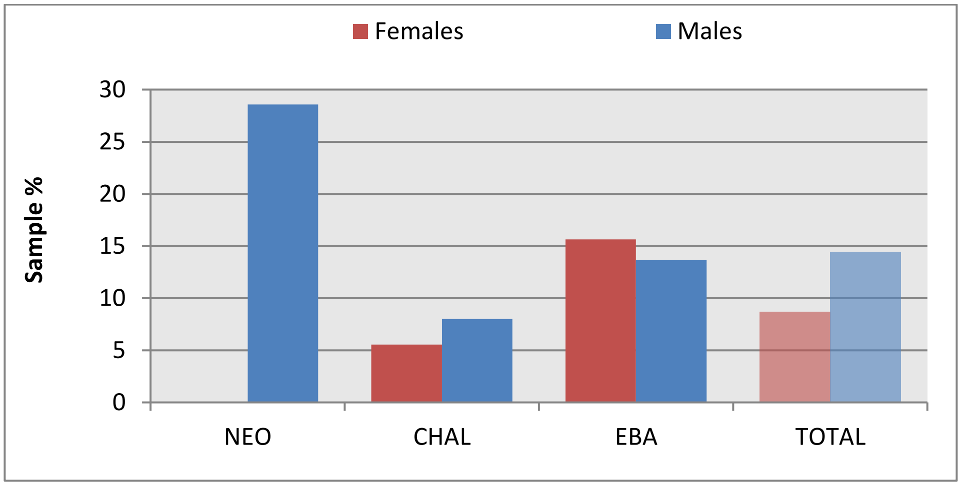

Figure 67. CPRs of spinal osteoarthritis. % = percentage of all individuals with the condition in the category.

The older the age, the more frequent spinal osteoarthritis was. However, in addition to the highest CPR of spinal osteoarthritis among EBA females, these women were also the only ones to be affected in the young and prime age adult age categories. Otherwise, the condition was present only in individuals older than thirty-six (Figure 68).

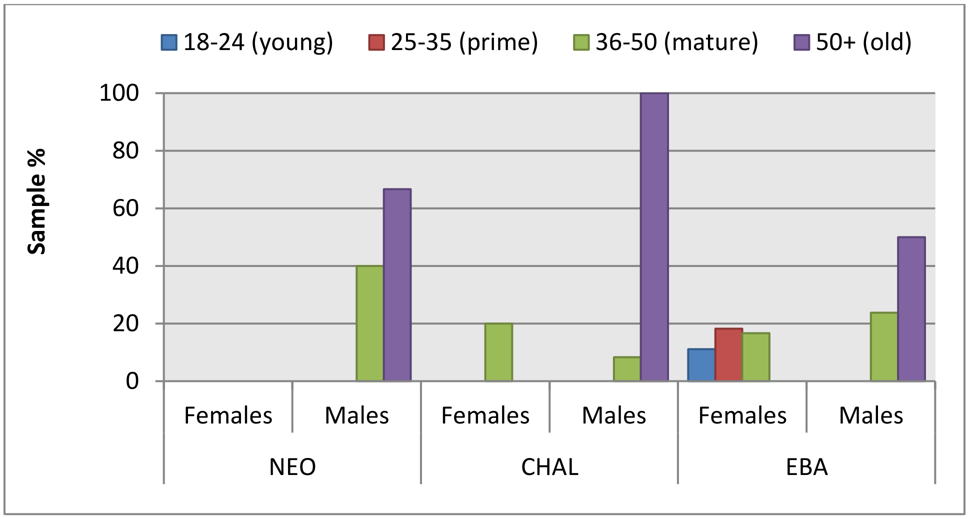

Figure 68. CPRs of spinal osteoarthritis in males and females by age category.

Of all individuals suffering spinal osteoarthritis, the vast majority of affected vertebrae were those of the cervical spine, followed by the thoracic and lumbar areas. However, when the sexes were assessed separately, differences between prevalence rates according to spinal region were evident. While Neolithic females were not affected by spinal osteoarthritis at all, males suffered the condition in all three spinal regions, the cervical area being affected the most of all males and in all individuals in general. In Chalcolithic females, only the cervical spine was affected, as in the case of Chalcolithic males. As mentioned above, the spinal osteoarthritis prevalence rate in female individuals was highest in the EBA. These females showed spinal osteoarthritis predominantly in their thoracic region, although the condition was present quite frequently also in cervical area. Males suffered from the condition in all three periods, the cervical area being the most usual region where the osteoarthritis occurred, the rate of osteoarthritis decreasing from the cervical to the lumbar areas. No thoracic and lumbar areas were affected in Chalcolithic males (Table 29, Figure 69).

NEO	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	4	12.1	0	0.0	4	28.6
Thoracic	1	3.0	0	0.0	1	7.1
Lumbar	1	3.0	0	0.0	1	7.1
CHAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	3	7.0	1	5.6	2	8.0
Thoracic	0	0.0	0	0.0	0	0.0
Lumbar	0	0.0	0	0.0	0	0.0
EBA	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	6	7.9	2	6.3	4	9.1
Thoracic	6	7.9	3	9.4	3	6.8
Lumbar	1	1.3	0	0.0	1	2.3
TOTAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	13	8.6	3	4.3	10	12.0
Thoracic	7	4.6	3	4.3	4	4.8
Lumbar	2	1.3	0	0.0	2	2.4

Table 29. CPRs[48] of spinal osteoarthritis by spinal region. NI = number of individuals affected; % = percentage of all individuals in the category.

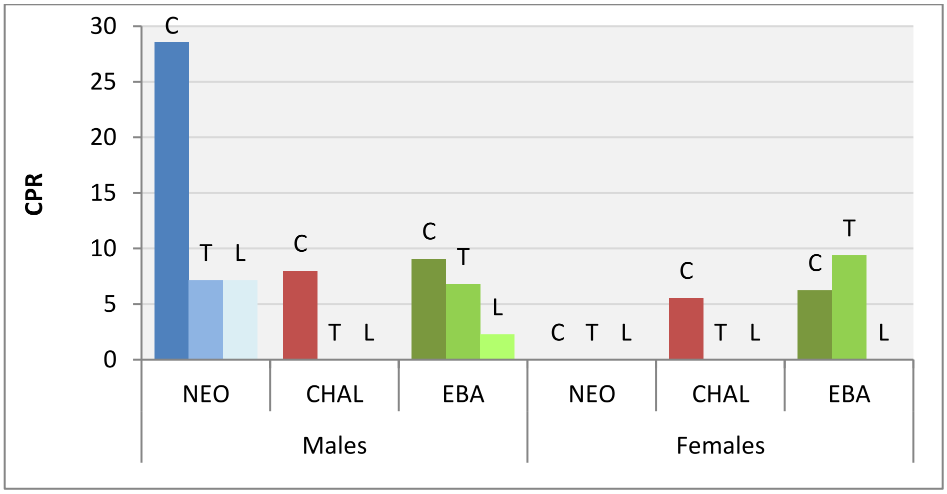

Figure 69. CPRs of spinal osteoarthritis by region. C = cervical; T = thoracic; L = lumbar; % = percentage of affected individuals.

5.5.4.1.2 *Vertebral osteophytosis*

Similar to spinal osteoarthritis, osteophytosis of vertebral bodies was only recorded in adult individuals. The overall CPR is 36.8% and the rates do not vary considerably between the periods, although prevalence rates are slightly smaller in the Neolithic. Table 30 provides CPRs for all adults by age and period.

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[48] calculated from all individuals in the category

		Females	%	Males	%	Total	%
NEO	Together	4	21.1	6	42.9	10	30.3
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	14.3	0	0.0	1	8.3
	36-50 (mature)	1	33.3	3	60.0	4	50.0
	50+ (old)	2	50.0	3	100.0	5	71.4
CHAL	Together	3	16.7	14	56.0	17	39.5
	18-24 (young)	0	0.0	1	33.3	1	12.5
	25-35 (prime)	1	12.5	3	33.3	4	23.5
	36-50 (mature)	2	40.0	9	75.0	11	64.7
	50+ (old)	0	0.0	1	100.0	1	100.0
EBA	Together	12	37.5	17	38.6	29	38.2
	18-24 (young)	1	11.1	0	0.0	1	6.3
	25-35 (prime)	3	27.3	2	14.3	5	20.0
	36-50 (mature)	8	66.7	13	61.9	21	63.6
	50+ (old)	0	0.0	2	100.0	2	100.0
All periods	Together	19	27.5	37	44.6	56	36.8
	18-24 (young)	1	5.3	1	9.1	2	6.7
	25-35 (prime)	5	19.2	5	17.9	10	18.5
	36-50 (mature)	11	55.0	25	65.8	36	62.1
	50+ (old)	2	50.0	6	100.0	8	80.0

Table 30. CPRs of spinal osteophytosis in adults. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

The greatest contrast between the sexes was recorded in the Chalcolithic sample, with significantly more males suffering from osteophytosis than females. Almost no difference between males and females is observed in EBA. From the total number of females, osteophytosis clearly prevails among EBA women. As regards male individuals, the CPR for Chalcolithic males is the highest of all males, whereas Neolithic and Bronze Age males were affected into a similar extent (Figure 70).

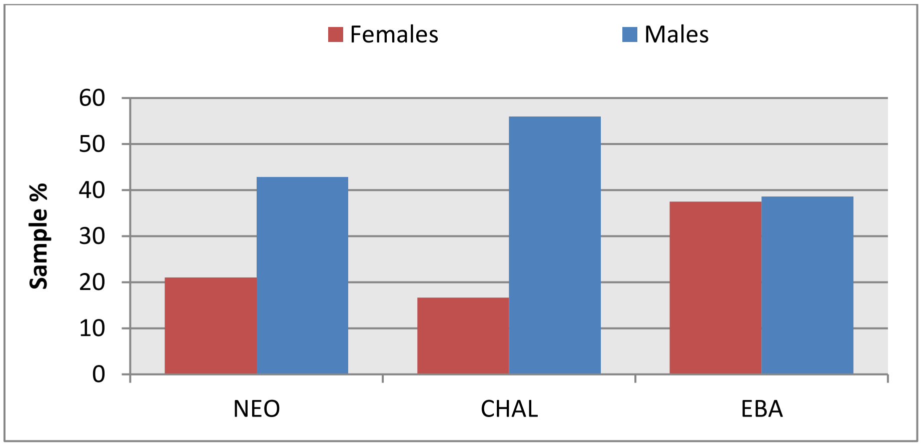

Figure 70. CPRs of spinal osteophytosis in males and females by period.

Osteophytosis was more frequent with older age. Neolithic females showed the condition from a younger age than Neolithic males. On the contrary, osteophytosis in Chalcolithic males occurred also in the young adult age, while Chalcolithic females were affected only from the age of twenty-five. In the EBA, as in the Neolithic, females were affected from a much younger age than males from the same period (Figure 71). While Neolithic males were not affected by the condition until mature age, Chalcolithic males showed the feature in all the age categories. All but the youngest adult males were affected in the EBA. Of all females, those from the EBA were the only ones affected from a young adult age. This may be why the CPR of osteophytosis among EBA women was extremely high in mature age (Figure 71), as the stress on the spine probably started very early in life.

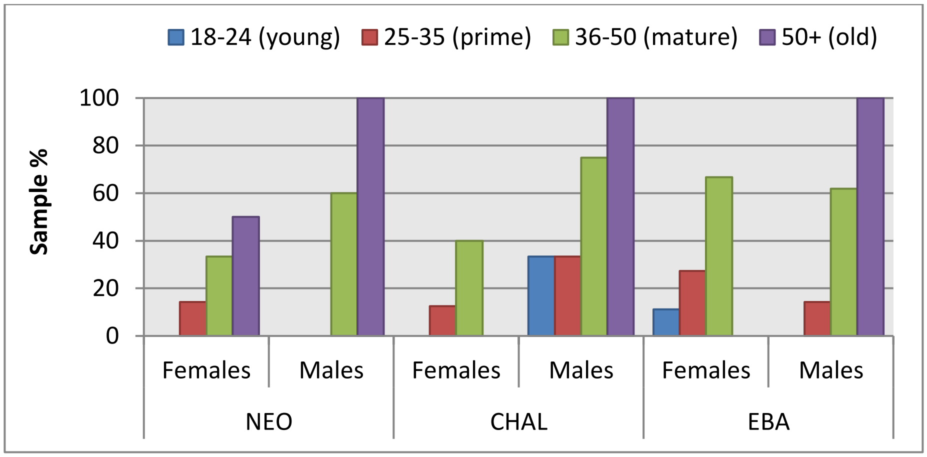

Figure 71. CPRs of spinal osteophytosis in males and females by age category.

Unlike spinal osteoarthritis affecting mostly the cervical spine, osteophytosis was more pronounced down the spine, the lumbar area being affected the most. This trend was similar in both sexes (Table 31), although when individual periods were considered, differences were noticed.

In the Neolithic, no osteophytosis in the cervical area was recorded among females, whereas the CPR for cervical osteophytosis was quite high in Neolithic males. Lumbar vertebrae were the most commonly affected by osteophytosis in Neolithic individuals of both sexes. Chalcolithic females were the only females in whom osteophytosis was more common in the thoracic rather than lumbar region. In males, the occurrence of cervical osteophytosis had a decreasing tendency from the Neolithic to the EBA. The situation is different for thoracic and lumbar spinal regions. While the former was affected the most in the Chalcolithic and least in the Neolithic, mainly Neolithic males suffered from lumbar osteophytosis and Chalcolithic males were affected the least. To summarise, in Neolithic males the CPR of osteophytosis was the highest in the cervical and lumbar areas, while osteophytosis prevailed in the thoracic region of Chalcolithic males. The distribution of osteophytes was quite balanced in EBA males, the cervical region being affected the least, and lumbar area the most frequently (Figure 72).

NEO	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	4	12.1	0.0	0.0	4	28.6
Thoracic	4	12.1	1	5.3	3	21.4
Lumbar	9	27.3	3	15.8	6	42.9
CHAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	7	16.3	1	5.6	6	24.0
Thoracic	11	25.6	2	11.1	9	36.0
Lumbar	8	18.6	1	5.6	7	28.0
EBA	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	13	17.1	3	9.4	10	22.7
Thoracic	17	22.4	5	15.6	12	27.3
Lumbar	22	28.9	9	28.1	13	29.5
TOTAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	24	15.8	4	5.8	20	24.1
Thoracic	32	21.1	8	11.6	24	28.9
Lumbar	39	25.7	13	18.8	26	31.3

Table 31. CPRs of spinal osteophytosis by spinal region. NI = number of individuals affected; % = percentage of all individuals in the category.

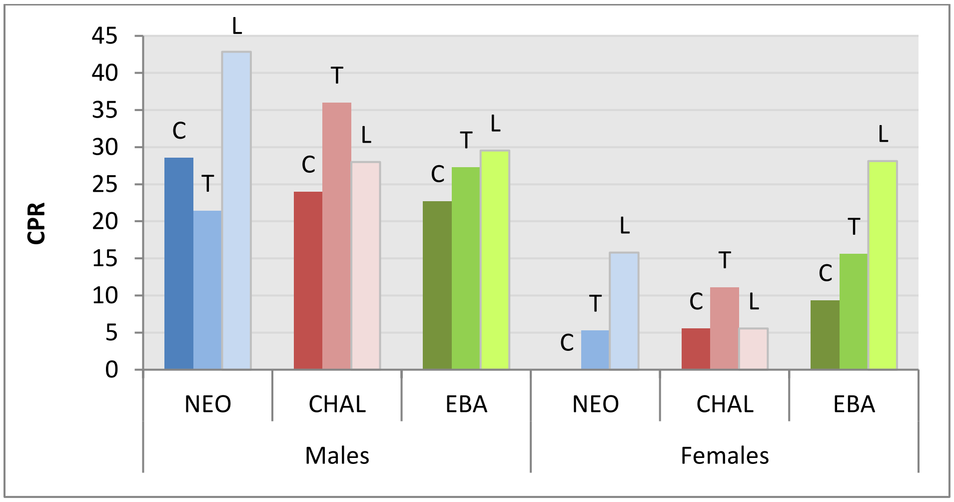

Figure 72. CPRs[49] of spinal osteophytosis by spinal region. C = cervical; T = thoracic; L = lumbar; % = percentage of affected individuals.

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[49] calculated from all individuals

5.5.4.1.3 Schmorl's nodes

No Schmorl's nodes were observed in subadults. In adults, the total CPR is 35.5% of all 102 individuals. The occurrence of Schmorl's nodes was revealed to be dependent on period, being the lowest in the Neolithic and highest in the EBA. The difference is also statistically significant (χ^2=12.815; df=2; p=0.002). The trend is the same when males and females are evaluated separately.

The presence of Schmorl's nodes appears also to be dependent on sex, as more males than females displayed the lesions (Table 32). The difference is also statistically significant (χ^2=12,815; df=2; p=0,002). Differences between CPRs calculated for males and females from individual periods are not large in the Neolithic and the Chalcolithic, while Schmorl's nodes significantly prevail in EBA males (Figure 73). The difference between prevalence rates of Schmorl's nodes in EBA males and females is also statistically significant (χ^2=6,725; df=1; p=0,010).

		Females	**%**	**Males**	**%**	**Total**	**%**
NEO	Together	3	15.8	2	14.3	5	15.2
	18-24 (young)	1	20.0	0	0.0	1	16.7
	25-35 (prime)	1	14.3	1	20.0	2	16.7
	36-50 (mature)	0	0.0	0	0.0	0	0.0
	50+ (old)	1	25.0	1	33.3	2	28.6
CHAL	Together	4	22.2	8	32.0	12	27.9
	18-24 (young)	1	20.0	0	0.0	1	12.5
	25-35 (prime)	2	25.0	1	11.1	3	17.6
	36-50 (mature)	1	20.0	6	50.0	7	41.2
	50+ (old)	0	0.0	1	100.0	1	100.0
EBA	Together	10	31.3	27	61.4	37	48.7
	18-24 (young)	1	11.1	3	42.9	4	25.0
	25-35 (prime)	1	9.1	9	64.3	10	40.0
	36-50 (mature)	8	66.7	13	61.9	21	63.6
	50+ (old)	0	0.0	2	100.0	2	100.0
All periods	Together	17	24.6	37	44.6	54	35.5
	18-24 (young)	3	15.8	3	27.3	6	20.0
	25-35 (prime)	4	15.4	11	39.3	15	27.8
	36-50 (mature)	9	45.0	19	50.0	28	48.3
	50+ (old)	1	25.0	4	66.7	5	50.0

Table 32. CPRs of Schmorl's nodes; % = percentage of affected individuals in the category.

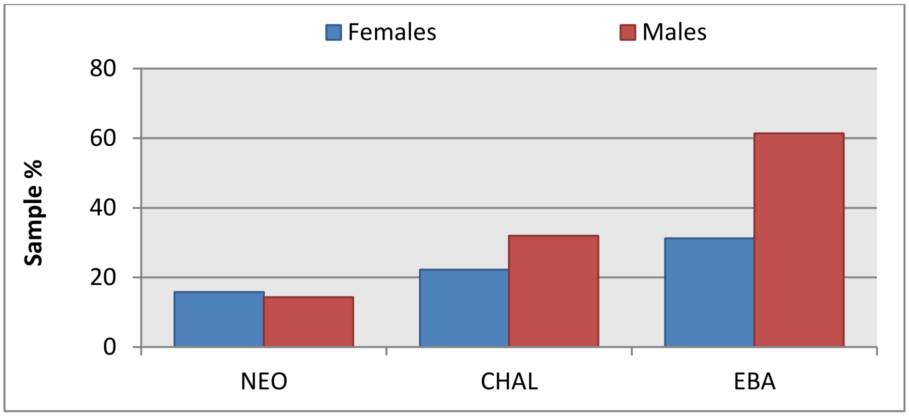

Figure 73. CPRs of Schmorl's nodes in males and females by period.

Age seems to have played a rather small role in the presence of Schmorl's nodes. In the Neolithic and the Chalcolithic, females showed the lesions at a younger age than males from the same period. In Chalcolithic females, the CPR of Schmorl's nodes was balanced between age categories, while the incidence of lesions increased with age in males. The prevalence rate of Schmorl's nodes in the EBA was considerably higher among mature females, but was more balanced in male individuals who developed the lesions from early adulthood onwards (Figure 74). Regardless of the high CPR of Schmorl's nodes among mature EBA females, prevalence rates do not seem to differ much between the females from different periods. Greater variation was observed between males. Schmorl's nodes were rather uncommon in Neolithic males; in the Chalcolithic, the frequency increased with age; in the EBA males were the only ones suffering from the condition from a young adult age, whereas the distribution in individual age categories was quite balanced (Figure 74).

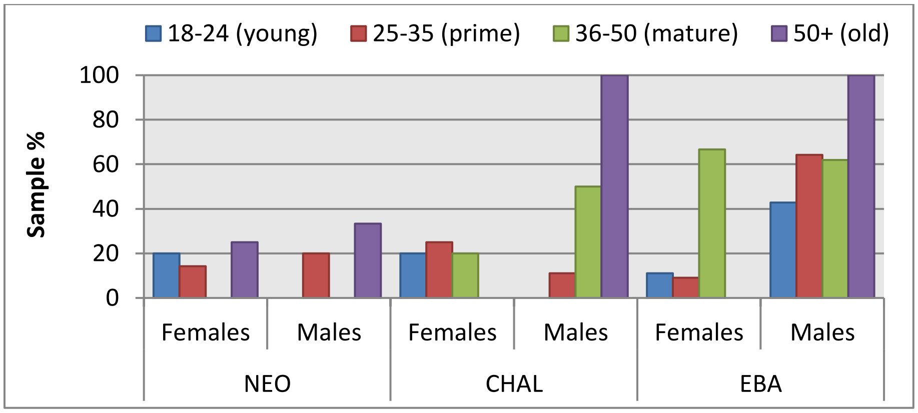

Figure 74. CPRs of Schmorl's nodes in individual age categories.

No cervical vertebrae were affected by Schmorl's nodes in any of the periods (Table 33). In general, the condition was commonest in the thoracic area, although the difference between the rates in the thoracic and lumbar areas was small. In all three periods, Schmorl's nodes in both spinal regions were more frequent among males than females, except for the Neolithic where males did not show the lesions in the lumbar area. All women with Schmorl's nodes (except for Chalcolithic females) had Schmorl's nodes in the lumbar area; on the contrary, Schmorl's nodes were more common in the thoracic region among Chalcolithic women, the pattern observed in male individuals of all three studied periods (Figure 75).

NEO	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	0	0.0	0	0.0	0	0.0
Thoracic	3	9.1	1	5.3	2	14.3
Lumbar	3	9.1	3	15.8	0	0.0
T+L	1	3.0	1	5.3	0	0.0
CHAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	0	0.0	0	0.0	0	0.0
Thoracic	10	23.3	4	22.2	6	24.0
Lumbar	8	18.6	3	16.7	5	20.0
T+L	6	14.0	3	16.7	3	12.0
EBA	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	0	0.0	0	0.0	0	0.0
Thoracic	31	40.8	5	15.6	26	59.1
Lumbar	23	30.3	6	18.8	17	38.6
T+L	17	22.4	1	3.1	16	36.4
TOTAL	**NI**	**%**	**Females**	**%**	**Males**	**%**
Cervical	0	0.0	0	0.0	0	0.0
Thoracic	44	28.9	10	14.5	34	41.0
Lumbar	34	22.4	12	17.4	22	26.5
T+L	24	15.8	5	7.2	19	22.9

Table 33. CPRs[50] of Schmorl's nodes by spinal region. NI = number of individuals with observed Schmorl's nodes; T = Schmorl's nodes present in thoracic vertebrae; L = Schmorl's nodes present in lumbar vertebrae; T+L = Schmorl's nodes present in both thoracic and lumbar vertebrae.

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[50] calculated from all individuals in the category

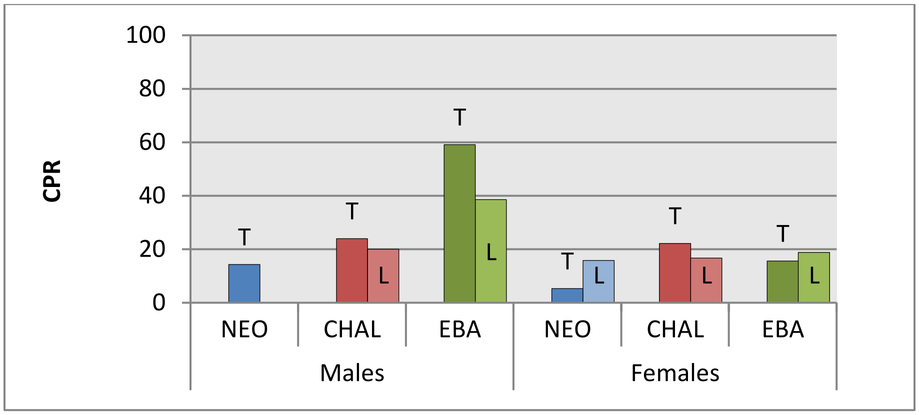

Figure 75. CPRs of Schmorl's nodes by spinal region[51]. T = thoracic; L = lumbar.

Spinal OA, osteophytosis, and Schmorl's nodes often occurred together as general signs of spinal joint disease. Below, the rate of co-existence of the three conditions is provided (Appendix 3, Table 56). Osteoarthritis was more often accompanied by osteophytosis than by Schmorl's nodes. No combination of all three conditions occurred in the Neolithic, unlike in the other two periods. However, in general, it was Schmorl's nodes and osteophytosis that occurred together the most frequently, namely in 21.1% of the whole sample. The situation was the same in the Chalcolithic and EBA, whereas in the Neolithic, the combination of OA and osteophytosis was the most common of all.

There were no differences detected between the prevalence rate of individual combinations between sexes of the whole sample, Schmorl's nodes and osteophytosis co-existing the most frequently among males and females, the combination of all three traits being the rarest of all the combinations (Figure 76). However, the number of Schmorl's nodes-osteophytosis combinations was much higher in males than females.

All the combinations were dependent on age, and had the highest prevalence among mature and elderly adults. It was only in the EBA when the combinations occurred in young and prime adults (OA and osteophytosis, and Schmorl's nodes with osteophytosis), although Schmorl's nodes with osteophytosis were also found in Chalcolithic prime adults (Figure 77). Only young EBA females were affected by a combination of traits, namely OA and osteophytosis. Osteophytosis combined with Schmorl's nodes was recorded in Chalcolithic and EBA prime adults. All the other combinations were present only in mature and elderly age.

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[51] no cervical vertebrae were affected, so they are not shown in the graph

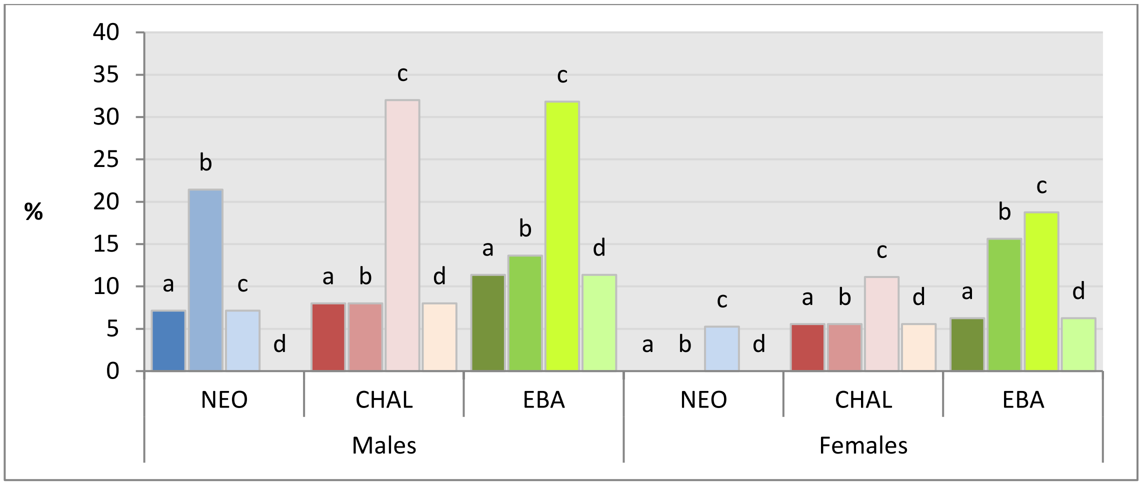

Figure 76. Percentual prevalence rates of individual combinations of spinal osteoarthritis (OA), osteophytosis, and Schmorl's nodes by sex. (a = OA+Schmorl's nodes; b = OA+osteophytosis; c = osteophytosis+Schmorl's nodes; d = OA+osteophytosis+Schmorl's nodes; % = percentage of individuals affected by a given combination).

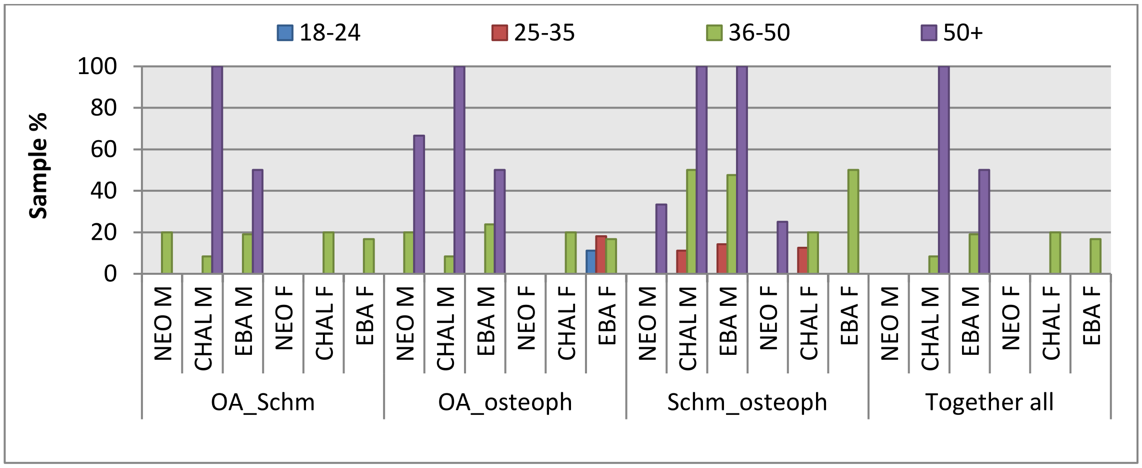

Figure 77. Prevalence rates of individual combinations of spinal osteoarthritis (OA), osteophytosis (osteoph), and Schmorl's nodes (Schm) by age.

5.5.4.2. Extra-spinal osteoarthritis

None of the subadults were affected by extra-spinal joint diseases, and so the results below refer solely to adult individuals. Cases of osteoarthritis (OA) secondary to trauma are not included in this section, but are considered with trauma. Cases of primary OA are considered below.

Of the total sample, almost a third showed signs of extra-spinal OA. The proportion of affected individuals increased from the Neolithic to the EBA, although the differences between periods were small (χ^2=0.510; df=2; p=0.775). The condition was commoner in males, the difference between the sexes being statistically significant (χ^2=4.736; df=1; p=0.030). The greatest disparity between males and females was recorded in the Chalcolithic and the lowest in the EBA (Table 34; Figure 78). Owing to the low numbers of affected individuals, no statistical test was performed regarding the differences between the sexes in individual periods.

		Females		**Males**		**All adults**	
		NI	%	NI	%	NI	%
NEO	**Together**	4	21.1	5	35.7	9	27.3
	18-24 (young)	1	20.0	0	0.0	1	16.7
	25-35 (prime)	0	0.0	1	20.0	1	8.3
	36-50 (mature)	2	66.7	1	20.0	3	37.5
	50+ (old)	1	25.0	3	100.0	4	57.1
CHAL	**Together**	3	16.7	11	44.0	14	32.6
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	12.5	2	22.2	3	17.6
	36-50 (mature)	2	40.0	8	66.7	10	58.8
	50+ (old)	0	0.0	1	100.0	1	100.0
EBA	**Together**	9	28.1	17	38.6	26	34.2
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	2	18.2	3	21.4	5	20.0
	36-50 (mature)	7	58.3	12	57.1	19	57.6
	50+ (old)	0	0.0	2	100.0	2	100.0
All periods	**Together**	16	23.2	33	39.8	49	32.2
	18-24 (young)	1	5.3	0	0.0	1	3.3
	25-35 (prime)	3	11.5	6	21.4	9	16.7
	36-50 (mature)	11	55.0	21	55.3	32	55.2
	50+ (old)	1	25.0	6	100.0	7	70.0

Table 34. CPRs of extra-spinal OA in adults. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

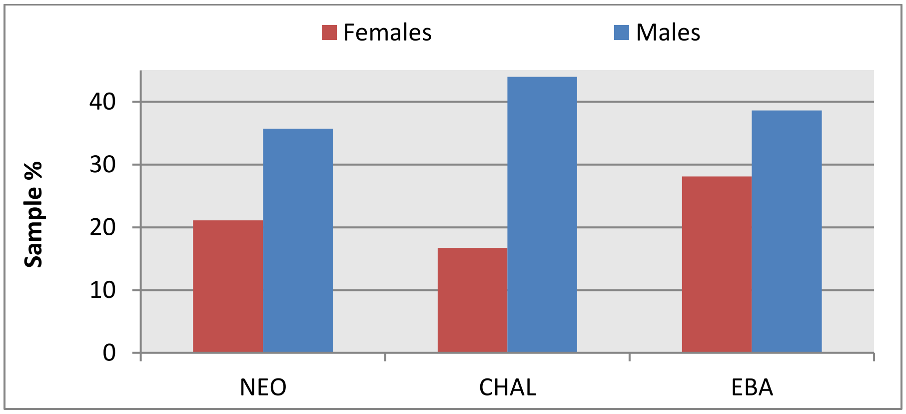

Figure 78. CPRs of extra-spinal OA in males and females by period.

The number of individuals with extra-spinal OA increases with age. Only one young adult individual was affected – a Neolithic female. In comparison to the Neolithic where the males exhibit OA lesions mostly later in life, the condition was observed also in younger age categories in Chalcolithic and EBA males (Figure 79).

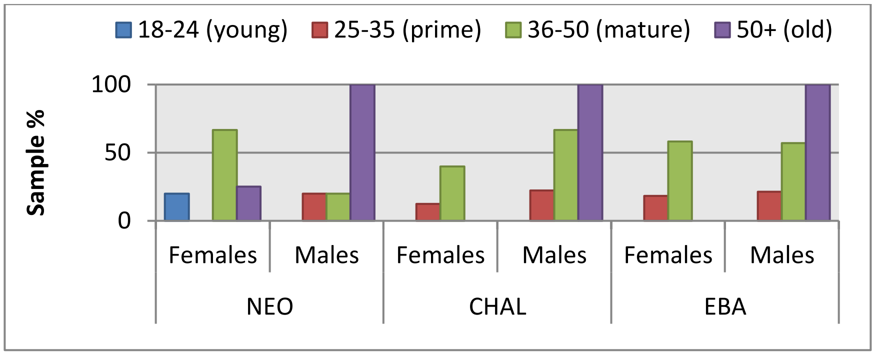

Figure 79. CPRs of extra-spinal OA in males and females by age.

The gleno-humeral joint (GHJ), temporo-mandibular joint (TMJ), wrist, and sterno-clavicular joint were the most frequently affected by osteoarthritis. In the Neolithic, OA was detected only in the TMJ and GHJ (in that order). In the other two periods, it was the GHJ that was affected the most of all. Among the Chalcolithic population, hand OA was almost as frequent as the occurrence of GHJ OA, followed by OA in the TMJ[52]. Lower yet common incidences were also recorded in the sterno-clavicular joint, the hip and the foot. Frequently affected joints among EBA individuals also included the TMJ, the wrist, and the sterno-clavicular joint, but quite high prevalence was also observed in almost all the other joints, especially the acromio-clavicular joint, ribs, elbows, and knees (Figure 80).

In female individuals, the prevalence rate was the highest in the TMJ, followed by the GHJ, elbows, wrists, and knees. On the contrary, males showed the highest occurrence of OA in the shoulder joints, followed by the TMJ and wrists. Hips and feet were also affected more than in females (Table 35). The distribution of OA was very similar in Neolithic males and females, both sexes suffering exclusively in the TMJ and shoulder region, with the latter being dominant in males. The situation is different in the Chalcolithic, where the knees and the joints of the arms and hands were the only affected areas in females. In males in the same period more joints were involved, OA dominating in the shoulders, TMJ, wrists, hips and feet. In the EBA, both sexes exhibited OA in almost all of the joints, whereas the joints of females

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[52] above 6% CPR

included mostly the TMJ, followed by elbows and knees. Male joints were affected to a slightly greater extent, especially in the upper body (Figure 81).

		Females		Males		All individuals	
		NI	%	NI	%	NI	%
NEO	TMJ	3	15.8	2	14.3	5	15.2
	SteCla	0	0.0	1	7.1	1	3.0
	AcroCla	0	0.0	0	0.0	0	0.0
	Ribs	0	0.0	0	0.0	0	0.0
	GleHum	1	5.3	3	21.4	4	12.1
	Elbow	0	0.0	0	0.0	0	0.0
	Wrist	0	0.0	0	0.0	0	0.0
	Hand	0	0.0	0	0.0	0	0.0
	Hip	0	0.0	0	0.0	0	0.0
	Knee	0	0.0	0	0.0	0	0.0
	Ankle	0	0.0	0	0.0	0	0.0
	Foot	0	0.0	0	0.0	0	0.0
CHAL	TMJ	0	0.0	3	12.0	3	7.0
	SteCla	0	0.0	2	8.0	2	4.7
	AcroCla	0	0.0	0	0.0	0	0.0
	Ribs	0	0.0	0	0.0	0	0.0
	GleHum	2	11.1	4	16.0	6	14.0
	Elbow	1	5.6	0	0.0	1	2.3
	Wrist	2	11.1	3	12.0	5	11.6
	Hand	0	0.0	1	4.0	1	2.3
	Hip	0	0.0	2	8.0	2	4.7
	Knee	1	5.6	0	0.0	1	2.3
	Ankle	0	0.0	0	0.0	0	0.0
	Foot	0	0.0	2	8.0	2	4.7
EBA	TMJ	4	12.5	2	4.5	6	7.9
	SteCla	1	3.1	4	9.1	5	6.6
	AcroCla	0	0.0	4	9.1	4	5.3
	Ribs	1	3.1	2	4.5	3	3.9
	GleHum	1	3.1	8	18.2	9	11.8
	Elbow	2	6.3	2	4.5	4	5.3
	Wrist	1	3.1	4	9.1	5	6.6
	Hand	1	3.1	1	2.3	2	2.6
	Hip	1	3.1	1	2.3	2	2.6
	Knee	2	6.3	2	4.5	4	5.3
	Ankle	0	0.0	1	2.3	1	1.3
	Foot	0	0.0	1	2.3	1	1.3
All periods	TMJ	7	10.1	7	8.4	14	9.2
	SteCla	1	1.4	7	8.4	8	5.3
	AcroCla	0	0.0	4	4.8	4	2.6
	Ribs	1	1.4	2	2.4	3	2.0
	GleHum	4	5.8	15	18.1	19	12.5
	Elbow	3	4.3	2	2.4	5	3.3
	Wrist	3	4.3	7	8.4	10	6.6
	Hand	1	1.4	2	2.4	3	2.0
	Hip	1	1.4	3	3.6	4	2.6
	Knee	3	4.3	2	2.4	5	3.3
	Ankle	0	0.0	1	1.2	1	0.7
	Foot	0	0.0	3	3.6	3	2.0

Table 35. CPRs of extra-spinal OA by skeletal area. NI = number of affected individuals; % = CPR of all individuals in the category (e.g., females, males, adults). SteCla – sterno-clavicular joint; Acro-Cla – acromio-clavicular joint; GleHum – gleno-humeral joint.

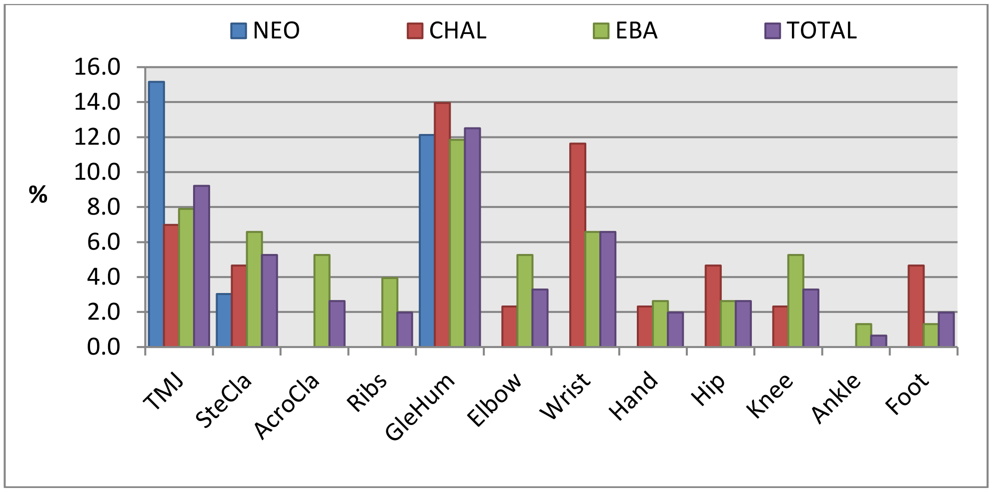

Figure 80. Regions affected by extra-spinal OA by period. % = percentage of individuals in the category. TMJ – temporo-mandibular joint; SteCla – sterno-clavicular joint; Acro-Cla – acromio-clavicular joint; GleHum – gleno-humeral joint.

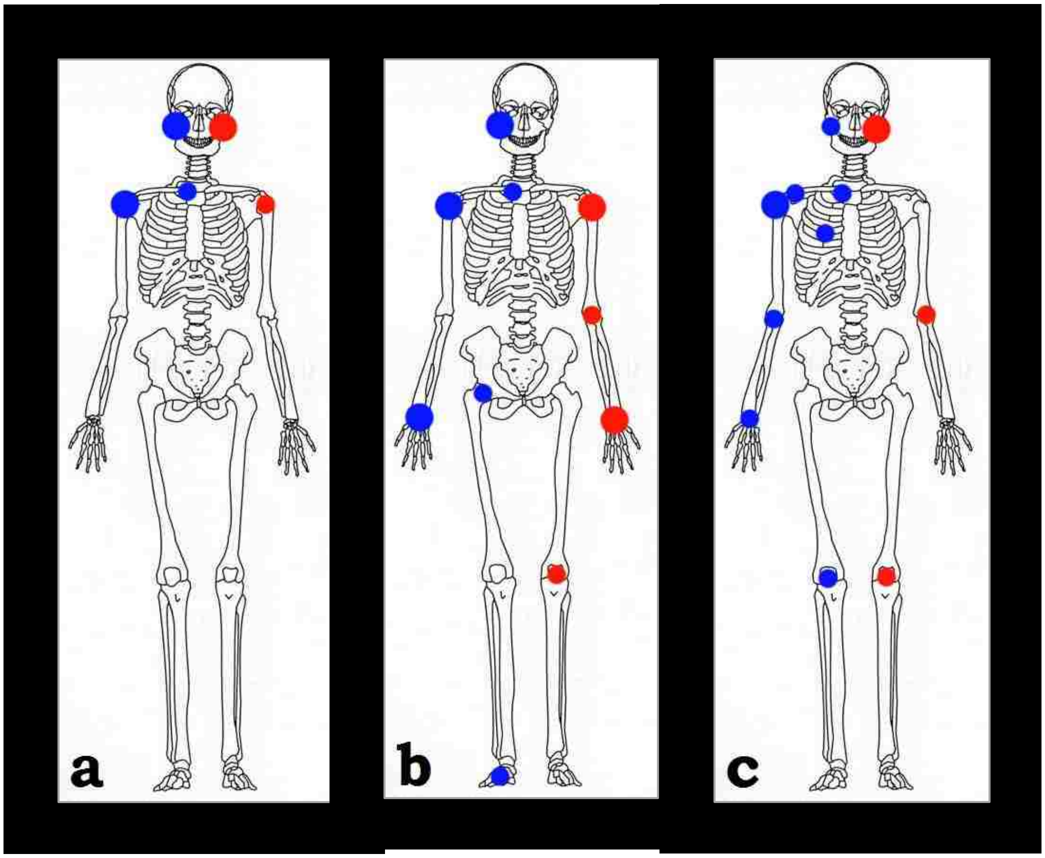

Figure 81. Joints of males and females affected by extra-spinal OA. Minimum 10% CPR is represented by a large dot, Minimum 5% CPR by a small dot. 1 – Neolithic; 2 – Chalcolithic; 3 – Early Bronze Age; blue = males; red = females. Laterality is not considered.

In general, joint disease (JD) - both spinal and extra-spinal – increases with age in all three periods, in both sexes. Additionally, in all three periods males were more frequently affected than females. Considering spinal joint diseases, their occurrence tends to increase with the period, although the difference between females from individual periods is more apparent than that between males - EBA females being much more frequently affected than in the previous periods, whereas the percentage of affected EBA males is higher than before, but the differences between the periods are small.

In the Neolithic, females were affected by joint disease at a younger age than males. On the other hand, extra-spinal OA was much more frequently detected in younger males than females. At the same time, Neolithic males were the youngest of all males to be affected by the condition. Spinal OA was also recorded mainly in Neolithic males who suffered from the condition the most frequently of all males in the assemblage, especially in cervical spine. In comparison to males, Neolithic females were more likely to be affected by spinal OA to the least extent of all females. No individuals in the Neolithic sample suffered from osteophytes and Schmorl’s nodes as frequently as those in the following periods. Females were affected by osteophytosis earlier in life than males, suffering mostly in the lumbar spine. The same spinal area of female spines was the most frequently affected by Schmorl’s nodes. On the contrary, male spines showed signs of osteophytosis and Schmorl’s nodes also in other spinal areas, mostly in the thoracic region.

The prevalence of extra-spinal JD was much higher in Chalcolithic males than females, who were affected by extra-spinal JD the least of all the females. In females, the signs of spinal JD developed earlier in life than in males. Similar to the Neolithic, in both sexes only the cervical spine was affected by spinal OA. However, it was the thoracic region that were affected the most, as far as osteophytosis and Schmorl’s nodes in Chalcolithic population are concerned, males being affected much more frequently and earlier in life than females.

The Early Bronze Age population was the one to be affected by JD the most and much earlier in life than before. Moreover, EBA females showed the signs of spinal JD noticeably more often than in previous periods. The same can be concluded about males, although the differences between the males of individual periods were not as large. In comparison to the Neolithic and the Chalcolithic, when it was females who suffered from spinal JD earlier in their lives, in the EBA it was males who showed the signs of spinal JD earlier. Of all the females, the prevalence rate of spinal OA was the highest in the EBA, and from an earlier age.

Unlike in previous periods, EBA individuals showed the signs of spinal OA in both the cervical and thoracic regions. Considering osteophytosis, both EBA sexes were affected to a similar extent, while in previous periods males were more affected than females, the only detected difference being that while in females osteophytosis was present more in the lumbar area, it was more equally spread in the case of male spines. In males, Schmorl's nodes were recorded at an earlier age than in females, but while the spread of the lesions was rather equal in all spinal areas of female individuals, it was mostly the thoracic region that was affected in male individuals, sometimes in combination with lesions in lumbar spine.

5.5.5. Trauma

Assessed traumatic lesions include antemortem fractures, dislocations, and *osteochondritis dissecans* (OD). Perimortem fractures are only briefly mentioned in the end of this section, but are further discussed in the discussion.

The CPR of general trauma (including antemortem fractures, dislocations and OD) is 17.4% (fifty individuals), of which there were forty-six adults (30.3% of all adults) and four (2.9% of all children) juveniles. The EBA is the period where traumatic lesions were most common (22%), followed by the Neolithic (16.1%) and the Chalcolithic (11.7%) (Table 36). In all three periods more traumatic lesions were observed in males than females. The frequencies of trauma in females were similar in all three periods. The differences between males from individual periods were more obvious, with apparent prevalence of trauma in EBA males (Figure 82).

Only a low level of trauma was recorded in pre-adolescent childhood (below twelve years of age). In adolescence and early adulthood the frequency of traumatic lesions was more common, especially in the Neolithic. More traumatic lesions in the older age categories could be expected owing to the fact that older individuals would have had more time to sustain injuries. In addition, another limitation in scoring traumas lies in the fact that well healed fractures, with no change to the bone contour, may not have been identified. However, in comparison to the Neolithic where it was mostly mature adults that exhibited traumatic lesions, Chalcolithic and EBA adults suffered much more injuries from an earlier age - in prime adulthood (Figure 83). Tables 57-59 in Appendix 3 provide a summary of traumatic lesions observed on the studied skeletal remains.

		Females	%	Males	%	All	%
NEO	Subadults	-	-	-	-	1	3.4
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	0	0.0
	12-17	-	-	-	-	1	16.7
	Adults	4	21.1	5	35.7	9	27.3
	18-24 (young)	1	20.0	0	0.0	1	16.7
	25-35 (prime)	1	14.3	0	0.0	1	8.3
	36-50 (mature)	1	33.3	4	80.0	5	62.5
	50+ (old)	1	25.0	1	33.3	2	28.6
	All					10	16.1
CHAL	Subadults	-	-	-	-	1	2.0
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	1	5.9
	12-17	-	-	-	-	0	0.0
	Adults	3	16.7	7	28.0	10	23.3
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	2	25.0	3	33.3	5	29.4
	36-50 (mature)	1	20.0	4	33.3	5	29.4
	50+ (old)	0	0.0	0	0.0	0	0.0
	All					11	11.7
EBA	Subadults	-	-	-	-	2	3.6
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	1	3.7
	12-17	-	-	-	-	1	8.3
	Adults	7	21.9	20	45.5	27	35.5
	18-24 (young)	1	11.1	0	0.0	1	6.3
	25-35 (prime)	3	27.3	8	57.1	11	44.0
	36-50 (mature)	3	25.0	11	52.4	14	42.4
	50+ (old)	0	0.0	1	50.0	1	50.0
	All					29	22.0
Total	Subadults	-	-	-	-	4	2.9
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	2	3.8
	12-17	-	-	-	-	2	5.9
	Adults	14	20.3	32	38.6	46	30.3
	18-24 (young)	2	10.5	0	0.0	2	6.7
	25-35 (prime)	6	23.1	11	39.3	17	31.5
	36-50 (mature)	5	25.0	19	50.0	24	41.4
	50+ (old)	1	25.0	2	33.3	3	30.0
	All					50	17.4

Table 36. CPRs of overall trauma.

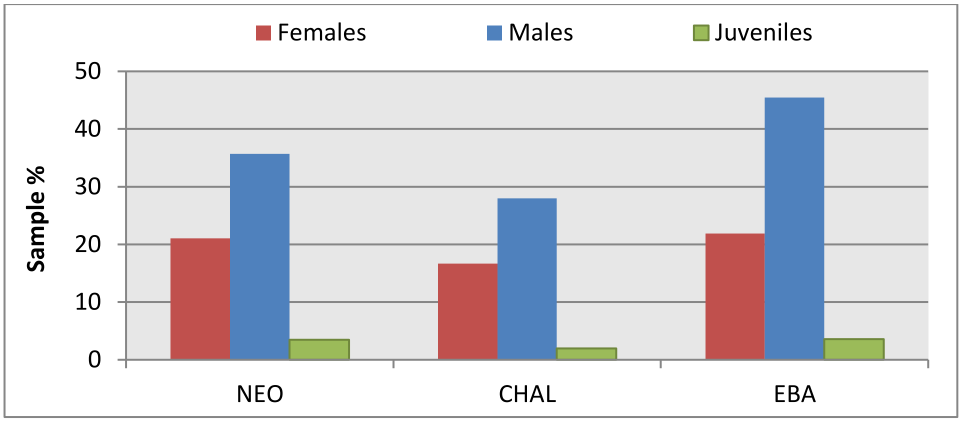

Figure 82. Prevalence of trauma by sex and period.

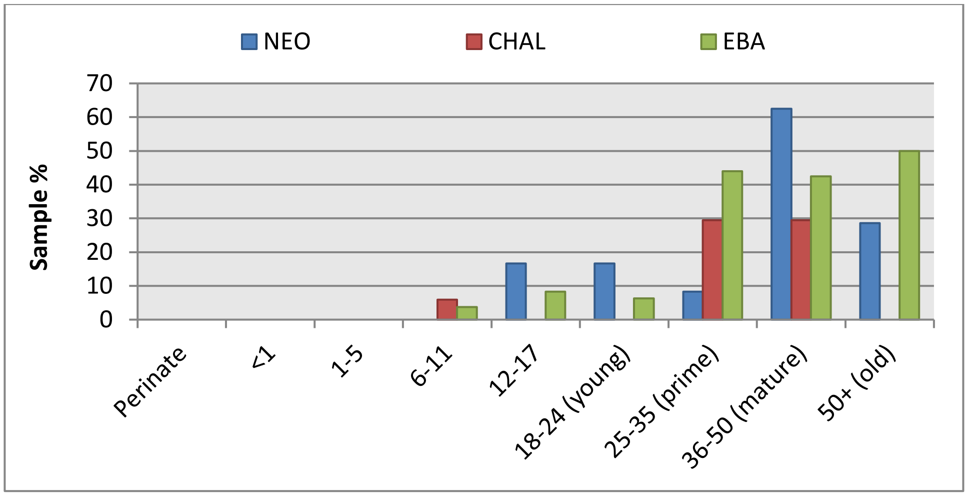

Figure 83. Prevalence of trauma in subadults and adults by age.

5.5.5.1. Antemortem fractures

The majority of traumatic lesions were represented by healed fractures (forty-six out of fifty traumatic lesions, i.e. 92%). The CPRs were therefore not much different from the overall rates of trauma. In Table 37, CPRs of antemortem fractures are provided. In total, forty-six individuals (16%) had healed fractures. Of this number, only four were subadults. This may be the result of poor preservation of juvenile bones, and it can be presumed that in reality the number of subadult individuals with fractures was higher than indicated. The proportion of affected adults is similar in the Neolithic and the EBA (27.3% and 32.9% respectively), Chalcolithic adults being affected the least (18.6%), and in general, fractures are more frequent in male individuals.

		Females	%	Males	%	All	%
NEO	Subadults	-	-	-	-	1	3.4
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	0	0.0
	12-17	-	-	-	-	1	16.7
	Adults	4	21.1	5	35.7	9	27.3
	18-24 (young)	1	20.0	0	0.0	1	16.7
	25-35 (prime)	1	14.3	0	0.0	1	8.3
	36-50 (mature)	1	33.3	4	80.0	5	62.5
	50+ (old)	1	25.0	1	33.3	2	28.6
CHAL	Subadults	-	-	-	-	1	2.0
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	1	5.9
	12-17	-	-	-	-	0	0.0
	Adults	2	11.1	6	24.0	8	18.6
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	12.5	2	22.2	3	17.6
	36-50 (mature)	1	20.0	4	33.3	5	29.4
	50+ (old)	0	0.0	0	0.0	0	0.0
EBA	Subadults	-	-	-	-	2	3.6
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	1	3.7
	12-17	-	-	-	-	1	8.3
	Adults	7	21.9	18	40.9	25	32.9
	18-24 (young)	1	11.1	0	0.0	1	6.3
	25-35 (prime)	3	27.3	7	50.0	10	40.0
	36-50 (mature)	3	25.0	10	47.6	13	39.4
	50+ (old)	0	0.0	1	50.0	1	50.0
Total	Subadults	-	-	-	-	4	2.9
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	2	3.8
	12-17	-	-	-	-	2	5.9
	Adults	13	18.8	29	34.9	42	27.6
	18-24 (young)	2	10.5	0	0.0	2	6.7
	25-35 (prime)	5	19.2	9	32.1	14	25.9
	36-50 (mature)	5	25.0	18	47.4	23	39.7
	50+ (old)	1	25.0	2	33.3	3	30.0
	All					46	16.0

Table 37. CPRs of antemortem fractures by period. NI = number of all affected individuals in the category.

No subadults younger than six years had evidence of fractures. In Neolithic subadults, fractures were observed only in adolescents. Juveniles aged six to eleven years were also affected in the Chalcolithic and the EBA, although the number of affected subadults was low (one Chalcolithic and two EBA). Fractures in EBA individuals were frequent from prime adulthood, while in the other two periods they were common from mature adult age (Figure 84). When compared to Neolithic and EBA male individuals, women from these periods show the signs of fractures from a younger age. Only in the Chalcolithic were no differences between males and females recorded when considering age categories (Figure 85). As far as males are concerned, only mature and old males were affected in the Neolithic, in contrast to the following periods when also prime aged males seem to have suffered to a greater extent (Figure 85).

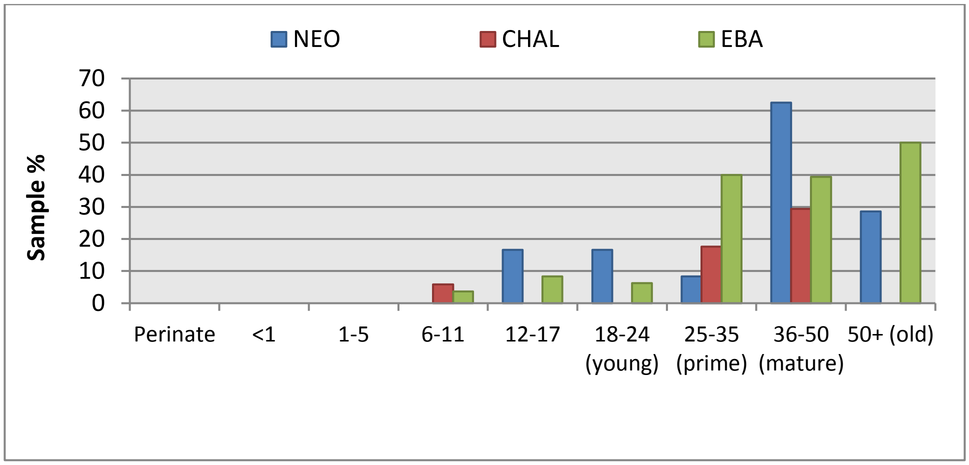

Figure 84. Percentage occurrences of antemortem fractures in subadults and adults by age.

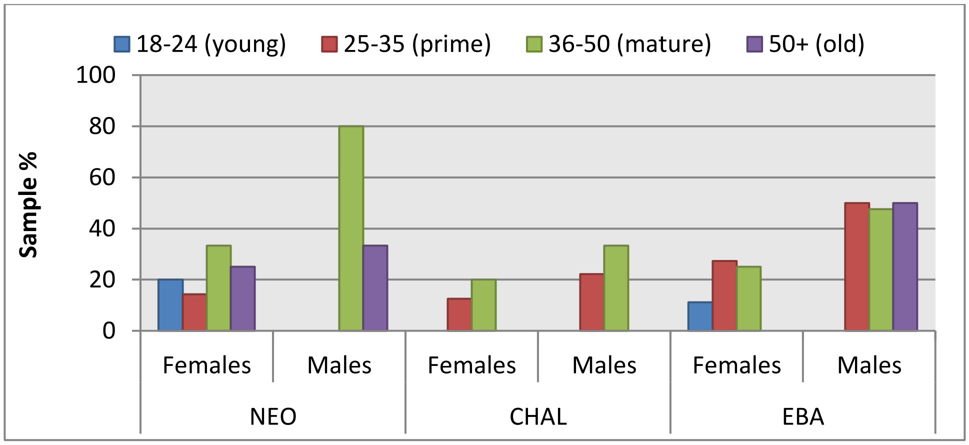

Figure 85. Percentage occurrences of antemortem fractures in males and females in individual periods by age. % - percentage of individuals in a given age category.

5.5.5.1.1. Skull fractures

Together, ten antemortem skull fractures (including both the cranial vault and facial area) were observed: four in the Neolithic (one subadult and three adults), one in the Chalcolithic, and five in the EBA (one subadult, four adults). This means that the CPR of cranial trauma was the highest in the Neolithic (6.5% *vs.* 1.1% and 3.8% in the later periods respectively). However, the intensity/indicated brutality and the size of the lesions were much more severe in the Chalcolithic and the EBA. While in the Neolithic, small healed depressions were mostly observed, in the other two periods the lesions were much deeper, clearly indicating that they had been caused by a deliberate attack (Appendix 6, Figures 112-115).

Eight of the fractured skulls were caused by a blunt-force. Apart from these, an antemortem fracture of the maxilla (a male from Nižná Myšľa H105), and a sharp-force trauma to the face (a male from Nižná Myšľa H53) were observed. One of the blunt-force injuries was found together with evidence of a healed trepanation (an EBA male from Praha – Malá Ohrada 8783C; Appendix 6, Figure 114; for more details and discussion see Chapter 6, Section 6.3.5. and photographs on the enclosed DVD). Only two subadults showed evidence of a fractured skull, a Neolithic adolescent (H183) and an EBA child aged six to eleven years from Nižná Myšľa (H148), both with traces of blunt-force trauma. In adults, skull fractures were observed in eight individuals, four of whom were EBA adults. Only one Chalcolithic female had a fractured skull, all the rest were males. In the EBA, skull fractures were recorded from a younger age than in previous periods (Table 38).

Blunt-force injuries were mostly located on the parietal bones (four cases on the left parietal, one case on the right parietal), frontal bone (two cases on the left side, one on the right side), and occipital bone (one case, left side). As mentioned above, sharp-force and non-specific fractures were located on the face. The distribution of skull fractures is illustrated in Appendix 3, Figure 104.

Five of the adults with cranial trauma (two Neolithic and three EBA) suffered also post-cranial fractures, and almost all were older than thirty-six years. A male H93 from Svodín had also a healed depression on the capitulum of the left humerus and an antemortem fracture of a foot phalanx; antemortem fractured bones of an old female (H41) from the same archaeological site were the distal humerus, distal ulna, and the distal shaft of the fibula, all from the right side. As regards the EBA individuals with post-cranial antemortem fractures, a prime male (H105) from Nižná Myšľa had fractured cervical vertebra and the right clavicle;

in addition to skull trauma, a male (H53) from the same site had a healed fracture of a hand phalanx and the left distal humerus; and fractured bones of a male from Praha – Malá Ohrada (8781) involved a thoracic vertebra, ribs, medial condyle of the right humerus, and the acetabular margin of the right ilium (see Appendix 3, Tables 57-59). In the other four adults and two subadults with cranial fractures no other traumatic lesions were observed, although evidence of other pathology was recorded in some of these individuals (see enclosed database). For instance, rib infection and several perimortem fractures were implied in a mature male from Svodín (H125) (Appendix 6, Figure 116).

		Females	%	Males	%	All	%
NEO	Subadults	-	-	-	-	1	3.4
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	0	0.0
	12-17	-	-	-	-	1	16.7
	Adults	1	5.3	2	14.3	3	9.1
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	0	0.0	2	40.0	0	0.0
	50+ (old)	1	25.0	0	0.0	0	0.0
CHAL	Subadults	-	-	-	-	0	0.0
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	0	0.0
	12-17	-	-	-	-	0	0.0
	Adults	0	0.0	1	4.0	1	2.3
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	0	0.0
	36-50 (mature)	0	0.0	1	8.3	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0
EBA	Subadults	-	-	-	-	1	1.8
	Perinate	-	-	-	-	0	0.0
	<1	-	-	-	-	0	0.0
	1-5	-	-	-	-	0	0.0
	6-11	-	-	-	-	1	3.7
	12-17	-	-	-	-	0	0.0
	Adults	0	0.0	4	9.1	4	5.3
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	1	7.1	0	0.0
	36-50 (mature)	0	0.0	3	14.3	0	0.0
	50+ (old)	0	0.0	0	0.0	0	0.0

Table 38. CPRs of antemortem cranial fractures by period.

5.5.5.1.2. Vertebral fractures

Altogether, four adult individuals (2.6% of all adults) showed evidence of vertebral fractures. All the affected individuals were males, one from the Neolithic (H83) and three from the EBA (Nižná Myšľa H215 and H310, Praha – Malá Ohrada 8781). Vertebral fractures were found especially among individuals older than thirty-six years, only one male was aged twenty-five to thirty-five (H310). Two were compression fractures (Svodín H83, Praha – Malá Ohrada 8781), one was a transverse fracture/crack of a vertebral body (Nižná Myšľa H310), and one vertebral body had been penetrated by a sharp implement shortly before death (Nižná Myšľa H215).

The Svodín male was old and, in addition to compression fracture in lower thoracic spine, he also exhibited numerous age-related degenerative changes such as spinal osteophytosis and early signs of osteoarthritis in the shoulders and knees. Moreover, he also suffered from severe periodontal disease. The male from Praha – Malá Ohrada displayed multiple healed fractures, including those of occipital bone, acetabulum, rib, and avulsion of medial condyle of the right distal humerus. In addition, osteochondritis dissecans (discussed below) was observed on a femoral condyle (Appendix 6, Figure 117). Both males from Nižná Myšľa also suffered additional lesions – H215 showed signs of possible spinal deformation (Appendix 6, Figure 118); and ongoing periosteal bone formation was observed at the inner occipital table of the prime male H310, possibly indicating intracranial bleeding (Appendix 6, Figure 119). Moreover, both males from Nižná Myšľa had probably used their teeth as tools, as suggested by grooves on the anterior teeth (Appendix 6, Figure 120).

5.5.5.1.3. Rib fractures

Rib fractures were observed in twelve adults (7.9% of all adults) and all showed signs of healing indicating they had been fractured antemortem. No subadult ribs were affected, although the lack of observed fractures may be the result of the poor preservation of juvenile rib cages. The lowest CPR among the adults was recorded in the Chalcolithic (only one individual, i.e., 2.3%), the highest in the EBA (nine individuals, i.e., 11.8%). In the Neolithic only two cases of fractured ribs were recorded (6.1%). Males with fractured ribs slightly outnumber females, although in the Chalcolithic no males with fractured ribs were recorded (Table 39). Small differences between the CPRs of rib fractures of males and females in all periods may be, however, influenced by the low number of affected individuals. Owing to the low number of individuals involved, it is not possible to state the relationship between age at death, sex, and the occurrence of rib fractures.

Seven adults whose ribs were fractured suffered additional fractures (Appendix 3, Tables 57-59), although it is not possible to state with any degree of certainty that multiple fractures occurred in the same event. In Svodín, ribs were the sole fractured bones (H182) or accompanied only by a fracture of a metacarpal (H10). With the exception of dental hypoplasia, female H182 did not suffer any other pathologies. In the case of the mature male H10, *cribra orbitalia*, vault porosity, and periodontal disease were also observed, possibly related to a systemic condition indicated by thickened and porous compact bone of the left forearm bones and the right femur (Appendix 6, Figure 141), as the periodontitis-related pathogens can cause serious additional health problems, including systemic diseases (for example, Garcia *et al.* 2001; Otomo-Corgel *et al.* 2012). In addition to the rib fracture, a Chalcolithic woman (Malé Březno 8880) had a healed fracture of the left humerus and no other pathologies were observed (Appendix 6, Figure 121). In four EBA adults (Nižná Myšľa H67, H253, Stekník 2422, and Praha – Libeň 2298), rib fractures were the only observed traumas. From these, the female H253 suffered possible scurvy (see section 5.5.3.); the rib of the female from Stekník was not truly fractured, but had been probably injured by a weapon/tool (Appendix 6, Figure 122). Apart from degenerative changes observed in arm joints and spine, and signs of gum inflammation, the man from Praha – Libeň did not have any significant pathological lesions. In the rest of EBA adults with fractured ribs, multiple fractures were recorded. The additional bones with fractures included vertebral fractures (Nižná Myšľa H215 – described above), humerus (Praha – Malá Ohrada 8750, individual with age-related changes and periodontal disease), clavicle (Praha – Malá Ohrada 8783A), or a combination of more bones (Praha – Malá Ohrada 8781 - described above, and Praha – Malá Ohrada 8792). The rib of the male from Praha – Malá Ohrada 8783A had not united with the other fractured half, although slight signs of bone remodelling were present at the margins. A similar non-united antemortem fracture was also observed on the lateral end of the left clavicle. In addition to this trauma, signs of rotator cuff disease and a non-specific cyst (possibly also related to trauma) on the right ilium were observed (Appendix 6, Figure 123). In the male 8792, a healed clavicular fracture and an avulsion of the distal styloid process of the right ulna occurred, and one rib fragment had the tip of an arrowhead embedded in it (Appendix 6, Figure 124).

		NEO		CHAL		EBA	
		NI	%	NI	%	NI	%
Females	**All females**	1	5.3	1	5.6	3	9.4
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	14.3	1	12.5	1	9.1
	36-50 (mature)	0	0.0	0	0.0	2	16.7
	50+ (old)	0	0.0	0	0.0	0	0.0
Males	**All males**	1	7.1	0	0.0	6	13.6
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	0	0.0	0	0.0	1	7.1
	36-50 (mature)	1	20.0	0	0.0	4	19.0
	50+ (old)	0	0.0	0	0.0	1	50.0
Adults	**All adults**	2	6.1	1	2.3	9	11.8
	18-24 (young)	0	0.0	0	0.0	0	0.0
	25-35 (prime)	1	8.3	1	5.9	2	8.0
	36-50 (mature)	1	12.5	0	0.0	6	18.2
	50+ (old)	0	0.0	0	0.0	1	50.0

Table 39. CPRs of antemortem rib fractures by period. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

5.5.5.1.4. Limb bone fractures

In total, eighteen individuals (6.3%) showed evidence of fractures of the long bones, only two of which were subadults – one from the Chalcolithic (Kněževes 772A) and one from the EBA (Nižná Myšľa H299). The lowest proportion of adults with limb bone fractures was recorded in the Chalcolithic, while Neolithic and EBA adults were affected to a similar degree (12.1% and 11.8% respectively). In the EBA the CPR is much higher in males (18.2%) than females (3.1%). In the previous periods, males were also more affected than females, but the differences between the sexes were not large. However, the low number of affected individuals needs to be born in mind (Table 40).

Upper limb bones were slightly more often fractured than those of the lower extremities (4.5% to 2.4% respectively), with the trend being the most apparent in the EBA. Both types of fractures clearly dominate in males. In Chalcolithic and EBA females, only the upper limb bones were fractured, while Neolithic females also had lower limb bones fractures (Figure 86). Owing to the low number of individuals with fractures of the extremities, no statistical tests were performed.

	NEO		CHAL		EBA	
	NI	%	NI	%	NI	%
All juveniles	0	0.0	1	2.0	1	1.8
All females	2	10.5	1	5.6	1	3.1
All males	2	14.3	2	8.0	8	18.2

Table 40. CPRs of antemortem long limb bones fractures by period. NI = number of all affected individuals in the category; % = percentage of all affected individuals in the category.

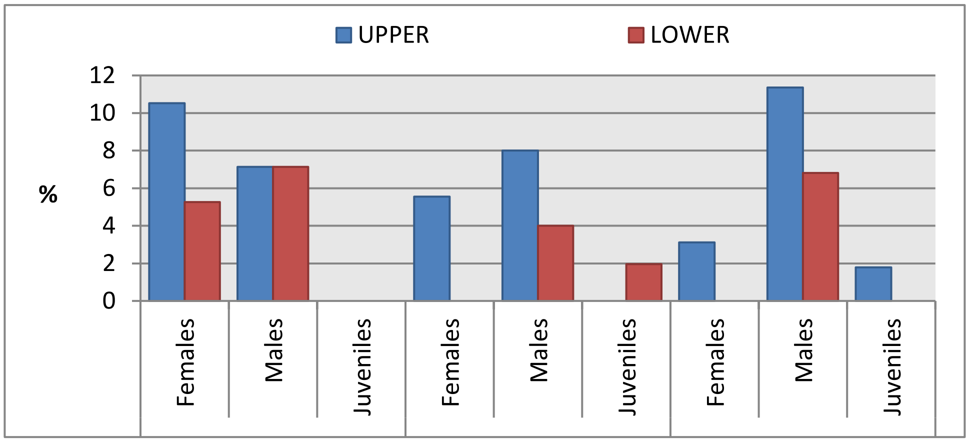

Figure 86. Percentage proportion of long limb bones fractures by sex. UPPER = upper extremities; LOWER = lower extremities affected. % - percentage of individuals with upper/lower fractures in the sex category.

5.5.5.1.5. Fractures of other bones

Below, the fractures of other bones are discussed, including clavicles, scapulae, metacarpals, metatarsals, pelvis, and both hand and foot phalanges. These fractures were recorded only in twenty-one adults, and no subadults were affected. The CPRs are provided in Table 41. Clavicles were the most commonly fractured bones, followed by metacarpals and pelves. Only the bones of hands were recorded as fractured in the Neolithic, while the fractures in Chalcolithic individuals were observed mostly in clavicles. In the EBA, almost all bones were affected. In all periods, CPRs indicated for males were higher than those for females. In summary, the bones most fractured in females were those of hands and clavicles, with a wider range of bones fractured in males.

		Females		Males		All adults	
		NI	%	NI	%	NI	%
NEO	Clavicle	0	0	0	0	0	0
	Scapula	0	0	0	0	0	0
	Sternum	0	0	0	0	0	0
	MCs	1	5.3	1	7.1	2	6.1
	HandPh	0	0.0	0	0.0	0	0.0
	Pelvis	0	0.0	0	0.0	0	0.0
	MTs	0	0.0	0	0.0	0	0.0
	FootPh	0	0.0	0	0.0	0	0.0
CHAL	Clavicle	1	5.6	1	4.0	2	4.7
	Scapula	0	0.0	1	4.0	1	2.3
	Sternum	0	0.0	0	0.0	0	0.0
	MCs	0	0.0	1	4.0	1	2.3
	HandPh	0	0.0	0	0.0	0	0.0
	Pelvis	0	0.0	0	0.0	0	0.0
	MTs	0	0.0	0	0.0	0	0.0
	FootPh	0	0.0	0	0.0	0	0.0
EBA	Clavicle	1	3.1	3	6.8	4	5.3
	Scapula	0	0.0	1	2.3	1	1.3
	Sternum	0	0.0	1	2.3	1	1.3
	MCs	1	3.1	0	0.0	1	1.3
	HandPh	1	3.1	1	2.3	2	2.6
	Pelvis	1	3.1	3	6.8	4	5.3
	MTs	1	3.1	1	2.3	2	2.6
	FootPh	0	0.0	1	2.3	1	1.3
Total	Clavicle	2	2.9	4	4.8	6	3.9
	Scapula	0	0.0	2	2.4	2	1.3
	Sternum	0	0.0	1	1.2	1	0.7
	MCs	2	2.9	2	2.4	4	2.6
	HandPh	1	1.4	1	1.2	2	1.3
	Pelvis	1	1.4	3	3.6	4	2.6
	MTs	1	1.4	1	1.2	2	1.3
	FootPh	0	0.0	1	1.2	1	0.7

Table 41. CPRs of other bone fractures. NI = number of individuals with a given fractured bone; % = percentage of the individuals with fractures long bones. MCs = metacarpals; HandPh = hand phalanges; MTs = metatarsals; FootPh = foot phalanges.

5.5.5.2. Perimortem fractures

Twenty-five individuals (three Neolithic, six Chalcolithic, sixteen EBA) had perimortem fractures; many of these individuals also had older healed fractures. One Chalcolithic subadult, a child aged six to eleven years (Tišice 633), had a perimortem fracture that was the result of deliberate blunt-force trauma to the left parietal bone (Appendix 6, Figure 125). In perimortem fractures affecting other individuals the precise timing and causes could not be established[53]. The perimortem fractures included skull fractures, the fracture of a tooth and adjacent jaw bones, maxillar fractures, vertebral fractures, and long limb bones fractures. For a list of perimortem traumatic lesions observed on the skeletons from individual periods see Tables 57-59 in Appendix 3.

5.5.5.3. *Osteochondritis dissecans (OD)*

Evidence of OD was found in both upper and lower limb bones. Only five adults were affected. Four were EBA males (Nižná Myšľa H200 and H290, Praha – Malá Ohrada 8781 and 8763) and one was a Chalcolithic female from Stehelčeves (3840). Three mature and two prime individuals were affected (Table 42). In three individuals OD was the only trauma observed, while both men from Praha – Malá Ohrada exhibited also healed fractures (see above; also Appendix 3, Table 59).

Period	Site	Context	Sex	Age
Chalcolithic	Stehelčeves	3840	Female	25-35
EBA	Nižná Myšľa	200	Male	36-50
EBA	Nižná Myšľa	290	Male	25-35
EBA	Praha – Malá Ohrada	8781	Male	36-50
EBA	Praha – Malá Ohrada	8763	Male	36-50

Table 42. Individuals with osteochondritis dissecans.

5.5.5.4. *Dislocations*

No dislocations were indicated in subadults, and only three cases of this trauma were implied in adults (2%). One of the hip (from a Chalcolithic male from Hulín H66), one of the hand (an EBA female from Praha – Malá Ohrada 8751), and one elbow dislocation (a male from Nižná Myšľa H273) were noted. No Neolithic individuals were affected. Affected males were all in their prime age, while the female was older (aged thirty-six to fifty). Apart from the hip dislocation, no other lesions were observed on the male from Hulín. As regards the female 8751 had a healed fracture of the hand phalanx, and the male H273 suffered the fracture of the lateral condyle of the distal humerus from the same side as the dislocations. This may imply that the fractures and dislocations could have occurred in the same event.

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[53] Owing to the limitations of perimortem fracture assessment, these fractures were recorded, but not further evaluated. Their occurrence is discussed marginally in the discussion.

In summary, the frequency of all traumas was almost identical to the frequency of fractures, as fractures represented 92% of all injuries. Males were affected to a much greater extent than females, especially in the EBA. Very little trauma was observed in pre-adolescents, while in adolescence the frequency of traumatic lesions rose, especially in the Neolithic. Chalcolithic and EBA adults displayed the lesions earlier in adulthood than the Neolithic individuals.

Almost all of the skull fractures (80%) were the result of blunt-force traumas inflicted to the left side of the cranium. One case of trepanation was also observed in the EBA male from Praha - Malá Ohrada (8783C). Only one female skull had been fractured antemortem (Svodín H41). Skull fractures were the most frequent in the Neolithic, although the severity of the injuries was much greater in the Chalcolithic and the EBA. In addition, the low number of affected individuals needs to be mentioned.

Vertebral and rib fractures were observed only on adult skeletons. The number of vertebral fractures was low (four, i.e., 2.6% of all adults); the CPR of rib fractures was slightly higher (7.9% of all adults). More than a half of the individuals with rib fractures also sustained injuries to other bones. In females, more upper long limb bones were fractured, while in males both upper and lower extremities were affected.

Perimortem traumas were the most frequent in the EBA, although the precise cause or time of occurrence could not be established.

5.5.6. Miscellaneous conditions

5.5.6.1. Button osteoma

Button osteomata – benign neoplasms, were observed in seven adults (4.6% of all adults), three Neolithic (9.1% of all Neolithic adults) and four EBA (5.3% of all EBA adults) individuals. All affected individuals were males older than thirty-six, but the number of affected individuals was too small for statistical analysis.

5.5.6.2. Multiple myeloma

A probable case of multiple myeloma was observed in a Chalcolithic female (H62) from Hulín, aged thirty-six to fifty years. Multiple bones (clavicles, scapulae, pelves, ribs, vertebrae, long bones, and skull) were affected by multiple circular osteolytic lesions with sharp margins (Appendix 6, Figure 126). No other lesions were observed.

The suggested diagnosis is multiple myeloma. Multiple myeloma tends to be commoner in elderly individuals, and it is the most common of the malignant tumours observable on the skeleton, and vertebrae, skull, ribs and pelvis are the most frequently affected bones (Roberts and Manchester 1995). The lesions are usually multifocal, manifesting as multiple perforations with sharp edges, and are believed to be a result of systemic bone marrow disease. This is what usually helps distinguish multiple myeloma from other bone-destructive conditions such as syphilis. It can be difficult to distinguish multiple myeloma from, e.g., secondary cancer lesions or taphonomic damage. However, although the lesions of secondary cancer are also multiple, the multiple myeloma lesions tend to be more uniform in size, with no sclerosis being usually observed (Jacobson *et al.* 1958; Waldron 2009: 184). However, the skeleton was quite incomplete, and so it was difficult to reach a precise diagnosis.

5.5.6.3. Gout

Bone destruction at the metatarso-phalangeal joint of the big toe was observed in an old female from Svodín (H174). Multiple small cavities were present mostly at the margins of the first metatarsal, with additional erosion on the articular facet (Appendix 6, Figure 127). The first phalanx was not preserved. The lesions are consistent with those seen in gout.

Gout develops when the level of uric acid in the blood is high, crystals of uric acid form and deposit in joints and surrounding tissues (Choi *et al.* 2005). The condition tends to be most common in the first metatarso-phalangeal joint (Choi *et al.* 2005). Owing to pressure erosion, in a bone it manifests as hollowed defects on the bones of the joint, possibly causing secondary osteoarthritis (Roberts and Manchester 1995; Ortner 2003). The condition is more frequent in males than females, although post-menopausal women are at much higher risk than pre-menopausal women (Marinello *et al.* 1985; Hak and Choi 2008). Other pathologies observed in the female from Svodín comprise of cranial vault porosity, *cribra orbitalia*, and periodontal disease. These have all been commonly found with gout in other skeletal collections, e.g., at St Martin's, Birmingham, or Gloucester (see Schweich 2005, 2010). Differential diagnoses include different types of joint infection (such as septic arthritis, or pseudogout), or destructive arthropaties, rheumatoid arthritis, erosive osteoarthritis, etc. (for more see Cush *et al.* 2005).

5.5.6.4. Spinal stenosis

Disorganised bone formation in the spinal canal was observed on the thoracic vertebrae of a Chalcolithic prime male from Plotiště (Ao 6100). Despite that the vertebrae were damaged and fragmented, masses of new bone were apparent at the vertebral foramina. The spinal canal was narrowed or completely blocked (Appendix 6, Figure 128). In addition to spinal lesions, there were signs of multiple healed traumatic lesions in the rest of the skeleton available for examination (Appendix 3, Table 58). These were: an impact fracture of the distal ulna at the styloid process, an oblique or greenstick fracture of the fifth metacarpal, an oblique fracture of the shaft of the fibula, and an avulsion fracture of a foot phalanx. Substantial force, such as in car accidents or falls from heights, is required to cause fractures at the ulnar styloid process, as the contact between the ulna and carpals is rather small (Galloway 1999). The sites of muscle insertions, overall robusticity, and joint wear indicate that the male was probably very muscular and physically active during his life, and so trauma seems to be a probable cause of the spinal stenosis in this individual. Other common causes of spinal canal narrowing (spinal stenosis) include genetics, age and age-related degenerative changes, spinal tumours, or Paget's disease.

5.5.6.5. Non-specific spinal deformations

A tilted sacrum, rotation of spinal processes, different shapes of right and left ribs and/or different shapes of (otherwise healthy) right and left clavicles were observed on twelve adult skeletons (7.9% of all adults). Even though a complete and well preserved spinal column would be needed to confirm the diagnosis, the abovementioned signs are often associated with incorrect postures (Ortner 2003: 468, Waldron 2009: 215-218). CPRs for individual periods are 12.1%, 4.7% and 7.9% respectively. In the Neolithic, more females than males were affected, whereas in the other two periods the CPRs were higher for males. No age-dependency was demonstrated (Appendix 3, Table 60).The numbers of individuals with the signs of spinal deformations were too low to be statistically evaluated.

5.5.6.6. Systemic conditions of unknown origin

A Neolithic male from Svodín (H102), aged twenty-five to thirty-five years[54], exhibited thickening with a sclerotic pattern at the glabella and the supraorbital region of the skull,

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[54] closer to thirty-five than younger

and the orbital roofs. Additionally, pitting and the grey-brown colour of the bone suggest increased vascularisation in the area, indicating an ongoing condition at the time of death. The area is also slightly deformed, as if pushed downwards towards the facial area. In addition, both tibiae exhibit periostitis, suggesting a systemic condition (Appendix 6, Figure 129). Differential diagnoses include, for example, Paget's disease (Schmorl and Junghanns 1932; Mirra *et al.* 1995; Roberts and Manchester 1995; Ortner 2003), fibrous dysplasia (Kelly *et al.* 2008), or hyperparathyroidism (Mirra *et al.* 1995; Ortner 2003). However, owing to similarities in skeletal manifestations of the three diagnoses, it was not possible to confirm any of the conditions.

The endocranial surface of a Svodín child (H163) aged six to eleven years showed reactive new bone formation, in the form of striated bone destruction of a dark brown colour on the occipital. In addition, cranial vault porosity was present on the parietal and temporal bones, and *cribra orbitalia* was present on the preserved orbit. Layers of periosteal bone formation manifesting as pitting and striations of dark brown colour were present on the ilium, femur, tibia, and fragments of the long bones (Appendix 6, Figure 130). Differential diagnoses include scurvy, meningitis, rickets, congenital syphilis, or anaemia (Vannier *et al.* 2014; Relvado *et al.* 2016). However, poor preservation of the remains (less than 25%) does not allow for more accurate interpretation of the lesions.

4.2. Principal Component Analysis (PCA)

Fifty variables were analysed by the PCA (Table 43), using the varimax rotation. This analysis identified ten components, whereas 43% of variance is reflected in Component 1. Highest loadings (higher than 0.500) were for variables related mainly to sex, robusticity and/or body mass. These include especially femoral subtrochanteric, midshaft and head measurements, and tibial dimensions at the nutrient foramen. Likewise, Component 3 had high loadings from variables associated with sex determination, including dimensions of humeral head, epicondyle breadth, length of glenoid fossa, and femoral head; the highest loading within this component was for talus dimensions. Variables with the highest scores in the second component appear to be those associated with stature, especially the lengths of metacarpals, metatarsals, and tibia. Similarly, main variables in Component 4 (mostly the lengths of the long bones) also indicate relation to stature. The rest of the Components comprise mostly of variables related to the same parts of the skeleton (e.g., Components 5 and 7 – mandible and skull), bones of similar size

(Component 6 – dimensions of talus, calcaneus, patella), or variables showing inverse proportion (Component 10 – anterio-posterior and medio-lateral diameters of ulna).

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stature mean	.424	.485	.416	.448	.090	.035	.036	.136	.118	.005
Orbital W	.021	.103	.025	.006	.002	-.013	-.047	**.694**	-.122	.016
Frontal bone cord	.049	.028	.040	.059	-.005	.048	**.949**	-.038	-.047	.013
Parietal bone cord	.085	.057	.044	.003	-.108	.019	**.946**	-.006	-.039	-.051
Mastoid L	.277	.129	.256	**.604**	.001	.068	.011	-.221	-.004	-.121
Chin H	.104	.055	.118	.200	**.840**	.053	.029	.022	-.048	.022
W at M2	.057	.033	.011	.026	.064	.062	-.088	-.112	**.856**	-.141
Mandibular ramus W	.098	.016	.067	-.218	**.761**	.063	-.137	-.044	.183	.097
Mandibular ramus H	.187	.167	.097	.115	**.837**	.074	-.021	.093	-.039	-.123
Mandibular ramus L	.331	.193	.129	.232	.355	-.080	-.061	-.120	.285	.289
Humerus L	.332	.302	.481	.409	.130	-.124	.030	.161	.023	-.042
Humerus epicond. W	.430	.141	**.630**	.189	.094	.182	.022	.204	.130	.042
Humeral head D	.414	.188	**.679**	.279	.144	-.062	.043	.060	-.005	.025
Humerus Max D	.464	.342	.394	.167	.081	-.055	.068	.309	.084	.097
Humerus MaxC	**.656**	.323	.430	.125	.110	-.067	.051	.101	.133	.055
Radius L	.299	.366	.349	**.590**	.111	.092	.025	.257	.110	-.081
Ulna L	.187	.393	.371	.476	.092	.170	.060	.340	.198	-.054
Ulna A-P D	.172	.085	**.509**	.039	.113	.087	.052	.046	.284	**.535**
Ulna M-L D	.106	.024	.061	.088	.032	-.058	.054	.013	.238	**-.739**
Radius Mid C	**.505**	.190	-.045	.220	.030	-.022	.031	.054	.228	.303
Femur L	.474	.279	.233	**.596**	.086	.012	.034	.158	-.022	.045
Femur distal W	.451	.131	.410	.428	.125	.273	.075	.118	-.003	.084
Femoral head D	**.551**	.194	**.504**	.357	.089	.122	.017	.116	.008	.002
Subtroch. A-P D	**.667**	.230	.254	.263	.076	-.067	-.008	-.109	-.048	.003
Subtroch. M-L D	**.573**	.158	.291	.080	.045	.148	.005	.389	-.016	-.004
Femur Mid A-P D	**.801**	.224	.225	.245	.121	-.008	.077	-.001	-.083	-.019
Femur Mid M-L D	**.724**	.174	.286	.052	.132	.146	.000	.264	.010	.044
Femur Mid C	**.826**	.239	.245	.228	.160	.051	.046	.051	.032	-.029
Tibia L	.281	**.550**	.022	.464	.035	.160	.004	.110	.104	.042
Tibia proximal W	.473	.199	.306	.428	.067	.161	.031	.053	-.121	.142
Tibia distal W	.320	.315	.474	.184	.074	.253	.023	.034	-.071	.225
Tibia A-P D	**.705**	.175	.324	.138	.105	.324	.022	-.013	.030	-.039
Tibia M-L D	**.702**	.240	.139	.088	.070	.218	.044	-.001	.107	-.079
Tibia C	**.745**	.155	.216	.144	.067	.298	.056	-.058	.095	-.111
Calcaneus L	.395	.416	.488	.171	.075	.270	-.008	.046	-.061	-.105
Calcaneus W	.237	.193	.161	.130	.151	**.690**	.063	.074	.124	.125
Calcaneus H	.277	.421	.482	.094	.123	.446	.019	-.102	-.066	-.089
Talus L	.282	.355	**.706**	.089	.053	.171	.033	-.033	-.012	.016
Talus W	.174	.367	**.561**	.256	.067	.372	.032	-.009	-.194	-.017
Talus H	.223	.333	**.658**	.102	.055	.196	.035	.004	.079	-.082
MC1	.322	.363	.234	.443	.067	.271	.058	.259	.134	-.037
MC2	.145	**.605**	.274	.386	.014	.195	.043	.358	.055	-.007
MC3	.255	**.607**	.170	.259	.083	.119	-.030	.277	-.013	-.104
MC4	.147	**.569**	.184	.313	.033	.092	.008	**.548**	.051	-.064
MT1	.282	**.727**	.164	.175	.006	.150	.041	.016	.145	.052
MT2	.220	**.838**	.260	.023	.076	.022	.035	.036	-.012	.080
MT3	.226	**.820**	.235	.132	.117	.038	.021	.035	-.056	.020
MT4	.208	**.847**	.238	.067	.086	.051	.040	.038	-.005	.035
Patella L	.383	.193	.171	.474	-.017	.421	.042	.035	-.047	.079
Glenoid cavity L	.374	.159	**.615**	.255	.086	-.162	-.006	.190	-.021	.016

Table 43. Principal component analysis (rotated component matrix) of the variables available for more than eighty individuals. L – length; W – width; H – height; D – diameter; C – circumference; A-P – anterio-posterior; M-L – medio-lateral.

Chapter 6:
DISCUSSION

In this part of the thesis, the findings covered in previous chapters are discussed, providing information on similarities and/or differences in general health and lifestyle of past populations in different periods. The results are compared with those of other collections from the study region, where available.

6.1. Demography

For the studied remains, reconstructing demography is problematic, since only subsets of skeletal populations were selected for analysis, and because the Neolithic assemblage comes from a single site, whereas the Chalcolithic and Bronze Age remains come from a variety of sites. Combining the data with other skeletal collections from the study region may therefore provide more accurate results when comparing demography of individual periods. However, the complexities of sex and age-profile comparisons need to be borne in mind, as various methods are used by different authors, and so the demography results should also be considered with caution.

The sex ratio and age composition of prehistoric populations can point to living conditions or lifestyle, as some diseases are sex or age-dependent. In addition to methodological problems, male-to-female ratio and age distribution can be affected, e.g., by poor preservation of skeletal remains or preferential burial rites. Demography may be also influenced by different food and care provisions, deliberate infanticide, migration, the death of individuals outside settlements, etc. (for example, Köhler 2012). Moreover, issues of the osteological paradox (Wood *et al.* 1992) discussed in Chapter 5 need to be borne in mind.

6.1.1. Sex ratio

In the study assemblage, the male-to-female ratio is in favour of females only in the Neolithic. When combined with the comparative data, the same results are indicated. In the other two periods the ratio appears to be slightly in favour of males, although the proportions of individual sexes vary between the EBA sites (Table 44).

		NI	M:F	M	F	Literature
Studied remains						
NEO (Svodín)		33	0.74	14	19	-
CHAL collection		43	1.39	25	18	-
EBA collection		76	1.38	44	32	-
of which Nižná Myšľa		*45*	*1.05*	*23*	22	-
of which Praha - Malá Ohrada		*19*	*2.80*	*14*	*5*	-
Comparative collections						
NEO	Vedrovice	72	0.57	26	46	Dočkalová (2008)
	NEO collection[55]	12	0.50	4	8	-
	Nitra	50	1.14	27	23	Pavúk (1972)
CHAL	Hoštice	76	1.00	38	38	Drozdová (2011)
	Ivanovice na Hané	12	1.40	7	5	Bálek *et al.* (2003)
	Pavlov – Horní Pole	29	1.42	17	12	Peška (2007)
EBA	Jelšovce UK	77	0.67	31	46	Koel (2011)
	Jelšovce NK	130	1.71	82	48	Koel (2011)
	Melčice	21	1.63	13	8	Horňák *et al.* (2010)
	Rebešovice	29	0.81	13	16	Jelínek (1959)
	Hulín 3 - U Potůčků	31	0.94	15	16	Pankowská (2007)
	Slavkov u Brna	34	1.13	18	16	Dočkalová and Svenssonová (2000)
	Slatinice na Hané	17	1.83	11	6	Dočkalová (2006)
	Holešov	226	1.69	142	84	Stloukal (1985)
	Velké Pavlovice	20	1.22	11	9	Stloukal and Stuchlík (1982)
Together:						
	NEO total	167	0.74	71	96	
	CHAL total	160	1.20	87	73	
	EBA total	661	1.35	380	281	

Table 44. Male-to-female ratios by period. NI = number of adult individuals with assessed sex; M:F = male-to-female ratio; M/F = number of males/number of females.

In the whole study collection, male skeletons were better preserved than those of females, probably owing to the generally greater robusticity of male bones. Yet, despite this, more female than male skeletons were discovered in Svodín. In addition, like in the Neolithic site of Svodín, also female skeletons from Vedrovice were less well preserved but more numerous than males (Dočkalová 2008). Preservation bias is therefore also an improbable reason for the low male-to-female ratio in the Neolithic. Chalcolithic and EBA males and females were similarly well preserved and preservation probably does not affect the sex ratio in these periods. Detailed preservation descriptions are not available for Chalcolithic and EBA

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[55] remains coming from sites listed in Appendix 4, Table 61

comparative collections, and so it is unclear if this could have affected results in any of the periods.

Many forms of burials leave no archaeological traces (as discussed, for example, by Neustupný 1978: 264; Kandert 1982; Turek 2000b: 144), and there is always the possibility that the burial of particular groups in this study left no traces (Matoušek and Turek 1998). Recent DNA analysis of Bell Beaker subadult burials from Hoštice, Moravia, has revealed that none of the sexed juveniles is female and that a significant number of boys were thus buried according to a burial rite characteristic for female individuals, including burial equipment (Vaňharová 2011). Together with the lack of burials of Bohemian Bell Beaker females (Turek 2002), it appears that the majority of girls were buried outside the communal cemetery (Turek 2013), although we do not know where. DNA studies are rare in the study region but as Hoštice clearly demonstrates, without such analyses our perception of prehistoric societies, including their demography, can be very biased and inaccurate.

Sexing bias can also considerably affect the estimation of sex ratios. For instance, older females tend to develop more ‘male’ cranial features; females above forty-five years tend to have more robust supraorbital ridges than younger females, whereas this age discrepancy is not usual in males. Older females may therefore be easily mistaken for males, producing an inaccurate sex ratio in a studied population (Meindl *et al.* 1985a; Walker 1995). There was a well-differentiated sexual dimorphism in all three studied collections. Moreover, old adults were recorded mostly in the Svodín assemblage, with a prevalence of females. Regardless, the majority of the Lengyel cemeteries typically show female predominance (for example, Zoffmann 1998-1999; Köhler 2004; 2012). In comparison, only one individual above fifty years was recorded in the Chalcolithic and two in EBA, all of which were assessed as males. In combined collections it was also the elderly females who prevailed over males, and so the difference in sex ratio was probably not caused by a sexing bias.

The possibility of parents favouring children whose contribution to subsistence is greater may also affect the sex ratio (for example, Hewlett 1988). If female individuals were preferred to males in the Neolithic, male children would exhibit a higher death rate either as a consequence of deliberate infanticide or preferential treatment of girls known as ‘delayed infanticide’ (Johansson 1984). Compared to other periods, the number of perinates is the highest in the Neolithic assemblages (Appendix 4, Table 62), and Neolithic children were also dying at a younger age (Appendix 4, Table 65). Additionally, the total percentage of young adult females from Svodín is much higher than that of young males (85.7% and 14.3%), while the differences between the sexes are smaller in other periods. Combined Chalcolithic and EBA data[56] suggest similar results (Appendix 4, Table 64). Deliberately inadequate food and care provisions during childhood and adolescence in male individuals would probably manifest in their higher mortality, yet the number of young Neolithic males is low. Deliberate infanticide in the Neolithic has not been proven either, as the cases of subadult skeletons with traces of violence are quite rare. Only two cases from south-western Slovakia indicated violence towards children (Niklová 2014). However, if suffocation, strangulation, or drowning were the methods of choice, there would be no traces of violence. When addressing archaeological evidence, countless female figurines with emphasized female characteristics in the Neolithic are sometimes interpreted by local authors as demonstrating the high status of women, connected with fertility and the cult of the 'great mother' (Podborský 1993: 151-152; 1994; Gimbutas 1999; Čermáková 2007). However, in none of the societies is there evidence of female status being higher than that of males and as Hayden (1992) suggests, the role of women may have been valued, but they were not necessarily in a position of control. A similar conclusion is reached by Bruce (2004) and the presumption is supported by Neolithic grave inventories, with more rich graves belonging to male individuals, whereas females and children were usually poorer and very similarly equipped (for example, Podborský 1993). Moreover, negative climatic change at the end of the Central-European Neolithic (see, for example, Tóth *et al.* 2011) may also imply that the abundant female figurines were symbols related to a need for higher agriculture-related fertility rather than a preference for female offspring. Studying social differences between the Svodín males and females, Demján (2010; 2012) reaches the same findings, concluding that it was young females and mature males who had the highest status indicators, and that the roles of males and females, while different, were equally important. To sum up, even though preservation and sexing bias may have played a role, the low sex ratio in the Neolithic was probably not a result of infanticide.

A connection between maternal malnutrition and the increased death of male foetuses in mammals has been revealed (Meikle and Drickamer 1986; Huck *et al.* 1996), with similar outcomes suggested for humans (Andersson and Bergström 1998; Song 2012). The height and body mass of females were suggested to affect the sex of their offspring, whereby taller and

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[56] due to a variety of ageing methodologies used for comparative collections, individuals with mean age lower or equal to twenty-five were considered in this comparison

slimmer females tend to give birth to boys (for example, as discussed by Susser and Stein 1994). Obesity and small stature have been associated with a low socio-economic status (Mascie-Taylor 1991), and so a relation between poor living conditions and higher number of female births can be suggested. A more recent study by Stein *et al.* (2004) did not find a relationship between a lack of nutrition and a lower number of male births following the Dutch Famine of 1944-1945, but the period of food shortage may have been too short to have an effect. Inferior living conditions and a poorer Neolithic diet could have resulted in fewer males being born. Periods of growth disturbance in childhood, indicated by dental enamel hypoplasia (DEH), were found within the widest age range in the Svodín sample, occurring between the ages of three and six. In comparison, the peak in the following periods was reached between the third and fourth year, suggesting a shorter period of stress in childhood. Jarošová and Dočkalová (2008) recorded increasing tendency of DEH occurring from the Early to Late Neolithic, and a study of Lengyel human remains from the Hungarian site of Alsónyék also yielded a higher number of skeletons with DEH, suggesting at least unpredictable food supply in the Lengyel period (Köhler 2012). Such fluctuations and periods of nutritional shortage in the Neolithic are suggested by proxies, such as calcareous tufa formations, or Sun radiation (Žák *et al.* 2002; Bryson and McEnaney DeWall 2007). Also Pavúk (personal communication, May 2013) and Karlovský and Pavúk (2004) presume that the sudden increase in game consumption in the Lengyel stage might indicate lower crop yield and a general food shortage. This interpretation is also supported by Tóth *et al.* (2011) who studied changes in Neolithic settlement structure and discovered significant settlement movement, corresponding with climatic changes, and thus suggesting worsened climatic conditions that could have affected crop yields in the late Neolithic period.

Non-specific skeletal lesions indicating compromised general health, such as *cribra orbitalia* (CO), vault porosity (with and without the diploë thickening), and non-specific periostitis are also the most frequent in the Svodín assemblage and they are especially common in women. The dominance of vault porosity in the Svodín collection is statistically significant when compared to the other two periods (using Pearson's Chi-Square) (Appendix 5, Test 18). A decreasing frequency of lesions is also indicated by comparison with other collections from the area. When Bell Beaker skeletons from Hoštice and scattered Neolithic remains from Moravia were compared, the prevalence rates of CO and vault porosity were also noticeably higher in the Neolithic assemblage (Shbat *et al.* 2009; Smrčka and Tvrdý 2009;

Drozdová 2011). In the Hoštice collection, non-specific periostitis was detected only in four out of 143 individuals (Smrčka and Drozdová 2011). Only a very low incidence of CO (12%) was detected among the EBA individuals from central Moravia studied by Pankowská (2009), although the number of studied individuals was quite low (forty-three). Low frequencies of CO (9.3%) and vault porosity (3.9%) were also detected by Wohlschlager (2011) who examined 258 individuals from the east-Austrian site of Gemeinlebarn. However, when all three stress indicators are considered together, they prevail in the Neolithic. Regardless, iron-deficiency anaemia is a widely accepted cause of CO and vault porosity (Ortner 2003); a detailed study by Walker *et al.* (2009), reappraising the aetiology of the two suggests that the conditions are caused by lack of vitamin B12 and poor living conditions rather than iron deficiency. The authors back up their study by a test case focused on Puebloan populations where the conditions were more prevalent during the periods of drought, warfare, famine and socio-economic collapse (Walker *et al.* 2009). Smrčka *et al.* (1989) also suggest that a lack of B12 may result in the presence of anaemic lesions such as CO and vault porosity, for instance owing to a lack of the consumption of cow's milk that is much richer in folic acid than, for example, goat's milk. As indicated by the archaeological record from Svodín, there was an overall decrease in the number of domestic animals (Němejcová-Pavúková 1998), and so the high amount of CO and vault porosity may indeed reflect a nutritional shortage. Moreover, Neolithic adults in this study also demonstrated the highest frequency of possible scurvy, whereas in modern developed countries, the occurrence of scurvy is low, being present mostly among the poor elderly (Hampl *et al.* 2004; Schneider and Norman 2004; Velandia *et al.* 2008). This again suggests lower dietary adequacy in the Neolithic when compared to the Chalcolithic and EBA. A link between porotic hyperostosis and parasitic infection has also been indicated (Smrčka 2005), and so the loss of nutrients could have also been caused, for example, via diarrhoea. Infections of parasitic origin are believed to have been frequent in agricultural populations (Beneš 1994; Horáčková *et al.* 2004). Given that the presumed contemporary importance of hunting suggests that the Svodín population was not an entirely agricultural society, perhaps lowering the possibility of parasitic infections playing a crucial role in poorer health status of these people. Another thing to consider is that the most frequent causes of death among pregnant or birth-giving women are connected to post-partum haemorrhage, infection, labour obstruction or high blood pressure (WHO 2015), many of which can be caused by poor sanitation or quality of care.

All in all, the high proportion of young adult females and neonates in the Neolithic may also point to poorer living conditions and inadequate health-care in general. However, insufficient preservation of infant bones in the other two periods needs to be considered as an influencing factor. An inferior living environment in the Neolithic is also indicated by lower adult stature than in later periods, with statistically significant differences suggested by One-Way ANOVA (Appendix 5, Test 1). Similar results were indicated for other skeletal assemblages in the region (Vančata and Charvátová 2001), although different methodologies for stature estimation were used. Together with the general health indicators, all the evidence points to poorer living conditions in the Neolithic that may have resulted in increased maternal malnutrition and a lower proportion of male births.

Modern studies analysing gender migration and its patterns in developing countries suggest that migration can also affect sex ratios (for example, Radcliffe 1992; Barbieri and Carr 2005). In 1970s-1980s Peru, young women from a poor agricultural Kallarayan community migrated to urban areas resulting in the larger cities being dominated by females and smaller urban areas by males (Radcliffe 1992). Males migrated as well, but while females usually stayed longer at the place of destination, migration of males was mostly seasonal. As recorded by Laurian *et al*. (1998), women from the settlers' families leave their original households mostly in order to marry (or study), whereas males stay on the family land and farm. Also Cronk's (1989) research on the Mukogodo tribe in Kenya revealed that the tribe was considered to be of lower-status in comparison to neighbouring tribes, and, because the bridewealth for a non-Mukogodo female was higher than that of a Mukogodo woman, the chances of Mukogodo females marrying a non-Mukogodo male were higher than for Mukogodo males marrying outside the tribe. Migration of females in the Central European Neolithic has been suggested by strontium isotope analysis, possibly associated with marriage (for example, Bentley *et al.* 2002). In the Late Neolithic, large fenced-off structures, known as 'roundels'[57], are common, as the one in Svodín. Their function is still not entirely clear, but many authors agree that they may have been common meeting places for a series of surrounding settlements, to exchange goods and ideas, perform ceremonies, or predict change in natural cycles (Ruttkay 1983-1984; Petrasch 1990: 518; Pavlů *et al.*1995: 98; Becker 1996; Podborský 2001; Karlovský and Pavúk 2004; Jelínek 2006: 177-180; Pavlů and Zápotocká 2007: 61). Living close to a roundel, which acted as an 'urban structure', may have had

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[57] circular compounds demarcated by concentric circles of ditches and palisades

numerous advantages, which would have made Svodín a lucrative location to move and marry into. Females also prevailed at other Lengyel sites, which are believed to have been of increased importance (Köhler 2004, 2012). Smrčka *et al*. (2005) and Lillie (2008a) propose that intermarriage may also have been responsible for the prevalence of females in Vedrovice, whereas a significant percentage of migrants came from the vicinity of Vedrovice (Zvelebil and Pettitt 2008). The immigration of females may thus be another factor contributing to the low sex ratio in the Neolithic, however short the distance was (Ravenstein 1885: 198). Alternatively, male emigration may have played a role. There was a much greater variability of goods in the graves of Svodín males than those of females, which were mostly equipped with pottery (Demján 2010). Svodín was a part of a large Lengyel cultural complex and long-distance goods movement has been indicated, for instance, by a rare type of flint[58] of north-western Hungarian origin (Demján 2010). Given that long distance trading is usually associated with male dominated cultures (Hayden 1992) it is possible that the prevalence of females on the site may also have been caused by the movement of males who died outside the settlements[59]. This would be consistent with Ravenstein's theory (1885) that it is more usual for males to migrate over longer distances, whereas females move over shorter distances usually to get married. However, according to Ravenstein (1885), migrations increase with technological progress, and so the long-distance migration of males, for example, for trading, is more likely to occur in the Chalcolithic, and especially in the EBA (see Podborský 1993; Jiráň 2008; Neustupný 2008b). A study by Price *et al.* (2004) using strontium isotope analysis has revealed that 63% of Central-European Bell Beaker individuals had moved during their lifetime, but in this study higher mobility was also detected for females. However, in general the 'migrants' of all age categories were recorded, and so the authors suggest that it was probably families and groups that were migrating, not only females (Price *et al*. 2004). Randomly selected individuals from Hoštice, Moravia, did not show higher mobility of young females either, although this was a small sample (Smrčka *et al.* 2011). The cranial index of the studied Bell Beaker populations well that of the Hoštice collection indicates that both sexes were short-headed which, in the context of predominantly dolichocephalic populations from the previous and following periods, may point to a foreign

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[58] tevel chalk flint

[59] The journeys were probably very dangerous and demanding. EBA Central Europe was covered with deep forests with numerous predators. Travellers had no maps and used probably only major landmarks. In the case of river paths, big rivers could be crossed only in few places, introducing the possibility of drowning.

origin for the population. Female crania were, however, longer than those of males, possibly indicating some local ancestry (Drozdová 2011). Similar results were obtained in the present thesis. Overall, the mean cranial index of the studied Chalcolithic population is 82.8, in comparison to Neolithic (73.7) and EBA (72.4) populations. Differences between males and females were also recorded, although they were small (see Chapter 5, section 5.4.1.). The differences between the Chalcolithic and the other two periods are also statistically significant when compared by One-Way ANOVA (Appendix 5, Test 4). As for the EBA, migration seems to have been a variable phenomenon. For instance, Pokutta (2013) found that males, females, and children migrated repeatedly to the Silesian region, whereas little immigration was confirmed for the EBA individuals from Jelšovce, Slovakia (Reiter 2013, 2014). The proportion of males to females at Chalcolithic and EBA sites from the area tends to be male-biased, even though the ratios in the EBA are variable (Table 44). Nevertheless, if migration had an influence on the significant difference between the sex ratio of the Neolithic and the following periods, the differences were probably caused by the immigration of Neolithic females rather than male emigration or human mobility during the other two periods.

6.1.2. Age composition

In the study collection, sub-adults are outnumbered by adults in all periods, apart from the Chalcolithic where the proportion of juvenile remains is higher. However, when combined with other collections from the region, adults are more numerous in all three periods, even though the proportion of juveniles is obviously lower in the Neolithic (Table 45).

A high proportion of subadults is often viewed as a signature of elevated fertility levels, often associated with the transition to agriculture (for example, Chamberlain 2006: 64-5; Bellwood and Oxenham 2008). On the other hand, high numbers of juveniles may also point to their higher morbidity, as suggested by findings within the Man Bac community with juveniles frequently suffering from *cribra orbitalia*, dental hypoplasia, and non-specific periostitis (Oxenham and Domett 2011). Non-specific stress indicators were lowest in the studied Chalcolithic subadults. This may imply higher fertility rather than high subadult mortality, even though the possibility that a higher number of juveniles died before they could develop any bone lesions needs to be considered (Wood *et al.* 1992). Additionally, the high number of Chalcolithic juveniles in the study sample could be the result of the sample selection process and the high number of sites from which the remains came. On the other hand, as Turek

(2013) suggested using the DNA results from the Bell Beaker site of Hoštice (Vaňharová 2011), young girls may have been buried outside the communal cemetery, and so the true number of Chalcolithic juvenile deaths may have been much higher (see also Chapter 6, Section 6.1.1.).

		NI	A:J	ADU	JUV
***Studied remains*:**					
NEO collection (Svodín)		62	1.14	33	29
CHAL collection		94	0.84	43	51
EBA collection		132	1.36	76	56
	of which Nižná Myšľa	*94*	*0.92*	*45*	*49*
	of which Praha – Malá Ohrada	*21*	*9.5*	*19*	*2*
Comparative collections:					
NEO	Vedrovice	110	2.14	75	35
	NEO collection[60]	26	0.86	12	14
	Nitra	72	2.27	50	22
CHAL	CHAL collection[52]	221	1.07	114	107
	Hoštice	137	1.40	80	57
EBA	EBA collection[52]	418	0.94	202	216
Together:					
	NEO	270	1.70	170	100
	CHAL	452	1.10	237	215
	EBA	550	1.02	278	272

Table 45. Adult-to-subadult ratios by period. NI = number of adult individuals with assessed sex; A:J = adults to juveniles ratio; ADU = number of adults; JUV = number of juveniles.

The proportion of adults to subadults in Svodín is more balanced than in the combined Neolithic sample where the number of subadults is significantly lower than in later periods. This inconsistency between the Neolithic assemblages may have two contradictory explanations – higher fertility or higher mortality. It is true that the occurrence of dental hypoplasia is lowest in the Svodín sample, but periods of stress are the longest of all the periods. On the other hand, the occurrence of DEH was lower in the Neolithic in both the studied remains and the remains from other assemblages from the study region (Jarošová and Dočkalová 2008). In addition, Schultz (2001a) also identified a very high DEH prevalence rate in EBA collections, similar to the Chalcolithic and especially the EBA collections examined in this thesis. This suggests that more Chalcolithic and EBA than Neolithic children may have been exposed to stress, but for a shorter period of time. In all three periods, the onset of the first indications of stress is at about two to three years, the age when weaning commonly takes place (Kennedy 2005).

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[60] remains coming from sites listed in Appendix 4, Table 61

Weaning is believed to be the most probable cause of stress resulting in DEH (for example, Temple *et al.* 2012), as the children face additional nutritional stress at this time and are more susceptible to pathogens (Schultz and Schmidt-Schultz 2008). The same onset of enamel defects in all three periods may thus be related to weaning. However, the longest period of stress indicated in the Neolithic may indicate that children had more difficulty adapting after they stopped being breastfed, either because of the lack of proper nutrition or generally poorer living conditions. On the other hand, Neolithic children may have also been more capable of surviving the stress, unlike the Chalcolithic and EBA children who may have died before the stress manifested on the teeth (see Wood *et al.* 1992). Non-specific periosteal lesions were also the most frequent in Svodín subadults, suggesting, e.g., repeated infections. However, incidences of *cribra orbitalia* and vault porosity are not different from the Chalcolithic and EBA, although the lesions occurred earlier in life in Svodín children. Late Neolithic children may thus have had more difficulty adapting to deteriorating conditions, possibly after weaning, but had a higher chance of survival (also Schultz 2001a). A trend towards decreasing child mortality in the course of the Neolithic has also been suggested by Dočkalová and Čižmář (2008a) and Lillie (2008b). In comparison to the LBK, rich child graves were found at several Lengyel sites, including Svodín (Zalai-Gaál 2001, 2002, 2003; Demján 2010). As suggested by Čermáková (2007: 232), grave goods reflected the social position of a clan, and children were part of this differentiation. It is possible therefore that the social position of children in the late Neolithic was better than in the beginning of the period, resulting in their lower mortality in the late stage. All this may explain the differences observed between Svodín and the Neolithic comparative sample that comprised mostly of LBK individuals. The significantly lower proportion of subadults in the total Neolithic assemblage is interesting given that the trend associated with the transition to agriculture is usually accepted as being the opposite (Sellen and Mace 1997; Bellwood and Oxenham 2008). Lower numbers of subadults is frequently ascribed to taphonomic processes or differential burial rites (Scott 1999; Chamberlain 2006; Whittle *et al.* 2013). In addition, it is probable that younger children were treated differently from older ones who may already have been recognised as full members of society. For instance, at the Hungarian Late Neolithic site of Berettyóújfalu-Herpály, young children were buried mostly within the settlement structures at the settlement itself, whereas older children were found in a trench 200 metres from the settlement (Kalicz and Raczky 1984; 1987). There are numerous cases of Neolithic children buried in settlement structures within the study region (Lichardus and Vladár 1964; Němejcová-Pavúková 1995; Pavúk and Bátora 1995; Humpola 2007), and so the above-mentioned spatial separation may be one reason for the under-representation of children in this period. However, individuals buried in the trench may have been buried around the same time, the authors suggesting causes such as disease, famine, etc. rather than different burial rites.

Biological processes associated with the female reproductive cycle and infant feeding habits may also affect the adult-to-subadult ratio. As a result of breastfeeding, ovulation is suppressed and new eggs are not released to be fertilised (Konner and Worthman 1980; Jackson and Glasier 2011; Berens and Labbok 2015). If Neolithic infants were exclusively and frequently breastfed, as for instance among the Ju'hoansi of the Kalahari Desert where mothers breastfeed their babies during the night and day (Haviland *et al*. 2007: 234) whenever they show any sign of discomfort, the number of pregnancies per woman may have been lower as the intervals between births would be extended (see also Pennington and Harpending 1988; Bentley *et al*. 1993). As pointed out by Haviland *et al.* (2007), the frequency of breastfeeding decreases with the introduction of soft foods, and fertility tends to increase. In comparison to the Neolithic, a softer diet including more meat and better food processing has been suggested for the Chalcolithic and the EBA in the study region (Jarošová 2008; 2012; Smrčka *et al.* 2008b; Horňák *et al.* 2010; for discussion see also Kolář *et al.* 2012). Moreover, it is females and children from the Bell Beaker site of Hoštice who had a higher protein intake than male individuals, as suggested by stable isotope analyses and the content of trace elements in bone tissue (Smrčka *et al.* 2011b). As a result, fertility in the later periods may have been higher. On the other hand, the high number of young Neolithic females buried at Central-European sites may also point to a higher maternal mortality, associated with a rise in fertility after the adoption of agriculture (for example, Eshed *et al.* 2004). Consequently, the overall number of children was probably also higher than indicated by archaeological research, and other than biological factors need to be addressed when looking for the cause for the low proportion of subadults at the Neolithic sites in the region since these differences were probably caused by a combination of factors.

Natural disasters as a factor affecting age distribution of past populations has also been suggested (Chamberlain 2006). Although catastrophic events such as flooding usually affect all age groups equally, there is an added risk for the weakest members of society, including children (Chamberlain 2006: Figure 3.9). The instability of climatic conditions in the study region throughout the Neolithic has been noted above, and so occasional catastrophes cannot be ruled out as a reason for the lower proportion of children in the Neolithic, as victims of natural disasters may not be visible in the archaeological record.

Famine can cause significant fertility reduction as suggested, for example, by the work of Kidane (1989) who studied the Ethiopian population after the harsh famine of the 1980s. On the other hand, as Watkins and Menken (1985) argue, a short period of even severe famine will not have a long-term demographic effect on human populations. Given that lengthy periods of severe famine are unlikely in agricultural societies, this is an equally improbable cause of the low proportions of subadults in the Neolithic. Nevertheless, inferior living conditions and/or health status in the Neolithic have been implied in the discussion above; longer periods of nutritional shortage among Neolithic children, indicated, for example by DEH, may have caused increased vulnerability to infectious diseases, including those that may have not have had time to manifest on bones (including diarrhoea, pulmonary infections, etc.) (De Waal 1989; Moore *et al*. 1993). A more detailed discussion of pathological lesions is provided later in the thesis.

With the transition to agriculture, there was a general decrease of postcranial injuries in the North American Eastern Woodlands, Southwest and Texas (Steinbock 1976). Studying forearm trauma of aboriginal populations in the Tennessee Valley, Smith (1990) came to a similar conclusion, suggesting a more dangerous lifestyle for hunter-gatherers than agriculturalists. In the study region, burials with boar/animal tusks and arrows start to occur more frequently from the late Neolithic onwards (Dombay 1960; Vladár 1973b; Turek and Černý 2001; Turek 2002; Bátora 2006; Nováček 2010; Demján 2010; Siklósi 2004, 2007; Drozdová *et al.* 2011). There are also greater numbers of wild animal bones found at the sites, suggesting increased interest in hunting (Ambros 1986: 12–13; Pavúk *et al.* 1995: 121; Dreslerová 2006; Demján 2011; Nováček 2010). As a result, the higher mortality of Chalcolithic and EBA subadults, especially adolescents, could have been caused by children being integrated into adult activities performed in a more difficult terrain as, e.g., training for their future roles. On the contrary, judging from the archaeological record, activities in the Neolithic were probably bound mostly to an area of the settlement, including simple cultivation, pottery production, animal husbandry, building activities, etc. (for example, Podborský 1993).

The mean age of Neolithic subadults was the lowest of all in both the studied and combined samples, whereas it is statistically significant in the combined collection when using One-Way ANOVA (Appendix 5, Tests 19-20). In Svodín, as well as in the combined Neolithic assemblage, children up to one year are more numerous than in the following periods. The only clear mortality peak in the study collection is that of the EBA assemblage, being reached between ages six and eleven. This is the same for the combined EBA data, although an additional peak was indicated in adolescence. On the contrary, both the study and the combined assemblages indicate that Neolithic children were more numerous in younger age categories. This may imply that Neolithic children had lower chances of surviving the perinatal period and frequently died before the age of eleven. In the Chalcolithic datasets, in addition to early childhood years (one to five years), adolescents were also numerous. However, these results may well be caused by method biases (Table 46).

		JUVENILES		**ADULTS**
		Main peak	Additional peaks	Main peak
Studied remains:				
NEO collection (Svodín)		1-11		25-35
CHAL collection		1-5	6-17	25-50
EBA collection		6-11		36-50
Comparative collections:				
NEO	Vedrovice	1-5	6-11	18-35
	NEO collection[61]	1-17		25-35
	Nitra	6-11	1-5	30-40
CHAL	CHAL collection[53]	6-17	1-5	35-50
	Hoštice	6-11		25-50
EBA	EBA collection[53]	6-11	12-17	35-50
Together:				
	NEO	1-11		25-35
	CHAL	1-17		30-50
	EBA	6-11		35-50

Table 46. Adult and subadult mortality peaks in individual periods.

When mean ages of the studied adult populations were compared using ANOVA, the mean age decreased slightly from the Neolithic to the EBA, without statistical significance (Appendix 5, Test 21). A similar trend was recorded when sexes were compared separately. Adult mean age in the combined assemblage was highest in the Chalcolithic, with statistical significance (Appendix 5, Test 22). When individual sexes were considered separately

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[61] remains coming from sites listed in Appendix 4, Table 61

in the combined collection, the mean age of Neolithic females was significantly lower when compared to males from the same period (Appendix 5, Test 23). In the other two periods, the ages of males and females were very similar (Appendix 4, Table 64). It is also in the Neolithic that the mortality peak is reached earlier in life (Table 46), which is probably determined by the higher mortality of young women, mentioned previously.

A number of explanations can be provided for the higher mean age of the Chalcolithic population. In the Neolithic, the percentage of young adults with a mean age lower than twenty-five is the highest of all periods, whereas in the EBA the mean-age peak is recorded for prime age individuals[62]. In comparison, the mortality of Chalcolithic adults seems to be much more evenly distributed within age categories, whereas a mean age above forty was the most frequently reached in Chalcolithic adults as well. In other words, the majority of adults from the other two periods died on average at an earlier age, whereas the Chalcolithic population was dying at all ages equally. In the Chalcolithic, the migration of groups/families has been indicated, including children (see discussion above). This could have amplified the number of subadults as well as middle-aged adults in the destination area, whereas the age distribution between males and females would not be too different (Castro and Rogers 1983; Chamberlain 2006: 38-9). Combined data for the Chalcolithic show that the mean ages of males and females are almost identical, unlike the other two periods where the mean age of females is lower than that of males. Consistent with the family-mobility hypothesis, the equal number of young Chalcolithic males and females suggests that only a low proportion of migrating Chalcolithic females gave birth after reaching the destination area. In comparison, the number of young females is higher in the other two periods (Appendix 4, Table 63). However, the proportion of Chalcolithic elderly would be expected to be low if the higher mean age of the Chalcolithic population was a reflection of higher mobility, as they are not expected to move as frequently. Yet, the percentage of individuals with a mean age above fifty was the highest in the combined Chalcolithic sample too, although it is difficult to say how many of those could be of non-local origin. However, it is necessary to mention that bones of old individuals are often under-represented owing to their poorer preservation, and so the proportion of elderly individuals in the different periods may not reflect the real numbers. Nevertheless, although fertility is usually the most common factor affecting age distribution of a population (for example, Chamberlain 2006), it seems that the higher mean age

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[62] mean age of twenty-five to forty years

of the Chalcolithic population in the study region may be at least partially attributable to increased migration.

6.2. Growth and stature

Skeletal and dental ages were compared only in the present study, with no data for the comparative collections. In all three periods, both growth retardation and growth acceleration were recorded in the study collection. No differences between the periods were recorded, suggesting similar growth conditions.

Using One-Way ANOVA, mean stature of the studied Neolithic population was statistically significantly lower than that of later periods, with the same results suggested for males and females separately (Appendix 5, Tests 1-3). Mean statures of combined samples from the area indicate similar results, with the Neolithic population being the shortest of all (Figure 87). Because different methodologies were used for stature evaluation of reference collections, and inter-observer errors cannot be estimated, no statistical evaluation of mean statures was performed for the combined collections. However, as Brothwell and Zakrzewski (2004: 32) suggest, statistical tests can be used for mean femoral lengths. Such data were available for the Vedrovice and Hoštice collections, and these were included in statistical comparisons when combined with the studied collections. For both Neolithic males and females the means were lower than for Chalcolithic and EBA individuals when compared by ANOVA (Appendix 4, Table 66), and the results were also statistically significant (Appendix 5, Test 24).

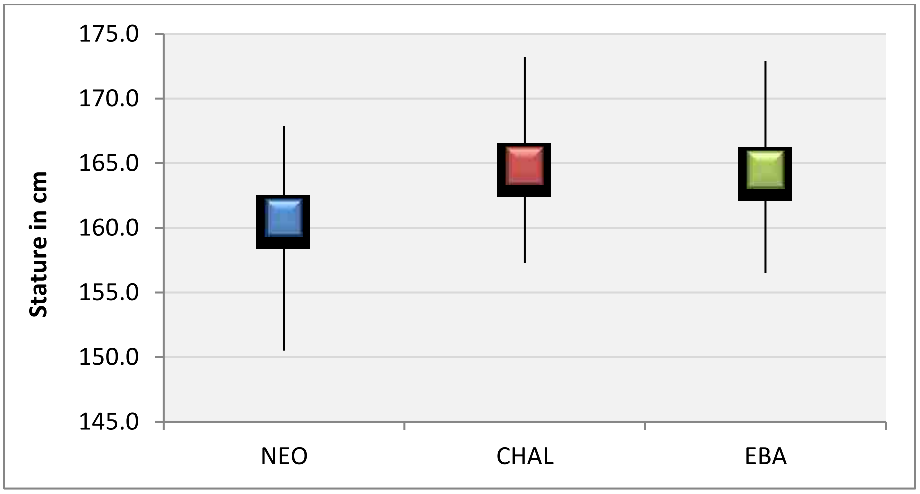

Figure 87. Statures in the combined collections by period.

The number of studies associating human stature with stress related to disease, malnutrition, and low socio-economic status is also abundant, and stature is commonly used as a health indicator (Floud *et al.* 1990; Komlos 1994; Steckel 1995). Brůžek *et al.* (2005) introduce a 'caloric requirements reduction' theory suggesting that in an environment providing poor but constant food provisions it is more advantageous to eat less, which may result in shorter body height. At the same time, higher protein intake during the years of growth results in taller stature in adulthood (Brůžek *et al.* 2005). Vančata and Charvátová (2001) noted similarities in skeletal morphology betwen Chalcolithic and EBA individuals and Mesolithic foragers. Similar observations were made by Shbat *et al.* (2009). Moreover, Kolář *et al.* (2012) discovered similarities between dentitions of Chalcolithic populations and hunter-gatherers with a mixed diet. Dental micro-abrasions and isotope analysis studies also demonstrate different meat intakes in the Neolithic and the following periods (Jarošová 2008, 2012; Smrčka *et al*. 2008b, 2011b, 2011c; Horňák *et al.* 2010). A less nutritious diet and generally worse health status in the Neolithic was suggested also by non-specific indicators of health such as *cribra orbitalia*, cranial vault porosity, or periostitis of non-specific cause (see discussion below). Even though dental enamel hypoplasia was more frequent among Chalcolithic and EBA individuals, the longest period of systemic stress indicated by the condition was demonstrated in the Neolithic (see discussion below). Greater differences between statures of Neolithic and Chalcolithic/EBA males may be caused by an enhanced natural immunity of female juveniles to dietary stress and disease (for example, Stini 1969; Stinson 1985; Ortner 1998). Even though factors such as genetics and climate can play a role in the final height of an individual, genetic differences were mostly discovered between the individuals of different races, and the stature was not proven to be significantly affected by latitude (Tanner *et al.* 1982; Ruff 1994). In summary, dissimilarities in stature of Central-European populations probably point to a lower level of health and poorer diet in the Neolithic when compared to the other two studied periods.

6.3. Pathology

6.3.1. Dental diseases

Dental pathology can be indicative of many aspects of past populations' lives, including nutrition, dietary habits, hygienic conditions, activity, enamel defects and composition, or the presence of systemic diseases (Molnar and Molnar 1985; Hillson 1996: 278; Ortner 2003;

Slade *et al.* 2013; Peres *et al.* 2016; for a discussion see also Larsen 1997: 65-67). Unfortunately, detailed data regarding dental disease from the region are not numerous, especially as regards the Chalcolithic and EBA. In addition, even available studies are sometimes difficult to compare owing to the different methodologies used. For instance, prevalence rates may or may not include subadults, and prevalence rates may be calculated either from the total number of dentitions or from the total number of preserved teeth. Direct links between individual dental pathologies are complicated and therefore difficult to establish. Inter-observer error also needs to be considered.

In spite of the incompletely understood aetiology of caries, the condition is believed to be caused by organic acids produced by the bacterial fermentation of carbohydrates (Waldron 2009: 237). Due to a high percentage of carbohydrates in the diet, caries tend to be frequent in agricultural societies (Turner 1979; Meiklejohn *et al*. 1984; Bennike 1985)[63]. Caries are regularly recorded in osteological studies from the study area, with TPRs being provided more frequently than CPRs. Figures 88 and 89 show TPRs between various adult populations from the study region. When the data from the present work are combined with those of other studies from the region, average rates do not vary dramatically between the periods (NEO – 40.1%; CHAL – 35%; EBA – 41.1%) although local variations do occur. Early Neolithic populations seem to have been affected to a greater extent than those later in the period (including the Lengyel culture). The lowest occurrence rates are indicated in the Chalcolithic, although these may be influenced by insufficient data and a lack of research. Like non-specific stress indicators, caries rates for Slovak populations are higher than for those in the western part of the study region. In the majority of sites caries prevail in females, a common observation in past populations (Larsen *et al.* 1991: 194-5; Stránská *et al.* 2008; Watson *et al.* 2010), although at the Lengyel and a number of EBA sites the opposite trend has been recorded. Given that agriculture and farming were the key methods of subsistence in all three studied periods, small differences in caries prevalence rates between periods are not surprising. Decreasing caries occurrence from the Neolithic to EBA may be explained by increasing meat consumption from the Neolithic to the EBA. Analyses of early Neolithic dental remains from the study area indicate mostly plant-based diet (Jarošová 2008; Smrčka

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[63] the percentage of carbohydrates in cereal grains is 66-76%, of which 3% are sugars (Koehler and Wieser 2013)

et al. 2008a; 2008b) and a rather high cariosity of teeth (Frayer 2004; Dočkalová 2008; Jarošová and Dočkalová 2008; Whittle *et al*. 2013).

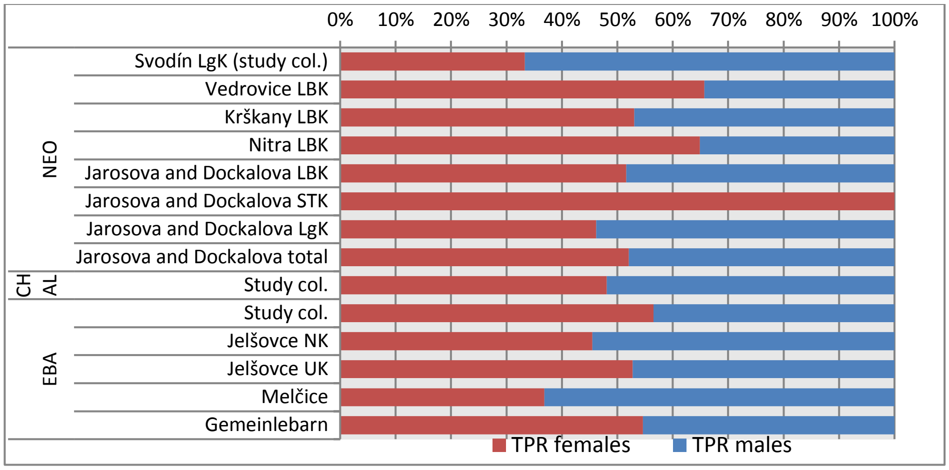

Figure 88. Caries TPRs of adult populations from the study region by sex. LBK – Linear pottery culture; STK – Stroke pottery culture; LgK – Lengyel culture; NK – Nitra culture; UK – Únětice culture.

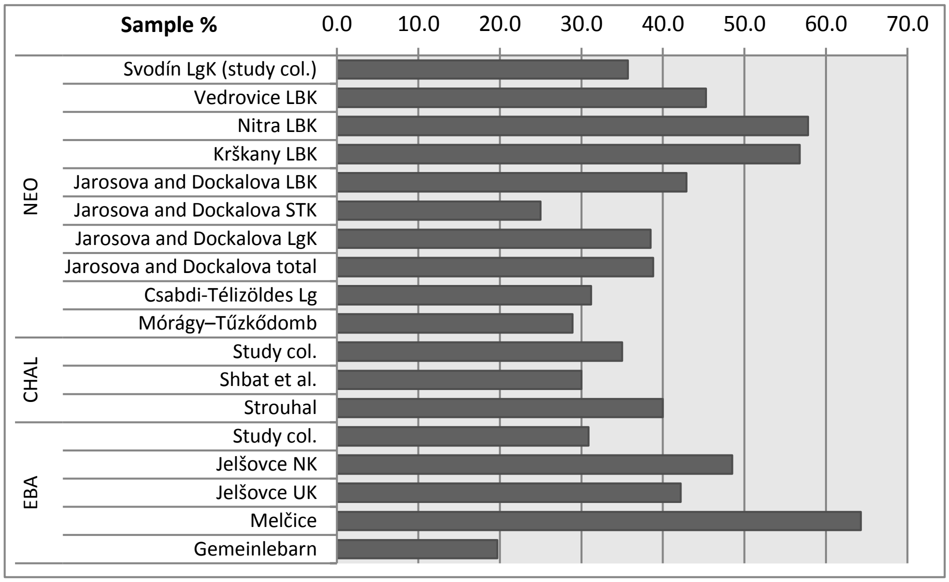

Figure 89. Caries TPRs of adult populations from the study region. LBK – Linear pottery culture; STK – Stroke pottery culture; LgK – Lengyel culture; NK – Nitra culture; UK – Únětice culture.

Lower than expected caries rates in the Svodín sample may be ascribed to the already-mentioned presumed crop failures in the Lengyel period, subsequent food shortage, and a temporary increase in the consumption of meat (see Němejcová-Pavúková 1998: 22).

Lower rates detected in Svodín correspond to those obtained from other Lengyel sites where caries were also quite infrequent when compared to the Early Neolithic sites (Köhler 2004; Jarošová and Dočkalová 2008). The previously widespread belief that Chalcolithic cultures were predominantly pastoral, mostly owing to the lack of discovered settlements and numerous exotic grave goods (Buchvaldek and Koutecký 1970; Buchvaldek 1986; Šebela 1999), has recently been challenged and a half-pastoral half-sedentary lifestyle has been suggested as more probable (Turek 2006; Smrčka *et al*. 2011b). Kolář *et al.* (2012) have also found similarities between Chalcolithic dental remains from Moravia and those of hunter-gatherer populations with a mixed diet. Higher ratios of meat consumption in the Chalcolithic have also been suggested by Jarošová (2012) who studied micro-abrasions of dental remains from the Bell Beaker site of Hoštice. It is therefore very possible that the Chalcolithic diet involved more meat than in the previous period. The highest meat consumption is, however, indicated for the EBA. The amount of selenium and zinc in bone tissues from individuals from the Únětice culture was much higher than in the Chalcolithic, pointing to a higher proportion of meat in the diet (Smrčka *et al.* 2011c). Dental microstriations of the Melčice population studied by Horňák *et al.* (2010) also indicated a diet with a high ratio of meat consumption, although the small sample size needs to be mentioned. Dietary differences between the periods may thus have really been the cause of higher caries frequency in the Neolithic.

Although higher meat consumption was indicated in the EBA, similar cariosity rates as in the Neolithic can be noted when data from the study and comparative collections are combined. This may be influenced by a lower number of EBA comparative samples and/or small sample sizes of EBA collections (for example, Melčice, Slovakia). Nevertheless, if not reflecting the frequent consumption of carbohydrates, high caries occurrence in the EBA may point to the consumption of other cariogenic foods. Since the EBA, regular mead consumption has been suggested for Northern Europe as well as for Austria (Koch 2003; Moe and Oeggl 2014). Despite the lack of palynological research in the study region, it can be presumed that honey and honey-related products were also known in Moravia, Bohemia, and Slovakia. It is true that honey was probably known from the earliest times (Needham and Evans 1987; Bernardini *et al.* 2012), but honey-based (alcoholic) drinks have not been implied for the Neolithic. Moreover, as suggested by the archaeological record[64], the importance of drinking rituals increased from the Chalcolithic onwards (Neustupný 2008; Turek 2011; Muzeum3000

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[64] by numerous finds of drinking sets (for example, Neustupný 2008: 59)

2015). Due to grain surpluses obtained thanks to the introduction of the plough, Turek (2011) suggests that it was mostly beer-like drinks that were consumed in the Chalcolithic, whereas mead was probably more dominant in the EBA. Together with a protein-based diet, this may also explain why the overall caries prevalence was lowest in the Chalcolithic. It is therefore possible that greater cariosity recorded in the EBA may also have been a result of increased consumption of other cariogenic drinks and foods.

On the other hand, cultural practices such as ritual drinking suggested above are more frequently associated with men than women (Muzeum3000 2015), and yet caries occurrence among the studied EBA sample was higher in females than males. According to some studies, females are biologically more predisposed to caries owing to the earlier development of dentition that are hence longer exposed to the oral environment (see, for example, Lukacs and Largaespada 2006). However, a study by Ferraro and Vieira (2010) has not proven a link between the extended exposure of teeth to the oral environment and higher cariosity. The higher number of affected females may therefore be associated rather with hormonal fluctuations during puberty and pregnancy, and also because of different saliva composition and flow during periods of hormonal oscillations (Dodds *et al.* 2005; Lukacs and Largaespada 2006; Ferraro and Vieira 2010). Besides, Dodds *et al.* (2005) also point to the possibility of frequent snacking by females during food preparation. Whereas males may have had better access to non-carbohydrate-based foods, either because of different social position/status, increased consumption of meat when outside of the settlement, or a combination of the two, females would have access to foods stored inside the settlement, such as grains. In addition, AMTL was also much higher among EBA males than females, and so the frequency of caries in males may be greater than indicated by osteological record. All in all, it is possible that mead consumption contributed to the high occurrence of caries in the EBA, especially in males, but there were probably other factors responsible for caries in females.

Unlike in the Neolithic and the Chalcolithic where the prevalence rate of caries increases with age, in the EBA almost all adult age categories seem to be affected to a similar extent, suggesting a common cause. In addition, young EBA adults were more frequently affected than young adults from previous periods, especially as regards females. Given that AMTL rates, one of the key factors affecting caries prevalence rates and also an age-dependent trait, were not very different between the periods, caries just probably developed earlier in life among the EBA population. In addition, EBA juveniles were also the most caries-affected subadults in the study sample. They also exhibited frequent enamel hypoplasia, which may point to a more cariogenic weaning diet. Hypoplastic enamel defects result in generally weakened enamel, making the teeth of affected individuals more prone to dental caries (Oliveira *et al.*2006), and so high rates of hypoplasia among the EBA populations from the region may have also contributed to higher tooth decay in this period. Unfortunately, no data were available for other populations from the study area.

Periapical lesions (dental abscesses) are frequently omitted from analyses of dental pathology, and only limited data were available for other skeletal collections from the study region. TPRs for several sites are provided in Figure 90 and 91, but the highest incidence is indicated for the Neolithic period (almost 20% in average). In the later periods, the average rates are smaller – 10.8% in the Chalcolithic and 12.6% in the EBA. Specific data comparing males and females are available only for Neolithic sites, with more males (35%) than females (22.7%) being affected at the Slovak site of Krškany the opposite trend being recorded at Vedrovice (28.6% and 31.6% respectively). Additionally, Shbat *et al.* (2009) mention that abscesses prevailed in males in their Chalcolithic collection, similar to the EBA remains from Gemeinlebarn (Wohlschlager 2011).

As in the case of dental abscesses, only a small number of studies from the study region provide data comparable with the study collections as regards ante-mortem tooth-loss (AMTL). Figures 92 and 93 compare the TPR data from available papers. A slightly higher prevalence is indicated for the Neolithic period (20-40%), with Slovak sites having higher rates than elsewhere. A Chalcolithic study by Shbat *et al.* (2009) shows a prevalence of 10%, but no comparable data were available for EBA[65] and further research is needed. Similar to the results obtained from the study collections, more Neolithic females than males were affected by AMTL, as suggested for Vedrovice (Lillie 2008a) and a Hungarian site of Csabdi-Télizöldes (Köhler 2004), although Krškany yielded the opposite results (Frayer 2004). A higher number of males than females was also recorded for the EBA by Pankowská (2009), who calculated prevalence rates from preserved teeth. Data for the Chalcolithic period were not available.

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[65] However, Pankowská (2009) indicates the 3.5% prevalence calculated from the total number of preserved teeth.

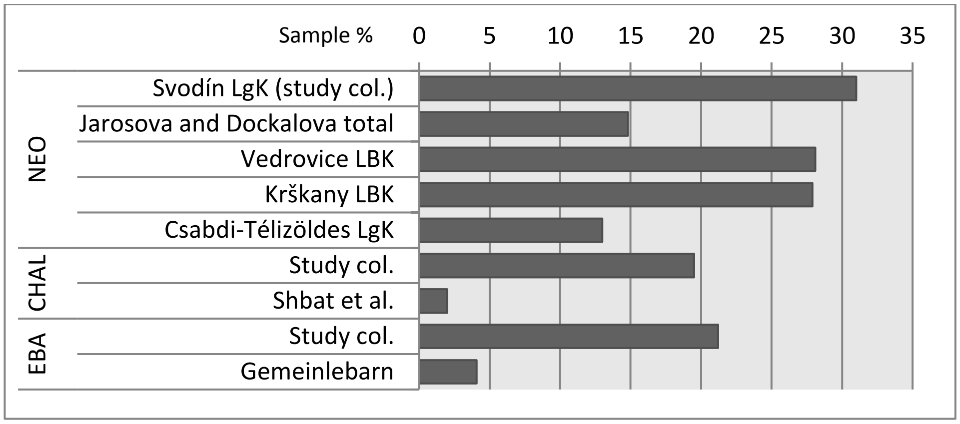

Figure 90. Dental abscess TPRs of adult populations from the study region. LBK – Linear pottery culture; LgK – Lengyel culture.

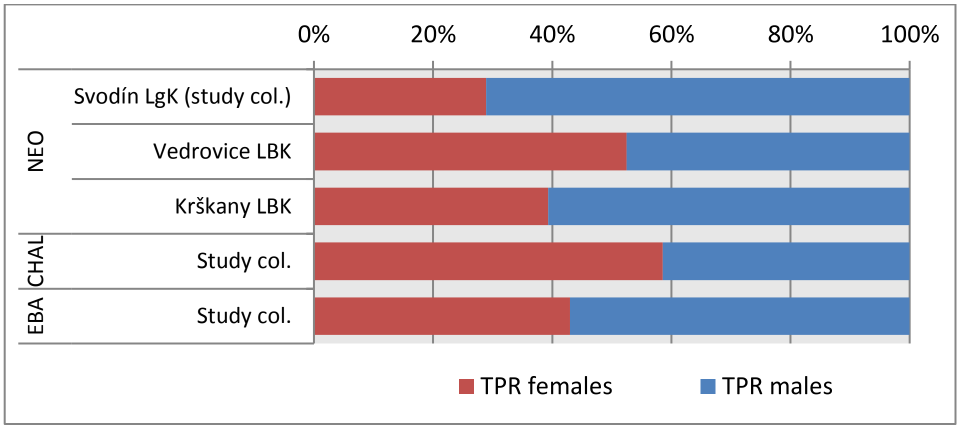

Figure 91. Dental abscess TPRs of adult populations from the study region by sex. LBK – Linear pottery culture.

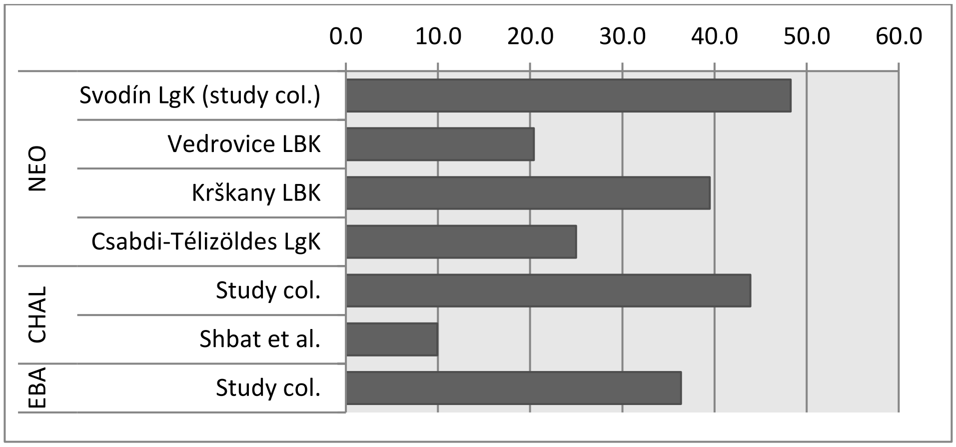

Figure 92. TPRs of AMTL of adult populations from the study region. LBK – Linear pottery culture; LgK – Lengyel culture.

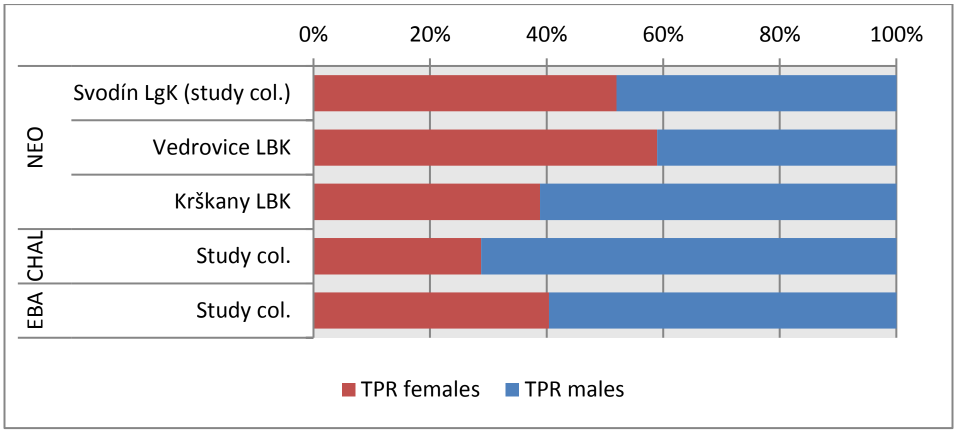

Figure 93. TPRs of AMTL of adult populations from the study region by sex. LBK – Linear pottery culture.

The exposure of the pulp cavity due to increased dental wear can boost oral pathogens, often resulting in dental problems and subsequent AMTL (Jurmain 1990; Meiklejohn *et al.* 1992; Lukacs and Pal 1993; Nelson *et al.* 1999). In addition to consumed foods, dental health may therefore result from other factors such as the abrasiveness of the diet and/or activity. The degree of dental attrition and dental microwear patterns of early Neolithic populations points to a mixed yet quite abrasive diet requiring grinding and/or a significant compression forces (Dočkalová and Čižmář 2007; Jarošová 2008; Jarošová and Dočkalová 2008; Nystrom 2008). Archaeobotanically analysed residues from late Neolithic settlements include mostly cereals and fibrous plants used for purposes other than consumption, such as flax (Lukšíková 2013). Despite the lack of bioarchaeological information for the late Neolithic populations, findings of querns and grinders from the period also suggest tough and resilient foods that required grinding (Hájek 2013; Lečbychová *et al.* 2013). Despite the presumption that the abrasiveness of food decreased from the Neolithic to the EBA, diet was probably still rather coarse also in the Chalcolithic and the EBA. In addition, the use of teeth as tools can also affect dental wear to a major extent. However, while dietary abrasion is usually more pronounced on the posterior teeth, activity-related tooth wear is usually seen on the anterior dentition (Irish and Turner 1989; Fox and Frayer 1997; for a discussion see also Larsen 1997: 247-262). All dental pathologies were the most frequent in the Neolithic. However, while the anterior teeth of Neolithic females were commonly affected by abscesses and AMTL, in males the conditions were more visible on the posterior dentition. This may point to different origin for dental problems in males and females in the period. It is possible that males' dental pathologies were of dietary and/or hygiene origin, whereas women were more frequently engaged in activities that required teeth to be used as tools.

Periodontal disease has also been suggested to be associated with excessive dental wear (see Costa 1982; Eshed *et al.* 2006), as severe attrition can result in the exposure of the pulp cavity, enabling bacteria easier access to the bone. Periodontal disease can further contribute to the development of abscesses and AMTL (Page 1998; Waldron 2009: 239-240). The amount of relevant data available for the prevalence of periodontal disease in the study region was literally non-existent. However, Wohlschlager (2011) recorded a high incidence of periodontal disease among the EBA population from the Austrian site of Gemeinlebarn, males (89.5%) being affected more than females (64.7%), which correlates with the results indicated by the study collection. While Neolithic females were those most affected by probable periodontal disease, it is possible that their overall dental conditions were strongly affected by occupational wear. In Vedrovice, only females showed work-related dental wear, and AMTL was also higher in females (Frayer 2004; Dočkalová 2008). Jarošová and Dočkalová (2008) established that it was mostly females who showed occupational incisor wear, although the number of males with the trait slightly increased in the Lengyel period. All this evidence points to a rather strong role division between males and females in the Neolithic, with females being engaged in such activities as repeated and habitual processing of some flexible but tough material (Frayer 2004; Whittle *et al.* 2013). In the other two periods, males had more pronounced occupational tooth wear, also on the anterior dentition. In addition, periodontal disease and AMTL were much more frequent among Chalcolithic males than females, with the difference being statistically significant. Although without statistical significance, EBA males also exhibited anterior dental pathologies more frequently than EBA females, whereas no females were affected by periodontal disease. This may suggest that Chalcolithic and EBA males used their teeth in strenuous habitual activities such as chewing sinew for bow strings, plant fibres for cordage, etc. (Larsen 1997: 259) more frequently than their Neolithic counterparts. A case study from Nemilany, Moravia, can be mentioned; dental microwear analysis of an individual indicates that he used his teeth for processing soft organic material such as wood or leather (Králík *et al.* 2006). While trauma has to be considered as a cause of abscess and AMTL (Lukacs 2007), no clear cases were observed in the studied populations. A link between periodontal disease, mortality risk, and stress indicators has been demonstrated (Clarke 1999; Page 2002; DeWitte and Bekvalac 2011), with the disease also being associated with psychosocial stress (Genco *et al*. 1998). This may imply that since the Chalcolithic, males may have experienced higher general stress than females (possibly related to their social role, long distance travelling, hunting, and/or more ‘dynamic’ interpersonal encounters). The incidence of periodontal disease among females was significantly higher in the Neolithic, which may be related to higher mental stress because of a higher dependence on crop yields in the period, possibly combined with general diet and the loss of nutrients during pregnancy. In addition, the suggested migration of Neolithic females may have as well be a result of raids for wives (see Section 6.3.5.), which would certainly have been stressful for the captives.

6.3.2. Non-specific stress indicators

Dental enamel hypoplasia (DEH) is caused by disruptions during the formation of the tooth. The aetiology of the defect is believed to be multifactorial (El-Najjar *et al.* 1978; Goodman 1989; Cucina 2002; King *et al.* 2005; Littleton 2005; Starling and Stock 2007), although it is claimed to be predominantly related to a metabolic disturbance – dietary or disease stress (Hillson 1996: 291; 2005: 175; Bennike *et al.* 2005).

Enamel defects were common in all three studied samples. The frequency of individuals with DEH was similar between the periods. However, the EBA sample was slightly more affected, especially among subadults. In all collections combined, the highest incidence of DEH occurred in the EBA[66] (Figure 94). The occurrence of DEH in both the sample studied and other assemblages from the study area was rather low in the Neolithic (Jarošová and Dočkalová 2008). Beyond the study collection, for Neolithic assemblages the lowest incidence of DEH was recorded at Nitra (12.7%) (Whittle *et al.* 2013), and the highest at Vedrovice and Krškany (18.2%) (Frayer 2004). Jarošová and Dočkalová (2008) recorded increasing frequency of DEH from the Early to the Late Neolithic, and a study of Lengyel human remains from the Hungarian site of Alsónyék also yielded a higher proportion of skeletons with DEH (Köhler 2012). This may be associated with climatic instability and related food shortage (see Chapter 2, section 2.3.1). Moreover, the prevalence of DEH was higher among individuals from the Slovak sites. In the Chalcolithic, only a collection of Bohemian remains studied by Shbat *et al.* (2009) was available for comparison, with a 5.4% prevalence rate. DEH occurrence among EBA sites was highly variable. The prevalence rates were very low in Moravian collections (0.4%-6.9%) (Pankowská 2009; Pankowská and Monik 2016) and very high at Slovak sites (42.2%-55.6%)

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[66] Neolithic average = 20.5%; Chalcolithic average = 21.3%; EBA average = 28.9%

(Horňák *et al.* 2010; Koel 2011). The differences imply that local factors may have played a role.

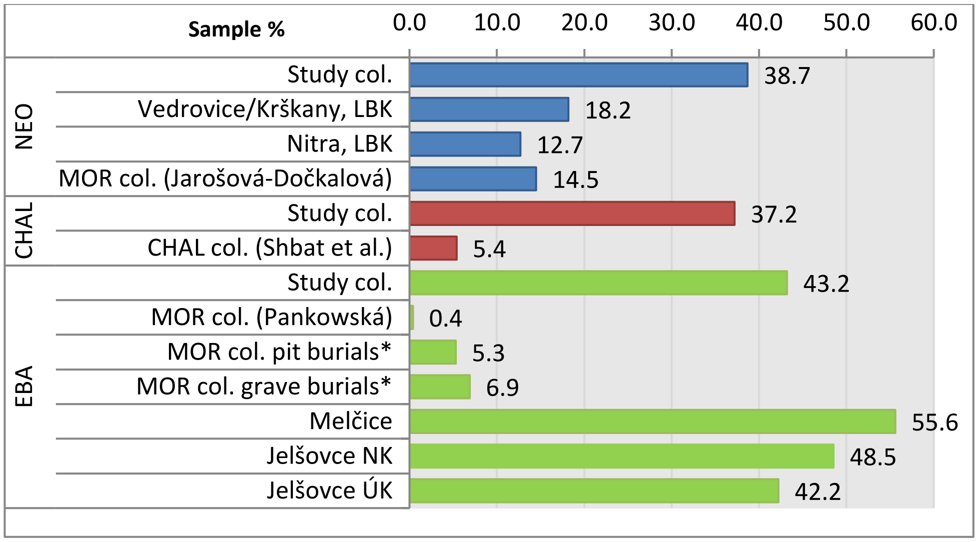

Figure 94. Comparison of prevalence rates of dental enamel hypoplasia by period. *collection studied by Pankowská and Monik (2016). LBK – Linear pottery culture; NK – Nitra culture; UK – Únětice culture.

Males were generally more affected than females, but there were no marked differences between the sexes in any of the periods. This suggests that neither boys nor girls were treated differently in any of the three periods. The higher frequency of hypoplasia and shorter periods of stress indicated in EBA individuals may point to greater (weaning-related) stress in the period. That EBA subadults were more frequently affected than adults may be a consequence of sample bias, as only a fraction of the Nižná Myšľa cemetery was processed. Alternatively, considered alongside the higher incidence of possible scurvy among the EBA subadults, a poorer childhood diet or an epidemic may have been the cause.

Although prevalence rates have been reported in previous studies from the region, age-related data for DEH are lacking. In the studied assemblages, the interval of growth disturbance in childhood, indicated by DEH, was broader in the Svodín sample, occurring between three and six years. As discussed above, the peak of occurrence in the later periods was reached between the third and fourth years of age, the age when, in some modern populations, weaning takes place (Kennedy 2005). The longest period of stress observed in the Neolithic may indicate that children had more trouble adapting after breastfeeding, either because of the lack of proper nutrition or less hygienic conditions which could result, for example, in more frequent episodes of diarrhoea or infections. Alternatively, the heretability of health, as suggested by Gowland (2016), needs to be considered as a factor as well. As discussed by the author, lives of childred are inevitably "entangled" with their mothers' health and conditions. In light of Gowland's (2016) discussion, the worse health status of the Svodín children may be related to the presumed environmental crisis in the end of the Neolithic (see Chapter 2, Section 2.3.1.) or a stress experienced by young women (see discussion below). On the other hand, Neolithic children may have just had stronger immunity and survived the stress long enough for skeletal manifestations to develop (see Wood *et al.* 1992).

Cribra orbitalia (CO) was regularly recorded in the populations within the study region. The frequency of CO was highest at Svodín, although differences between the periods were quite small. After the data were combined with those from the study collections, the frequency of *cribra orbitalia* was recorded as having increased from the Neolithic to the EBA, whereas the individuals from the Slovak site of Jelšovce were the most affected of all (Figure 95). Also Smrčka and Tvrdý (2009) indicate decreasing incidence of CO since the Neolithic (Linear pottery culture – 55%[67]; Lengyel culture – 33%; Stroke pottery culture – 15%). Owing to inconsistent methodology for scoring cranial porosity, comparison with the reference collections was complicated. In addition, increased vault porosity with no thickening of the diploë may or may not indicate healed PH. In the present study, the percentages for cranial porosity with and without thickening are provided, whereas the criteria for the comparative collections were not clear. Smrčka and Tvrdý (2009) detected porotic hyperostosis among a few individuals of the Linear pottery culture (LBK), but they do not provide specific diagnostic criteria or the overall frequency of the condition. Whittle *et al.* (2013) mention one case of porotic hyperostosis from Nitra, Slovakia. Studying the Hoštice population, Smrčka and Drozdová (2011) compare the occurrence of hyperostosis among Bell Beaker individuals with females from Neolithic populations. However, the authors not mention their sources for the Neolithic sample. The porotic hyperostosis frequency they provide for Neolithic females is approximately 13%; the incidence among males and subadults is not mentioned. Approximately 10-15% prevalence rate among Bell Beaker males and children from Hoštice has been recorded, and 15-20% in females (Smrčka and Drozdová 2011). Shbat *et al.* (2009) recorded only three individuals with the condition (4.3%), two of them children aged about nine years. For the EBA, the prevalence rate for the Nitra Culture

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[67] on average (the frequencies for right and left orbits were calculated separately)

at Jelšovce was 70%, while among Únětician individuals from the site it was 38% (Koel 2011). For comparison, Wohlschlager (2011) mentions a prevalence rate of 55.6% at the Austrian site of Gemeinlebarn, while Pankowská and Monik (2016) include porotic hyperostosis as one of the indicators for overall general health. However, any of the above-mentioned authors provide statistical data. Prevalence rates for Neolithic, Chalcolithic and EBA females from both the study and available comparative collections are provided below (Figure 96), but for the reasons above they need to be regarded with caution.

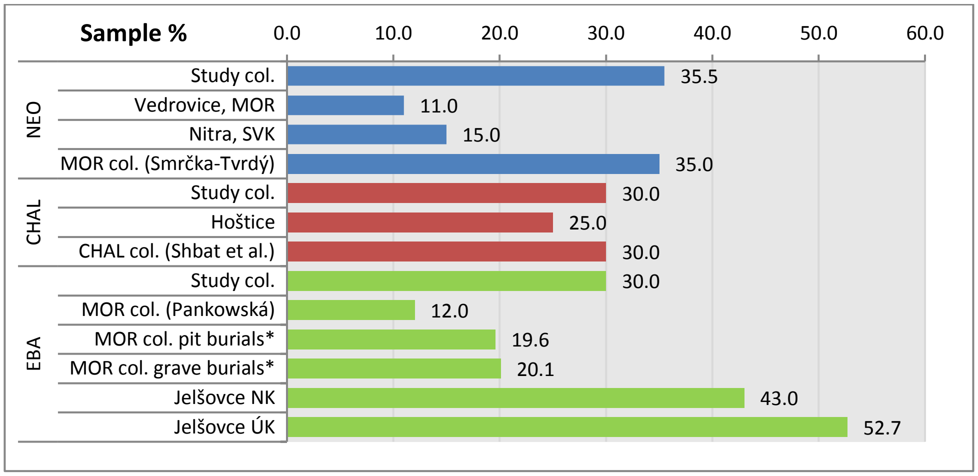

Figure 95. Comparison of prevalence rates of *cribra orbitalia* by period. *collection of remains studied by Pankowská and Monik (2016). NK – Nitra culture; UK – Únětice culture.

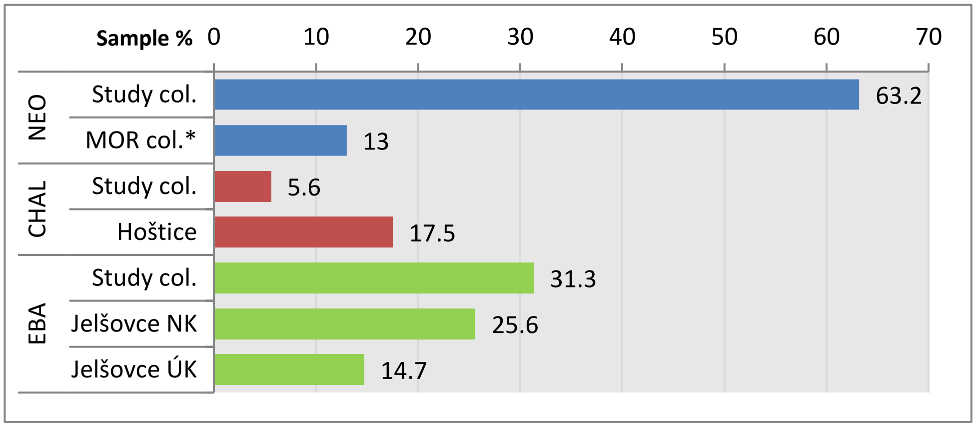

Figure 96. Comparison of prevalence rates of vault porosity in females by period. *collection of Moravian remains mentioned by Drozdová (2011). NK – Nitra culture; UK – Únětice culture.

The highest frequency of vault porosity[68] and CO was detected among Svodín individuals. An overall decrease in the number of domestic animals and the increased importance of hunting has been suggested for the period between *c.* 4000 and 3700 cal. BC (Němejcová-Pavúková 1998), thus the high level of CO and vault porosity may be linked to a nutritional deficiency. Svodín adults also manifested the highest frequency of possible scurvy. As vitamin C plays a role in the intestinal absorption of folic acid, a relationship between the conditions is possible. In modern developed countries, the occurrence of scurvy is low, being present mostly among the poor and elderly (Hampl *et al.* 2004; Schneider and Norman 2004; Velandia *et al.* 2008), suggesting that the Neolithic diet may have been less diverse than that in the Chalcolithic and EBA. Moreover, the wheat-based diet of the Neolithic populations was a diet rich in phytic acid, which, when bound with iron and zinc, is much less absorbable in the intestines (Oberleas 1973; American Dietetic Association 2003; Hurrell 2003), causing storing of minerals in the gastrointestinal tract and possibly resulting in inflammations, early osteoporosis and CO formation (Smrčka *et al.* 1989; Wapler *et al.* 2004; Dupras and Tocheri 2007; Walker *et al.* 2009). Pregnant women and children are more vulnerable to the lack of folic acid and B12 (WHO 2004: 294-5) and the most frequent causes of maternal deaths are also connected with post-partum haemorrhage and infection (WHO 2015). Both cranial porosity and CO were the most frequent lesions among Svodín females and juveniles, and may thus be connected with both dietary insufficiency and hormonal changes experienced by girls from early adolescence. However, the high prevalence rate among the Svodín females may have also been a result of a higher level of systemic stress rather than a biological factor, if the natural biologically enhanced immunity of females is considered (Ortner 1998). A link between porotic hyperostosis and parasitic infection has been suggested (Smrčka 2005), and agricultural populations are believed to be frequently affected by infections of parasitic origin (Beneš 1994; Horáčková *et al.* 2004), resulting in the loss of nutrients, for example, via diarrhoea. On the other hand, the differences in subsistence between the periods were probably not that large as to have caused such a big difference between the Svodín Neolithic population and those from the Chalcolithic and the EBA.

The low prevalence of PH and CO among the majority of Neolithic collections points to local factors affecting the Svodín population. Such stress may be related to the higher migration of Neolithic females, as suggested by isotope analyses (for example, Bentley

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[68] with and without diploë thickening

et al. 2002; see also section 6.1.1.). Such movements may have been linked to taking captives, e.g., during raids for wives, as practised, for example, in the modern-day Kyrgyz Republic (O'Neil Borbieva 2012). In Native American societies, social positions of such females vary from slaves to full spouses (for discussion see Keeley 1996). Martin and Harrod (2015) provide a list of activities related to captivity and slavery that may leave skeletal traces, including restriction of food resources or stress. Moreover, extra-spinal osteoarthritis was also very frequent among the young Neolithic females, possibly indicating hard labour and long 'working hours' (for more detail see section 6.3.4. and 6.3.5.). Such a hypothesis seems also to be supported by the highest frequency of non-specific periostitis suggesting systemic conditions among these females (see Chapter 5). Together, these could point to the generally inferior social position of Svodín females. However, burials of females exhibiting stress-indicating lesions do not suggest an inferior social status for these females, as many of them were located in the areas with exceptional grave goods or were quite richly equipped (Demján 2010, 2012). Hence, a lower status for women at the site is improbable. Increased frequency of CO and PH among the Svodín females may thus be a result of several factors, including the practice of captivity. However, the lack of accurate comparative data needs to be considered.

The formation of periostitis is believed to be indicative of inflammation of the periosteum and a systemic infection, especially when found on juvenile bones (Waldron 2009: 115). However, the causes of periosteal new bone formation are varied, including non-inflammatory and non-infectious origins (Ortner 2003: 206-7; *cf.* Waldron 2009: 116). In other words, the condition is considered more descriptive than diagnostic. The incidence of periosteal lesions, both isolated and those observed on multiple bones indicating a systemic condition was 17.7% in the Neolithic, 7.4% in the Chalcolithic, and 13.6% in the EBA sample. In the Neolithic, more females (21.1%) than males (7.1%) were affected; in the EBA the opposite was observed (3.1% in females and 11.4% in males), while only one Chalcolithic adult (a young female) exhibited periostiteal lesions. There was only a low frequency (ca. 4%) of non-specific periostitis at Vedrovice (Dočkalová 2008) and in the Moravian collection (ca. 2%) studied by Smrčka and Tvrdý (2009), both referring to localised lesions. At Nitra, a 20% crude prevalence rate was recorded. As at Svodín, in Nitra, periostitis indicating systemic conditions was more frequent (ten cases) than localised periosteal lesions (five cases). Subadults were affected twice as commonly as adults, associated by authors to the high mortality of juveniles observed at this site (Whittle *et al.* 2013). Localised periosteal reactions were also observed predominantly on subadult remains, although this may be a reflection of the poorer preservation of juvenile skeletons. Only four individuals from Hoštice exhibited periostitis, unrelated to any visible disease. These were observed on single bones, although bad preservation of the remains needs to be noted (Smrčka and Drozdová 2011). Shbat *et al.* (2009) list five cases of non-specific periostitis (11.1%), although their descriptions are vague and the provided rate is ambiguous. Nevertheless, together with the results from Hoštice and those from the study collection, the rates of non-specific periostitis in the Chalcolithic seem to be quite low. In their EBA assemblage, Pankowská and Monik (2016) identified a 9.1% occurrence of non-specific periostitis among individuals from pit burials and 7% from graves. However, the authors do not provide more detailed analysis of the lesions. In Jelšovce, periosteal lesions of unknown aetiology were detected among 17% of NK individuals and 14% of UK individuals, but details are not provided in the text (Koel 2011). A summary of findings is provided in Figure 97, but it should be noted that periosteal lesions can be under-recorded mostly because of poor post-excavation treatment of bones or because periosteal lesions can be mistaken for taphonomic damage. In summary, when the data are combined, the prevalence of non-specific periostitis in general was still high in the Neolithic sample (10.7%), although the rates in the EBA were slightly higher (13.2%). Interestingly, Neolithic as well as EBA human remains from Slovak sites were more frequently affected, suggesting that local conditions played a role.

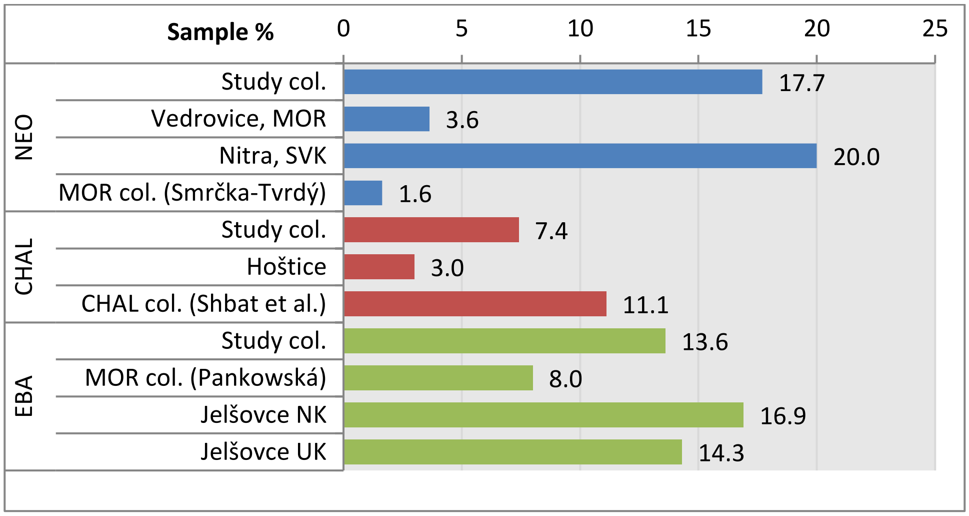

Figure 97. Comparison of prevalence rates of periostitis observed on multiple and single bones by period.

Seventy-five percent of studied individuals who exhibited periosteal lesions had multiple bones affected, suggesting that periostitis was a manifestation of a systemic condition. Periostitis located on single bones was recorded in nine individuals. However, the completeness of six of these individuals was too bad to estimate if the periosteal lesions were more widespread. The CPRs of non-specific periostitis indicating systemic stress were similar in the Neolithic and the EBA (11.3% and 10.6%), the frequency being much lower in the Chalcolithic (6.4%). In Svodín, legs and ribs were affected, although no combination of the two occurred. On the contrary, in the other two periods, when periostitis was found on multiple bones, it was very commonly seen in a combination of skeletal areas (legs and ribs being most frequent, but the lesions were also observed on arms and pelves – see enclosed database). Tibia, femur or ribs are commonly affected by periostitis (Roberts and Manchester 1995: 129; Ortner 2003: 209) and are associated mainly with non-specific blood infection, improper circulation of blood, localised injury of surrounding soft tissues, or skin ulcers (Roberts and Manchester 1995: 130; Ortner 2003: 207; Nicholls 2005; Weston 2008). On ribs, periostitis can indicate a lung infection, cancer or a lower respiratory tract problem, i.e., conditions that can affect more areas of human body at the same time (Bruce *et al.* 2000; Riojas-Rodriguez *et al.* 2001; Nicklisch *et al.* 2012). This may indicate more severe conditions in the Chalcolithic and especially in the EBA, although Neolithic individuals may have just died before a disease reached the stage which would be visible osteologically. In the Neolithic, non-specific periostitis was detected frequently in young and prime females who exhibited the lesions also in their pelvic area. This may indicate that the occurrence of periosteal lesions in Neolithic females may have been related to pregnancy and birth, considering the poorer sanitary conditions discussed above. The higher incidences among Neolithic females may also point to their poorer health status or higher levels of systemic stress. Given that females' immunity tends to be biologically stronger (Nunn *et al.* 2009), environmental stress is a more probable explanation. Chalcolithic adults showed almost no periostitis, but this may be a post-depositional artefact. In the EBA sample, a low number of females were affected, although the absence of lesions can also indicate that the females had died before periostitis could develop (Wood *et al.* 1992).

The CPRs of periostitis for subadults are especially high in the EBA (17.9% of EBA subadults) when compared to the Neolithic and the Chalcolithic (6.9% and 9.8% respectively). Moreover, it was also EBA juveniles who exhibited periostitis on multiple bones (always including ribs), suggesting that they were affected by systemic diseases to a greatest extent and/or were the least capable of surviving them. Population density may have played an important role in the speed of disease spread. Given the large size of some EBA sites, it is possible that the highest frequency of periosteal lesions suggesting systemic disease and greater population density than in previous periods were related.

6.3.3. Metabolic diseases

Although the number of individuals affected by metabolic diseases was too small to run statistical tests, the identification of such conditions revealed important information regarding the habits of the studied populations.

Marked signs of osteopenia/osteoporosis were detected in all three periods, although the overall number of affected individuals was low. The conditions prevailed among Neolithic elderly individuals. Osteoporosis signs are not commonly recorded in human remains from the study region, and so no inter-sample comparison was performed. Bone mass decline and age have been associated (Mays 2000; Mays *et al.* 2006), hence the prevalence observed on the individuals from the Neolithic sample may have been influenced by the highest number of elderly individuals from this period. Additionally, it may have also been determined by the fact that the better preserved of skeletal remains were mostly selected for examination. Given that osteoporotic bones are usually very fragile, individuals with the condition may have not been chosen for this study in the selection process, and so a bias needs to be considered.

Determination of a specific cause of vitamin deficiencies is complicated mostly by the huge number of factors that may contribute to their development. Moreover, skeletal changes are often indistinct, and so vitamin deficiencies may be missed or misdiagnosed. Another complication is represented by the fact that several deficiencies, such as rickets or scurvy, can occur simultaneously (see Ortner 2003). As a result, no firm conclusions can be made considering studied archaeological populations from the study region, although possible indications are discussed below. Evidence for possible scurvy (vitamin C deficiency) was together observed on six adults (3.9 % of all adults) and three of all subadults (2.2 %). Diagnostic features included new bone formation together with increased porosity on the skull (esp. frontal bone, sphenoid, zygomatic bones, occipital, alveoli), and enlarged and porous epiphyses of the long bones. Bickle and Fibiger (2014) mention several cases of possible scurvy in their Early Neolithic collection from the study region, mostly in individuals aged between one and four years (also Hedges *et al.* 2013). They suggest that weaning may have played a crucial role in the development of subadult scurvy. The evaluation of scurvy on archaeological skeletal remains is highly observer-dependent, not to mention that the condition is difficult to diagnose due to its vague manifestations (Ortner 2003). Furthermore, except for the aforementioned studies, no cases of scurvy are reported in literature from the study region and further anthropological research is vital. Vitamin C cannot be produced by the human body itself; therefore, people are dependent on its intake from diet (Waldron 2009: 131). However, even a quarter-dose of a recommended daily intake of vitamin C would prevent scurvy from developing (WHO 2004: 133). If no vitamin C is consumed, the first scurvy signs tend to develop after about six months (Crandon *et al.* 1940), which is longer than seasonal deficiencies caused by, for example, winter. A probable climatic crisis in the late Neolithic has already been mentioned, and may have contributed to the development of scurvy among the Svodín adults. In Svodín females, scurvy may also have developed as a response to blood loss related to birth, possibly combined with vitamin deficiency associated with unsanitary living conditions and infectious diseases such as diarrhoea (*cf.* Scrimshaw and SanGiovanni 1997) or seasonal food shortage. In addition, the migration of females for marriage has been suggested (see Section 6.1.), whereas the re-locations may have not been entirely voluntary. Capturing and slavery are often associated with nutritional stress as suggested, for example, by Martin and Harrod 2015 (for more discussion see Section 6.3.5.). Neolithic males who spent more time outside the settlement (slashing and burning, hunting, exploiting material, or founding new locations), may have developed the lesions due to living on vitamin C poor diets. The overall number of Svodín children was very low, and thus prevalence of the condition may be under-represented. However, modern clinical studies suggest that children who are exclusively breastfed receive sufficient amounts of vitamin C via their mother's milk (Salmenperä 1984). As discussed in the demographic section above, it is possible that Neolithic children were mostly breastfed in their early years, which may have lowered the risk of scurvy development. Alternatively, Vedrovice children were suggested to have consumed more forest fruits than adults, especially males (Jarošová 2008; Smrčka *et al.* 2008a; Smrčka *et al.* 2008b), and thus their level of vitamin C intake may have been sufficient. Based on the isotope results, Whittle *et al.* (2013) suggest that dietary practices were probably very similar across the Moravian and western Slovak region during the early Neolithic. In the light of these observations, generally different food sources of Neolithic adults and subadults could be suggested, possibly also in Svodín. Such dietary habits would explain why the prevalence of scurvy among the Svodín children was so low, but so high among the Svodín males. Koel (2011) observed possible status-related differences and suggests that the members of the lower class had to give up fresh fruits and vegetables in favour of more privileged individuals. However, the identification of a social hierarchy in Svodín is a challenging task, although social differentiation cannot be ruled out (Demján 2010). Comparative data for the Chalcolithic are severely missing. Studies evaluating EBA skeletal remains from the region (Schultz *et al*. 1998; Bátora and Schultz 2001) indicate that scurvy was probably quite a frequent condition, especially among juveniles. In Jelšovce, thirteen (7.6%) Nitra culture and fourteen (14.7%) Únětice culture individuals with evidence of scurvy were discovered, with children being affected the most[69] (Bátora and Schultz 2001a; Schultz *et al*. 1998). No differences between the sexes were reported. On the other hand, Weston (2009) questions Schultz's criteria for scurvy diagnosis (as proposed in Schultz 2001b; 2003) owing to the fact that many periosteal lesions are non-specific. As a result, the percentages need to be treated with caution. Compared to incidence rates suggested by the human remains analysed in this study, the prevalence of scurvy observed in the assemblages from the same region seems to be slightly higher. This may be ascribed to the above-mentioned criteria limitations and/or the selective process concerning the study assemblage. Considering both the study collection and other assemblages from the region, scurvy was more common in the EBA, especially among subadults. Given that all but one case of possible EBA scurvy come from Nižná Myšľa, bio-cultural factors may have played a role. Despite the possible occurrence of seasonal shortages, they alone would probably not have led to the development of scurvy (Brickley and Ives 2008). Furthermore, food allocation by status, as suggested by Koel (2011), seems to be an improbable cause, as the graves of individuals with possible scurvy were quite richly equipped. The fact that the lesions prevailed among children may point to their inferior social status in Nižná Myšľa society. Even though the fact that food sources other than fruits and vegetables (for example, meat) might have been regarded as a high-class fare should be taken into account, high nutritional stress among EBA children is also suggested by high rates of non-specific stress indicators such as *cribra orbitalia* and dental enamel hypoplasia (see Section 6.3.2.).

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[69] Rates for juveniles are: 12.8% NK and 21.4% UK. In addition, 24.5% prevalence among the Maďarovce culture children was detected (Weihmann 2013).

Credible palaeopathological cases of rickets are not numerous (Brickley and Ives 2008), mostly because its identification is complicated apart for severe cases. The identification of such a condition on juvenile remains is also complicated because of the little attention paid to subadults in general (Giuffra *et al.* 2015). Unlike vitamin C, the human body is able to synthesise vitamin D if exposed to sunlight (Waldron 2009:127). Vitamin D plays an important role in calcium and phosphorus absorption, both essential for bone modelling (Holick 1994:308). In juveniles, vitamin D deficiency can result in rickets (Waldron 2009:128). In severe cases the condition can be also persist into adulhood in the form of bowed femurs or tibiae (Waldron 2009: 128-129). Dietary sufficiency and sunlight exposure are both affected by a number of factors, including food accessibility, prolonged swaddling, abundant clothing, or the amount of time spent outdoors (Leeuw 1992; Veselka 2015). However, rickets has been documented also in sunny countries such as Iran and Israel, where its incidence is ascribed to cultural practices related to clothing and prolonged breastfeeding (Costeff and Breslaw 1962; Salimpour 1975). It is unlikely that central-European prehistoric populations were wearing long garments throughout the whole year; moreover, only fifteen minutes per day of exposing the face, neck and forearms are sufficient for the prevention of vitamin D deficiency (Brickley and Ives 2008:77). Nevertheless, exposure to the sun could have varied by age, sex, health condition, etc. For instance, sickly children may have been kept indoors, as suggested also for a 19th century Birmingham population (Mays *et al.* 2006). The amount of clothing can also be expected to have been higher if a child was frequently sick. As discussed above, sanitation may have been worse in the Neolithic than in the other two periods, possibly resulting in more gastrointestinal infections. In addition, modern studies have demonstrated that infants severely lacking vitamin D are also more prone to gastrointestinal and respiratory infections (Pettifor 2003). Hence, insufficient calcium intake and rickets may have more easily occurred in the Neolithic than in later periods (see Section 6.3.2.). Yet, only two individuals from Svodín, both subadults, exhibited the signs of possible rickets. In other collections from the study area, Bickle and Fibiger (2014) also mention only one possible case of rickets, also a child (aged three to six months at death). In the other two periods, only a low number of juveniles with possible rickets was observed, although these were mostly young adults. Although no rickets was mentioned in regards to the Chalcolitic comparative collections, four individuals from the studied sample were affected. In the studied EBA remains, only one individual with possible D deficiency was observed, but Koel (2011) observed the condition among ca. 6%

of adults and 5% of subadults at the EBA site of Jelšovce, while the EBA site of Hainburg, Austria, yielded a similar percentage for subadult rickets (Schultz 2001a). With regards to prolonged breastfeeding, a mother's milk contains enough vitamin D for about the first two to three months of breast-feeding, but afterwards the amount of the vitamin decreases significantly (Balasubramanian and Ganesh 2008; Guifra *et al.* 2015). Prolonged breastfeeding may therefore lead to vitamin D deficiencies unless supplemented by other sources. Therefore, if not exposed to sufficient sunlight and before the introduction of foods rich in vitamin D, breastfed children would have been more prone to developing rickets. Two out of three children of the study collection showing evidence for rickets were in the peak incidence age for rickets, i.e., between three and eighteen months (Brickley and Ives 2008: 91-2). However, a similar weaning time has been suggested by DEH for all three periods, hence considerably different breastfeeding practices between the periods are improbable. Prolonged suckling, associated with increased calcium loss, may also affect the mother (Steinbock 1976: 272; Kovacs 2008). In the study collection, three out of four adults with bent lower limb bones, which can also be connected to calcium loss, were evaluated as females. On the other hand, that females showed more signs of childhood rickets may be also associated with labour division. In post-Medieval Netherlands, women are believed to have been engaged in house-related work, including childcare, whereas men were probably working outside in the fields. This division was applied from childhood; therefore, girls were more liable to develop rickets (Haks 1985; Schenkeveld 2008). Skeletal remains analysed for the present study suggest different roles of males and females in all three periods. As suggested by degenerative joint diseases and dental lesions, the activity of females may have indeed been tied to the house and males probably engaged in activities outdoors (see Chapter 7).

6.3.4. Joint diseases

Joint diseases are the most common pathologies identified on skeletal remains (Roberts and Connell 2004: 38), and are most frequently associated with age-related degenerative changes. The most frequently affected are the synovial joints, joints with a membrane-lined cavity filled with synovial fluid, such as the knee, elbow, etc. (Roberts and Manchester 1995: 101; Waldron 2009: 25-6). In synovial joints, changes are often related to lifestyle and activity performed during life. Other joint diseases can be related to inflammation (such as septic arthritis), metabolic (such as gouty arthritis), or be endocrine related (for example, ankylosing spondylitis) (Roberts and Manchester 1995: 99-101; Ortner 2003: 561-588). Many joint diseases share symptoms, although the pattern of the joints affected by individual diseases may be different for each condition (Roberts and Manchester 1995: 100; Ortner 2003: 561). Therefore, accurate diagnosis requires the preservation of as many bones as possible. Spinal degenerative changes, such as spinal and extra-spinal osteoarthritis, vertebral osteophytosis, and Schmorl's nodes examined in this study are discussed below.

Most frequently, the causes of osteoarthritis are mechanical, and the changes tend to affect the most loaded joints (see Larsen 1997: 162-195). Various researchers have studied the relation between osteoarthritis and activity in people with labour-intensive professions or athletes (Rossignol *et al.* 2003; Shepard *et al.* 2003; Thelin *et al.* 2004; Croft 2005), finding a connection between the two. However, as Weiss and Jurmain (2007) point out in their review of osteoarthritis aetiology, multiple non-activity related factors may contribute to the emergence of osteoarthritis, most of all genetics, body size and anatomy, weight, age, sex, or trauma (Waldron 1994; Loughlin 2001; Buckwalter 2003; Dominick and Barker 2004; Spector and MacGregor 2004; Hunter *et al.* 2005; Wearing *et al.* 2006; O'Connor 2007; see also Larsen 1997: 162-195). For instance, due to human bipedalism, similar spinal joint involvement can be seen in numerous skeletal samples (Bridges 1994; Jurmain 2000; Resnick 2002), as also suggested by Knüsel *et al.* (1997) who studied three medieval monastery groups. In spite of the fact that each of Knüsel *et al.*'s study groups had different lifestyles, thus with different expected patterns of spinal degenerations, no statistically significant differences were detected. In general, spinal osteoarthritis affects mostly the joints of the cervical vertebrae (Knüsel *et al.* 1997; Moromizato *et al.* 2007). This may be explained by the biomechanics of human skeleton, as the cervical spine rotates easily, and thus the joints are more prone to be affected by osteoarthritis. In comparison, the movements of the thoracic spine are mostly axial, while the large facet joints of the lumbar spine do not allow lateral rotation or bending (Resnick 2002; Hsu *et al.* 2008). In the study sample, cervical vertebrae were the most frequent locations of spinal osteoarthritis both in males and females of all periods, with the exception of EBA females who exhibited osteoarthritic changes more in the thoracic (9.4%) rather than cervical region (6.3%). This means that while spinal osteoarthritis in all other males and females may have been related to biological/biomechanical factors rather than activity, in EBA females it may be occupational in origin. As Weiss and Jurmain (2007) point out, if the stress is high and begins early in life, osteoarthritis is more likely to develop. When looking at the age distribution of spinal osteoarthritis, the only individuals exhibiting osteoarthritic changes in the young age category are EBA females, often showing lesions in the cervical area (Chapter 5, Section 5.5.4.1.1.). This suggests that EBA females could have been engaged in strenuous activities placing excessive loads on the cervical spine from a young age. For instance, Geere *et al.* (2010) revealed an increased risk of cervical spine degeneration caused by carrying water containers on the head. A study by Jäger *et al.* (1997) also found that 88.6% of individuals who regularly carried loads on their heads exhibited degenerative changes in the cervical spine. It is therefore possible that cervical OA in EBA females was related to occupational loading.

As regards the frequency of spinal osteoarthritis, the lesions clearly prevailed in Neolithic males. Given that only males older than thirty-six were affected, the cause of their spinal degeneration may also have been age-related. On the other hand, males from the other two periods also exhibited the lesions, but only later in life. However, more mature males (40%) suffered from spinal osteoarthritis in the Neolithic than in the Chalcolithic (8.3%) or the EBA (23.8%) where males in old category prevailed. This may imply that, in addition to biological/biomechanical factors, the load on Neolithic men's spines was more systematic and greater than in their Chalcolithic and EBA counterparts. The cervical region was especially affected in Neolithic males. As suggested for EBA females, frequent osteoarthritis in the cervical spine may be caused by the regular carrying of heavy loads on the head. However, the CPR of cervical lesions among Neolithic males is highest in the mature age category. This may imply that the load on the cervical spine may have been less intense as in case of EBA females, or that the relevant activity was not practiced during their early years (see Weiss and Jurmain 2007). The inventory of these males' graves comprised of axes, battle-axes, shoe-adzes, animal remains, and boar tusks, possibly reflecting a demanding lifestyle such as hunting.

Not many studies from the study area deal with spinal osteoarthritis. The closest study, aimed at the Lengyel population from Csabdi-Télizöldes, Hungary, is that by Köhler (2004), who mentions only one case of spinal osteoarthritis, in the cervical vertebrae of a mature male. From 257 Chalcolithic remains studied by Shbat *et al.* (2009), no skeleton with the signs of spinal arthritis was recorded. The only study involving information about spinal degeneration in the EBA is that by Wohlschlager (2011), who studied the population from the Austrian site of Gemeinlebarn. However, the author does not distinguish osteoarthritis from other degenerative joint diseases, so the sample is not truly comparable with the results obtained in the presented study.

In archaeological samples, extra-spinal osteoarthritis is very common in frequently used joints such as the shoulders, hands, hips, knees, and feet (Roberts and Manchester 1995: 100; Waldron 1995). For the most part, the studied remains fit the above-mentioned pattern, although some differences and anomalies were noted. A few papers by local authors deal with extra-spinal degenerative joint disease. Only six out of 171 assessable Chalcolithic individuals (3.5%) with degenerative joint lesions are mentioned by Shbat *et al.* (2009). The authors report osteoarthritis of the femoral heads, glenoid fossae, ribs, elbows, knees, and distal metatarsals. The range of affected joints is quite wide, especially in males who suffered mostly in the costo-vertebral joints, elbows, knees, and the metatarsals/phalangeal areas. A similar pattern was observed in the study assemblage. The overall number of involved joints was far higher in the Chalcolithic and the EBA than it was in the Neolithic, especially those of the lower limb bones. The generally higher occurrence of osteoarthritis in the later periods may have several causes, including bias caused by small sample size of the Neolithic assemblage. In addition, greater body weight or different lifestyles in different periods also need to be considered. A relationship between osteoarthritis (especially in lower limb joints) and body weight has been established (for example, Felson and Chaisson 1997). Based on body mass calculations suggested by Ruff *et al.* (2012), the Neolithic population was the lightest of all[70], and an overall increase in weight since the Chalcolithic may have been at least a contributing factor in osteoarthritis development. Apart from weight, Larsen (1982) points out that increased degenerative pathology in the legs and feet may point to more intensive activities such as walking, running, and riding (also Rossignol *et al.* 2005). Shepard *et al.* (2003) have come to a similar conclusion, as they revealed increased hip osteoarthritis prevalence among ex-professional footballers although none of the subjects had suffered notable hip trauma. Hip and foot osteoarthritis were more pronounced in Chalcolithic and EBA males than females, which may possibly be associated with increased long-distance movements, for example, for trade. The only comparative EBA population where joint degenerative diseases have been at least partially evaluated is the Austrian Gemeinlebarn population (Wohlschlager 2011). Similar to the study collection, multiple joints were affected especially in males (mostly arm

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[70] BM: 60.2 vs. 65.9 vs. 65.3 respectively; statistically significant when compared using One-Way ANOVA (Appendix 5, Test 5)

and hand joints, knees, and ankles). However, the author does not distinguish between osteoarthritis and other degenerative joint diseases, neither does she differentiate between primary and secondary conditions. In both periods, studied females showed osteoarthritic changes in knees more frequently than males. Knee osteoarthritis is common in occupations that involve kneeling and squatting, as these cause constant pressure on the joint (Rossignol *et al.* 2005). The higher biological predisposition of females to develop osteoarthritis in old age (for example, Srikanth *et al.* 2005) does not seem to be the only cause, as females below the elderly age category were also affected. A higher body mass when compared to Neolithic females (mean BMs: 57.4 vs. 60.6 vs. 61.2 respectively) needs to be born in mind as well, but otherwise knee osteoarthritis in Chalcolithic and EBA females may have been mainly occupational in origin. In addition, Wohlschlager (2011) mentions that among females, degenerative joint diseases prevailed in the ankle, a joint also involved in kneeling and squatting. In the study collection, joints of arms and hands of Chalcolithic and EBA female individuals were also frequently affected.

In summary, together with a generally lower prevalence of osteoarthritic changes and frequent knee osteoarthritis the pattern can be interpreted as that the females from these periods were involved in manual activities involving kneeling/squatting, i.e., those related to food and material preparation, or other settlement-bound tasks. Given that only prime and especially mature females were affected, the activities may have not been intense, but regular (see Weiss and Jurmain 2007). In comparison, Neolithic females are the only individuals showing excessive joint wear from the young age category, suggesting more strenuous activity. Besides the lumbar spine, only two joints showed the signs of osteoarthritis in Neolithic females, the temporomandibular joint (TMJ) and the glenohumeral joint. Some studies (Hinton 1981; Hodges 1991) revealed a significant association of TMJ osteoarthritis with dental attrition. Given that dental wear was more pronounced on anterior teeth, the TMJ osteoarthritis in both Neolithic males and females was probably related to teeth being used as tools rather than to an abrasive diet.

TMJ osteoarthritis is quite rare in archaeological populations (Waldron 1995), but as suggested by a recent review of the condition (Rando and Waldron 2012), the methodology of recording the condition strongly affects prevalence rates in archaeological samples (Rando and Waldron 2012: Table 1). Eburnation, a key diagnostic feature of osteoarthritis, is rare at this joint (Rando and Waldron 2012), which may also result in under-representation of TMJ osteoarthritis. In the studied sample, the rates of osteoarthritis in the TMJ are greatest in the Neolithic population, possibly related with the use of teeth as tools (discussed above). In the Chalcolithic, osteoarthritis of the TMJ is indicated only for males. The high occurrence of AMTL and periodontal disease among Chalcolithic males may also point to the increased use of teeth as tools. However, it was mostly the posterior teeth that were lost antemortem, and their loss may have also been of dietary cause. Occupational wear was detected only in two Chalcolithic males (and no females), a male from Hulín (H66) showing occupational signs on his anterior teeth, and a male from Stehelčeves (3839) on his posterior dentition. Owing to the low number of affected individuals, it is difficult to assess the precise cause of incidence of TMJ osteoarthritis in the Chalcolithic period. As regards EBA females, whose rates of TMJ osteoarthritis were also quite high, neither AMTL nor periodontal disease were common, but occupational wear was very frequent among these females[71], observed exclusively on anterior dentition, suggesting an occupational cause. However, EBA females may simply have not lost their teeth before death as frequently as males Nevertheless, given that mainly posterior teeth were lost antemortem in both EBA sexes, diet seems to have been a more probable cause of AMTL in the EBA, and so osteoarthritis of the TMJ among EBA females could be occupational rather than diet-related. In summary, TMJ osteoarthritis may have been predominantly the result of teeth being used as tools in all three periods, as suggested by Hodges (1991). However, the rates obtained for the study sample should be considered informative only, as there are no comparable data available for any other collection from the study region and the sample was rather low.

Given the generally similar pattern of the distribution of extra-spinal osteoarthritis, albeit of different intensity, osteoarthritis among Chalcolithic and EBA individuals is probably largely occupationally-related, although joint anatomy or genetic predisposition may have played a role. Compared to the Neolithic, the wider range of affected joints in the Chalcolithic and the EBA may point to a wider range of activities in which the individuals were engaged. Nevertheless, the absence of osteoarthritis in the Neolithic assemblage may be the result of the sample-selection process and generally lower sample size.

When evaluating spinal degenerative joint disease other than osteoarthritis, many skeletal samples display vertebral body degeneration in the weight-bearing areas of greatest curvature (cervical/thoracic, mid-thoracic and mid-lumbar region) (Knüsel *et al.* 1997; Resnick

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[71] all females with evidence of using teeth as tools were from Nižná Myšľa

2002; Bonsall 2013). These findings are consistent with those of the study assemblages as well as the comparative assemblages. The Neolithic collection studied by Smrčka and Tvrdý (2009) indicate that spinal osteophytes affected the thoracic and lumbar spines equally (at the rate of 25%). In Vedrovice males, the thoracic and lumbar areas were also equally affected, whereas the condition was more common in the lumbar spine among females. The Chalcolithic samples studied by Shbat *et al.* (2009) and Drozdová (2011) also indicate an approximately equal distribution in the thoracic and lumbar spines. No data were available for EBA remains. In the study samples, the severity of osteophytosis was found to increase down the spine, although it was the thoracic spine that was the most affected in Chalcolithic males and females. The onset of osteophytes is associated with several aetiological factors such as compressive forces on vertebral endplates (Nathan and Islael 1962), bone density (Kinoshita *et al.* 1998), obesity (O'Neill *et al.* 1999) and genetic factors (Sambrook *et al.* 1999). Only a very small number of Chalcolitic females suffered from osteophytosis, mostly in the mature age category. However, osteopenia was not observed in these females. Pathologically, the sites where the most persistent strain occurs tend to be affected by osteophytosis, its severity usually increasing with age, and as a response to load on the spine or some intrinsic spinal disease (Bick 1956; Lane *et al.* 1993; O'Neill *et al.* 1999). Kneeling/squatting activities of Chalcolithic females, indicated above, and osteophyte development among these females may have been age and occupation related. The prevalence of thoracic osteophytosis among Chalcolithic males, who exhibited the condition from the young adult age, may be related to more intense load in the spinal area, starting early in life. Moreover, osteopenia was also observed in 12% of Chalcolithic males, suggesting a metabolic cause probably related to age. Shbat *et al.* (2009) and Drozdová (2011) also mention that only individuals older than thirty were affected by probable osteoporosis in their collections, with the prevalence of male individuals. However, osteophytosis can also be related to numerous spinal conditions, including spinal OA, intervertebral disc disease, ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH)[72], inflammations in the spinal column, or conditions such as scoliosis or compression fracture of the vertebrae, etc. (for example, Bick 1954; 1956; Waldron 2009). Spinal osteoarthritis has already been discussed above, and no individuals with spinal osteoarthritis were included in the evaluation of spinal osteophytes. No Chalcolithic individual showed clear signs of disc disease, although spinal deformation and fusion of the sacrum with the fifth lumbar

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[72] although in ankylosing spondylitis and DISH a fusion of vertebrae would be expected

vertebra was suggested in one mature male, and another young male had lumbo-sacral fusion. Vertebral fractures or signs of DISH were not observed among the Chalcolithic males either. Consequently, an excessive load on the thoracic spine is the most probable cause of osteophytic prevalence among the Chalcolithic males, possibly related to an activity such as archery, as the bow is believed to have been commonly used by the Central-European Bell Beaker population (Turek 2008), which involves frequent rotation of the torso.

Considering females, the clearly highest CPR of osteophytes among EBA women may have several explanations. When looking at the age distribution, EBA females are the only females who suffer from osteophytosis from the young adult age category, and is the youngest of all studied females. This corresponds with the results indicated by the prevalence of spinal osteoarthtitis in these females, suggesting that osteophytic activity may have been a response to increased spinal load from an early age (see discussion above). In addition, one probable case of a vertebral compression fracture was observed (H257), as were spinal deformations, fusion with the ilium, and a case of lumbo-sacral fusion (H2, H10, H23, H66, H195 and H196). All the above-mentioned findings could have contributed to the high prevalence rate of spinal osteophytosis among EBA females. Metabolic diseases were rare among EBA females, and no other spinal pathologies were implied either.

In general, Schmorl's nodes are especially common in the lower thoracic and lumbar areas, suggesting that the anatomy of the spine and its use play a role in the presence of the lesions (Waldron 2009: 45; Burke 2012; Dar *et al.* 2010). However, the frequency of Schmorl's nodes increases from the Neolithic to the EBA (see Chapter 5), which points to additional factors influencing their rates. No comparative EBA population from the study region were examined for Schmorl's nodes. However, the prevalence rate for the Austrian EBA site of Gemeinlebarn (Wohlschlager 2011) was very high (although only TPR was calculated, reaching 65.6%). In comparison, a 3.9% CPR of Schmorl's nodes is mentioned by Dočkalová (2008) for the whole Vedrovice population, whereas a 10.5% TPR (2.3% CPR) was detected by Shbat *et al.* (2009) for their Chalcolithic assemblage. In Hoštice, Drozdová (2011) also mentions only a 2.4% CPR. Although there are only a small number of studies evaluating Schmorl's nodes, they do point to a higher occurrence in EBA populations. Studies on elite athletes have demonstrated that Schmorl's nodes reflect strenuous activity (Hellstrom *et al.* 1990; Sward *et al.* 1991; Sward 1992; Klaus *et al.* 2009). Above, as well as in other parts of this thesis (Section 6.3.5.), increasing intensity of lifestyle from the Neolithic to the EBA has been indicated, suggesting that the high CPR of Schmorl's nodes in the EBA may also be stress-related. The aetiology of Schmorl's nodes is still debated, as they can accompany almost any condition that results in the weakening of the cartilagionous endplate of the vertebral body. In addition to excessive loading (see also Dar *et al.* 2010), other possible causes involve trauma (Burke 2012) or heredity (Kyere *et al.* 2012). As shown in Chapter 5 of this study, traumatic lesions also increased from the Neolithic to the EBA, including those that could have affected spine (see also Section 6.3.5.). In summary, the remarkable prevalence of Schmorl's nodes in the EBA may have been the result of a combination of biomechanical factors, excessive loading, as well as traumatic injuries.

In all three studied periods quite a high percentage of young females were affected by Schmorl's nodes (20% vs. 20% vs 11%) was noted. In Vedrovice, two out of three affected individuals were also young females, showing the lesions in lumbar spine. In the comparative Chalcolithic collections, males with Schmorl's nodes prevailed (Shbat *et al.* 2009; Drozdová 2011), with only one old female exhibiting the trait (Drozdová 2011). Wohlschlager (2011) does not include specific ages for the EBA population from Gemeinlebarn. In young individuals, Schmorl's nodes are associated with trauma, metabolic disease such as osteoporosis or neoplastic disease (Faccia and Williams 2008; Dar *et al.* 2010). Metabolic diseases were quite frequent among the young females of the Neolithic and the Chalcolithic, although only Neolithic females were affected by osteopenia/osteoporosis (see Chapter 5, Section 5.5.3.). No neoplastic signs or clear signs of vertebral trauma were observed in the study sample's females, and so the early occurrence of Schmorl's nodes among the young Neolithic women may have been caused by metabolic deficiencies or excessive loading earlier in life.

The CPR of Schmorl's nodes among young EBA males was especially high (43%) in contrast to the previous periods in which no young males were affected. In the comparative collections, no Neolithic males were said to have suffered from Schmorl's nodes. In the Chalcolithic collection of Shbat *et al.* (2009) males of all age categories were reported to exhibit the lesions, and Drozdová (2011) recorded only one male with the trait, an individual aged thirty to thirty-five years. Unfortunately, no data regarding the age of affected males are available for the EBA populations from the area. In the studied EBA assemblage, only 6.8% of young males suffered from a metabolic disease (of which only 2.3% had the signs of bone loss). Despite the signs of spinal trauma being quite common among EBA males (18.2%), none of the men younger than twenty-five were affected. The prevalence of spinal degeneration among the young EBA males may thus have been caused by exposure to excessive stress, because of an overload of the spine (Dar *et al.* 2010).

6.3.5. Trauma and violence

The evaluation of trauma is limited by many factors. Skeletal evidence observable on archaeological remains represents only the tip of the iceberg, owing to the fact that injuries both fatal and non-lethal may affect bone, soft tissue or both. Soft tissue traumas are not necessarily traceable on skeletal remains, although they may be equally deadly. Even skeletal trauma may not be visible if remodelled away (Roberts 2000), especially if it takes the form of incomplete cracks that heal quickly (Lewis 2007: 163, 167). Taphonomic damage and brittleness of bones in, for example, elderly individuals suffering from bone loss can also contribute to the low scoring of trauma in skeletal remains (for discussion see also Larsen 1997). The identification of when an injury occurred represents another key limitation in ancient remains, as the fully healed fractures could have occurred months or years before death. Distinguishing between perimortem and post-mortem trauma can also be problematic, as neither show bone remodelling, a clear sign of healing (Lovell 1997). The origins of trauma can also vary, from occupational and accidental to deliberately inflicted injuries. Accidental trauma is often occupational, and is thus mostly environment and lifestyle-dependent. Owing to the abovementioned restrictions, the origin of traumatic lesions can only rarely be accurately estimated. Traumatic lesions observed in this study are discussed below within their prehistorical and archaeological contexts. Because most osteological studies focus on fractures when assessing traumatic lesions, these will be the prime focus of the discussion below, although findings regarding other types of trauma recorded for the purposes of this thesis are incorporated throughout the discussion.

Only four juveniles in the study collection suffered antemortem fractures and in the published studies only perimortem fractures of juvenile remains were indicated. However, the lack of traumatic lesions in subadults may also be influenced the fact that children were commonly buried in shallower graves (for example, Demján 2010; Olexa and Nováček 2013), making them more prone to post-mortem damage. Moreover, antemortem fractures of soft juvenile bones may not leave any trace if healed properly, especially greenstick fractures (Lewis 2007: 83). As a result, trauma in juveniles can be more easily missed and its rates under-recorded. In the Neolithic, a healed blunt-force trauma on the left parietal was observed on the skull of an adolescent. The individual did not suffer any other traumas; other pathologies included only *cribra orbitalia* and dental hypoplasia. While no perimortem fractures were observed in the juveniles from Svodín, two cases of perimortem skull fractures were recorded in the Neolithic collection from Nitra, Slovakia (Whittle *et al.* 2013). However, the causes of the fractures were difficult to determine. Similar to Svodín, in the Chalcolithic study collection only one child (Kněževes 772A) experienced antemortem fractures, namely the fracture of the proximal femoral shaft. The fracture was non-fused, but the degree of bone remodelling (Appendix 6, Figure 131) suggested the trauma probably occurred shortly before death. In addition, three subadults had perimortem fractures, although only one child from Tišice, aged six to eleven, could be interpreted as having suffered deliberate trauma (Tišice 633). Although the bone was incomplete and the precise size of the perforation could not be assessed, the approximate width was 2 cm, and the length certainly more than three centimetres. There was no bone remodelling, and the fracture lines indicate a probable blunt force trauma (Appendix 6, Figure 125). The force needed to cause such a perforation and the inward-impressed edges, suggests intentional attack using a weapon, possibly pointing to a violent encounter. Moreover, the trauma was located on the left parietal, the part of the skull most commonly affected by violent injuries (for example, Fibiger *et al.* 2013). Such a pattern is often seen in face-to-face violent encounters of two right-handed opponents (Novak 2000). The dental age of the child was estimated to *ca*. eight years, and although a child of such a young age may not be expected to have been involved in a battle encounter, it may still have been a victim of violence. Neither Shbat *et al.* (2009) nor Smrčka and Drozdová (2011) observed subadult antemortem fractures in their Chalcolithic samples. However, when perimortem fractures are considered, subadults from the Chalcolithic combined collection experienced fractures more frequently than those from the previous period (Figure 98).

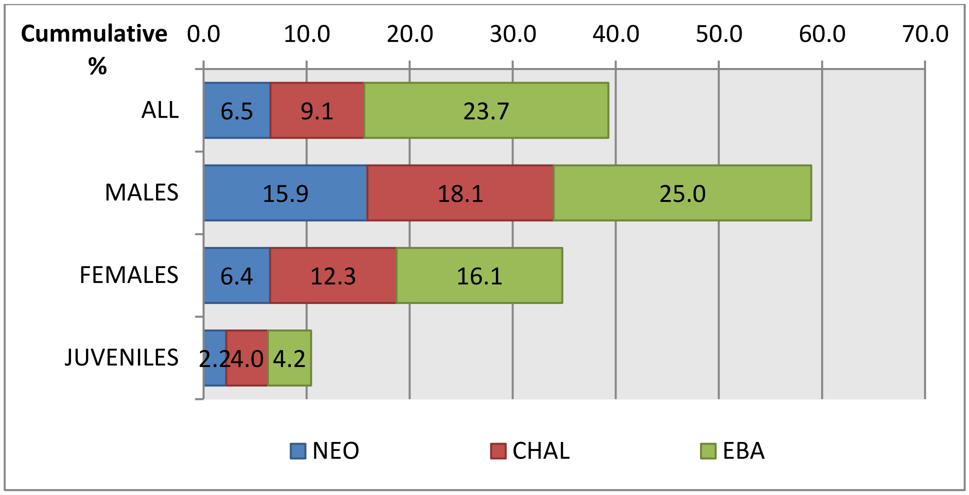

Figure 98. Prevalence rates of antemortem and perimortem fractures in the combined collections. % - average percentage calculated from CPRs from individual assemblages.

In total, skulls and feet were most frequently fractured in Chalcolithic juveniles of both the study and the comparative collections and perimortem cranial traumas are suggestive of violence more frequently than in the Neolithic. On the posterior of the left parietal of an adolescent from Mochov (4070) an elongated opening (30 x 5 mm) was observed. Colouration and the absence of remodelling suggest perimortem trauma. Bevelling on the outer and inner table could point to a trauma caused by a pointed tool, for example, a blade or arrow (Appendix 6, Figure 132). Shbat *et al.* (2009) recorded a similar yet much smaller lesion on a six-year-old child from Vikletice (4821), ascribing the lesion to a probable arrow trauma. In the EBA, only two subadult healed fractures occurred, a child aged six to eleven years from Nižná Myšľa (H148) with a blunt-force trauma to the right parietal (Appendix 6, Figure 133) and an adolescent also from Nižná Myšľa (H299) with the fracture of the distal epiphysis of the right humerus (Appendix 6, Figure 134). No further evidence of trauma was observed. Perimortem fractures were recorded in another two individuals from the same archaeological site, one had a perimortem fracture to the atlas (H94), and a second child (H141) had fractured shafts of the right tibia and the fibula from the same side which, based on the colouration of the bones, may have been exposed to fire (Appendix 6, Figure 135). The cause of perimortem fractures is extremely difficult to evaluate, and the damage to the bones of the child H141 may have been the result of a burial practice. Cremation was not commonly practiced in Nižná Myšľa (Olexa 2003) but since the burial of the child H141 showed also abnormalities as regards burial position[73], it is possible that a different type of burial was applied in the case of this individual. From a comparative site of Zohor, Slovakia, one child had a perimortem fractured skull (Šefčáková 2014). Based on the radial fractures and the appearance of the margins of the breaks the author assessed the fracture as a "probable unhealed injury" (Šefčáková 2014). However, the precise cause of the lesion could not be evaluated. No other injuries in EBA subadults were observed. Based on the above-mentioned cases, the level and amount of violence in individual periods cannot be estimated, although the number of antemortem fractures apparently increased when compared to the Neolithic (Figure 99). However, bigger and better preserved sample would yield more relevant results.

In adults, the CPRs of healed fractures were similar in the Neolithic and the EBA (27.3% and 32.9% respectively), while Chalcolithic adults were the least affected (18.6%). But while in the Neolithic fractures prevailed in skulls and upper extremities, EBA fractures were distributed throughout the whole skeleton (see Chapter 5). In addition, cranial trauma, in archaeological remains often associated with violence, was most frequent in the Neolithic as well. However, the brutality of cranial lesions appeared to be more intense in the Chalcolithic and the EBA. To be more specific, in the Neolithic small healed depressions on cranial vaults were usually observed, in the other two periods skull lesions were much deeper, indicating that they had probably been caused by a deliberate attack (Appendix 6, Figures 112-115). In general, antemortem fractures were more frequent in male individuals, what is also suggested by the combined data (Figure 99). In other words, men were probably more frequently exposed to traumatic events, be they accidental or intentional.

As indicated by the study remains, fractures in the Neolithic were probably mostly accidental in both sexes. Violence was indicated by a few cases from the comparative collections, almost all dated to the Lengyel period. The majority of fractures in the Neolithic study collection were observed on the bones most commonly involved in accidents – the upper arm, ribs, and lower leg (Ortner and Puschar 1985), although skull fractures were the most frequent. In comparison to the Chalcolithic and the EBA, fractures of skulls, upper extremities and fibulae were especially common in the Neolithic (see Chapter 5). When data were combined with those from published research, skull fractures were not as frequent (yet the CPR was rather high - 3.4%), whereas humeral and fibular traumas remained slightly

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[73] the individual was placed on the right side, heading to the north and facing west, whereas the majority of the skeletons with N-S orientation were facing east

higher than in the following periods (Figure 100). The large difference between the CPRs of cranial fractures in the study and the combined Neolithic samples may point to a site-specific factor resulting in high percentage of affected individuals in Svodín (see discussion below).

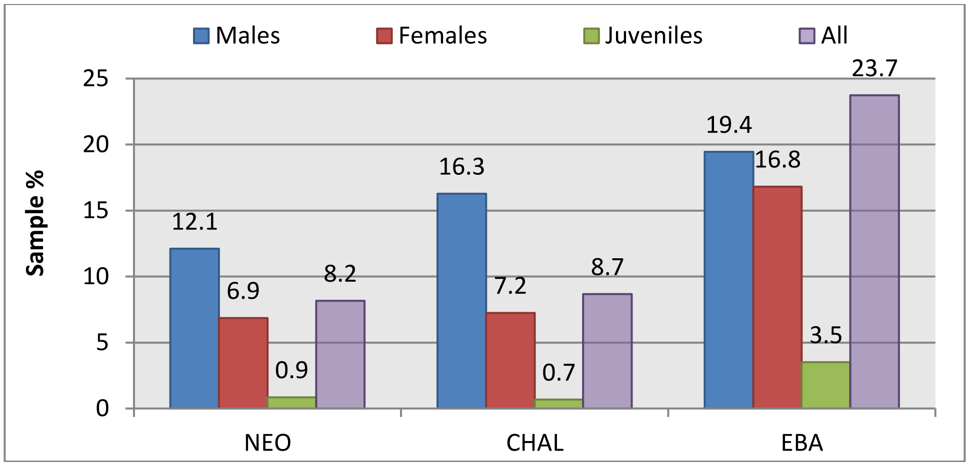

Figure 99. Prevalence rates of antemortem fractures in the combined collections. % - average percentage calculated from CPRs from individual assemblages.

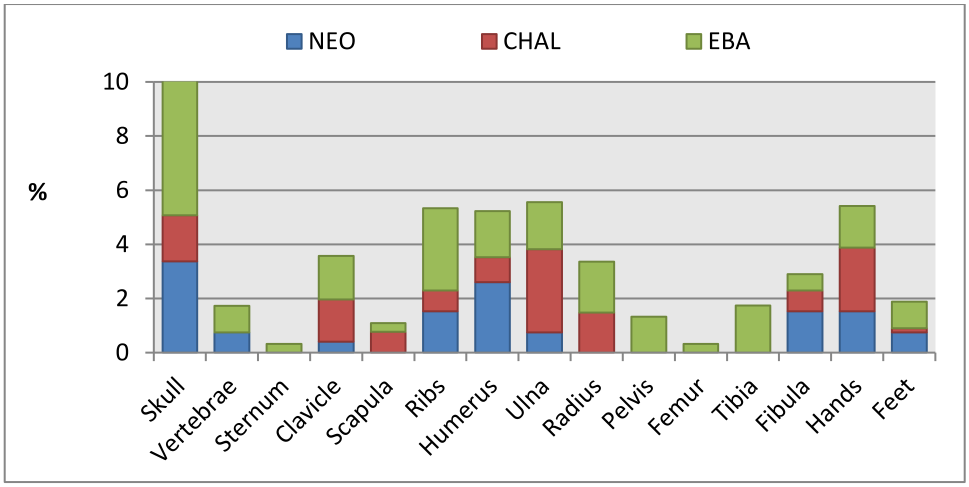

Figure 100. Prevalence rates of antemortem fractures by skeletal area in the combined collection.

Among Neolithic females, only four had fractures. Two females (H107 and H182) suffered from single fractures (an avulsion of the third metacarpal and a rib, respectively). The female H107 also displayed evidence of ankylosis of the first two thoracic vertebrae (Appendix 6, Figure 136). The line between the bodies is still visible, so a congenital anomaly such as Klippel-Feil syndrome is unlikely. As this area is the most naturally stressed spinal area and no other pathologies were observed, trauma is the most likely cause. It is most likely that such a trauma was caused by accident and not intentionally. A young female aged eighteen to twenty-four (H113) exhibited a badly healed fracture of the humeral shaft (Appendix 6, Figure 105). The fracture was fully healed, without the callus, so the precise type of fracture could not be assessed. However, the bone appeared to be bent, which in combination with the age of the individual may point to a greenstick fracture. Falling with an outstretched arm is the most common cause of humeral shaft fractures in young individuals, although twisting of the arm and direct blows can also result in this type of fracture (Cole *et al.* 2010). The individual also exhibited signs of scurvy which can be associated with fractures owing to the fact that vitamin C is essential for collagen formation (Paterson 2010), suggesting that this may have been also a pathological fracture.

Skull, humeral, ulnar and rib fractures were observed in an old female (H41). Among the Svodín adults, cranial and humeral fractures were the most frequent found (CPR of both was 9.1%), followed by rib, fibula, and hand fractures (CPR of each being 6.1%). Based on different stages of healing, the injuries of female H41 were not the result of a single event. Fully healed fractures of a rib and a depression trauma on the left parietal (about 12 mm in diameter) may have occurred long before the woman's death. In archaeological remains, cranial trauma is frequently ascribed to violence (for example, Bennike 2007), although people in close contact with dairy cows and horses have been proven to be at increased risk of trauma, especially to the skull and legs (Busch *et al.* 1986). Busch *et al.* (1986) recorded that 61% of patients, the majority of whom were farmers, had traumatic injuries caused directly by animals. Of these, 21% were kicked by a cow and 19% assaulted by the animal[74] (Busch *et al.* 1986). In addition, Judd and Roberts (1999) studied farmers of the medieval village of Rounds and found that fractures of the forearm and shin were the most frequent injuries among the female farmers. As suggested by the vertebrae, ribs, pelvis, humeral and femoral heads, the female also suffered from probable osteoporosis (Appendix 6, Figure 137). The healed injuries of the female H41 could therefore be occupational, especially if the individual suffered from significant bone loss already by the time when the injuries occurred. Fractures of the lateral condyle of the right humerus, right distal ulna, and a pseudojoint of the right shaft of the fibula were also observed in this individual, showing

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[74] the rest of the cases were accidents caused by horse, such as falls from horse, direct assaults or animal-drawn vehicle accidents

only a small amount of new bone formation (Appendix 6, Figure 138). The fractures thus probably occurred not long before death, and so it is difficult to evaluate their origin. However, owing to the significant bone loss, the fractures could have been caused by even a minor force. A more detailed evaluation was not possible because the humerus and ulna were also broken post-mortem. Palvanen *et al.* (2000) studied the injury mechanisms of upper limb fractures in osteoporotic elderly individuals and they found that 26% of elbow fractures were caused by a direct fall on the elbow (Palvanen *et al.* 2000: Fig. 2). When considered together with the ulnar and fibular fractures, a fall is a plausible cause. Gowland (2016) provides an alternative explanation to the injuries observed in elderly people. She notes that bioarchaeological papers tend to ascribe such injuries mostly to accidents, even though at least some older individuals can be expected to have been victims of abuse or domestic violence (see also Bennett and Rowe 2003: 488; Lachs and Pillemer 2004; Novak 2006; McDowell 2010; Daly *et al*. 2011). Gowland (2016) summarises the most indicative bones on which abuse-indicative injuries are most common, including cranium, dentition, ribs, and humeri (see also Dyer *et al*. 2003; Püschel 2008; Rubio, 2009). Moreover, multiple fractures of different ages are more consistent with abuse than a single injury. In the light of these observations, it is possible that the woman H41 from Svodín was (also) a victim of abuse or violence. As suggested by Gowland (2016), social marginalisation suggested by archaeological cotext may also be an indication of abuse among the elderly (see also Gowland 2007). The old woman from Svodín was discovered within the roundel area where mostly juveniles were buried (Demján 2010). Čermáková (2005) sees a similarity in Lengyel children burials placed separately from those of adults and Irish small cemeteries called “cillins” where children and/or other ambivalent individuals used to be buried. These burial grounds are often placed at the margins of the communal area, in ruins or old megalithic tombs (Finlay 2000). Irish fairy-tales often mention children who were returned by supernatural entities, resulting in associating children with “the world of supernatural” (Finlay 2000). The woman H41 was affected by apparent plagiocephaly (Appendix 6, Figure 139), that would also have affected her appearance. In addition to the parallelogram-shaped skull, a ‘harlequin’ deformity of the face and different orbital shapes are often observed (Taub 2010; Khanna *et al.* 2011). An unusual appearance is consistent with the interpretation that she was “different” and thus buried in a marginal area. Although difficult to assess in archaeological remains, abuse is certainly one of the most probable causes of this woman’s injuries.

In the comparative assemblages, fractured bones were found mostly among females older than forty. Healed forearm fractures were the most common traumas and were interpreted as occupational (Whittle *et al.* 2013). However, for the Lengyel females from Střelice (aged >50) and Předmostí (aged forty to forty-five) violence-related cranial injuries were suggested, although mostly by perimortem injuries (Schenk *et al.* 2007; Dočkalová and Čižmář 2008; Smrčka and Tvrdý 2009). A perimortem fracture of a female from Střelice also included star-shaped fracture lines (Smrčka and Tvrdý 2009), and the depth of the lesion suggested a strong blow to the head. In the female from Předmostí only a healed circular depression on the right parietal was recorded (Schenk *et al.* 2007). Ambushes and raids are quite common in primitive societies (for example, Otterbein 1989), resulting in a small number of killed (mostly those who got in the way and were unable to defend themselves or were caught by surprise [Lovejoy and Heiple 1981; Keeley 1996]). The types of injuries as well as the age pattern observed in female remains from the study region support this theory, whereas older females may represent settlement inhabitants who “got in the way”. An under-representation of females in the Austrian Schletz-Asparn population was recorded by Windl (1999: 43) who also suggests that they may have been taken alive as captives. It is therefore possible that at least some females were brought to the settlement as captives or were victims of raids.

Even though a certain amount of violence is indicated for the Neolithic, no brutal encounters with the intention to kill were frequently suggested by the osteological record. Almost none of the trauma suffered by males from Svodín could be clearly related to violence. Instead, there is an indication that they were connected with the individuals’ way of life. All males with fractures (H10, H27, H83, H93, and H125) were older than thirty-six and all presented with signs of trauma indicating occupationally-related hazards. Unlike in females, where mainly the arms and ribs were affected, fractures of males were distributed over almost all skeletal areas, fractures of skulls, vertebrae, ribs, and fibulae being especially frequent (see Chapter 5). Such distributions are more characteristic of the lifestyle of hunter-gatherers than that of farmers. Berger and Trinkaus (1995) noticed an increased number of head and neck injuries in Rodeo athletes who, like prehistoric hunters, were in close contact with agitated animals. Moreover, hunting involves long-distance running and jumping, the former easily resulting in stress fractures of the lower extremities (Waldron 2009), the latter in accidental falls and fractures caused by a single incident. A mature male (H93) exhibited a minor fracture of the capitulum of the left humerus, which showed traces of healing, but the fracture lines were still visible, indicating that the trauma had occurred not long before death. The depth and intensity of the lesion suggest that the trauma was caused by a strong force where the radius was forced into the capitulum, possibly in a fall. The partially healed fracture of a foot proximal phalanx and a trauma-induced defect on the right patella may have occurred in the same event (Appendix 6, Figure 140). Alternatively, the latter may have resulted from a repetitive activity such as prolonged walking or running (Waldron 2009). Nevertheless, none of the lesions are suggestive of intentional injuries. In addition to a rib and a metacarpal fracture, the left forearm and the right femur of a mature male (H10) exhibited thickening of compact bone, implying a systemic disease (Appendix 6, Figure 141). However, based on the combination of the injuries, violence does not seem a probable cause of this man's fractures.

Another male from Svodin (H27) had a healed fracture of the fibula shaft. The fracture line is not clear, so the type of fracture was difficult to determine in the absence of radiology. This man also suffered probable scurvy, fractures being one of the consequences of the condition (for example, Paterson 2010). However, the fibula was fractured in its distal third and, because it was the only fracture observed, the injury may have also been caused by a direct blow.

In addition to a minor healed blunt-force trauma (10 x 5 mm) on the left side of the frontal bone, multiple perimortem fractures were observed on another male from Svodín (H125). In addition to oblique fractures of the right fibula and tibia, a spiral fracture of right femur and a fractured atlas were observed (Appendix 6, Figure 116). They probably all occurred at the same time and were probably related to the death of the individual. In non-osteoporotic individuals all of the above-mentioned fractures are usually related to high-energy collisions such as falls from heights (Barwick and Nowotarski 2011; Foster 2015). The individual (H125) also exhibited evidence of a rib infection or a systemic disease, suggested by bone thickening, sclerotic pattern, porosity, and darker colouration at the point of fracture. Together with multiple signs of rotator cuff disease the antemortem and perimortem fractures correspond to a demanding lifestyle, as suggested for foragers and Rodeo athletes (Berger and Trinkaus 1995). Given the archaeological context the male was found in (his grave comprising boar tusks), he may have been engaged in hunting activities (see also discussion below).

The probability that all the above-mentioned males were hunters representing local elite is suggested not only by the osteological evidence but also by archaeological data. Demján (2010, 2012) found that the majority of rich graves belonged to mature males, including the above-mentioned males. All but one of their graves (H83) included boar tusks (Demján 2010). The inventory also comprised of stone flakes and blades, stone tools or weapons such as shoe-adzes, axes and battle axes, implying the important social position of these men. Increased game consumption in consequence of deteriorating climatic conditions in the Lengyel period (Němejcová-Pavúková 1998; Karlovský and Pavúk 2004; Tóth *et al.* 2011; Pavúk personal communication, May 2013) supports this finding, and males who were able to provide for their kin can be expected to have been regarded with respect. A slightly different situation is suggested for the region west of Slovakia, where males, especially young individuals, were associated with violence (Dočkalová and Čižmář 2008; Smrčka and Tvrdý 2009; Whittle *et al.* 2009). A young male from Mašovice, Moravia, suffered from numerous unhealed injuries to the skull, upper limbs and ribs (Dočkalová and Čižmář 2008). Based on the pattern of fracture lines, Smrčka and Tvrdý (2009) suggest intentional attacks from a dorsal direction and from the sides. Perimortem traumas on the long bones of an unsexed and un-aged individual from Těšetice (12/1987) also included traces of incisions and blows (Dočkalová and Čižmář 2008), strongly suggesting a violent event. Apart from the young males, a violent skull perforation and a possible unassociated amputation of the left forearm with distinct signs of healing were also recorded in a mature male from Vedrovice (Crubézy 1996; Dočkalová 2008; Lillie 2008a). So, in the combined Neolithic collection, accidental trauma seems to prevail as well, although violent encounters are suggested to have occurred in the late Neolithic especially in the western part of the study region. The difference between the study and comparative collections may be caused by a sample bias, as the Lengyel remains from that comparative collection were collected from a variety of settlements whereas Svodín represents a single community. However, neither Köhler (2012) recorded more than a few cases of possible violent trauma at the Hungarian Lengyel sites. In fact, only Vencl (1999) mentions several cases of violent trauma occurring in one location – ten skeletons excavated from a ditch at the Lengyel site of Ružindol-Borová, Slovakia, although the detailed anthropological data remain unpublished and a firm conclusion cannot be determined without a thorough examination of the remains. Mass graves from early Neolithic Central Europe have also been discovered (Wahl and König 1987), suggesting that intense violent encounters in the period occurred.The difference in the eastern and western parts of the study region needs to be noted: there are numerous designated cemeteries recorded in the eastern part of the Lengyel complex (such as Lengyel, Zengövárkony, Svodín), but the skeletal remains from the western part of the mid-Danubian region come from settlements and are represented mostly by skeletons buried or dumped in the settlement pits (Trňáčková 1962; Podborský and Vildomec 1970; Urban 1979). The reason for the absence of designated cemeteries in the west is not known, but may be related to immigration from the Carpathian Basin to Lower Austria and Moravia, indicated in the Late Neolithic (Pavúk 1983: 41–42; 2007: 16–17). In addition to cultural factors, Chapman (1999) distinguishes two principal spheres that are involved in the emergence of violent encounters: frontier differentiation and resources distribution. The arrival of new cultural groups settling near the established groups could easily result in violent encounters. In addition, the struggle for control of local raw material sources has a good potential for violent interaction between two local groups as well as between the original settlers and the new-comers (Chapman 1999: 122). In a prehistoric Chilean population living in the Atacama Desert, Torres-Rouff and Costa Junqueira (2006) found that rates of trauma increased during periods of resource shortage and great social change, which have also been indicated in the study region. A similar trend was indicated for other populations (for example, Ember and Ember 1992; Theisen 2008; Diamond 2006). The low number of individuals with evidence of interpersonal violence also from the western part of the region may indicate that a similar situation occurred in Central Europe, with only small parties of aggressors acting against small target groups (Smith 2014), for example, in raids. The fact that mostly older females and younger males from the Moravian sites showed signs of perimortem trauma also fits the pattern observed in raids, as these groups can be expected to have been usually present in a settlement as, for example, in the late prehistoric population from Libben, Ohio (Lovejoy and Heiple 1981). Here, fractures were also most common among the young (fifteen to twenty-five year) adults and adults older than forty-five. The authors suggest that the young males were those included in direct conflict (for example, being left to defend the settlement), while the older individuals represent those who were unable to defend themselves, and were thus more prone to be killed. In summary, violence in the Central-European Neolithic seems to have been limited to encounters between smaller groups, such as raids for captives or raw resources.

In the adults from the studied Chalcolithic assemblage, only one case of violence was recorded (a mature male from Tišice 634). At least six injuries associated with violence were implied by Shbat *et al.* (2009) in the comparative Bohemian sample, while Smrčka and Drozdová (2011) did not observe any clear violence-related trauma in their Moravian collection from Hoštice. As in the Neolithic, the western part of the study region seems to have been more violent than the east. Antemortem fractures in the combined Chalcolithic collection were more frequent in the bones of the upper extremities, especially the ulna (2.2%) and hands (1.5%), and skulls (1.3%). Percentages of other antemortem fractured bones were lower (0.2-1.1%) (Figure 100).

In Chalcolithic females, non-violent trauma was more frequent, although intentional injuries were also implied when perimortem fractures were also considered. Only two females from the studied assemblage had antemortem fractures. A mature female from Březno u Loun (7012) exhibited a healed clavicle fracture and a prime female from Malé Březno (8880) had fractured ribs and her left proximal humerus showed the evidence of a severe fracture. The bone was healed, with extensive bone remodelling in the deltoid area. This may indicate that the bone was being burdened after the injury, but the type of the fracture could not be precisely estimated as no X-ray was performed. Two of the female's rib-shafts had depressed fractures, suggesting a direct blow to the rib-cage (Appendix 6, Figure 121), possibly pointing to interpersonal violence. However, in archaeological remains accidental fractures are more common than those caused intentionally (Lovejoy and Heiple 1981; Grauer and Roberts 1996), especially in bones that are frequently injured in accidents, such as ribs or the upper arm (for example, Ortner and Puschar 1985). Owing to the severity of the humeral fracture, an intense force such as kick from an animal or a high-velocity fall are possible causes although deliberate attack cannot be ruled out.

Apart from antemortem trauma, a perimortem cranial trauma in a young female from Kněževes (767) was the only indication of possible violence observed in females from the study collection. An opening on her occipital had with no signs of healing, with this perimortem injury being a probable cause of death. The longitudinal opening is about 2 cm long and 1 cm wide, with bevelling on both surfaces of the cranial vault (Appendix 6, Figure 142). The direction of the wound suggests it came from the bottom left, so the woman may have fallen on a sharp pointed object, or had been injured by a projectile while lying on her stomach (Lovell 1997). Based on the location of the injury, it can be presumed that the woman was a victim of a conflict.

Other than fractures, osteochondritis dissecans on the joint surfaces of the right distal radius and the distal tibia from the same side was indicated in study-sample prime female from Stehelčeves (3840). Osteochondritis dissecans is mostly associated with trauma such as a fall (as suggested by, Schenck and Goodnight 1996; Edge and Porter 2011), although the exact aetiology is still unclear. As the affected bones of the woman from Stehelčeves were from the side, an accidental aetiology can be assumed.

In total, the number of Chalcolithic females with traces of deliberate violence and perimortem wounds was low (two, if also the woman 8880 from Malé Březno is considered as a possible victim of violence), supporting the hypothesis of females being only passive participants in conflicts. The implied perimortem projectile injuries in females and juveniles imply that they were attacked from a distance, indicating possible violent encounters between groups. In the comparative samples, both intentional and unintentional traumas were also indicated and, similar to the study sample, the number of affected females was only four. Two females from Vikletice (4818 and 5367), both over forty, suffered cranial trauma (Shbat *et al.* 2009). The skulls of both women had penetrating injuries, only one showing signs of healing (4818). No bone remodelling was observed in the case of the second woman who, in addition to cranial trauma, also had a ”non-penetrating longitudinal foramen” in the right internal part of the pelvis (Shbat *et al.* 2009). The authors describe these lesions as probable weapon wounds. Apart from violent trauma, a young female from Čachovice showed evidence of healed fractures of the metatarsals (Shbat *et al.* 2009). In Hoštice, Smrčka and Drozdová (2011) recorded five individuals with fractures, all older than forty. From these, only one was female (H907) and she suffered from a healed fracture of the distal ulna, but neither these injuries were assessed as violent (Smrčka and Drozdová 2011).

Regarding Chalcolithic males, healed intentional trauma was indicated in the cranium of a mature male from Tišice (634). The skull was fractured at the pterion[75], with clear evidence of bone remodelling. The fracture had not fully healed and may have been related to the individual’s death. Based on the imprint of the fracture, the wound was probably caused by a battle-axe or similar weapon (Appendix 6, Figure 113). His right wrist was affected by osteoarthritis that, together with a robust right humerus and marked muscle attachments, could indicate that he was also using his right hand in holding heavy objects. Other than this, no clear violent antemortem related trauma was suggested in Chalcolithic males from the study assemblage. On the other hand, if perimortem fractures were also considered, intentional trauma

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[75] the area where the frontal, parietal, temporal, and sphenoid bone meet (Buikstra and Ubelaker 1994: 33)

was more frequent in males than females. All skull fractures in both the study and comparative remains suggest violent encounters.

In comparison to cranial fractures, postcranial trauma in Chalcolithic males suggests more accidental than violent causes. The right fifth metacarpal of a mature male (Sulejovice 1820) was fractured and had healed antemortem, and his left distal ulna was fractured perimortem. Metacarpals are frequently fractured during fist fights (Lovell 1997), but because there are no other indications of trauma, the cause of the fractures was difficult to assess. However, the man’s vertebrae as well as his ilia indicate that he may have also suffered from bone loss, and so a fall or stress fractures are also possible causes. The fracture of the left fifth metacarpal of a prime-aged male from Plotiště (Ao 6100) was probably related to trauma to the left hand. The fracture of the fifth metacarpal, also called a ‘boxer’s fracture’, is usually caused by hitting a hard object with a fist (Greer and Williams 1999), for example, in a fall or a fight. The individual also suffered from a healed fracture of left distal fibula and excessive bone remodelling in the spinal canal of the thoracic spine was also observed (Appendix 6, Figure 128). With regards to all the traumatic lesions observed in the skeleton, accidental injury is a probable cause.

Other than fractures, a prime-aged male from Hulín (H66) suffered from a probable hip luxation, including avascular necrosis of the femoral head (Appendix 6, Figure 143). In comparison to the shoulder, hip dislocations are quite rare and require a much stronger force to occur (for example, Brav 1962). In modern populations, hip luxations are mostly caused by car accidents or in contact sports such as rugby (Schuh *et al.* 2009; Clegg *et al.* 2010), and are more common in young men (Dreinhofer *et al.* 1994). Hip dislocation can also be of congenital aetiology, but more commonly they are caused by trauma (Lovell 1997). In prehistory, falls from higher than standing heights, e.g., from a ladder or horseback, could be the most relevant analogies.

In comparison to only one case of violent trauma in males from the study collection (Tišice 634), three weapon wounds (two skulls and one forearm fracture) were recorded by Shbat *et al.* (2009) in their Bohemian sample of adult males and provide evidence that violence may have been common in the Chalcolithic. In addition to the three weapon wounds, the authors recorded three more cases of cranial trauma, although no details about the origin of the lesions were mentioned (also Hanáková and Vyhnánek 1981). In Moravia, Smrčka and Drozdová (2011) recorded only five individuals with minor fractures, out of which four were males older than forty-five. The distal forearms of two males had been fractured and two others had fractured metacarpals (Smrčka and Drozdová 2011). All were ascribed to falls or accidents (also Vyhnánek 1999). In relation to the low level of fractures, preservation bias needs to be taken into account as regards this site. In summary, more violence is indicated for the Chalcolithic than the Neolithic, with cranial traumas being associated with deliberate injuries.

The number of studied EBA adults with fractures was the highest of all periods, although the CPR in the Neolithic sample was almost as high (27.3%, 18.6% and 32.9% from the Neolithic to the EBA). In the combined collections, the CPR of fractures was definitely highest in the EBA. Nevertheless, in spite of the high frequency of healed fractures in Svodín, in the EBA sample more violence-related traumas were indicated.

Minor traumas probably related to accidents were observed mostly in females. The most affected bones were the clavicles and ribs, all of these being common fractures, for example, from falls. No cranial fractures were observed. Even though interpersonal violence cannot be ruled out, the majority of the females did not have any major trauma. As regards males, almost all individuals with probable non-violent traumas were from Nižná Myšľa, where a great proportion of the injuries is consistent with falls. Intense contacts with the South-west and long distance travel were suggested for the EBA populations (see Chapter 2), most likely carried out by males, which may have resulted in an increased risk of accidents on the way. The graves of two of the males were richly equipped and included specific items such as boar tusks, bronze pins, shells, and arrows. The suggestion of craft and occupation specialization at Nižná Myšľa (see Chapter 2) indicate that the items could be related to status and occupation (for example hunters or warriors).

Antemortem fractures of two EBA females (6.3% of EBA females) and five males (11.4% of EBA males) from the study assemblage indicated intentional trauma. Both females were from Bohemia (Praha – Malá Ohrada 8768 and Stekník 2422). The right upper acetabulum of the woman 8768 had been penetrated by a sharp tool directed from the top, the lesion being about 15 mm deep (Appendix 6, Figure 144). No other pathologies were observed in this individual. A penetration injury was also observed in the second female, although inflicted on the rib-shaft. A 6 mm long and about 2 mm wide groove was lined with a rim of bone formation, and the lesion was fully healed (Appendix 6, Figure 122). The bones of this woman were short and robust, with marked entheses (e.g., the linea aspera), spinal OA, osteophytic bone formation on the patella and distal fibula, all suggestive of an intense lifestyle.

Three of the five men, all of whom had probably been involved in interpersonal violence, had fractured skulls. Lesions on the skull belonging to one male from Praha – Malá Ohrada (8783C) indicate violent blunt-force trauma to the top of the skull. There was a further large (about 10x5cm) opening on the left parietal. Only the left cranium was preserved, but the opening on the preserved fragment is 50 mm long and 15 mm wide, suggesting that the lesion was quite large. The round and smooth edges of the lesion indicate healing, with the bone around the whole perforation depressed inwards and healed (about 2 cm on each side) (Appendix 6, Figure 114). Nerlich *et al.* (2003) demonstrated that bone remodelling of the cranial table is much slower than in other bones and that even long-term healing does not result in the complete closure of the opening. They note that even an old injury of several years would still show rounded margins and a loss of the diploic layer (Nerlich *et al.* 2003). Based on the shape of the depressed table and an elongated perforation in the centre, the male (8783C) may have had an old injury caused by a blunt weapon. The origin of the additional large foramen is more difficult to evaluate. It may have been a result of a single intervention (a trepanation) or caused by multiple events (a trepanation and a fracture). The completely remodelled and smooth posterior edges of the large foramen suggest that the healing process must have lasted at least several months, if not years (Nerlich *et al.* 2003), similar to the lesion on the top of the skull, and it is possible that the two were related. The outer table was slightly sloping inwards and the angle of the edges appears similar along almost the whole lesion. No depressions or internal bevelling were observed. The inferior margin was slightly thinner and more uneven, but this may be because the inferior part of the parietal bone is generally thinner. The anterior of the perforation was also very irregular, possibly indicating a third traumatic event. Erdal (2005) describes a large trepanation on the skull of a İkiztepe individual, with the edges of the lesion also being irregular at the thinnest part of the bone, that could be ascribed to the scraping method used for the surgery. An extensive successful trepanation, triangular in shape, with irregular margins was also recorded in another individual from İkiztepe (Erdal 2005), where a sawing technique was applied. Özbek (1994) describes a trepanation combined with a trauma caused by an edged weapon, the latter resulting in a foramen of irregular shape, similar to the lesion on the skull from Malá Ohrada. Regardless of the method used, the lesion on the EBA skull was most probably the result of a successful trepanation, possibly related to the injury on the top of the head.

A further violent incident at the site of Praha – Malá Ohrada is suggested by an arrowhead embedded in the rib of a prime male (8792). The area around the arrowhead tip had remodelled, suggesting that the man survived the injury. A healed elliptical lesion on the posterior of the right parietal and healed fractures of the clavicle and rib (Appendix 6, Figure 124) indicate that the individual may have been involved in hazardous situations before, although not necessarily of a violent nature. His skull had been fractured perimortem, although it was difficult to determine the cause of this fracture.

When perimortem fractures are also considered, in Praha – Malá Ohrada almost all males showed evidence of violent trauma (Appendix 3, Table 59; see also enclosed database). In addition to the above-mentioned cases, several other skulls from the site indicate violence, such as a probable healed sharp-force trauma on the left frontal bone of another male from Malá Ohrada (8759). This individual suffered a perimortem trauma to the right maxilla and the right side of the frontal bone, and a perimortem fracture of the shaft of the left humerus; the face being the most frequently injured area in interpersonal encounters (Lovell 1997, Béogo *et al.* 2013; Arslan *et al.* 2014). Koel (2011) suggests that men were frequently absent from the settlement, probably on raids or travels. She proposes that the males injured and in a need of healing were those that had remained in the settlement, to defend it from attack. In the study sample, the majority of the males with violent trauma were more than thirty-five years old. It can be presumed that it was the young and prime-aged males who were sent on raids or on travels, and so Koel's theory may well be true of the study sample. Alternatively, Praha – Malá Ohrada may have been a base of a raiding military group (Chochol 1989). Shallow depressions on the sagittal suture above the lambda were recorded in several males, all from Praha – Malá Ohrada and Nižná Myšľa. Despite the fact that the lesions resembled healed depression fractures, that they were observed repeatedly may indicate occupational impressions related to, e.g., wearing some head protection (Chochol 1987). This may point to the existence of specialised organised groups of warriors/raiders in the western EBA oikumene.

In a mature male from Nižná Myšľa (H53) a sharp-tool trauma beginning above the right orbit and continuing down to the nasal bones was observed (Appendix 6, Figure 115 c-d). Healing at the orbital ridge was obvious, but the injury at the nasal bones was still open, with only minimum signs of bone remodelling. This suggests that the injury took place shortly before death, and that the individual may have died as a consequence. The man also had multiple healed traumas, including a small (about 5 mm) circular depression fracture on the skull, a fractured proximal hand phalanx, unknown trauma to the spinal process of a thoracic vertebra, and a fracture of the lateral condyle of the left humerus. The archaeological record indicates that the individual was probably a member of a local elite and/or a chieftain of a military group (for more details see Nováček 2010: 51-52). This is consistent with the overall robusticity of the individual's bones, which also indicate marked muscle attachments. Cases of deliberate violence are less numerous in the bones of the postcranial skeleton. Minimal remodelling at the edges of a 5mm long cut/perforation injury on the thoracic vertebra of a male from Nižná Myšľa (H215) suggests that he may have been injured, for example, by an arrow[76] shortly before death (Appendix 6, Figure 145), indicating an attack from a distance. Same type of attack is indicated in a male from Praha – Malá Ohrada (8792) whose rib had a stone arrow-point embedded in the visceral side of the shaft. In addition, this man also suffered healed fractures of a rib and clavicle, and an avulsion fracture of the distal ulnar process (Appendix 6, Figure 124).

In comparative collection from Jelšovce, Koel (2011) recorded only a low percentage of cranial trauma (about 4% in both the Nitra and Únětice cultures), and she observed that wounds of males and females were very similar and they were probably inflicted in the same event, such as a raid (Koel 2011). In comparison, violent injuries differed between the studied males and females, and so a different environment in which they were caused can be presumed. As suggested by the present study, the EBA was the only period with females suffering from spinal joint disease to a greater extent than males and from a younger age (see Chapter 5). As the lesions were most probably occupational (see the discussion above), females were probably engaged in repetitive hard work for long hours. Martin and Harrod (2015) mention such signs as one of those observed in slavery/captivity. Moreover, some prime females also showed evidence of vitamin D deficiency, possibly implying that they had been kept mostly inside. As mentioned above, violent lesions in females included mostly sharp-force trauma, injuries being inflicted on the bones of the ribcage and abdomen (anterior vertebral bodies and ribs). Moreover, the vertebral bodies of two females from Nižná Myšľa (H71 and H262), both younger than thirty-five, displayed evidence of perimortem cuts with no signs

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[76] the rich grave inventory contained also arrowheads

of deliberate removal of body parts or any ritual burial practice. The injuries also suggest the penetration of the abdominal cavity, with the probability of wounding vital organs. Such wounds are often seen in modern homicides (for example, Karlsson 1998). For a stabbing injury to occur, the attacker and the victim have to be close to each other. Together with the fact that none of the females' skulls bore the signs of deliberate violence often seen in raids, it can be presumed that such injuries were caused by another member of their own social or cultural group, or by their "master" if captivity and slavery are also considered. As indicated by clinical studies, women themselves may be the aggressors, especially in shared households (van Willigen and Channa 1991; Gangoli and Rew 2011). Raj *et al.* (2011) and Gangoli and Rew (2011) describe violent conflicts between mothers- and daughters-in-law, whereas van Willigen and Channa (1991) mention dowry-associated murder. Moreover, several authors also recorded aggression among the co-wives in polygynous arrangements (Madhavan 2002; Jankowiak *et al.* 2005), although the exact marital arrangements of the EBA are unknown.

EBA males from the study sample often suffered multiple wounds with varying stages of healing, suggesting that they had been exposed to violence and/or a demanding lifestyle repeatedly and more frequently than females. Skull fractures were also clearly dominant in males when compared to females not only in the study sample but also at Jelšovce (Hårde 2005; Koel 2011). Robb (1997), who studied cranial trauma in Italian collections from the Neolithic to the Iron Age, also recorded increased frequencies of cranial injuries in males. The author associates this with different gender roles, and he demonstrates that females were not active participants in warfare and usually stayed in the settlements (Robb 1997). In the study assemblage, obviously violent skull trauma was observed exclusively in mature males. As indicated by Koel (2011), most of the cranial fractures recorded at Jelšovce also point to interpersonal violence, as suggested by a combination of blunt-force trauma and parry fractures. Penetrating injuries were also recorded, especially in the Únětice culture, also in males (Koel 2011). Even though some healed depression fractures from Jelšovce could equally have been caused by accidents, these were much fewer in number than those indicating violent encounters (Hårde 2005). In Jelšovce, Koel (2011) also records frequent violent trauma found on the postcranial skeleton. These were also predominantly present in males. However, Koel (2011) noted that the wounds of females were similar to those of males, indicating that they were direct participants in violent conflicts, probably as victims. Such injuries might have occurred in raids on a settlement (Koel 2011). Furthermore, an urban environment has proven to be more violent than that in rural settlements, owing mostly to increased population density, social differences or cultural diversity (Pollard 1999: 232). Although the theory may not be directly applied to archaeological populations, tensions in more densely populated places such as Nižná Myšľa, a settlement of urban structure, can be expected. In addition, the site is presumed to have been a production and a trading place (Olexa 2003), with culturally different (groups of) individuals most probably visiting the site and potentially increasing the risk of interpersonal violence. All in all, the increase in violence in the EBA seems to be predominantly related to intentional clashes of different groups, including raiding, increased trade and contact, and possibly capture.

In summary, it appears that despite the high incidence of trauma in the Neolithic period, only a few were possibly related to violent encounters, with more violence being observed in the western part of the study region. As suggested by both the studied remains and published data, traumatic events increased at the end of the Neolithic. The higher frequency of injuries could have been related to climatic change in the Lengyel period, either as a result of increased violence between cultural groups or a demanding lifestyle associated with hunting. In comparison to the other two periods, trauma in the Chalcolithic population was not very common, although more violent injuries were observed than in the Neolithic. As in the Neolithic, the frequency of intentional injuries increased towards the west of the study region, and this trend was also observed in the EBA. In addition, in the EBA the range of injury types was wider, affecting also more skeletal areas than in previous periods, especially in males. This may suggest that males were engaged in a greater variety of activities than females from the same period. The character of traumatic lesions together with other skeletal markers (such as the occupational use of teeth, joint diseases, etc.) suggest that activities of females in all three periods were probably bound to the settlement area, whereas males were also engaged in activities outside the living areas.

6.3.6. Key findings from the perspective of current research

6.3.6.1. Late Neolithic period (Lengyel) – environmental crisis and the importance of women

Svodín population has certainly revealed several interesting facts in respect to the Late Neolithic period of Central Europe. Above all, the results are consistent with the hypothesis suggesting environmental and probably also a social crisis at the end of the Neolithic. The instability of the environment is indicated by the bad health status of the Svodín population (indicated by, for example, low stature, long-lasting stress indicated by dental enamel hypoplasia, high frequency of non-specific stress indicators, or high occurrence of possible scurvy cases), extraordinary position of mature males, and grave inventories of these men (equipped with boar tusks and weapons) suggesting increased role of hunting and those who were able to provide a solution for the food shortage. Robertshaw *et al.* (2004) analysed repeated episodes of climatic changes in pre-modern Uganda and found out that they were also accompanied with political changes, whereas the power went to those who were able to provide food security. In the case of Central Europe, these seem to have been hunters. Not only in Svodín there is an evidence for the existence of elite groups (represented by mature men equipped with boar tusks), similar finds can be found across the region. Large cemeteries from the period such as Aszód, Zengövárkony, Móragy (Hungary) also yielded extraordinarily rich graves of (predominantly mature) males with boar tusks and contemporary weapons (Dombay 1960; Kalicz 1985; Zalai-Gaál 2007; Demján 2010). When compared to health and stress indicators observed in the populations from the previous and following prehistoric periods, lower health status of the Late Neolithic populations was observed also by other researchers in the area (Hampl *et al.* 2004; Schneider and Norman 2004; Jarošová and Dočkalová 2008; Velandia *et al.* 2008; Köhler 2012), providing further evidence for increased environmental stress and related food shortage in the end of the Neolithic. In addition, as discussed in this thesis, traumatic lesions of male individuals from Svodín indicate active and a rather dangerous lifestyle similar to that of foragers and Rodeo athletes. Marks of physical overload and active lifestyle, indicated by enthesopathies of the heel bones and traumatic lesions, were also observed in individuals from Alsónyék (Köhler 2012). Environmental crisis in Late-Neolithic Central Europe has also been suggested by radiocarbon dates used as population-history proxies (Shennan and Edinborough 2007). Although slightly speculative, the results of Shennan and Edinborough (2007) indicate populational rise from *c.* 3500 BC, and archaeobotanical studies point to a re-increase of agriculture at that period in Switzerland (Schibler *et al.* 1997) and Germany (Kalis and Meurers-Balke 2005). Moreover, higher level of hunting in the periods of climatic deteriorations was indicated by Schibler and Jacomet (2010) in Switzerland. Like Pavúk and Karlovský (2004), the authors conclude that during the phases of food crises, wild animals were more intensively used as a food source (Schibler and Jacomet 2010). The Late Neolithic environmental and food crisis is thus suggested not only by archaeological and osteological data from the study region, but also by studies from west-central Europe. Another phenomenon suggested by data from Svodín is the practice of raids for brides. This is indicated by apparent prevalence of females in Late Neolithic sites, quite a low occurrence of violence, yet higher than in previous stage of the period, patterns of traumatic lesions, and individual health indicators (see discussion above). Ambushes and raids are quite common in primitive societies (for example, Otterbein 1989), and usually result only in a small number of killed (Lovejoy and Heiple 1981; Keeley 1996). The types of injuries and the age pattern observed in the remains from the study region (especially the skulls) were similar than those recorded in the societies practising raids. The fact that mostly older females and younger males from the Moravian sites showed signs of perimortem trauma also fits the pattern observed in raids, as these groups can be expected to have been usually present in a settlement as, for example, in the late prehistoric population from Libben, Ohio (Lovejoy and Heiple 1981). Here, fractures were also most common among the young (fifteen to twenty-five year) adults and adults older than forty-five. The authors suggest that the young males were those included in direct conflict (for example, being left to defend the settlement), while the older individuals represent those who were unable to defend themselves, and were thus more prone to be killed. An under-representation of females in the Austrian Schletz-Asparn population recorded by Windl (1999: 43) was also suggested to indicate that women may have been taken alive as captives. Moreover, migration of Neolithic females in Central Europe has been suggested by isotope analyses (for example, Bentley *et al.* 2002) and the majority of the Lengyel sites are typical for female predominance (for example, Zoffmann 1998-1999; Köhler 2004; 2012). Nevertheless, more research into this topic would be needed, as no investigation into this field in prehistoric Central Europe has been made until these days.

6.3.6.2. Bell Beaker Culture – migrations and origins

Although the Bell Beaker phenomenon has long been discussed by researchers from the whole continent, it still represents a hotly-debated topic, especially when it comes to the origins and the spread of the culture and the lifestyle of the population. Brachycephalism of studied Bohemian Bell Beaker individuals as well as Moravian collection studied by Drozdová (2011) seems to support the migration hypothesis and the foreignness of the Bell Beaker folk in Central Europe. Recent DNA studies also support a theory of mobility of Bell Beaker people in contitental Europe (Allentoft *et al.* 2015; Haak *et al.* 2015; Hervella *et al.* 2015). Although specific homeland could not be evaluated for any of the Bell Beaker individuals studied by Price *et al.* (2004)[77], all of the 63% of individuals whose isotope values suggested immigration were suggested to have come to the region from the outside of the Danube valley. As regards the mobility as such, several earlier researches indicated migrations of small groups or individuals during the late Chalcolithic period (Grupe *et al.*1997; 1999; 2001; Price *et al.*1994; 1998; 2004), which seems to be consistent with the findings of the presented research. Moreover, the 'migrants' of all age categories were recorded by Price *et al.* (2004), and so the authors suggest that it was probably families that were migrating. This theory is consistent with the hypothesis of small groups or individuals migrating into the region, especially via a major communication corridor such as Danube river (Turek 2006). As suggested by a large number of horse bones at Hungarian sites[78] (Kalicz-Schreiber 1976; Endrödi 2003a; 2003b), horses may have been intentionally bred in this part of Europe, making travelling even easier (see also Peške 1986; Anthony 2007: 203-204). Vitamin D deficiency was highest in the studied Chalcolithic population, especially in females and children. As discussed elsewhere in the thesis, vitamin D is mostly acquired through sunlight. Clay cart models from the Chalcolithic indicate that carts were commonly used in this period (Točík 1970: 186, 189; Kruk-Milisaukas 1999: 166-170). If travelling long distances, women and children could have been travelling on covered wagons, thus receiving limited sunlight. Moreover, if coming to colder climate, wearing heavier clothing covering most of the body (especially in children) is also probable. The results of the present thesis also indicate that only the Chalcolithic sample comprised of nearly equal numbers of juveniles in almost all age categories (aged one to seventeen). In addition, the majority of adult individuals were in their prime age (25-35). Although such a demographic composition may be sample-biased, it may as well indicate that it was groups/families with children which migrated into the region, with just a small number of children being born in the destined region. Similar numbers of juveniles in all age categories as well as the low proportion of young adults were also detected in Hoštice, whereas the whole assemblage from the site was osteologically evaluated. Owing to a high proportion of cremations, data from Hungary do not provide much information about the demography either. However, as indicated by burial grounds where the majority

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[77] including individuals from Germany, Austria, Czech Republic, and Hungary

[78] the proportion of horse bones at the settlement of Hollandi utca was 36% of all animal bones

of buried remains were juveniles or young adults (Moucha 1966; Hájek 1968; Černý 2000; Skružný *et al.* 2000), children may have been buried in separate burial grounds, what would skew the overall demographic image. Alternatively, it is also possible that only a part of burial ground including a group of juveniles had been excavated, like at Brandýsek, Bohemia (Kytlicová 1960). Even though the presented results seem to support the hypothesis of migrating Bell Beaker families or small groups, in order to prove the theory of family/close-group migrations into the region, detailed chemical analyses including DNA or isotope data from the region would be vital.

Cranial indices of males in both the studied and Drozdová's samples were higher than those of females, possibly suggesting mixing with local populations. However, these were no considerable differences, and so the number of mixed unions was probably limited. This is in contrast with several marriage models working with a theory that Bell Beaker individuals married out of their group and thus contributed to the spread of the culture (Brodie 1994; 2001; Needham 2005; 2007; Vander Linden 2006; 2007). The research by Pearson *et al.* (2016), focusing on migration and movement of the Beaker people in Britain, indicated only small migration differences between male and female individuals of this population, also suggesting living in closed communities, whereas these results were derived from osteological as well as isotope analyses.

As to the place of the origin of local Bell Beaker groups, the question remains open. A basic six-region division of Bell Beakers exists in Europe, Bohemian and Moravian finds belonging to the eastern group further comprising of Hungary, Lower Austria, Little Poland, Bavaria and south-eastern Germany (Turek 2008). However, such a division seems to be functional rather than corresponding with actual cultural data. Differences between Bohemian and Moravian Bell Beakers are quite apparent, key differences include burial rite, demography, settlement structures, pottery production, and the use of copper. Only small cemeteries (counting about ten to twenty graves) were discovered in Bohemia, similarly to the finds from eastern Germany (Saale basin) where the concentration of the Bell Beaker sites is rather high, but they comprise almost exclusively of single burials or small cemeteries (see Turek 2006). On the contrary, Moravian sites bear more similarities with (especially) Hungarian sites, whereas the burials often count more than a hundred graves[79]. Furthermore, cremations are more frequent in the eastern and south-eastern part of the area occupied by the Bell Beaker culture. In comparison to a high proportion of cremations in Moravia and Hungary (20% and 60-75% respectively), Bohemian and east-German sites yielded at most 8% of such burials (Turek 2006). Similarities between Bohemian and western Bell Beaker groups, and Moravian and south-eastern region are also visible in settlement structures. Endrödi (1998; 2003) describes several large pole houses from the Bell Beaker period (Csepel group), while only surface structures were uncovered in Bohemia and no clear settlement features were excavated in Eastern Germany (Behrens 1976; Hille 2003). Two different influences manifest also in pottery shapes and decorations (Neustupný 1976b; Turek 2006). Moreover, in Moravia, copper metallurgy is suggested by several finds of casting moulds, while no such finds have been discovered in the western part of the region (Hájek 1966; Kuna and Matoušek 1978; Šumberová 1992; Turek 2006). All the above-mentioned features indicate that Bohemian Bell Beaker groups were affected by the region north-west of Bohemia while Moravia bears more similarities with the Bell Beakers from the Carpathian Basin. All these suggest that there was no single path via which the Bell Beaker package spread throughout the continent, be the disseminators single individuals or small groups. The hypothesis of two different waves of migrants seems to be supported also by different sex ratios in eastern and western groups. While the ratio of male and female individuals in Moravia is close to one, the ratio in Bohemian and the eastern German cemeteries is clearly in favour of males (see Turek 2002a: 225-229). Even though such a proportion of sexes may be caused by different burial rite for males and (some) females (for discussion see Turek 2002a), higher number of male individuals and more frequent and more severe violent encounters suggested by osteological record (also by the present study) can also indicate that the western Bell Beaker "branch" was more violent than that under the southern influence. Owing to the little indicated violence and different "business" strategies in the east-south (breeding horses, copper metallurgy), the area may have been focused on barter rather than expansion. In their study of mitochondrial haplogroup H genomes and European genetics, Brotherton *et al.* (2013) discovered striking genetic affinities between the Bell Beakers from Germany and current Iberians, suggesting migration into the region from that part of Europe. On the contrary, the direction in which the eastern

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[79] Hoštice – more than a hundred graves (Drozdová 2011); Békásmegyer with more than a hundred graves (Kalicz-Schreiber 1998/2000; Endrödi 2013); Budakalász with more than a thousand graves (Czene 2008; 2011; Endrödi 2013)

Bell Beakers moved into the study region is unclear. Together with the physical environment of Central Europe, the differences between the eastern oikumene and the north-west of Central Europe can possibly be explained by two migrating groups – western, coming from the north-west Europe via Elbe River to the Elbe Lowlands, and eastern group spreading in north-western direction from the south-east. Alternatively, two different waves of migrants from the west may have existed[80] - one from the north-west heading to the Elbe Lowlands, second one proceeding along Danube, settling down either in the Moravian Lowland or continuing further to the east, whereas the intentions of these two fractions may have been different (for example, searching for a new land, prospecting, trade, etc.). Depending on their aims, the size and "composition" of migrating groups may have differed, so could their "openness" to local customs. For example, Mikołajczak and Szczodrowski (2012) point out that a tradition in cremations in Hungarian region was so strong that it resisted the new tradition presented by the Bell Beakers. This would correspond with a theory of lower level of migrations in the eastern area, whereas small groups or individuals would probably not be able to affect habits and traditions of indigenous populations into a great extent. Eastwards direction of Bell Beaker diffusion is suggested by the material culture, especially the bow-shaped pendants. These items were only rarely discovered in the early phase of the Hungarian Csepel group and are presumed to have spread to the area through contacts with Czech/Moravian region (Metzinger-Schmitz 2004; Endrödi 2011). But to shed more light into the original homeland of the eastern group, more research would be needed.

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[80] chemical analyses indicate that the Bell Beakers spread from the south-west (for example, Brotherton *et al.* 2013)

Chapter 7:

CONCLUSIONS

This thesis presents a rare comparative study of populations occupying modern-day Slovakia, Moravia, and Bohemia from the Neolithic to the Early Bronze Age. Overall, the thesis covers the time range from about 4800 to 1700/1600 cal BC. Two hundred and eighty-eight skeletons were analysed, 152 were adults and 136 subadults. The Neolithic material consists of the Late Neolithic skeletal remains from Svodín, Slovakia, the site representing one of the very few well-preserved Late Neolithic skeletal collections from the region. The Chalcolithic collection comprises Bell Beaker skeletal material from a number of Moravian and Bohemian sites such as Hulín, Brandýsek, Kněževes, Lochenice and Mochov. Human remains from Nižná Myšľa, Slovakia, comprise the greater part of the Early Bronze Age collection, whereas additional material from Bohemian sites such as Praha – Malá Ohrada was also examined. By examining skeletal indicators of health and lifestyle, this thesis provides a significant contribution to bioarchaeological research in the study region. It also introduces new insights into a series of important sites where no osteological evaluation of skeletal remains was previously undertaken, such as Svodín and Nižná Myšľa. Demographic, pathological and metric data were recorded, evaluated, and compared with previously published data from contemporaneous populations, in order to create a more comprehensive representation of the populations in the area. Aiming to shed light on health and lifestyle of prehistoric populations in Slovakia, Moravia and Bohemia, the following topics were examined:

- Differences in health between the periods as a result of different subsistence strategies and living conditions
- Gender, age and social differentiation as reflected in skeletal remains
- Incidence and nature of violence in different periods
- The alleged foreign origin of Chalcolithic Bell Beaker population

The analysed skeletal material yielded a considerable amount of data. Interpretations of the osteological findings have been suggested in this thesis but, owing to the general ambiguity of the osteological data, some questions remain open.

7.1. Key findings

Several differences between the Neolithic and following periods have been suggested, mostly regarding health status. Greater dietary and environmental stress characterised the Neolithic, as suggested, for example, by the higher mortality of younger individuals (especially of females and subadults), or a *c.* 5 cm reduction in average stature when compared to the Chalcolithic and EBA populations. The increased frequency of non-specific health indicators such as dental enamel hypoplasia, *cribra orbitalia* and cranial vault porosity also point to poorer conditions in the Neolithic. The periods of stress indicated by dental hypoplasia are greatest in the Neolithic population, suggesting that Neolithic children had difficulty in adapting after weaning, either because of a lack of proper nutrition, or generally worse living and/or sanitary conditions resulting in loss of nutrients from infections or gastrointestinal problems. Moreover, as suggested by Walker *et al.* (2009) reappraising the aetiology of *cribra orbitalia* and vault porosity, the two conditions may also have been caused by lack of vitamin B12. In females, inadequate nutrition can be even more pronounced owing to pregnancies and hormonal changes, whereas the higher mortality of young females and infants in the Neolithic can be also connected to post-partum haemorrhage, infection, or labour obstruction (WHO 2015). The Neolithic is also the only period where females were more numerous than males, a trend observed also in neighbouring countries. Even though burials may not reflect the true demographic composition of archaeological societies, poorer nutrition evident at the end of the Neolithic could have also resulted in the death of male foetuses owing to maternal malnutrition as suggested by a number of studies (Andersson and Bergström 1998; Song 2012). In addition, the lower sex ratio may also be the result of the increased migration of young females in the period, which has been suggested by stable isotope analyses especially for the Neolithic (Bentley *et al.* 2002). Even though the health status of young Late Neolithic females was poor in comparison to those of older age, suggesting their lower social position, archaeological record does not agree with such a conclusion. Together with apparent prevalence of females in Late Neolithic sites, a low occurrence of violence, yet higher than in previous stage of the period, and patterns of traumatic lesions, a hypothesis of women being captured during the raids for brides has been proposed for the Late Neolithic period.

Poor health status, lower stature, and increased violence[81] indicated for Svodín as well as other Lengyel populations from the region strongly agree with the theory of the existence of environmental crisis in the end of Central-European Neolithic, as suggested by archaeological and proxy data. Increased dietary and environmental stress may have been related to climatic fluctuations and nutritional shortage. Food crisis was also indicated by the important role of hunters, as suggested by the rich burials of mature men buried with boar tusks and hunting equipment. Traumatic lesions observed on mature males (aged thirty-six to fifty years) were distributed in virtually all skeletal areas, fractures of skull, vertebrae, ribs, and fibulae being especially frequent. Moreover, the higher prevalence of head and neck trauma resemble injuries of Rodeo athletes who, like prehistoric hunters, are in close contact with agitated animals (Berger and Trinkaus 1995). Although there is no evidence in the later prehistory of Central Europe for horse riding linked to hunting, the use of Neolithic weapons (most probably spears or battle axes) places Neolithic hunters into a close proximity to aggravated animals, increasing the potential of injury. Fractures indicating accidental falls and other fractures caused by high energy/velocity are suggestive of an active and demanding lifestyle resembling that of foragers; stress fractures of the lower extremities frequently occur in long-distance running and jumping (Waldron 2009), which may also be implied. As indicated also by their burial equipment (comprising boar tusks, axes, blades, etc.), the men could have been hunters and their social status may have been acquired by their ability to actively contribute to solving the food shortage. Based on the concentration of such individuals in Svodín, the site could have been a location of contemporary elites.The presence of traumatic lesions suggests that males were more physically active than females in all three periods, including involvement in violent encounters. Evidence of violence was recorded in all three periods, but the intensity and brutality of the assaults appears to increase in the Chalcolithic, and even more so in the EBA. This is mostly indicated by traumatic lesions observed on skulls, including sharp-force injuries. EBA males often exhibit multiple wounds with different stages of healing, suggesting they were exposed to repeated violence and/or a demanding lifestyle. Skull fractures in males are also clearly greater in comparison to females whose traumatic injuries were located elsewhere in the skeleton (mostly in the clavicles and ribs). The frequency of violent trauma tends to be higher in the western part of the study region, especially in the EBA. In Bohemia, the injured were almost exclusively males, and almost all males bore

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[81] also when compared to the Early Neolithic period

traces of violent trauma. Moreover, in Praha – Malá Ohrada the sex ratio at the site was clearly in favour of males, suggesting that the site may have been the base of a raiding or military group. This may therefore point to the existence of specialised organised groups of warriors/raiders in the EBA.

That males and females had different lifestyles is suggested for all three periods studied. Variations in the abrasiveness of the diet and/or occupational wear on the teeth may indicate differences in the lifestyles of males and females. Dietary abrasion is usually present on the posterior teeth and activity-related tooth wear is usually seen on the anterior dentition (Irish and Turner 1989; Fox and Frayer 1997; for discussion see also Larsen 1997: 247-262). Abscesses and AMTL were common in the anterior teeth of Neolithic females and the prevalence of abscesses and AMTL in the posterior teeth in males from the same period imply that these were more probably diet- or hygiene-related, while females may have had a more abrasive diet and also used their teeth more intensively as tools. Dodds *et al.* (2005) point to the possibility of frequent snacking by females during food preparation, an activity performed within a settlement. These activities are consistent with the finding that more Neolithic females than males showed the signs of osteoarthritis at the temporo-mandibular joint. In the two later periods more males than females used their teeth as tools. In addition, the dental health of males was generally worse than that of females, including the anterior teeth. This may suggest that Chalcolithic and EBA males used their teeth in strenuous habitual activities (such as chewing sinew for bow strings, plant fibres for cordage, etc.) (Larsen 1997: 259). A higher frequency of osteoarthritis of the temporo-mandibular joint among males in the Chalcolithic is consistent with this interpretation. Archaeological finds of arrowheads from these periods point to a similar conclusion. Osteoarthritis of the lower limbs was also more common in Chalcolithic and EBA males than females. Such degeneration is often associated with intensive activities such as walking, running, and riding (Larsen 1982; Rossignol *et al.* 2005). In both periods, the knees of females were affected to a greater extent than those of males. Knee osteoarthritis is common in occupations that include kneeling and squatting, which cause constant pressure on the joint (for example, Rossignol *et al.* 2005). The most marked difference between the lifestyles of males and females is indicated in the EBA. Both accidental and intentional traumas prevail in males, while only a small proportion of females exhibit traumatic lesions. This points to a much more intense and demanding lifestyle for male individuals, probably related to their occupations. Moreover, almost all joints are affected in males, especially those of the shoulder and the upper body in general, whereas in females the temporo-mandibular joint is the most commonly affected, followed by elbows and knees. Given that the degenerative changes appear to have been occupational rather than biological, the different roles of males and females in the period are demonstrated.

In spite of certain differences in lifestyle implied for Chalcolithic males and females, the Chalcolithic population show the least differences between males and females in almost all pathologies, implying that the Bell Beaker population possibly lived in communities with limited contact with other communities. This finding is consistent with published data suggesting that the Bell Beaker individuals of both sexes and all ages (possibly families) migrated into the region. The still hotly-debated topic of the foreign origin of the Chalcolithic Bell Beaker population in Central Europe has also been touched upon in this study. As expected, the Chalcolithic population shows variation in cranial shape when compared to Neolithic and EBA individuals. The cranial index of the Bell Beaker population shows that their crania were considerably shorter than those of the other two populations. Both the Neolithic and the EBA populations were primarily dolichocephalic (long-headed), whereas Chalcolithic individuals of the Bell Beaker culture were mostly brachycephalic (short headed). This finding therefore also suggests that the Bell Beaker population preferred living among their own cultural group rather than mixing with local populations. Differences between Bohemian and Moravian groups need to be mentioned, suggesting that there were two waves of migrants coming to the east of Central-European region.

Poorer health status was recorded for EBA children, almost exclusively those from Nižná Myšľa. About 50% of all Nižná Myšľa individuals, both adults and subadults were affected by dental enamel hypoplasia[82]. These enamel defects are most commonly related to a metabolic disturbance – dietary or disease stress – during the formation of the tooth, i.e., childhood. This means that in every generation there was quite a high proportion of individuals with much higher dietary and/or disease stress, possibly reflecting social differences between the members of the community. However, more research in this area would be needed to confirm such a conclusion.

The higher prevalence rates of caries, as well as non-specific health indicators such as enamel hypoplasia, *cribra orbitalia*, and non-specific periostitis in the prehistoric populations

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[82] the CPR in the Neolithic is 27.6%, in the Chalcolithic 37.3%

in the area of modern-day Slovakia, especially in the EBA, suggest that local factors may have played an important role, although further systematic research would be needed to test this conclusion.

7.2. Limitations of the research

This thesis presents the first detailed comparative study of the general health and lifestyle of populations occupying the study region from the Neolithic to the Early Bronze Age. The conclusions of the research were affected by limitations generally common to the field of bioarchaeology, including variability in the preservation of skeletal remains, the invisibility of many diseases, or issues related to the ‘osteological paradox’ (Ortner 2012; Wood *et al.* 1992). Although preservation of the majority of the remains was good, many skeletons, especially those from older excavations, were incomplete, probably because they had been badly curated. This is especially true in the case of the remains from Nižná Myšľa which were stored an open-air depository in paper bags and boxes, easily accessible to small animals, and so the bones were often comingled and could not be always associated with the individual they belonged to. In addition, some bones, especially skulls, had undergone post-excavation treatment using glue and consolidants, predominantly in the Bohemian skeletons. Often, skeletal elements did not always match field records and in some cases were missing. The preservation and curation of Svodín material were generally good, although the material was often covered by a thin layer of sinter, complicating the evaluation, and while sex and age-at-death indicators were mostly unaffected, the visibility of pathological lesions may have been negatively affected. Owing to the above-mentioned restrictions, the overall picture may be skewed to some extent. Apart from preservation and curation-related problems, many burials have no ^{14}C dates and were dated purely on the basis of the grave inventory and relative chronology. This is especially true in the case of single burials, i.e., those from the Bohemian sites. In fact, only two out of first three hundred graves from Nižná Myšľa were dating using ^{14}C analysis, both dated to 1866 ± 61 cal BC.

The sizes of the studied assemblages from the Neolithic and the Chalcolithic were not sufficient for general conclusions to be made. Moreover, not all the remains coming from single sites (Svodín, Nižná Myšľa) could be used in this study, either due to the incompleteness of the remains, poor post-excavation storage, or because the remains were not available for examination at the time. From one hundred and six graves dated to the Lengyel period only sixty-two were used, and from the first three hundred graves from Nižná Myšľa only ninety-seven individuals could be analysed. As a result, the selection process may have resulted in an inaccurate demographic composition or a skewed distribution of sex-related pathologies. As regards pathologies, in spite of numerous healed fractures observed on the skeletal material, not all could be fully evaluated, mostly because in healed traumas the type of fracture is difficult to distinguish macroscopically, and thus the cause of the injury is more difficult to determine. Both the absolute dating and ambiguity of skeletal pathologies could have been partially alleviated by chemical or radiographic analyses, but these are too expensive, time demanding and destructive, and so they could not be performed.

As regards the comparison with other samples from the region, some data were not specified for comparative collections, for example, prevalence rates for periodontal disease, peaks of occurrence of dental hypoplasia, prevalence rates by affected tooth, or osteopenia/osteoporosis. The lack of bioarchaeological research in the study area represents another problem. Owing to the dearth of sufficiently preserved and documented Neolithic remains and the emphasis placed on the LBK population in previous research, other Neolithic cultures from the study area remain poorly characterized bioarchaeologically (including those from the Lengyel culture). Like the Neolithic LBK population, the Bell Beaker culture dominates research in the Chalcolithic of the study region. However, with Moravia being considered the easternmost boundary of this culture, the results may not be fully applicable to the Slovak Chalcolithic populations. The main problem of osteoarchaeological research on EBA samples is that the skeletal material has not been evaluated, or was studied more than a half a century ago, or is described in several unpublished dissertations of varying quality. Moreover, different methodologies, such as the definition of age categories, have been used for comparative collections.

7.3. Significance of the study and recommendations for the future

Interpreting the results of osteological analyses within their historical and archaeological contexts has partially alleviated some of the aforementioned limitations. As a result, a more detailed picture of the health and lifestyle of the Neolithic, Chalcolithic and Early Bronze Age populations of the region has been obtained. The thesis sheds more light on the lifestyle of the (previously unevaluated) Lengyel population of Svodín and also the EBA Otomani population of Nižná Myšľa, although evaluation of the rest of the assemblages would be useful. The present work represents a preliminary study with significant potential for further research. Moreover, comparison of palaeopathological data, which are not usually recorded by local authors, revealed research topics worth pursuing in the future, such as the inferior health status of prehistoric populations of present-day Slovakia.

Slovakia, Moravia and Bohemia are very rich in archaeological finds, including human remains. Despite that, our knowledge of certain populations (including the Lengyel culture) is fragmentary, mostly because the material remains unprocessed or unpublished. This thesis has revealed the potential of skeletal remains from the region and the application of an osteoarchaeological approach. However, in order to exploit the full potential of (the studied) remains further research is vital. The first crucial step would be to obtain high-precision, single-entity ^{14}C dates for representative series of human remains, especially those coming from large, homogenous sites such as Svodín and Nižná Myšľa. The remains from Nižná Myšľa in particular call for ^{14}C dating, owing to the enormous size of the necropolis, amounting to about eight hundred graves.

In order to get as accurate a demographic composition as possible, evaluation of the rest of the remains from the above-mentioned sites would be beneficial. In addition, such analyses might provide more information on social differentiation, as individuals of lower status may have been buried in shallow graves[83] and thus been exposed to more postdepositional damage.

The findings of this thesis support the theory of climatic deterioration at the end of the Neolithic, the archaeological record suggesting increased consumption of meat at Svodín. However, macroscopic analysis of skeletal and dental remains is insufficient for estimating diet in past populations and additional methods should be used. These include, among others, dental microwear and microabrasion analyses, and stable carbon and nitrogen isotope analyses. Differences in food consumption patterns might be revealed, shedding more light on social stratification at the site. At Svodín, strontium stable isotope analysis could also bring interesting results, especially regarding the mobility of females.

As evidenced by DNA analyses performed at the Hoštice sample (Drozdová 2011), subadult individuals were not always buried following the burial rite specific for their biological sex, suggesting that factors other than individual's sex were also important. In subadults, the evaluation of sex cannot accurately be determined osteologically and DNA analysis of subadult remains would yield valuable data that could contribute to our better understanding

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[83] this is indicated in Nižná Myšľa

of the past societies. DNA analysis of juvenile remains would be especially beneficial at Nižná Myšľa where a specific burial rite appears to have been applied to subadults. Given that, osteologically, juvenile remains have attracted rather little attention in the studied region, obtaining such data could be especially revealing.

The potential of DNA analysis also rests on its ability to determine family relations. The results of the present thesis imply that the Chalcolithic Bell Beaker population lived in rather ethnicly-closed communities. However, osteological examination is an inadequate method for revealing family ties. Therefore, DNA analysis of the remains from larger sites such as Hulín, Kněževes, Brandýsek, Lochenice or Mochov could be of interest. As regards the Bell Beaker population, the findings of the present study suggest that despite having generally shorter crania than preceding and later populations, male cranial vaults were shorter than those of females. Revealing family ties, using DNA analysis, or migrations using the stable isotopes of strontium could contribute to the ongoing discussion of the origin of the Bell Beaker population.

On the subject of pathologies and their accurate assessment, the research could benefit from radiographing some of the healed fractures. In the case of implied systemic conditions, such as Paget's disease, multiple myeloma, or in the case of conditions suggested by severe periosteal lesions, only chemical analyses could reveal their aetiology.

In order to compare the existing results suggested in this study more accurately, re-evaluation of older remains from the geographical region is needed, preferably using modern international standards. This is especially the case with ageing techniques and pathology evaluations. Moreover, more pathological data could be obtained from more recently studied assemblages where information about, for example, prevalence rates of periodontal disease, peaks of occurrence of dental enamel hypoplasia, prevalence rates of dental pathologies by affected tooth, osteopenia/osteoporosis, is currently lacking. Ideally, bioarchaeological analyses of the remains belonging to the less well known archaeological cultures could be performed, thereby contributing to our understanding of the development in modern-day Slovakia, Moravia and Bohemia.

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APPENDIX 1

Supporting information for archaeological background

	NEOLITHIC	References	CHALCOLITHIC	References	EBA	References
Settlement location	in the vicinity of water sources, often at the confluence of streams	Točík 1970; Podborský 1993; Pavlů and Zápotocká 2007	near rivers; in undulated terrain	Točík 1970; Neustupný 2008b	near water sources; in lowlands and land elevations	Podborský 1993; Jiráň 2006; 2008
Type of settlement	mostly open and non-fortified	Točík 1970; Podborský 1993; Čižmář *et al.* 2004; Čižmář 2008b	open settlements		open settlements	Jiráň 2008
	caves	Lichardus 1968; Točík 1970; Šiška 1995	caves (especially Slovakia)	Točík 1970; Horváthová and Soják 2012		
			fortified hilltop settlements	Točík 1970; Podborský 1993; Neustupný 2008b	fortified hilltop settlements	
Houses	long houses (about 5 metres wide and 10-40 metres long). Occupied by more family units	Točík 1970; Jelínek 2006; Čižmář 2008b; Dočkalová and Čižmář 2008b; Pavlů and Zápotocká 2007	scarce; on-surface built smaller houses (about 6-8 metres long and 4 metres wide) clustered more densely than in previous period	Točík 1970; Podborský 1993; Turek and Peška 2001; Neustupný 2008	vary	Stuchlík 2000; Pleinerová 2002; Jiráň 2008
	smaller houses (in the east)	Točík 1970; Šiška 1986; 1989; Bálek 2002; Kazdová 2008				
Other structures	loam pits at the houses (after exploited, used as waste or burial pits)	Pleiner and Rybová 1978; Podborský 1993; Jelínek 2006				
	ovens	Točík 1970; Pavlů 2000				
	wells	Rulf and Velímský 1993; Tichý 1998				
	roundels	Petrasch 1990; Podborský 1994; Němejcová-Pavúková 1995; Becker 1996; Pavúk and Karlovský 2004; Jelínek 2006; Pavlů and Zápotocká 2007	roundels	Sankot and Zápotocký 2011		

Table 47. Main settlement features of the Neolithic, Chalcolithic, and Early Bronze Age in the study region.

	NEOLITHIC	References	CHALCOLITHIC	References	EBA	References
Households	multiple family units in one house	Dočkalová and Čižmář 2008b	smaller familyunit within one house	Neustupný 1983; 2008; Podborský 1993; Šmíd 2008	probably smaller flatland settlements numbering a few families	Jiráň 2008
Crafts					advanced craft specialisation and labour division	Sládek *et al.* 2007; Sosna 2007
Long-distance contacts	exchange	Točik 1970; Todorová 2000; Hladilová 2002; Rosania *et al.* 2008; Zvelebil and Pettitt 2008	exchange		advanced exchange	Venclová 1990; Podborský 1993; Frána *et al.* 1997; Anthony 2007; Jiráň 2008
Society	roundels as social and meeting points	Podborský 1988; Jelínek 2006; Pavlů and Zápotocká 2007				
	structured society	Podborský 1994; Pavlů and Zápotocká 2007	probable gender differentiation	Neustupný 1967; Turek and Daněček 2000; Sosna 2007	probable gender differentiation	Sládek *et al.* 2007
Knowledge	roundels as structures related to astronomy and geometry	Podborský 2001; Pavúk and Karlovský 2004			spread of knowledge, technologies and/or discoveries	Jiráň 2008
	medicine	Crubézy *et al.* 2001				
Beliefs	closely connected with nature and agriculture	Točík 1970; Pavlů 2004; Podborský and Čižmář 2008	closely connected with nature and agriculture	Neustupný 2008	closely connected with nature and agriculture	Podborský 1994; Harding 2000; Harding *et al.* 2007
	offerings and sacrifices (animals, items)	Farkaš 2002; Podborský 2004	offerings (hoards of items or materials)	Podborský 1993; Neustupný 2008	offerings (hoards of items or materials) and/or sacrifices (possibly also human)	Demeterová 1988; Podborský 1993; 1994; Jiráň 2008
	belief in afterlife, that soul is separated from the body	Campbell 1995; Fuller and Grandjean 2001	belief in afterlife, separation of the worlds of the living and the dead - extramural cemeteries	Podborský 2006b		
Cult	possibly a cult of a "great mother" - signs of theism	Podborský 1993; 1994			signs of polytheism	Podborský 1994
					existence of special cult-related places	Podborský 1994
Violence			more frequent violent encounters	Harding 2000; Kristiansen and Larsson 2005; Turek 2007	more frequent violent encounters	Harding 2000; Kristiansen and Larsson 2005; Turek 2007

Table 48. Main social features of the Neolithic, Chalcolithic, and Early Bronze Age in the study region.

Table 49. Burial rites in individual phases of the Neolithic by region (based on Točík 1970; Podborský 1993; Pavlů and Zápotocká 2007; Bistáková and Pažinová 2010).

		Slovakia (W)	Slovakia (E)	Moravia	Bohemia
Type of burial (inhumation or cremation)	**Early Neolithic**	Mostly inhumation	Mostly inhumation	Mostly inhumation	Mostly inhumation
	Middle Neolithic			Cremation and inhumation (more inhumation)	Cremation and inhumation
	Late Neolithic				
Location	**Early Neolithic**	*Single graves within settlements *Burial grounds	*Single graves within settlements	*Single graves within settlements *Burial grounds	*Single graves within settlements
	Middle Neolithic	*Single graves within settlements	*Single graves within settlements or caves	*Single or mass graves within settlements	*Single or mass graves within settlements *Burial grounds
	Late Neolithic	*Single or mass graves within settlements *Burial grounds	*Single graves within settlements		
Burial position		*Flexed position *On the left side mostly *Unconventional interments with bodies in bizarre positions			
		Late Neolithic also on the right side	-	-	-
Grave inventory		Pottery Chipped stone items Polished stone items Grain grinders Spondylus shell jewellery Later also animal bones			
		*Later also small copper items *Ochre or red pigment	*Later also small copper items *Figural sculpture	Ochre or red pigment	White marble bracelets
Amount of grave goods		-	-	*Rather rich graves *Female graves with less items	*Poorly equipped graves *No differences between the graves of males and females
Burial grounds examples	**Early Neolithic**	Nitra Veľký Grob	-	Vedrovice Kralice na Hané	-
	Middle Neolithic	-	Zemplínske Kopčany	Těšetice-Kyjovice	Praha-Bubeneč Plotiště nad Labem
	Late Neolithic	Svodín Výčapy - Opatovce	Oborín	-	

Table 50. Burial rites in individual phases of the Chalcolithic by region (based on Točík 1970; Podborský 1993; Neustupný 2008; Šmíd 2008).

		Slovakia (W)	Slovakia (E)	Moravia	Bohemia
Type of burial (inhumation or cremation)	**Proto&Early Chalcolithic**	Mostly inhumation	Cremation and inhumation	*Cremation and inhumation *Symbolic	Mostly inhumation
	Middle Chalcolithic	Lack of material (but possibly more inhumation)	Lack of material (but possibly both cremation and inhumation)	Lack of material (but possibly both cremation and inhumation)	Cremation and inhumation
	Late Chalcolithic	Lack of material (but possibly both cremation and inhumation)	Lack of material	Lack of material	Inhumation
	Post Chalcolithic	Lack of material	Cremation and inhumation	Cremation and inhumation, but stronger preference of inhumation (esp. Bell Beakers)	
Type of graves	**Proto&Early Chalcolithic**	*Single interments within settlements *Smaller groups of graves	*Single interments within settlements *Separated cemeteries with graves in rows	*Single interments within settlements *Mounds (graves with stone lining)	*Single interments *Long mounds *Smaller groups of graves *Grave inside mound trench *Graves with stone lining/cists *Ritual or casual
	Middle Chalcolithic	*Single interments within settlements *Also multiple individuals in graves	Single interments within settlements	Lack of material (but a mound and a single grave found)	*Single graves *Graves with stone lining *Mounds *Burial grounds
	Late Chalcolithic	*Single graves *Cremated bones in urn or separately	Lack of material	Lack of material	*Burial grounds *Mounds *Flat graves *Single interments
	Post Chalcolithic	Lack of material	Low mounds on long cemeteries placed in higher altitudes	*Single graves on cemeteries *Mounds	
Burial position	**Proto&Early Chalcolithic**	* flexed position * no gender differene	*males on R side, *females on L side, head to the east	* flexed or stretched position * R side, head to the north-west	* flexed position * on L or R side (no gender difference)
	Middle to Post-Chalcolithic	* flexed position * usually males on R side, females on L side, head to the east	* flexed position * on side, head to the NW	* flexed position * males on R side, females on L side, torso on back (CW) * males on L side, head to the north, females on R side, head to the S (BB)	* flexed position * on back or on side * males on R side, females on L side, torso on back (CW) * males on L side, head to the north, females on R side, head to the S (BB)
Grave goods		Pottery Stone tools Jewellery (e.g. earrings, necklaces, beads) Animal bones Copper goods			
			Early Chalcolithic: *Numerous copper and golden items *Clay pearls	*Arrowheads and wrist guards, daggers (BB male graves) *V-shaped buttons and amber beads (BB female graves)	

Grave inventory		No difference between male and female graves	*Male graves richer than others *Post-Chalcolithic: Poorly equipped graves, but no differentiation	Higher ranked individuals - rich graves	*Poorly equipped *Mounds mostly for male individuals *Also graves without goods *Social differentiation *Gender and age differentiation
Burial Sites	**Proto-Chalcolithic**	Branč Jelšovce Výčapy-Opatovce	Tibava Veľké Raškovce Barca	Němčice na Hané Olomouc	Třebestovice Velká Ves Plotiště Praha-Bubeneč Velké Žernoseky Makotřasy
	Early Chalcolithic			Kosíř u Slatinek Křemela I and II	
	Middle Chalcolithic	Bajč Šarovce Nitriansky Hrádok – Zámeček	Včelince Seňa	Ohrozim - Horka Hlinsko	Běchovice Úholičky Tuchoměřice
	Late Chalcolithic	Čaka Šaľa Ivanka pri Dunaji	Lack of material	-	Vikletice Toužetín Mochov Brandýsek Kněževes
	Post Chalcolithic	Sládkovičovo (BB) Trenčin (CW)	Giraltovce Radoma Kožany Budimír	Velešovice Holubice Dřevohostice Letonice Šlapanice Brno-Holásky	

(Table 50 continued).

Table 51. Burial rites in individual phases of the EBA by region (based on Točík 1970; Furmánek *et al*. 1991; Podborský 1993; Olexa 2003; Jiráň 2008).

		Slovakia (W)	Slovakia (E)	Moravia	Bohemia
Type of burial (inhumation or cremation)	**Early Bronze Age**	Mostly inhumation	Mostly inhumation	Mostly inhumation	Mostly inhumation, locally both
Type of graves	**Early Bronze Age**	*Single graves *Graves with wooden lining, ochre dye, or lime	*Single graves, groups of graves *Graves with wooden and other organic lining or 'coffins'	*Single graves, groups of graves *Frequent use of 'baumsarg' coffin *Sometimes graves lined with stone	*Single graves, groups of graves *Frequent use of 'baumsarg' coffin or lined with stone *Mounds
Burial position		Flexed position Males on R side with head to the W, females on L side, head to the E.	Flexed position, face to the east, males on R side, females on L side.	*Únětice Culture: Flexed position Head to the W, S, SW. *Nitra Culture: Flexed position Males on R side with head to the W, females on L side, head to the E.	Únětice Culture: Flexed position On R side N-S orientation Head to the S, facing E
Grave goods		Mainly pottery Tools Bone, amber or glass beads Small items/jewellery Pins			
Grave goods (continued)		*Lack of pottery in Nitra Culture graves *Nitra culture: willow-leaf-shaped jewellery, ochre colouration *Meat (animal bones) *Numeros copper and bronze industry	*Food and drinks *Headbands	Nitra culture: willow-leaf-shaped jewellery	*Weapons *Animal bones (also cremated) *Drinking sets
Amount of grave goods		*Differentiation according to status or wealth *Females with beads, males with more tusks and alike	Differentiation according to status or wealth	Differentiation according to status or wealth [of an individual or a clan]	Differentiation according to status or wealth [of an individual or a clan]
Burial Sites	**Early Bronze Age**	Jelšovce Branč Výčapy-Opatovce Chotín	Nižná Myšľa Streda nad Bodrogom	Rebešovice Holešov Velké Pavlovice Těšetice-Vinohrady Jiříkovice Oblekovice	Únětice Blšany Kněževes Vraný Polepy Červený Újezdec

Table 52. Formulae used for stature calculations (after Trotter 1970; Jantz 1992).

	Males	SE	**Females**	SE
Humerus	3.08*Hum+70.45	4.05	3.36*Hum+57.97	4.45
Radius	3.78*Rad+79.01	4.32	4.74*Rad+54.93	4.24
Ulna	3.70*Uln+74.05	4.32	4.27*Uln+57.76	4.3
Femur	2.38*Fem+61.41	3.27	2.47*Fem+54.74	3.72
Tibia	2.52*Tib+78.62	3.37	2.90*Tib+59.24	3.66
Fibula	2.68*Fib+71.78	3.29	2.93*Fib+59.61	3.57
MC1	1.659*MC1+91.77	5.52	1.659*MC1+90.02	5.52
MC2	1.261*MC2+85.51	5.15	1.261*MC2+82.52	5.15
MC3	1.279*MC3+85.98	5.36	1.279*MC3+83.44	5.36
MC4	1.375*MC4+89.54	5.33	1.375*MC4+86.44	5.33
MC5	1.443*MC5+93.16	5.67	1.443*MC5+89.95	5.67
MT1	15.2*MT1+76.8	6.32	16.3*MT1+65.6	4.96
MT2	11.3*MT2+86.8	7.01	12.8*MT2+71.2	5.2
MT3	12.0*MT3+86.2	6.89	13.3*MT3+73.2	5.76
MT4	12.3*MT4+86.3	6.85	13.8*MT4+71.9	5.75
MT5a[84]	12.8*MT5a+93.16	7.22	12.3*MT5a+90.0	6.63
MT5b[85]	11.2*MT5b+93.16	7.03	10.6*MT5b+90.5	6.49

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[84] the length measured from the head to the end of articular facet for 4th metatarsal
[85] full length

Table 53. The list of measured dimensions on skull in adults, and their database codes.

PART	MEASUREMENT	Database CODE
Cranial and facial part of the skull	Maximum cranial length	SK1
	Maximum cranial breadth	SK2
	Bizygomatic diameter	SK3
	Cranial height	SK4
	Cranial base length	SK5
	Basion-prosthion length	SK6
	Maxillo-alveolar breadth	SK7
	Maxillo-alveolar length	SK8
	Biauricular breadth	SK9
	Upper facial height	SK10
	Minimum frontal breadth	SK11
	Upper facial breadth	SK12
	Nasal height	SK13
	Nasal breadth	SK14
	Orbital breadth	SK15
	Orbital height	SK16
	Biorbital breadth	SK17
	Frontal chord	SK19
	Parietal chord	SK20
	Occipital chord	SK21
	Foramen magnum length	SK22
	Foramen magnum breadth	SK23
	Mastoid length	SK24
Mandible	Chin height	MA25
	Breadth of the mandible	MA27
	Bigonial width	MA28
	Bicondylar breadth	MA29
	Minimum ramus breadth	MA30
	Maximum ramus breadth	MA31
	Maximum ramus height	MA32
	Mandibular length	MA33

Table 54. The list of measured dimensions on postcranial skeleton in adults, and their database codes.

BONE	MEASUREMENT	Database CODE
Clavicle	Maximum length	PS35
Scapula	Height	PS38
	Breadth	PS39
	Length of glenoid cavity	PS95
	Length of posterior spine	PS96
	Infraspinal length	PS97
Humerus	Maximum length	PS40
	Epicondylar breadth	PS41
	Vertical diameter of head	PS42
	Maximum diameter	PS43
	Minimum circumference	PS44
Radius	Maximum length	PS45
	Head circumference	PS98
	Midshaft circumference	PS100
Ulna	Maximum length	PS48
	Antero-posterior diameter	PS49
	Medio-lateral diameter	PS50
	Minimum circumference	PS52
Sacrum	Anterior length	PS53
	Anterior superior breadth	PS54
	Max.transverse diameter of base	PS55
Os coxa	Height	PS56
	Iliac breadth	PS57
	Pubis length	PS58
	Ischium length	PS59
	Acetabulum diameter	PS99
Femur	Maximum length	PS60
	Epicondylar breadth	PS62
	Maximum head diameter	PS63
	Anterior-posterior subtrochanteric diameter	PS64
	Medial-lateral subtrochanteric diameter	PS65
	Anterior-posterior midshaft diameter	PS66
	Medial-lateral midshaft diameter	PS67
	Midshaft circumference	PS68
Tibia	Maximum length	PS69
	Maximum proximal epiphyseal breadth	PS70
	Maximum distal epiphyseal breadth	PS71
	Maximum diameter at nutrient foramen	PS72
	Medial-lateral diameter at nutrient foramen	PS73
	Circumference at nutrient foramen	PS74
Fibula	Maximum length	PS75
Calcaneus	Maximum length	PS77
	Middle breadth	PS78
	Height	PS79
Talus	Maximum length	PS80
	Middle breadth	PS81

	Height	PS82
Metacarpals	Length of 1st MC	PS83
	Length of 2nd MC	PS84
	Length of 3rd MC	PS85
	Length of 4th MC	PS86
	Length of 5th MC	PS87
Metatarsals	Length of 1st MT	PS88
	Length of 2nd MT	PS89
	Length of 3rd MT	PS90
	Length of 4th MT	PS91
	Length of 5th MT	PS92
Patella	Length	PS93
	Width	PS94

(Table 54 continued).

Table 55. CPRs of developmental anomalies and non-metric traits by period.

	NEO		CHAL		EBA		All periods	
FEATURE	**NI**	**%**	**NI**	**%**	**NI**	**%**	**NI**	**%**
Ossicles	22	35.5	33	35.1	52	39.4	107	37.2
Shoveled incisors	7	11.3	26	27.7	32	24.2	65	22.6
Metopic suture	5	8.1	6	6.4	14	10.6	25	8.7
Parietal foramina	10	16.1	12	12.8	32	24.2	54	18.8
Septal aperture	14	22.6	7	7.4	23	17.4	44	15.3
Squatting facet	25	40.3	23	24.5	59	44.7	107	37.2
Vastus notch	13	21.0	8	8.5	28	21.2	49	17.0
Pigeon chest	2	3.2	0	0.0	1	0.8	3	1.0
Dental anomaly[86]	1	1.6	3	3.2	10	7.6	14	4.9
Additional cusp(s)	1	1.6	2	2.1	1	0.8	4	1.4
Hypoplasia of femoral neck	3	4.8	0	0.0	7	5.3	10	3.5
Plagiocephaly	1	1.6	2	2.1	0	0.0	3	1.0
6th sacral segment	0	0.0	1	1.1	1	0.8	2	0.7
Cleft of neural arch	0	0.0	0	0.0	1	0.8	1	0.3
Improperly fused vertebrae	0	0.0	1	1.1	2	1.5	3	1.0
Improperly fused epiphysis	0	0.0	0	0.0	2	1.5	2	0.7
Calcaneus secundarius	0	0.0	0	0.0	1	0.8	1	0.3
Cervical rib	0	0.0	0	0.0	1	0.8	1	0.3
Cleft of sternum	0	0.0	0	0.0	1	0.8	1	0.3
Conjoined MTs	0	0.0	1	1.1	0	0.0	1	0.3
Hypoplasia of mandibular ramus	1	1.6	0	0.0	0	0.0	1	0.3
Klippel-Feil syndrome	0	0.0	0	0.0	1	0.8	1	0.3
Nasal cleft	1	1.6	0	0.0	0	0.0	1	0.3
Os trigonum	0	0.0	0	0.0	1	0.8	1	0.3
Sternal foramen	0	0.0	0	0.0	1	0.8	1	0.3
Supracondylar process of humerus	0	0.0	0	0.0	1	0.8	1	0.3

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[86] other than shovelled incisors and additional cusps

Figure 101. Incidence of developmental anomalies and non-metric traits in the Neolithic by sex.

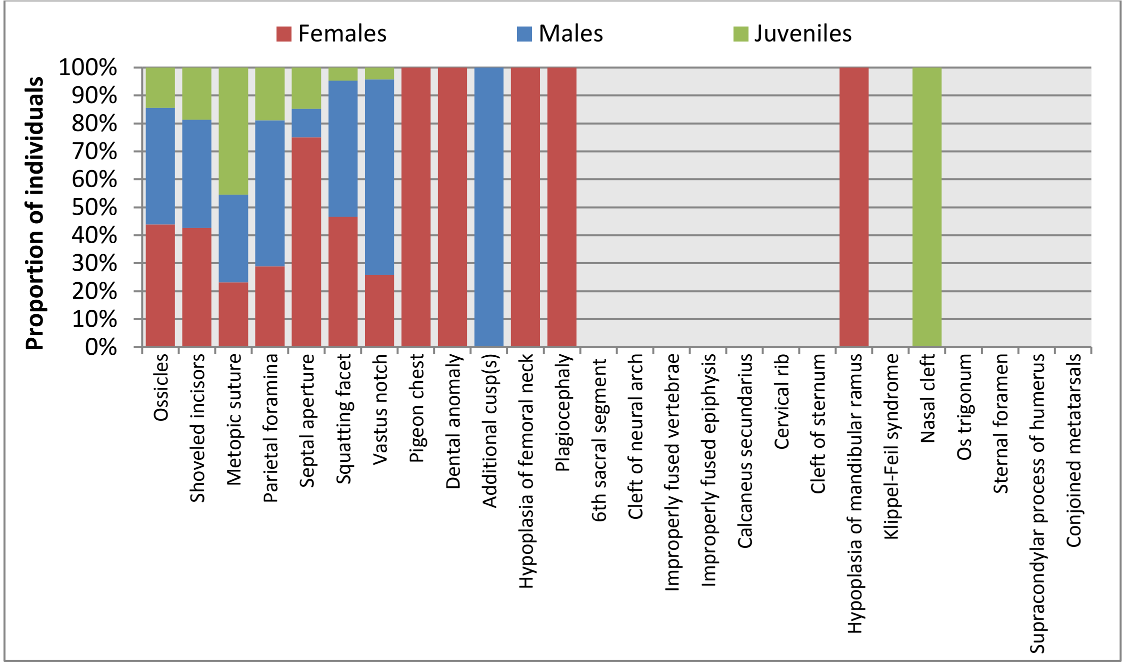


Figure 102. Incidence of developmental anomalies and non-metric traits in the Chalcolithic by sex.

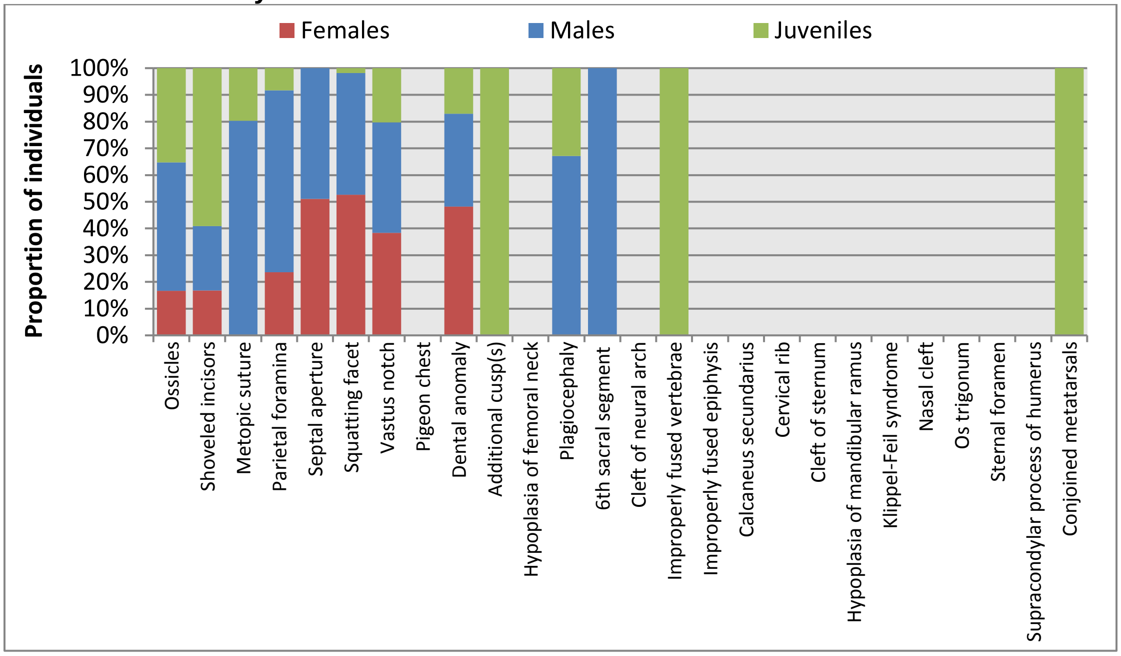


Figure 103. Incidence of developmental anomalies and non-metric traits in the EBA by sex.

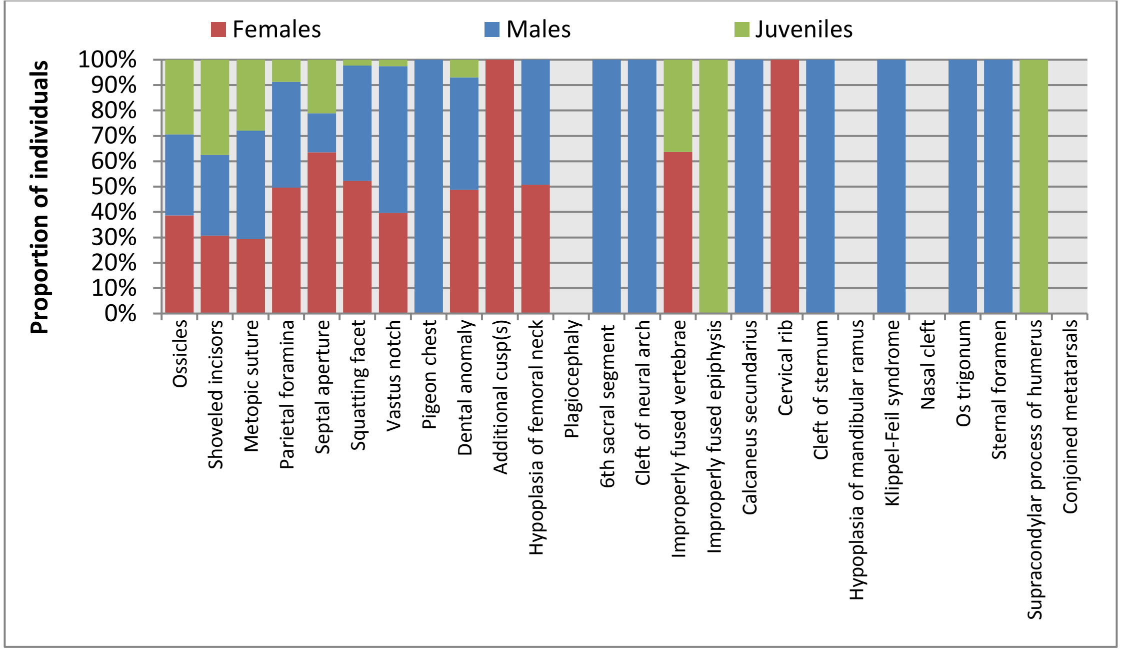


Table 56. Table showing the rates of individual combinations of spinal osteoarthritis (OA), osteophytosis (osteoph), and Schmorl's nodes (Schm). NI = number of affected individuals; % = percentage of all individuals in the category.

	OA_Schm		OA_osteoph		Schm_osteoph		OA_ osteoph_Schm	
	NI	%	NI	%	NI	%	NI	%
Total	11	7.2	17	11.2	32	21.1	10	6.6
NEO	1	3.0	3	9.1	2	6.1	0	0.0
CHAL	3	7.0	3	7.0	10	23.3	3	7.0
EBA	7	9.2	11	14.5	20	26.3	7	9.2
Females	3	4.3	6	8.7	9	13.0	3	4.3
Males	8	9.6	11	13.3	23	27.7	7	8.4
NEO								
Females	0	0	0	0	1	5.3	0	0
Males	1	7.1	3	21.4	1	7.1	0	0
CHAL								
Females	1	5.6	1	5.6	2	11.1	1	5.6
Males	2	8.0	2	8.0	8	32.0	2	8.0
EBA								
Females	2	6.3	5	15.6	6	18.8	2	6.3
Males	5	11.4	6	13.6	14	31.8	5	11.4

Table 57. List of individuals with traumas in the Neolithic.

Site	Context	Sex	Age	AM/PeM	Location	Trauma	Notes
Svodin	H183	J	12-17	AM	Posterior left parietal	Healed blunt-force traumas	
Svodin	H113	F	18-24	AM	Left humerus	Healed fracture	possibly a greenstick fracture
Svodin	H182	F	25-35	AM	Ribs	Healed fracture	
Svodin	H10	M	36-50	AM	Ribs, right 5th metacarpal	Healed fractures	
				PeM	Left forearm	Perimortem fractured forearm	also signs of infection
Svodin	H27	M	36-50	AM	Right fibula	Healed fracture	
Svodin	H125	M	36-50	AM	Frontal bone	Healed blunt-force trauma	
				PeM	Right femur, right tibia, right fibula	perimortem fractured	
Svodin	H93	M	36-50	AM	Frontal bone, left humerus, foot phalanx	Healed blunt force trauma on the right side of the frontal bone at the orbit, depression on the capitulum of the left humerus, antemortem fractured foot phalanx	
Svodin	H107	F	36-50	AM	Left 3rd metacarpal	Healed avulsion of metacarpal base	
Svodin	H41	F	50+	AM	Left parietal, right humerus, right ulna, right fibula	Healed blunt force trauma to the left parietal, antemortem fractured and badly healed distal humerus, healed fracture of distal ulna, antemortem fractured and badly healed fibula	False joint of the shaft of the fibula
Svodin	H83	M	50+	AM	Thoracic vertebra	Compression fracture	

Table 58. List of individuals with traumas in the Chalcolithic.

Site	Context	Sex	Age		Location	Trauma	Notes
Tisice	Ao 633	J	6-11	PeM	Left parietal bone	Perimortem fracture	possibly a blunt-force trauma
Knezeves	Ao 772a/H2	J	6-11	AM	Right femur	Partially healed fracture of proximal epiphysis	probably fractured shortly before death
Mochov	Ao 4070	J	12-17	PeM	Left parietal	Perimortem penetration trauma	possibly caused by an arrow or a tip of a sharp weapon
Kneževes	H766	J	12-17	PeM	Left 1st metatarsal	Perimortem sharp-tool trauma	
Knezeves Praha zapad	Ao 767	F	18-24	PeM	Occipital	Perimortem penetration trauma	possibly caused by an arrow or a tip of a sharp weapon
Zabovresky	Ao 2293	M	25-35	AM	Left clavicle	Healed fracture	
Stehelceves	Ao 3840	F	25-35	AM	Right radius, right tibia	Osteochondritis dissecans on distal ends	
Hulin 1	H66	M	25-35	AM	Right os coxa, right femur	Antemortem hip dislocation	
Male Brezno	Ao 8880	F	25-35	AM	Ribs, left humerus	Healed fracture of ribs, healed fracture of humerus	possibly badly fused and healed
Plotiste	A0 6100	M	25-35	AM	Right 5th metacarpal, left fibula, left ulna, left carpals	Healed fracture of the distal ulna, the metacarpal and the fibula; dislocation of left wrist	also signs of spinal stenosis
Sulejovice Litomerice	Ao 1820	M	36-50	AM	5th right metacarpal	Healed fracture	
				PeM	Left ulna	Perimortem fracture of distal ulna	probably fractured shortly before death
Libochovice Litomerice	Ao 2244	M	36-50	AM	Right ulna, right radius	Healed fractures	
Brezno,	Ao 7012	F	36-50	AM	Left clavicle	Healed fracture	
Zelesice	Ao 8340	M	36-50	AM	Right scapula	Partially healed fracture of the lateral site of the spine of the scapula	
				PeM	Left humerus	Perimortem cutmark on the capitulum of the distal humeurs	
Tisice	Ao 634	M	36-50	AM	Left side of the cranium	Antemortem blunt-force trauma	violent trauma

Table 59. List of individuals with traumas in the EBA.

Site	Context	Sex	Age		Location	Trauma	Notes
Nizna Mysla	H94	J	6-11	PeM	Atlas	Perimortem fracture of the anterior arc	at the still weakened fusion point
Nizna Mysla	H141	J	6-11	PeM	Right tibia, right fibula	Perimortem fractured shafts	also signs of having been exposed to fire
Nizna Mysla	H148	J	6-11	AM	Right parietal	Healed blunt-force trauma	
Nizna Mysla	H299	J	12-17	AM	Right humerus	Distal epiphysis fractured	distal epiphysis still non-fused
Praha Mala Ohrada	Ao 8778	M	18-24	PeM	Left parietal, mandible, maxillae	Perimortem fracture of the parietal, perimortem fracture of the anterior mandible and maxillae, including a tooth fracture	
Vrany	P7A 31589	M	18-24	PeM	Cranium, mandible	Perimortem fractures	glued and lacquered bones, may have also been broken shortly after death under the weight of the earth or in secondary grave opening
Nizna Mysla	H143	F	18-24	AM	Right 4th metatarsal	Healed fracture	
Nizna Mysla	H71	F	18-24	PeM	Lumbar vertebra	Perimortem cutmark	
Praha Mala Ohrada	Ao 8792	M	25-35	AM	Left clavicle, ribs, right ulna	Healed fracture of the clavicle and a rib, avulsion of distal process of the ulna	one rib shaft also with embedded arrow-point
				PeM	Right parietal	Fracture	possibly fractured postmortem under the weight of earth
Praha Mala Ohrada	Ao 8768	F	25-35	AM	Left clavicle, left ilium	Healed fracture of the clavicle, penetration injury at the acetabulum	
Nizna Mysla	H105	M	25-35	AM	Frontal bone, parietals, maxillae, cervical vertebra, right clavicle	Antemortem fractures	
Cicovice	Ao 9318	M	25-35	AM	Left scapula	Fracture with periostitis	probably fractured shortly before death
Nizna Mysla	H34 (35)	M	25-35	AM	Right acetabulum	Antemortem fracture with periostitis	
Nizna Mysla	H67	F	25-35	AM	Rib	Healed fracture	
Nizna Mysla	H310	M	25-35	AM	Cervical vertebra	Antemortem transverse fracture of the body	also periosteal lesion on the interior cranial table possibly indicating intracranial bleeding
Nizna Mysla	H262	F	25-35	PeM	Thoracic vertebra	Perimortem fracture of the anterior vertebral body	vertebral lesion is horizontal, possibly caused by a blunt weapon with sharper edge
Praha mala Ohrada	Ao 8783B	M	25-35	AM	Ribs	Antemortem cutmarks	not fully healed, probably occurred shortly before death
Nizna Mysla	H290	M	25-35	AM	1st right metatarsal	Osteochondritis dissecans	
Praha Mala Ohrada	Ao 8759	M	25-35	PeM	Maxillae, left humerus	Perimortem fracture of the left frontal bone, perimortem fractured right maxilla under the orbit, perimortem fractured diaphysis of the humerus	
Praha Mala Ohrada	Ao 8794	F	25-35	AM	Right radius	Partially healed fracture	still visible fracture line, the fracture probably occurred shortly before death
Nizna Mysla	H6	M	25-35	AM	Right tibia	Antemortem fractured lateral plateau of proximal epiphysis	severe, partially healed, could have resulted in individual's death

Site	Context	Sex	Age		Location	Trauma	Notes
Nizna Mysla	H6	M	25-35	AM	Right tibia	Antemortem fractured lateral plateau of proximal epiphysis	severe, partially healed, could have resulted in individual's death
Nizna Mysla	H273	M	25-35	AM	Right humerus, right radius, right ulna	Healed fracture of distal lateral condyle of the humerus; probably related to a trauma (a dislocation) indicated by proximal radius and ulna	
Praha Mala Ohrada	Ao 8763	M	36-50	AM	Left clavicle, left femur	Healed fracture of the clavicle, osteochondritis dissecans on the distal condyle of the femur	badly fused clavicle
				PeM	Thoracic vertebra, left tibia	Perimortem fractured tibia, perimortem depression on the anterior vertebral body	
Praha Mala Ohrada	Ao 8752	M	36-50	AM	Left fibula, left 5th metatarsal, 1st right foot phalanx	Healed fracture of the fibula, healed fracture of the 5th metatarsal and the foot phalanx	
				PeM	Skull, mandible, right humerus, right ulna, right radius, 1st right metatarsal	Skull fractured perimortem under pressure, coronoid process of the mandible fractured perimortem, perimortem fractures of the humerus, radius and the ulna, perimortem fractures of the 1st metatarsal	
Nizna Mysla	H82	M	36-50	PeM	Left humerus	Perimortem depression on the capitulum	
Praha Liben	Ao 2298	M	36-50	AM	Ribs	Healed rib fracture	
Nizna Mysla	H213a	M	36-50	AM	Right acetabulum, left femur	Antemortem fracture of the acetabular margin, healed fracture of the proximal shaft of the femur	
Nizna Mysla	H253	F	36-50	AM	Rib	Healed fracture	
Praha mala Ohrada	Ao 8783C	M	36-50	AM	Left side and the top of the cranium	Healed blunt-force trauma on the top of the vault, probably a healed trepanation on the side	
Nizna Mysla	H200	M	36-50	AM	Right talus	Osteochondritis dissecans on the superior facet of the talus	
Nizna Mysla	H53	M	36-50	AM	Frontal bone, nasal bones, right hand phalanx, left humerus	Partially healed sharp weapon injury across the face (frontal bone, nasals), possibly another healed trauma on the right side of the frontal bone, healed fracture of the phalanx and distal lateral humerus	
Nizna Mysla	H215	M	36-50	AM	Thoracic vertebra, ribs	healed fracture of the rib, penetrated vertebral body	possibly an arrow trauma to the vertebra. Slight signs of healing indicate that it may have occurred shortly before death
				PeM	Maxillae	Perimortem fracture of the maxilla at the orbit	
Vrany	P7A 31006	M	36-50	AM	Sternum	False joint of the sternum	
				PeM	Cranium, scapulae	Perimortem pressure fracture of the cranium and scapulae	
Praha Mala Ohrada	Ao 8781	M	36-50	AM	Occipital bone, thoracic vertebra, ribs, right humerus, right ilium, left femur	Healed blunt-force trauma on the occipital, compression fracture of the vertebra, healed fracture of the rib, healed avulsion of humeral medial condyle, healed fracture of acetabular margin, osteochondritis dissecans on the left distal femur	
Nizna Mysla	H121	M	36-50	PeM	Left parietal bone, left temporal bone, mandible	Perimortem fractures	possibly post-mortem caused, e.g., by the weight of earth

(Table 59 continued).

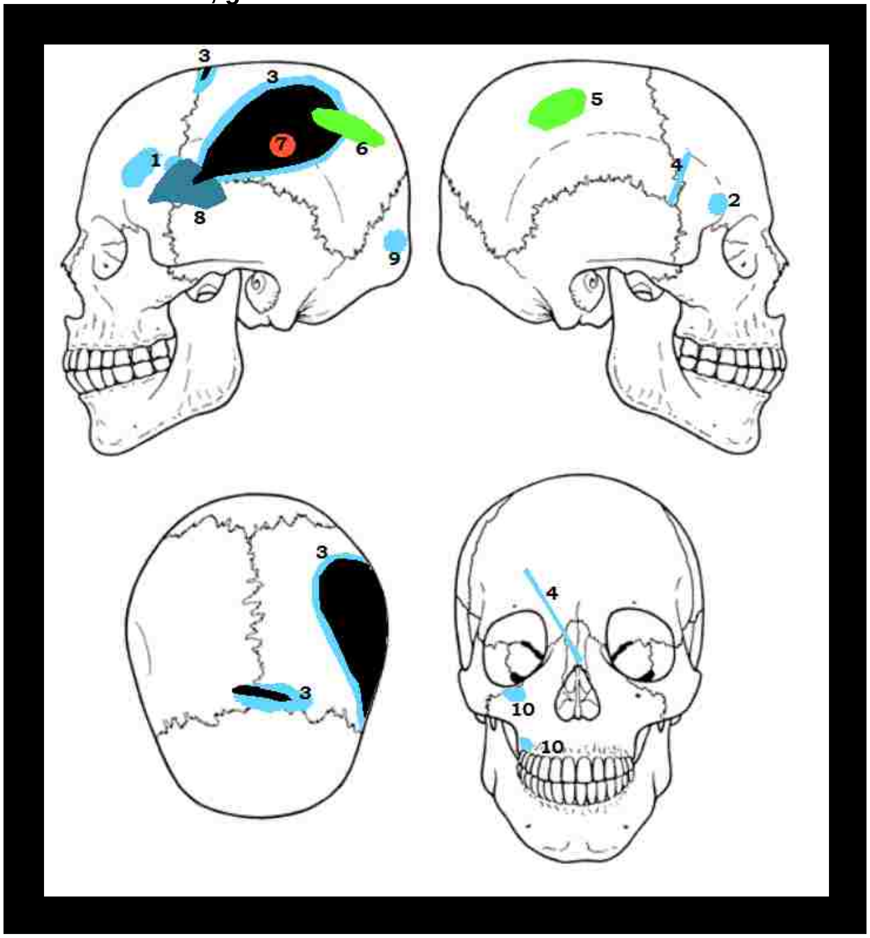
Site	Context	Sex	Age		Location	Trauma	Notes
Praha Mala Ohrada	Ao 8751	F	36-50	AM	Left wrist, hand phalanx	Possible wrist dislocation, healed fracture of the phalanx	
Steknik	P7A 32422	F	36-50	AM	Ribs	Healed sharp-tool trauma	
Nizna Mysla	H279	M	36-50	PeM	Right parietal	Perimortem pressure fracture	possibly post-mortem caused, e.g., by the weight of earth
Praha Mala Ohrada	Ao 8783A	M	36-50	AM	Ribs, left clavicle, right ilium	Healed fracture of the rib, improperly fused, antemortem fracture of the clavicle, also probably improperly fused or fractured perimortem; opening (c.1 cm in diameter) on the right ilium, edges are smooth, possibly also a healed trauma	
				PeM	Right humerus	Perimortem cutmark on the humeral head	
Nizna Mysla	H257	F	36-50	PeM	Right fibula	Perimortem fractured fibula	
Praha Mala Ohrada	Ao 8750	M	50+	AM	Ribs, left humerus	Healed fracture of the rib, antemortem blunt-force trauma of the proximal humerus	only slight signs of healing on the humerus, probably occurred shortly before death

(Table 59 continued).

Table 60. Frequency of non-specific spinal deformation by period.

Period	Age	Frequency	%
NEO	18-24	1	16.7
	25-35	2	16.7
	36-50	1	12.5
	50+	0	0.0
CHAL	18-24	0	0.0
	25-35	0	0.0
	36-50	2	11.8
	50+	0	0.0
EBA	18-24	2	12.5
	25-35	1	4.0
	36-50	2	6.1
	50+	1	50.0

Figure 104. Distribution of antemortem fractures on the skulls. blue – males, red – females, green – subadults.



1 – Svodín H125;
2 – Svodín H93;
3 – Praha-Malá Ohrada 8783C;
4 – Nižná Myšľa H53;
5 - Praha-Malá Ohrada 8792;
6 – Svodín H183;
7 – Svodín H41;
8 – Tišice 634;
9 - Praha-Malá Ohrada 8781;
10 - Nižná Myšľa H105.

Table 61. List of Neolithic, Chalcolithic and EBA sites from Databazelkp.cz included in demography comparison. Criteria settings: Period – non-specific Neolithic; Sex – male&female&child; Age – older than 18 & younger than 18.

NEO	Brno-Starý Lískovec	**CHAL**	Blučina	**EBA**	Bedřichovice
	Držovice		Bolelouc		Blučina
	Hluboké Mašůvky		Boleradice		Bolelouc
	Hodonice		Brno - Líšeň		Brno-Juliánov
	Loštice		Brno-Lužánky		Budkovice
	Mašovice		Brodek u Prostějova		Bystročice 1
	Modřice		Bučovice		Čejč
	Moravský Krumlov		Bukovany		Hodonice
	Nová Ves u Oslavan		Čelechovice		Holešov
	Rybníky		Hlinsko u Lipníku nad Bečvou		Holubice
	Seloutky		Hluboké Mašůvky		Horní Dunajovice
	Slatinky-Močílky		Holubice		Hradisko u Kroměříže
	Trstěnice		Chrlice		Hulín 1
	Vyškov		Ivanovice na Hané		Křenovice
			Kostelec u Holešova		Lovčičky
			Kralice na Hané		Mikulov
			Krumlovský les		Milonice
			Krumvíř		Miroslav
			Letonice		Moravská Nová Ves
			Marefy		Moravský Krumlov
			Modřice		Mušov - štěrkovna
			Moravská Nová Ves		Němčice na Hané
			Morkůvky		Olbramovice
			Mostkovice		Otrokovice-Chmelín
			Nechvalín		Pavlov
			Ostopovice		Přerov - Horní náměstí
			Pavlov		Přibice
			Podolí u Brna		Příkazy
			Prostějov		Rajhrad
			Prostějov-Čechůvky		Rajhradice
			Rousínov		Rebešovice
			Seloutky		Rybníky
			Sivice		Slatinice na Hané
			Slatinky		Slavkov u Brna
			Stříbrnice		Sobůlky
			Tovačov		Suchohrdly
			Tvarožná		Šlapanice
			Újezd u Brna		Těšany
			Určice		Těšetice-Kyjovice
			Vedrovice		Tvarožná
			Velešovice		Újezd u Brna
			Vřesovice		Vedrovice
			Vyškov		Velešovice
			Znojmo		Velké Pavlovice
			Žádovice		Věteřov
			Želešice		Znojmo-údolí Leska

Table 62. The amount of perinates by period in combined collections.
NI – number of individuals.

	NI	%
NEO	14	51.9
CHAL	6	22.2
EBA	7	25.9
Total	27	100

Table 63. Proportion of young females and males in individual periods.
NI – number of individuals; % - percentage of all individuals in the category.

PERIOD	Sex	NI	%
NEO	Females	27	62.8
	Males	14	32.6
	Total	41	95.3
CHAL	Females	22	45.8
	Males	24	50
	Total	46	95.8
EBA	Females	34	54.8
	Males	28	45.2
	Total	62	100

Table 64. Mean ages of Chalcolithic and EBA males and females in the combined collection.

Chalcolithic					
	SEX	N	Mean	Std. Deviation	Std. Error Mean
MeanAge	Males	120	37.465	11.0854	1.0120
	Females	107	37.586	11.2895	1.0914
Early Bronze Age					
	SEX	N	Mean	Std. Deviation	Std. Error Mean
MeanAge	Males	141	35.617	9.0759	.7643
	Females	129	34.186	9.2402	.8136

Table 65. Mean ages of subadults in individual periods, combined collections

Neolithic		Frequency	Cumulative Percent
Mean age	,0	7	7,0
	,1	2	9,0
	,5	4	13,0
	,8	1	14,0
	1,0	5	19,0
	1,5	2	21,0
	1,8	1	22,0
	2,0	1	23,0
	2,5	1	24,0
	3,0	16	40,0
	3,5	5	45,0
	4,0	3	48,0
	4,5	2	50,0
	5,0	1	51,0
	6,0	1	52,0
	6,5	2	54,0
	7,0	4	58,0
	7,5	3	61,0
	8,0	1	62,0
	8,5	10	72,0
	9,0	3	75,0
	10,0	1	76,0
	11,0	2	78,0
	11,5	1	79,0
	12,0	1	80,0
	12,5	2	82,0
	13,0	1	83,0
	14,0	2	85,0
	14,5	13	98,0
	17,0	2	100,0
	Total	100	

Chalcolithic		Frequency	Cumulative Percent
Mean age	,0	2	1,0
	,5	4	2,9
	3,0	53	28,2
	6,0	4	30,1
	8,5	78	67,5
	14,5	68	100,0
	Total	209	
Missing		6	
Total		215	

EBA		Frequency	Cumulative Percent
Mean age	,0	2	,7
	,5	3	1,8
	,6	1	2,2
	,9	1	2,6
	1,5	1	2,9
	1,7	1	3,3
	1,8	2	4,0
	2,5	7	6,6
	2,9	1	7,0
	3,0	46	23,9
	4,0	1	24,3
	4,3	1	24,6
	4,3	1	25,0
	4,9	1	25,4
	5,4	1	25,7
	6,0	2	26,5
	6,4	1	26,8
	6,8	3	27,9
	7,0	1	28,3
	7,0	2	29,0
	7,5	1	29,4
	7,9	1	29,8
	8,1	1	30,1
	8,1	1	30,5
	8,5	82	60,7
	8,6	1	61,0
	8,8	1	61,4
	8,9	1	61,8
	9,0	1	62,1
	9,2	1	62,5
	9,5	1	62,9
	9,6	1	63,2
	9,6	1	63,6
	9,8	1	64,0
	9,9	1	64,3
	10,2	1	64,7
	10,2	1	65,1
	10,5	1	65,4
	10,9	1	65,8
	10,9	1	66,2
	11,4	1	66,5
	11,5	8	69,5
	11,7	1	69,9
	12,3	1	70,2
	13,0	1	70,6
	13,4	1	71,0
	14,5	70	96,7
	15,0	1	97,1
	16,5	1	97,4
	16,7	1	97,8
	17,5	1	98,2
	17,6	1	98,5
	17,8	1	98,9
	17,9	1	99,3
	18,2	1	99,6
	19,9	1	100,0
	Total	272	

Table 66. Mean femoral lengths of males and females by period, combined collection (study collection, Vedrovice, and Hoštice data). NI – number of individuals assessed.

Period	Sex		Right	Left	Average
NEO	Females	Mean	401.76	400.91	401.33
		NI	27	22	
		Std. Deviation	19.466	20.508	
	Males	Mean	436.52	439.81	438.16
		NI	25	26	
		Std. Deviation	22.944	22.416	
CHAL	Females	Mean	412.94	420.42	416.68
		NI	16	12	
		Std. Deviation	15.264	19.110	
	Males	Mean	458.44	455.35	456.90
		NI	27	20	
		Std. Deviation	23.199	20.205	
EBA	Females	Mean	416.64	418.47	417.56
		NI	22	19	
		Std. Deviation	23.413	24.570	
	Males	Mean	455.03	457.30	456.16
		NI	30	27	
		Std. Deviation	21.237	19.789	

Appendix 5
Statistical tests

Test 1. Comparison of mean stature between periods, study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Neolithic	33	161.0394	8.32928	1.44994	158.0860	163.9928	147.30	180.30
Chalcolithic	41	168.0122	7.76206	1.21223	165.5622	170.4622	152.60	182.50
EBA	74	168.1216	7.41454	.86192	166.4038	169.8394	149.30	182.20
Total	148	166.5122	8.21297	.67510	165.1780	167.8463	147.30	182.50

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1272.330	2	636.165	10.672	.000
Within Groups	8643.248	145	59.609		
Total	9915.578	147			

Test 2. Comparison of mean stature between females from different periods, study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Neolithic	19	156.0105	6.04804	1.38752	153.0955	158.9256	147.30	165.00
Chalcolithic	17	160.7588	4.31017	1.04537	158.5427	162.9749	152.60	167.60
EBA	32	161.8219	5.32382	.94113	159.9024	163.7413	149.30	170.60
Total	68	159.9324	5.79808	.70312	158.5289	161.3358	147.30	170.60

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	418.095	2	209.048	7.408	.001
Within Groups	1834.294	65	28.220		
Total	2252.389	67			

Test 3. Comparison of mean stature between males from different periods, study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Neolithic	14	167.8643	5.74478	1.53536	164.5473	171.1812	156.40	180.30
Chalcolithic	24	173.1500	5.04251	1.02930	171.0207	175.2793	166.20	182.50
EBA	42	172.9214	4.67737	.72173	171.4639	174.3790	157.00	182.20
Total	80	172.1050	5.29726	.59225	170.9262	173.2838	156.40	182.50

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	305.975	2	152.988	6.165	.003
Within Groups	1910.843	77	24.816		
Total	2216.818	79			

Test 4. Comparison of cranial indices means between periods, study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Neolithic	13	73.6610	3.62650	1.00581	71.4696	75.8525	65.95	77.33
Chalcolithic	14	82.8147	3.52937	.94326	80.7769	84.8525	77.84	88.24
EBA	22	72.3556	4.62719	.98652	70.3040	74.4071	62.89	81.77
Total	49	75.6902	6.08646	.86949	73.9420	77.4385	62.89	88.24

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1008,781	2	504.390	30.157	.000
Within Groups	769,381	46	16.726		
Total	1778,162	48			

Test 5. Comparison of mean body mass between periods, study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Neolithic	29	60.2116	5.70866	1.06007	58.0402	62.3831	50.29	71.47
Chalcolithic	27	65.9020	6.50011	1.25095	63.3306	68.4733	53.56	78.87
EBA	63	65.3465	6.75884	.85153	63.6443	67.0487	49.20	87.50
Total	119	64.2212	6.80576	.62388	62.9857	65.4566	49.20	87.50

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	622.269	2	311.135	7.452	.001
Within Groups	4843.304	116	41.753		
Total	5465.573	118			

Test 6. Mean body mass - tests of normality (studied EBA population).

Descriptives				
Sex			**Statistic**	**Std. Error**
Females	Mean		61.2045	1.09170
	95% Confidence Interval for Mean	Lower Bound	58.9605	
		Upper Bound	63.4485	
	5% Trimmed Mean		61.1573	
	Median		60.1128	
	Variance		32.179	
	Std. Deviation		5.67264	
	Minimum		49.20	
	Maximum		73.21	
	Range		24.02	
	Interquartile Range		6.55	
	Skewness		.258	.448
	Kurtosis		.524	.872
Males	Mean		68.4530	.96978
	95% Confidence Interval for Mean	Lower Bound	66.4842	
		Upper Bound	70.4218	
	5% Trimmed Mean		68.1028	
	Median		68.3845	
	Variance		33.857	
	Std. Deviation		5.81869	
	Minimum		57.90	
	Maximum		87.50	
	Range		29.60	
	Interquartile Range		7.40	
	Skewness		.932	.393
	Kurtosis		2.420	.768

Tests of Normality						
Sex	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Females	.127	27	.200	.963	27	.424
Males	.163	36	.016	.923	36	.016

Test 7. Dependency of abscess on period. X – condition present.

Period * abscess Crosstabulation				
		abscess		Total
			x	
Period	**Neolithic**	24	9	33
	Chalcolithic	35	8	43
	EBA	62	14	76
Total		121	31	152

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.229	2	.541
Likelihood Ratio	1.167	2	.558
N of Valid Cases	152		

Test 8. Dependency of AMTL on period. X – condition present.

Period * AMTL Crosstabulation				
		AMTL		Total
			x	
Period	**Neolithic**	19	14	33
	Chalcolithic	25	18	43
	EBA	52	24	76
Total		96	56	152

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.812	2	.404
Likelihood Ratio	1.817	2	.403
N of Valid Cases	152		

Test 9. Dependency of hypoplasia on period, both adults and subadults considered (based on CPRs). X – condition present.

Period * HYPO Crosstabulation				
		HYPO		Total
			x	
Period	**Neolithic**	38	24	62
	Chalcolithic	59	35	94
	EBA	75	57	132
Total		172	116	288

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.888	2	.641
Likelihood Ratio	.888	2	.641
N of Valid Cases	288		

Test 10. Dependency of hypoplasia in adults on period (based on CPRs). X – condition present.

Period * HYPO Crosstabulation				
		HYPO		Total
			x	
Period	**Neolithic**	17	16	33
	Chalcolithic	27	16	43
	EBA	44	32	76
Total		88	64	152

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.974	2	.615
Likelihood Ratio	.973	2	.615
N of Valid Cases	152		

Test 11. Dependency of hypoplasia in subadults on period (based on CPRs). X – condition present.

Period * HYPO Crosstabulation				
		HYPO		Total
			x	
Period	**Neolithic**	21	8	29
	Chalcolithic	32	19	51
	EBA	31	25	56
Total		84	52	136

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.387	2	.303
Likelihood Ratio	2.435	2	.296
N of Valid Cases	136		

Test 12. Dependency of hypoplasia on sex in the Neolithic (based on CPRs). X – condition present.

Sex * HYPO Crosstabulation				
		HYPO		Total
			x	
Sex	**Females**	10	9	19
	Males	7	7	14
Total		17	16	33

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.022	1	.881
Continuity Correction	.000	1	1.000
Likelihood Ratio	.022	1	.881
Fisher's Exact Test			
N of Valid Cases	33		

Test 13. Dependency of hypoplasia on sex in the Chalcolithic (based on CPRs). X – condition present.

Sex * HYPO Crosstabulation

		HYPO		Total
			x	
Sex	**Females**	12	6	18
	Males	15	10	25
Total		27	16	43

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.199	1	.655
Continuity Correction	.016	1	.899
Likelihood Ratio	.200	1	.655
Fisher's Exact Test			
N of Valid Cases	43		

Test 14. Dependency of hypoplasia on sex in the EBA (based on CPRs). X – condition present.

Sex * HYPO Crosstabulation

		HYPO		Total
			x	
Sex	**Females**	19	13	32
	Males	25	19	44
Total		44	32	76

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.050	1	.824
Continuity Correction	.000	1	1.000
Likelihood Ratio	.050	1	.824
Fisher's Exact Test			
N of Valid Cases	76		

Test 15. Dependency of spinal diseases on sex in the Neolithic. X – condition present.

Sex * SPINAL Crosstabulation

		SPINAL		Total
			x	
Sex	**Females**	13	6	19
	Males	7	7	14
Total		20	13	33

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.146	1	.284
Continuity Correction	.504	1	.478
Likelihood Ratio	1.145	1	.285
Fisher's Exact Test			
N of Valid Cases	33		

Test 16. Dependency of spinal diseases on sex in the Chalcolithic. X – condition present.

Sex * SPINAL Crosstabulation

		SPINAL		Total
			x	
Sex	**Females**	13	5	18
	Males	11	14	25
Total		24	19	43

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.380	1	.066
Continuity Correction	2.332	1	.127
Likelihood Ratio	3.461	1	.063
Fisher's Exact Test			
N of Valid Cases	43		

Test 17. Dependency of spinal diseases on sex in the EBA. X – condition present.

Sex * SPINAL Crosstabulation

		SPINAL		Total
			x	
Sex	**Females**	15	17	32
	Males	15	29	44
Total		30	46	76

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.267	1	.260
Continuity Correction	.789	1	.374
Likelihood Ratio	1.264	1	.261
Fisher's Exact Test			
N of Valid Cases	76		

Test 18. Dependency of vault porosity (with and without thickening of the diploë) on period, study collection. X – condition present.

Period * VaultPOR Crosstabulation

		VaultPOR		Total
			x	
	Neolithic	36	26	62
	Chalcolithic	81	13	94
	EBA	109	23	132
Total		226	62	288

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.898	2	.000
Likelihood Ratio	18.025	2	.000
N of Valid Cases	288		

Test 19. Differences in mean ages of subadults in study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
NEO	29	6.900	5.3429	.9922	4.868	8.932	.0	14.5
CHAL	51	8.657	4.6016	.6444	7.363	9.951	3.0	14.5
EBA	56	8.885	5.1261	.6850	7.512	10.257	.0	19.9
Total	136	8.376	5.0074	.4294	7.527	9.225	.0	19.9

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	81.682	2	40.841	1.644	.197
Within Groups	3303.313	133	24.837		
Total	3384.995	135			

Test 20. Differences in mean ages of subadults in combined collections.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
NEO	100	6.421	5.0632	.5063	5.416	7.426	.0	17.0
CHAL	209	8.775	4.6311	.3203	8.144	9.407	.0	14.5
EBA	272	9.009	4.6235	.2803	8.457	9.561	.0	19.9
Total	581	8.480	4.7905	.1987	8.089	8.870	.0	19.9

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	518.357	2	259.178	11.711	.000
Within Groups	12791.862	578	22.131		
Total	13310.219	580			

Test 21. Differences in mean ages of adults in the study collection.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
NEO	32	37.078	10.4044	1.8393	33.327	40.829	21.0	53.0
CHAL	43	35.355	9.1378	1.3935	32.542	38.167	19.5	51.5
EBA	76	34.217	9.5647	1.0971	32.031	36.403	19.3	57.5
Total	151	35.147	9.6301	.7837	33.599	36.696	19.3	57.5

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	186.907	2	93.454	1.008	.368
Within Groups	13724.047	148	92.730		
Total	13910.954	150			

Test 22. Differences in mean ages of adults in the combined collections.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
NEO	156	34.984	11.3325	.9073	33.192	36.776	17.5	55.0
CHAL	232	37.452	11.2054	.7357	36.002	38.901	18.5	74.5
EBA	270	34.933	9.1657	.5578	33.835	36.032	19.0	57.5
Total	658	35.833	10.5010	.4094	35.029	36.637	17.5	74.5

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	938.730	2	469.365	4.299	.014
Within Groups	71509.697	655	109.175		
Total	72448.427	657			

Test 23. Comparison of mean ages of Neolithic males and females, combined collection.

SEX	N	Mean	Std. Deviation	Std. Error Mean
Males	65	37.392	10.9152	1.3539
Females	89	33.607	11.2605	1.1936

Independent Samples Test

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
MeanAge	Equal variances assumed	2.087	152	.039	3.7856	1.8137
	Equal variances not assumed	2.097	140.447	.038	3.7856	1.8049

Test 24. Comparison of mean femoral lengths in combined collection (study collection and Vedrovice and Hoštice data).

Side	Period	NI	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
Right	**NEO**	25	436.52	22.944	4.589	427.05	445.99	384	494
	CHAL	27	458.44	23.199	4.465	449.27	467.62	430	508
	EBA	30	455.03	21.237	3.877	447.10	462.96	402	487
Left	**NEO**	26	439.81	22.416	4.396	430.75	448.86	384	499
	CHAL	20	455.35	20.205	4.518	445.89	464.81	407	499
	EBA	27	457.30	19.789	3.808	449.47	465.12	407	488

ANOVA

Side		Sum of Squares	df	Mean Square	F	Sig.
Right	Between Groups	7206.614	2	3603.307	7.169	.001
	Within Groups	39705.873	79	502.606		
	Total	46912.488	81			
Left	Between Groups	4689.946	2	2344.973	5.382	.007
	Within Groups	30500.218	70	435.717		
	Total	35190.164	72			

Figure 105. Badly healed fracture of humeral shaft of a young female (H113) from Svodín.

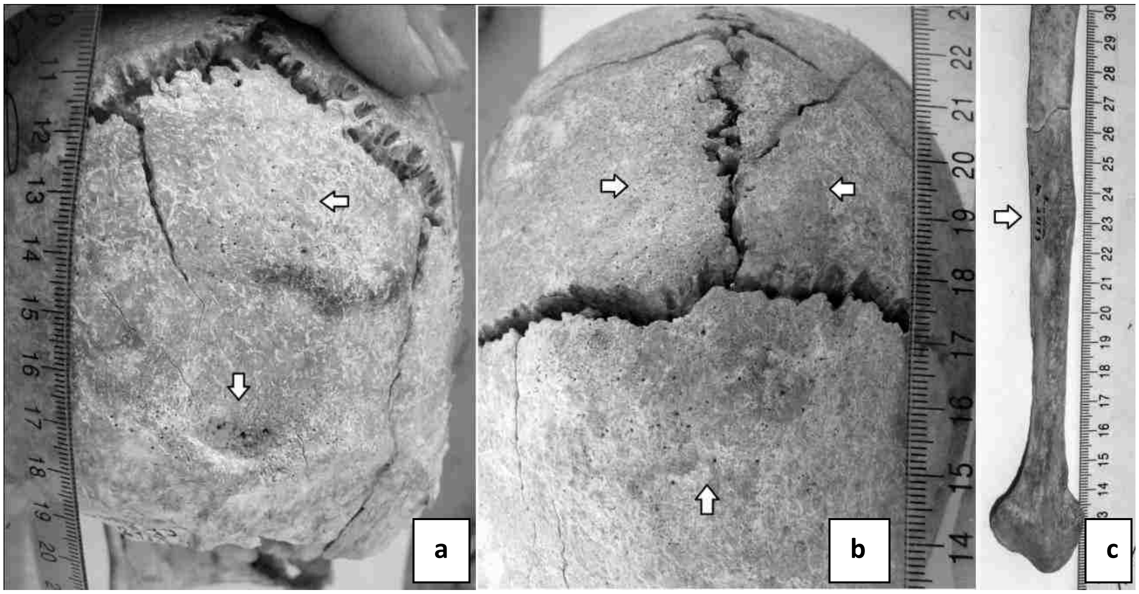


Figure 106. Healed porotic hyperostosis of cranial vault (a – occipital bone, b – frontal bone and parietals) and a healed fracture of distal fibula (c) of a mature male (H27) from Svodín.

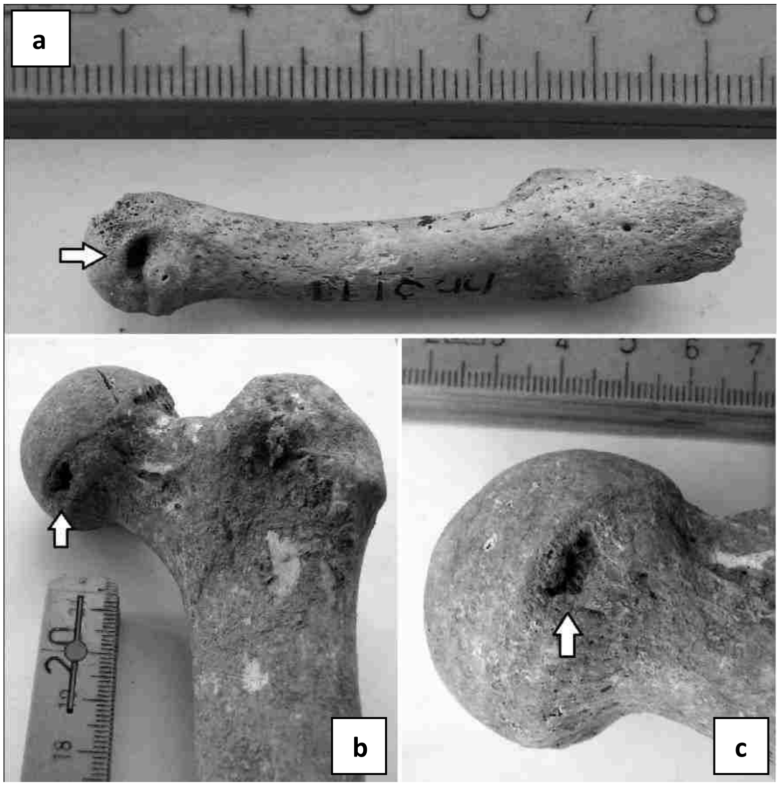


Figure 107. Cysts of unknown origin on the metatarsal (a) and femoral necks (b, c) of a prime male (H3) from Svodín.

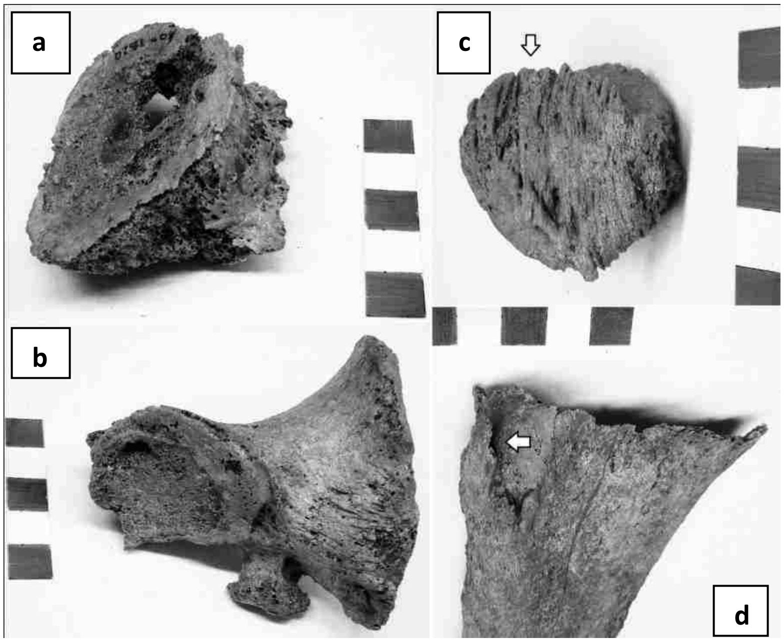


Figure 108. A Chalcolithic male from Sulejovice (1820) with the signs of osteopenia/osteoporosis on the lumbar vertebra (a) and the sacrum (b) and ossified tendons of patella (c) and proximal anterior tibia (d).

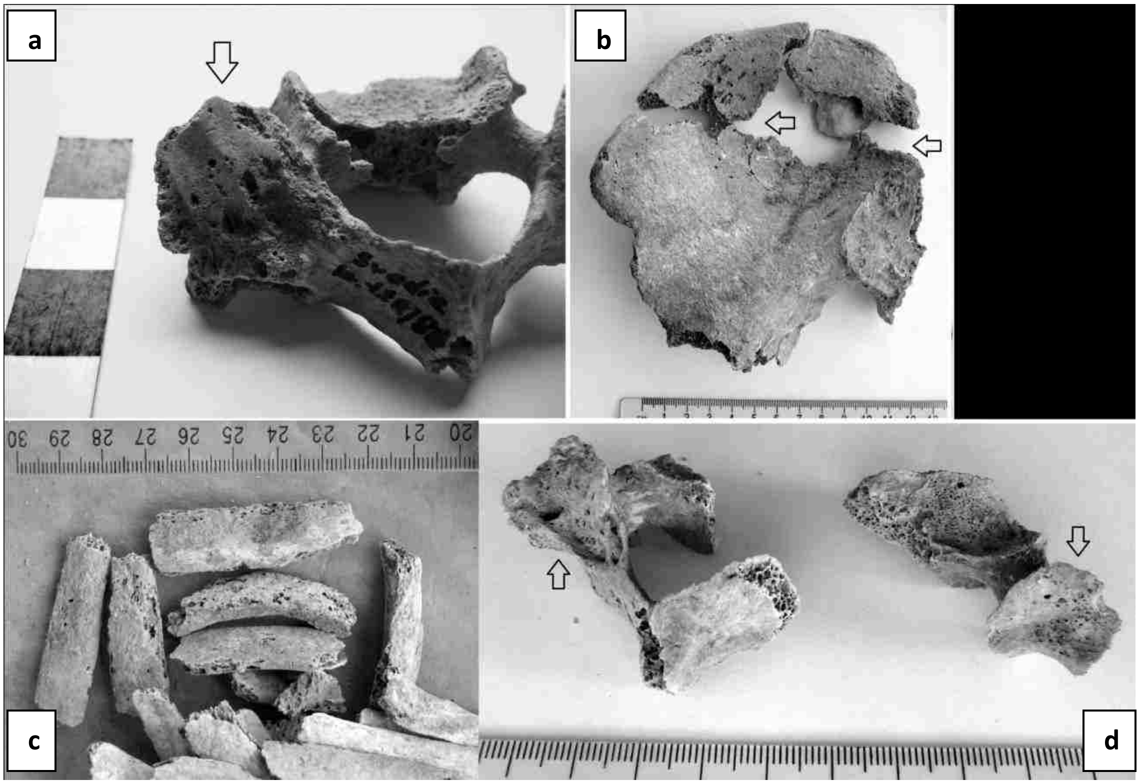


Figure 109. Individuals with signs of bone loss and osteoarthritis. a – OA on the articular facet of a cervical vertebra of an old male from Svodín (H122); b-d – bones of a mature male from Svodín (H169), b – ilium with sign of bone loss, c – ribs with signs of bone loss, d – articular facets of thoracic vertebrae with evidence of OA.

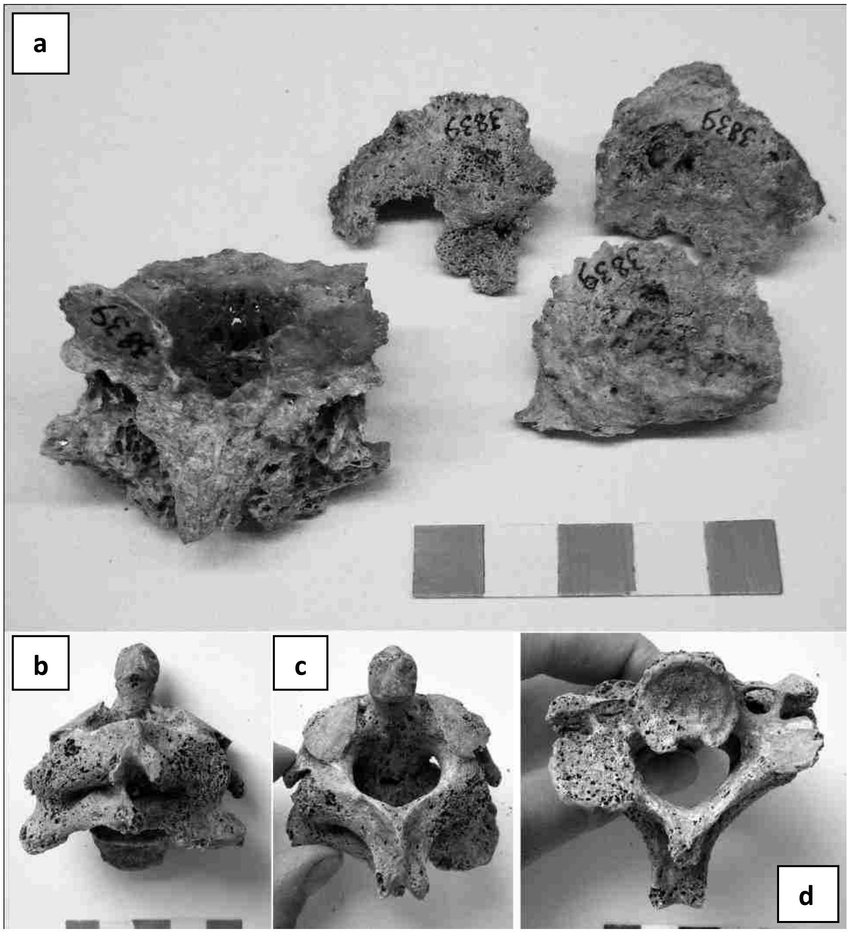


Figure 110. Possible case of ankylosing spondylitis in a mature male from Stehelčeves (3839) (a) and a probable ankylosing spondylitis in an old male from Nižná Myšľa (H19) (b-d).

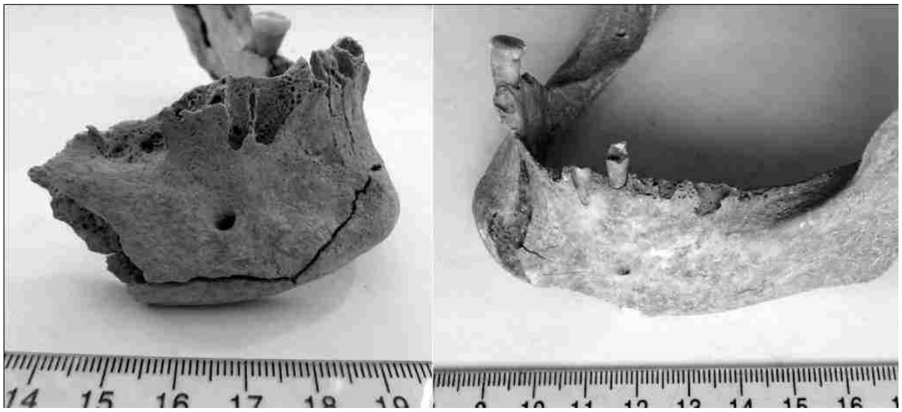


Figure 111. Periodontal disease in two old females (H6 [left] and H41 [right]) from Svodín.

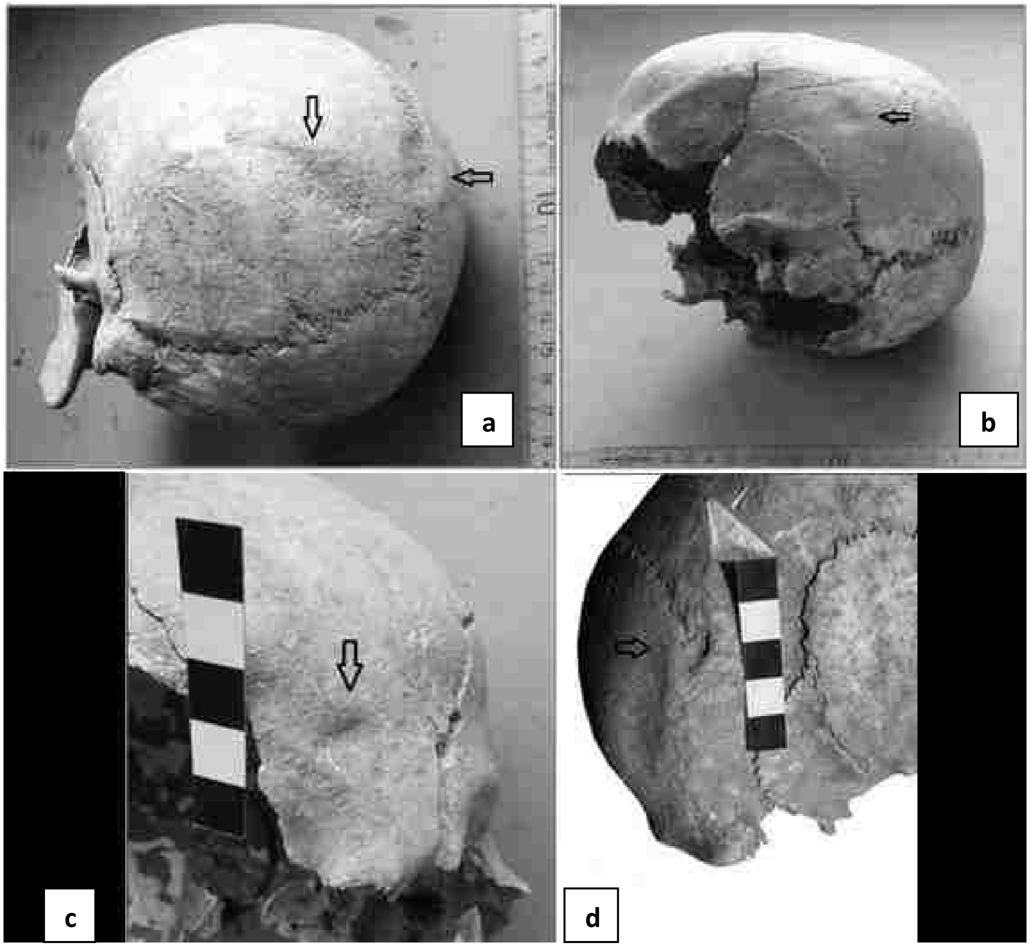


Figure 112. Antemortem fractures of cranial vault in the Neolithic. a – an adolescent H183, b – an old female H41, c – a mature male H93, d – a mature male H125.

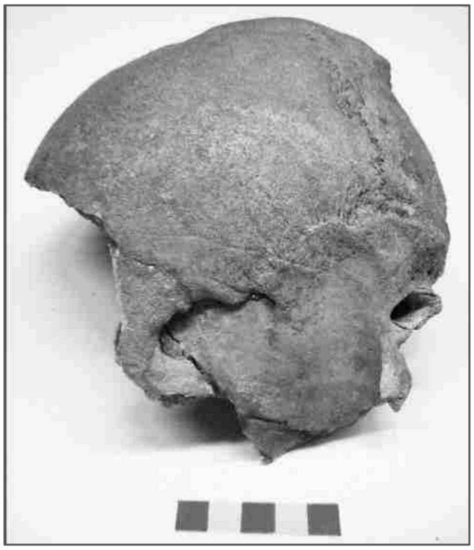


Figure 113. Partially healed blunt-force trauma on the left side of the cranium of a mature Chalcolithic male from Tišice (Ao 634). Anterior side is left.

Figure 114. Skull of an EBA mature male from Praha – Malá Ohrada (Ao 8783c) showing the signs of healed trepanation and a healed blunt-force trauma to the top of the cranium. a – cranium showing the locations of the lesions; b – interior view of the posterior margin of the trepanned bone; c – outer margin of the trepanned bone; d – trauma on the top of the cranial vault; e – healed depression of the cranial table.

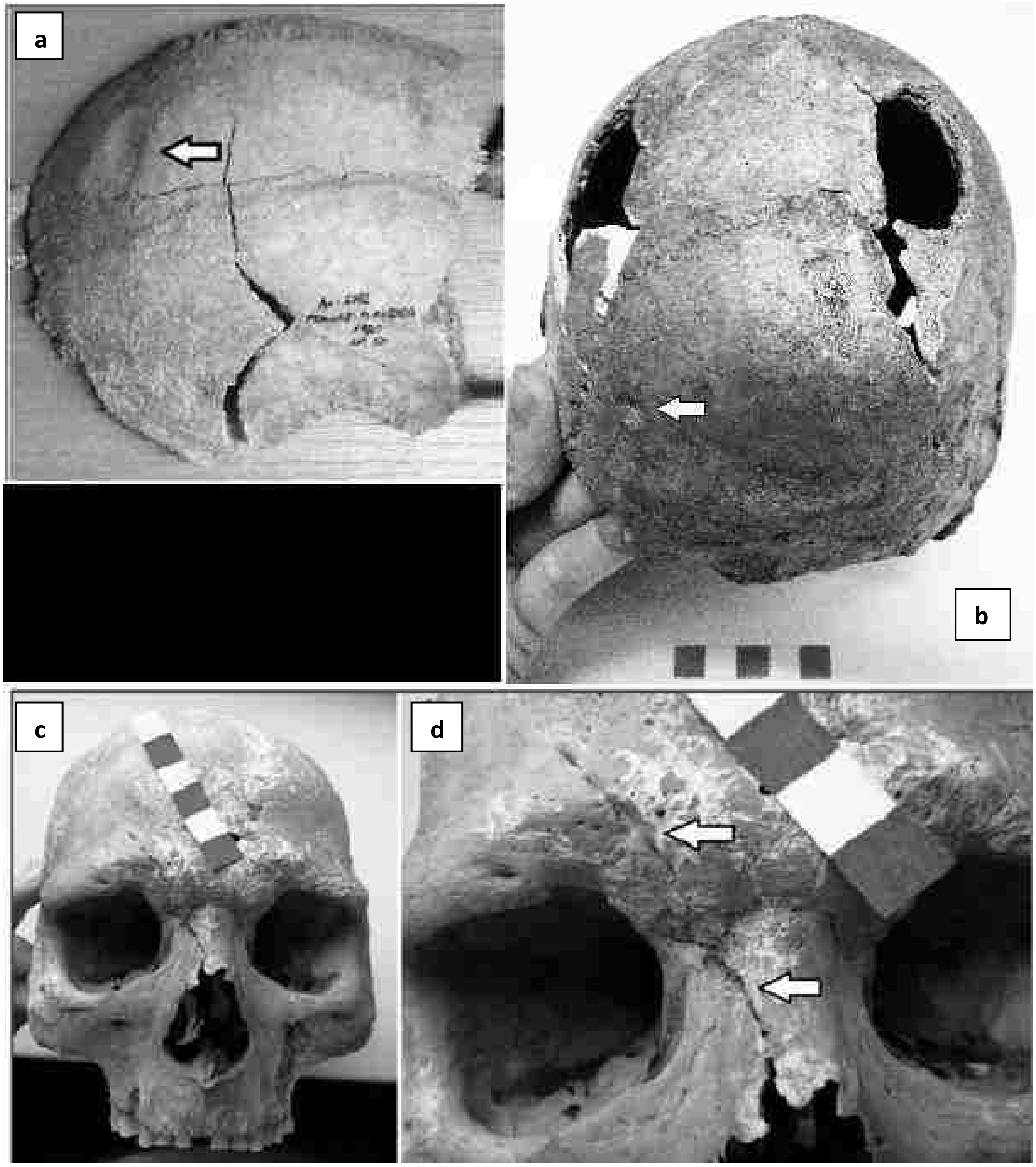


Figure 115. Antemortem skull fractures in the EBA. a – a healed blunt-force trauma on the posterior right parietal of a prime male from Praha – Malá Ohrada (8792) aged 25-35 years; b – healed circular blunt-force trauma on the left side of the occipital of a prime male from Praha – Malá Ohrada (8781); c, d - partially healed sharp-tool trauma on the frontal bone and adjacent facial part of a mature man from Nižná Myšľa (H53).

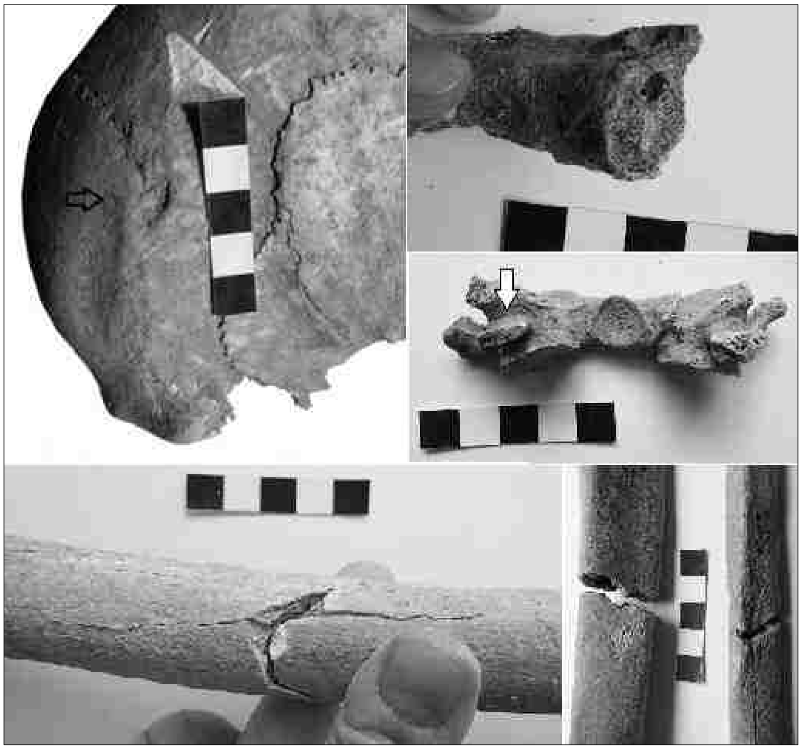


Figure 116. Traumatic lesions and a probable infection of the rib observed on the skeleton of a mature male from Svodín (H125).

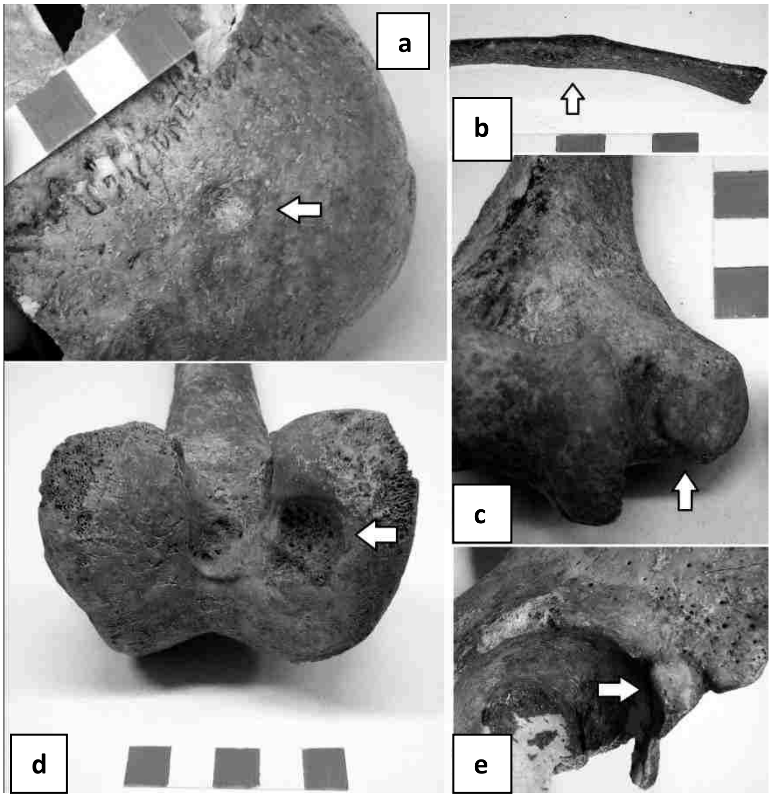


Figure 117. Antemortem traumas on the skeleton of a prime EBA male from Praha – Malá Ohrada (8781). a – blunt-force trauma on the occipital; b – healed rib fracture; c – avulsion of the medial humeral condyle; d – OD on distal femur; e – antemortem fracture of superior margin of the acetabulum.

Figure 118. Possible spinal deformation in a prime male from Nižná Myšľa (H215).

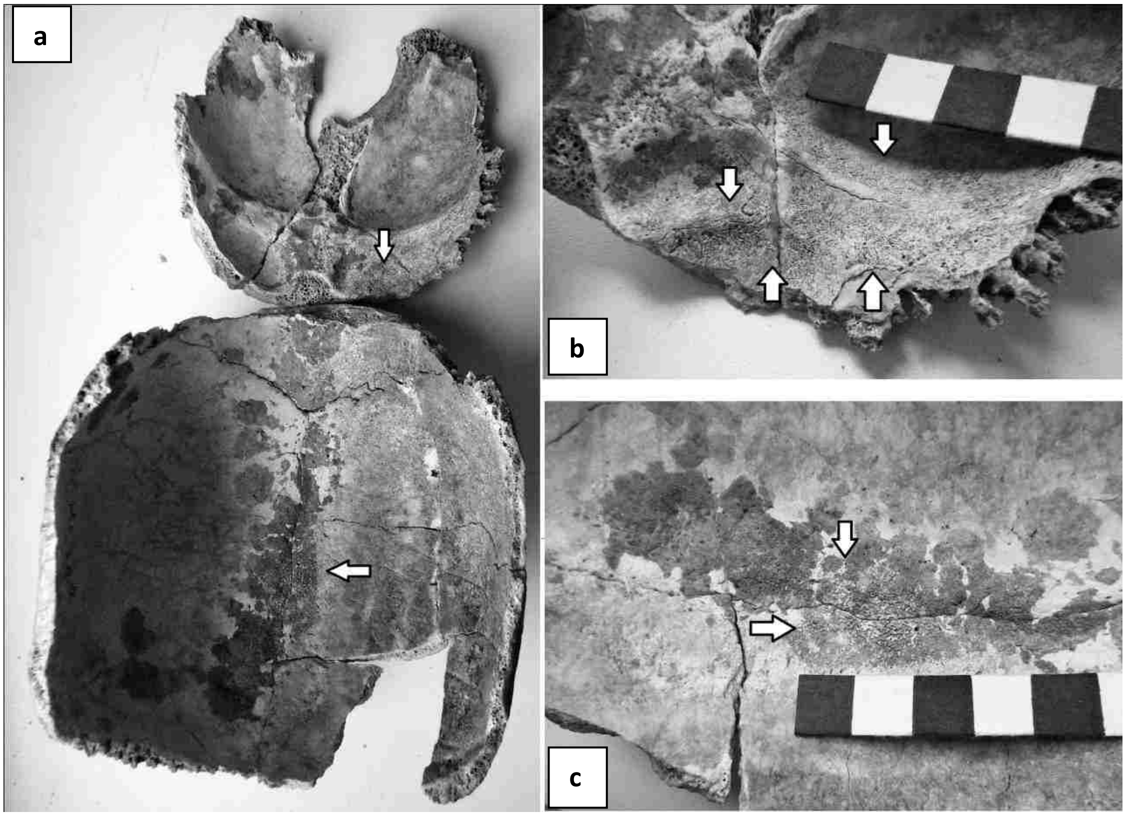


Figure 119. Ongoing periosteal bone formation on the inner occipital table of a prime male from Nižná Myšľa (H310). a – location of the lesions (occipital bone is up); b – lesion on the occipital bone; c – lesion on the sagittal suture.

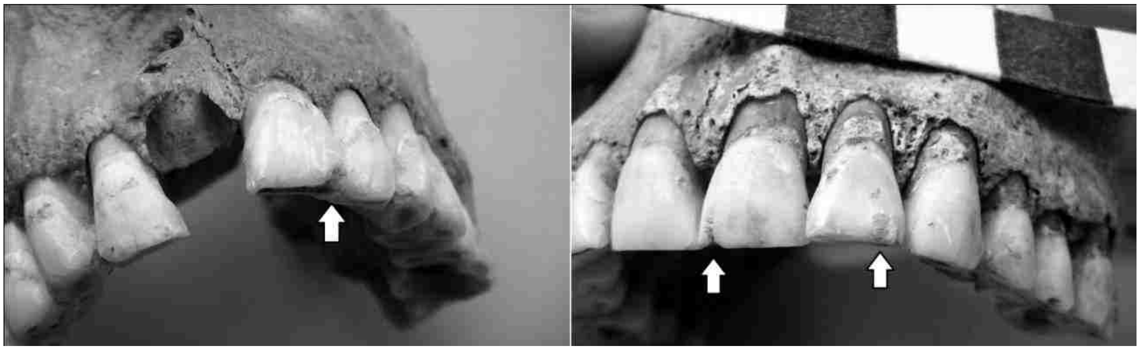


Figure 120. Grooves on the anterior teeth of males from Nižná Myšľa (H215 on the left and H310 on the right), suggesting using teeth as tools**.**

Figure 121. Badly healed fracture of the left humerus and healed fracture of ribs observed on the skeleton of a female from Březno (8880) aged 25-35 years.

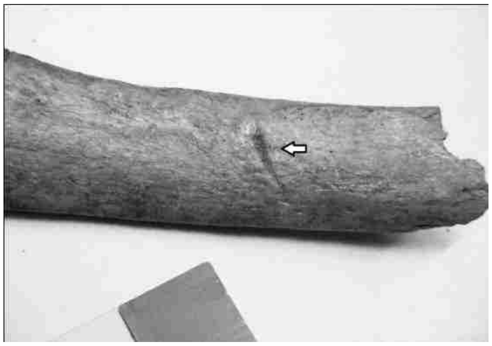


Figure 122. A rib of an EBA female 2422 from Stekník, aged 25-35 years.

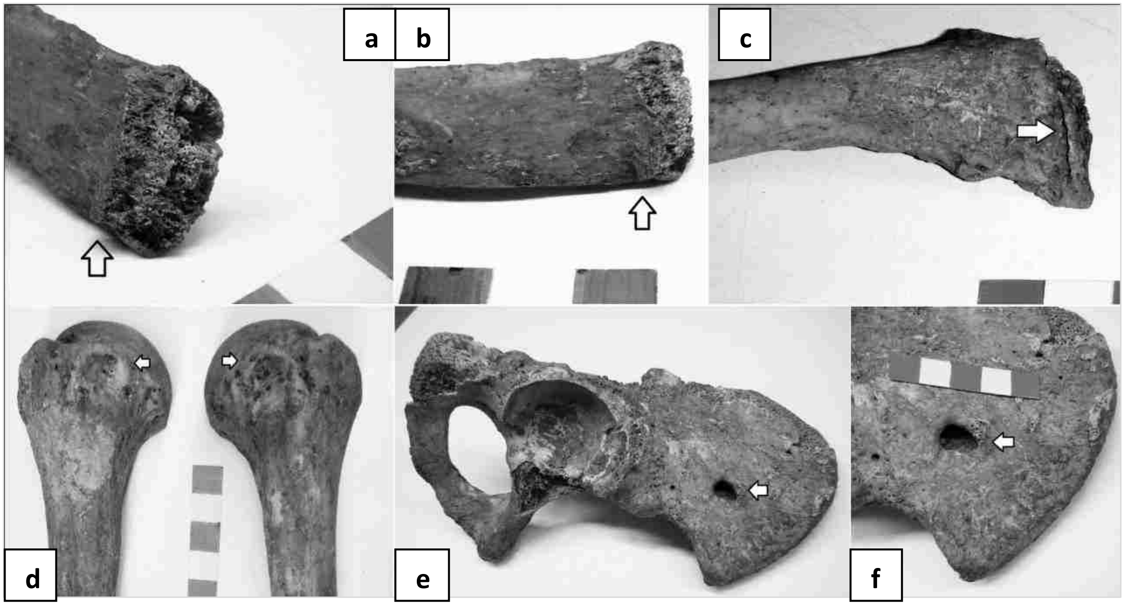


Figure 123. Lesions observed on the skeleton of a mature male from Praha – Malá Ohrada (8783A). Fractured rib-shaft (a, b) and lateral clavicle (c) not united with the other fractured half, with slight signs of bone remodeling visible at the inferior margin (arrows). Possible signs of rotator-cuff disease visible on proximal humeri (d) and a non-specific cyst (possibly also a trauma) on the right ilium (e, f).

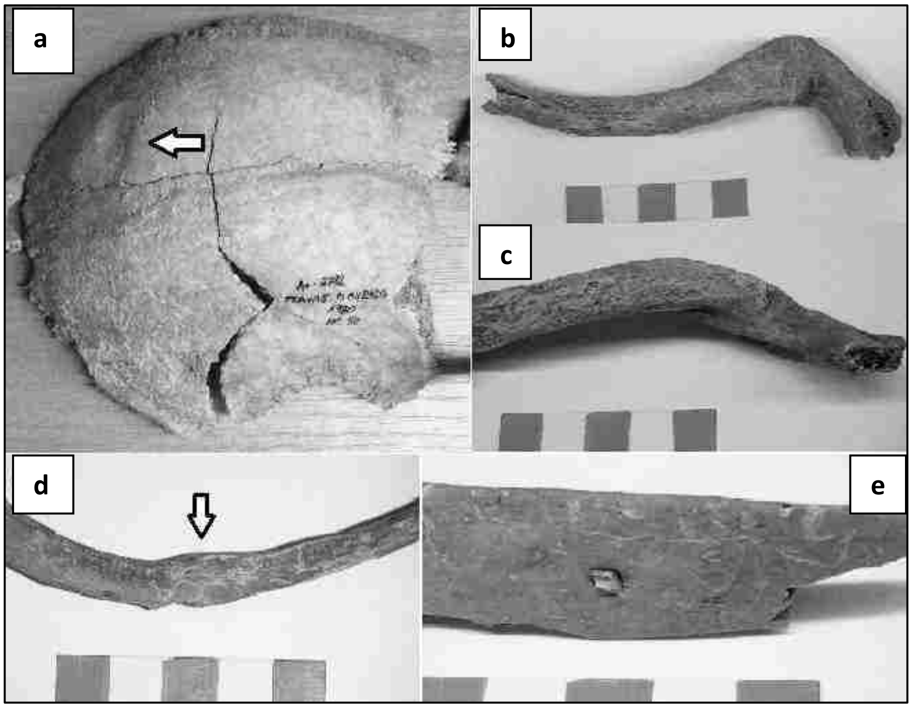


Figure 124. Traumas observed on a male from Praha – Malá Ohrada (8792), aged 25-35 years. a – healed blunt-force trauma; b+c – healed fracture of the clavicle; d – healed fracture of a rib; e – arrowhead embedded in the rib

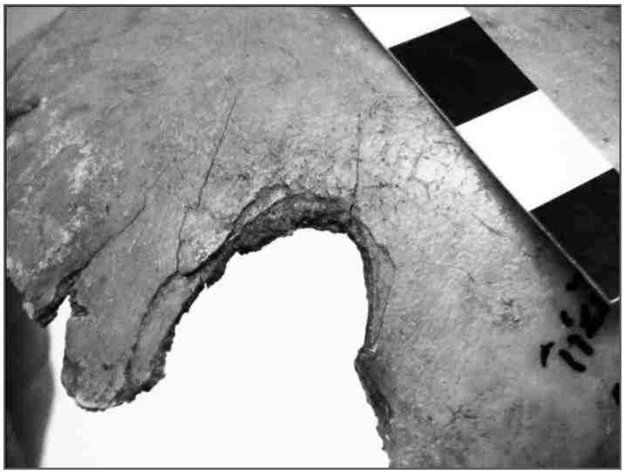


Figure 125. Perimortem fracture on the left parietal bone of a Chalcolithic child aged 6-11 years from Tišice (633).

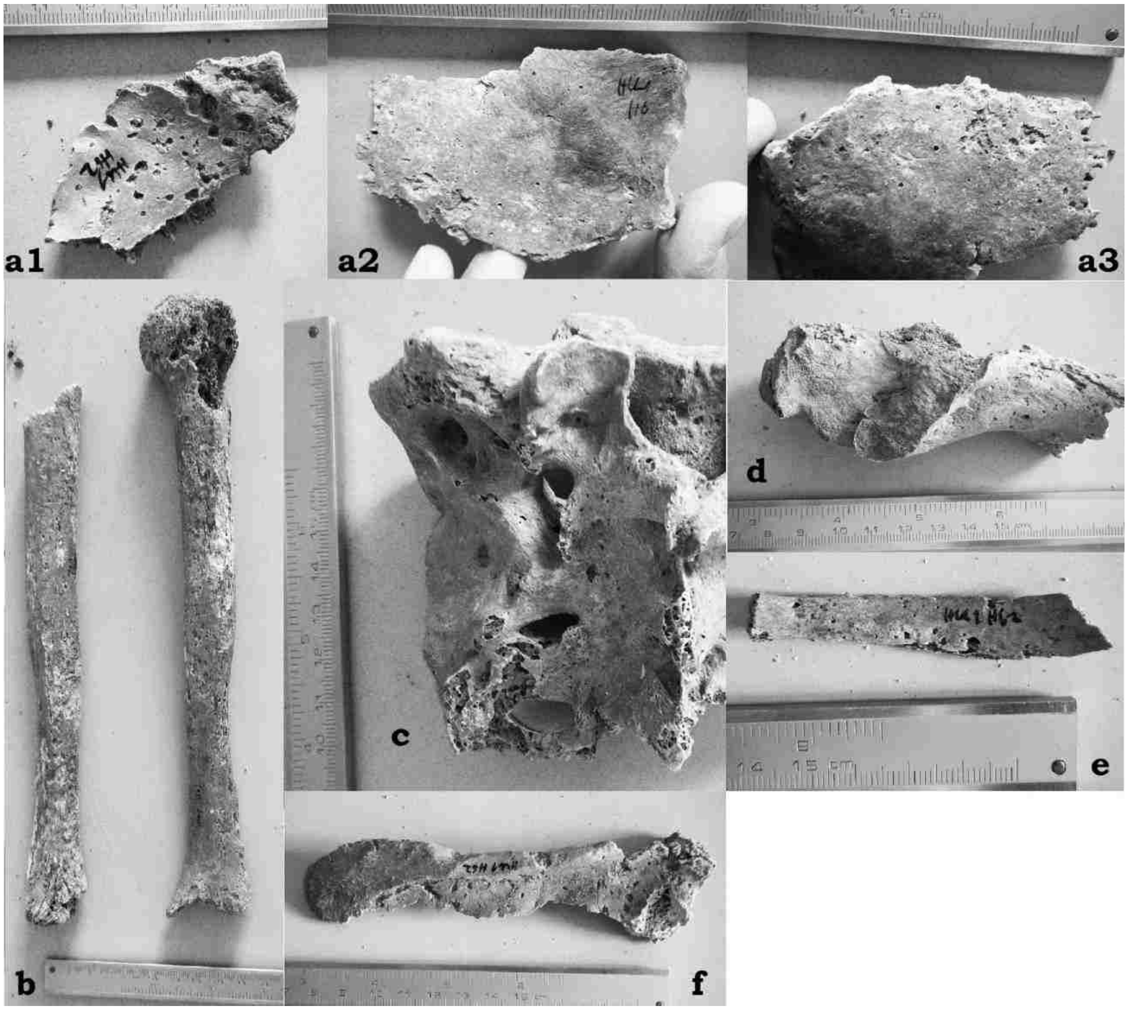


Figure 126. Bones affected by probable multiple myeloma. Mature Chalcolithic female from Hulín (H62). a – skull fragments; b – humeri; c – sacrum; d – ilium; e – rib; f – scapula.

Figure 127. Probable gout in an old female from Svodín (H174).

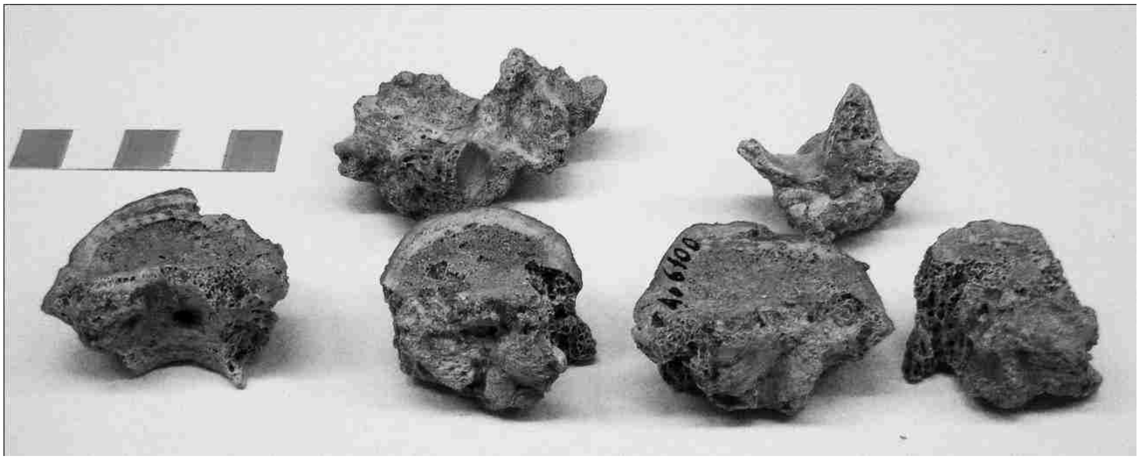


Figure 128. Bone formation in spinal canal of a Chalcolithic male from Plotiště (6100), aged 25-35, indicative of spinal stenosis.

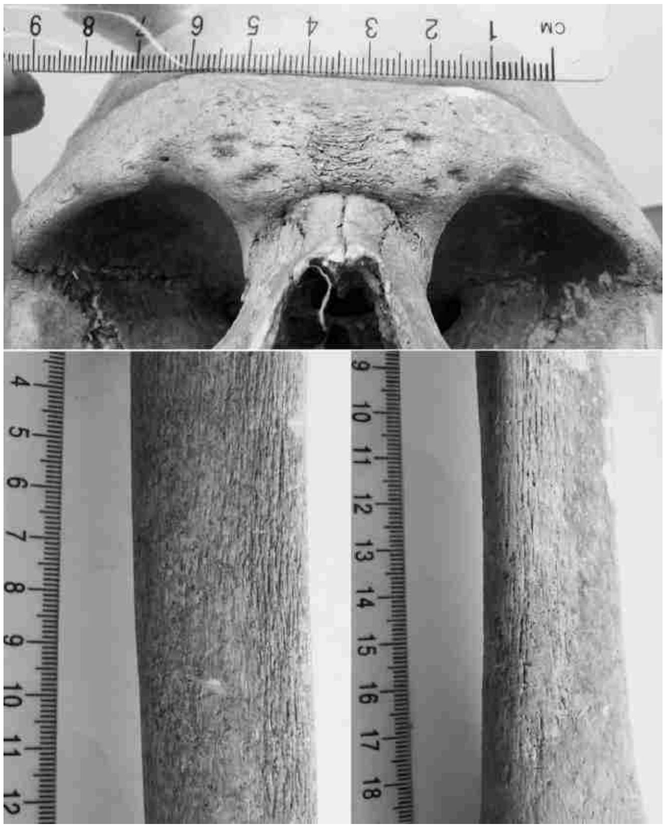


Figure 129. Non-specific thickening at the glabella and the supraorbital region of the skull of a male from Svodín (H102), aged 25-35, with a sclerotic pattern and periosteal lesions on the tibiae.

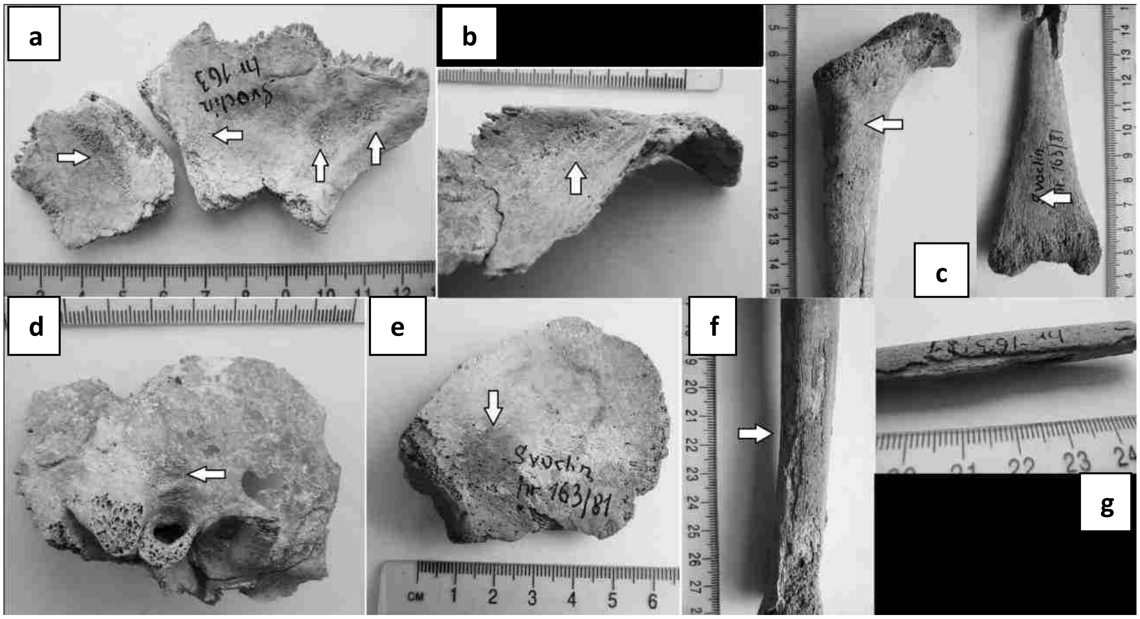


Figure 130. Possible meningitis on the juvenile aged 6-11 from Svodín (H163). a – periostitis on the interior of the skull; b – cribra orbitalia; c – periostitis on the femur; d – porosity on the temporal bone; e – periostitis on the ilium; f – periostitis on the tibial shaft; g – periostitis on the fibular shaft.

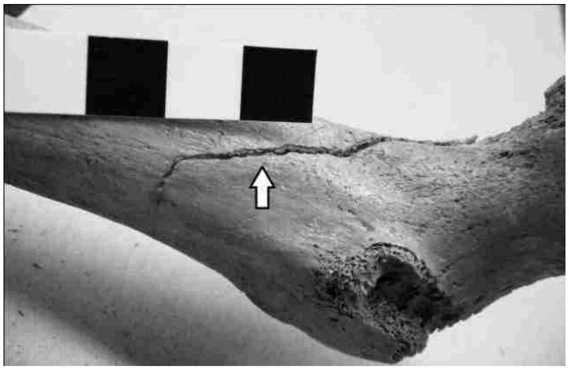


Figure 131. Antemortem fracture (arrow) of the proximal femur of a Chalcolithic child from Kněževes (772A), aged 6-11.

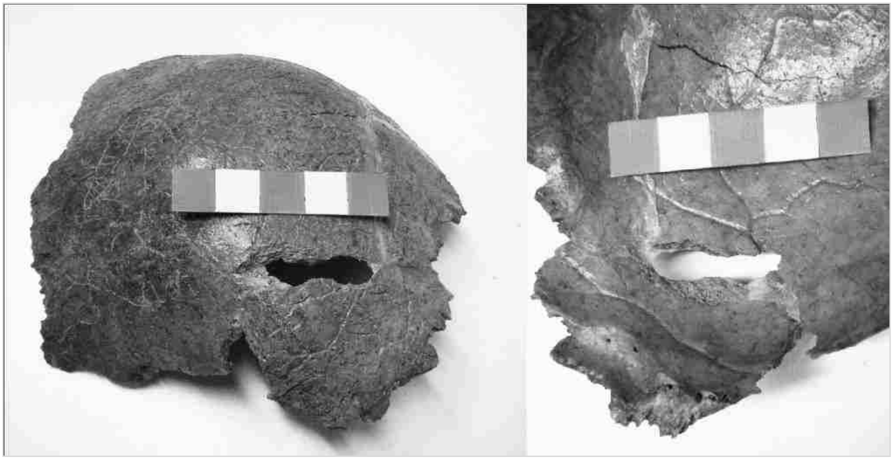


Figure 132. Perimortem fracture on the left parietal of a Chalcolithic adolescent from Mochov (Ao 4070), probably caused by a projectile or a point of a sharp tool.

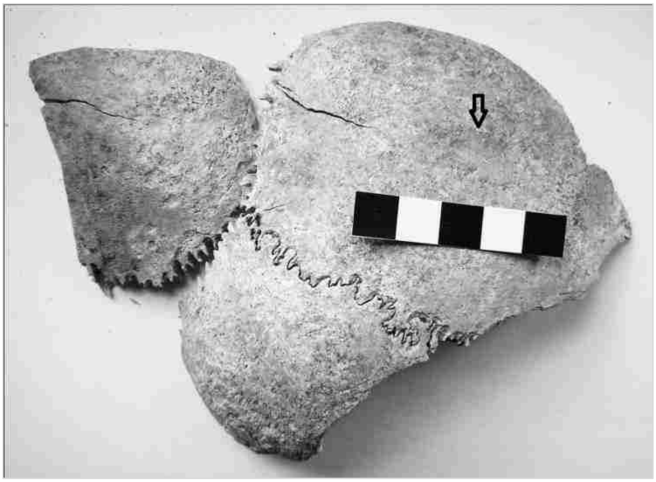


Figure 133. Healed blunt-force trauma on the right parietal of a child from Nižná Myšľa (H148), aged 6-11.

Figure 134. Perimortem fractured distal epiphysis of right humerus in an adolescent from Nižná Myšľa (H299).

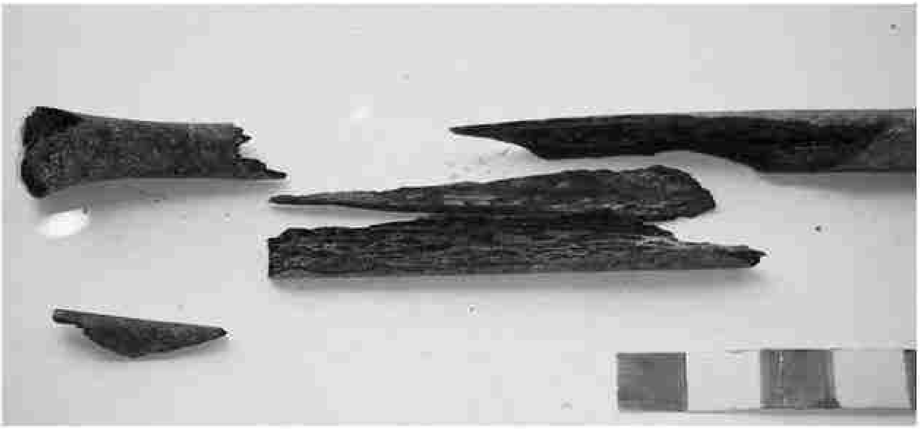


Figure 135. Perimortem fractured long bones of a child from Nižná Myšľa (H141) aged 6-11, probably exposed to fire.

Figure 136. Evidence of vertebral ankylosis of the first two thoracic vertebrae of a mature female from Svodín (H107).

Figure 137. Evidence of osteoporosis in the old female (H41) from Svodín.

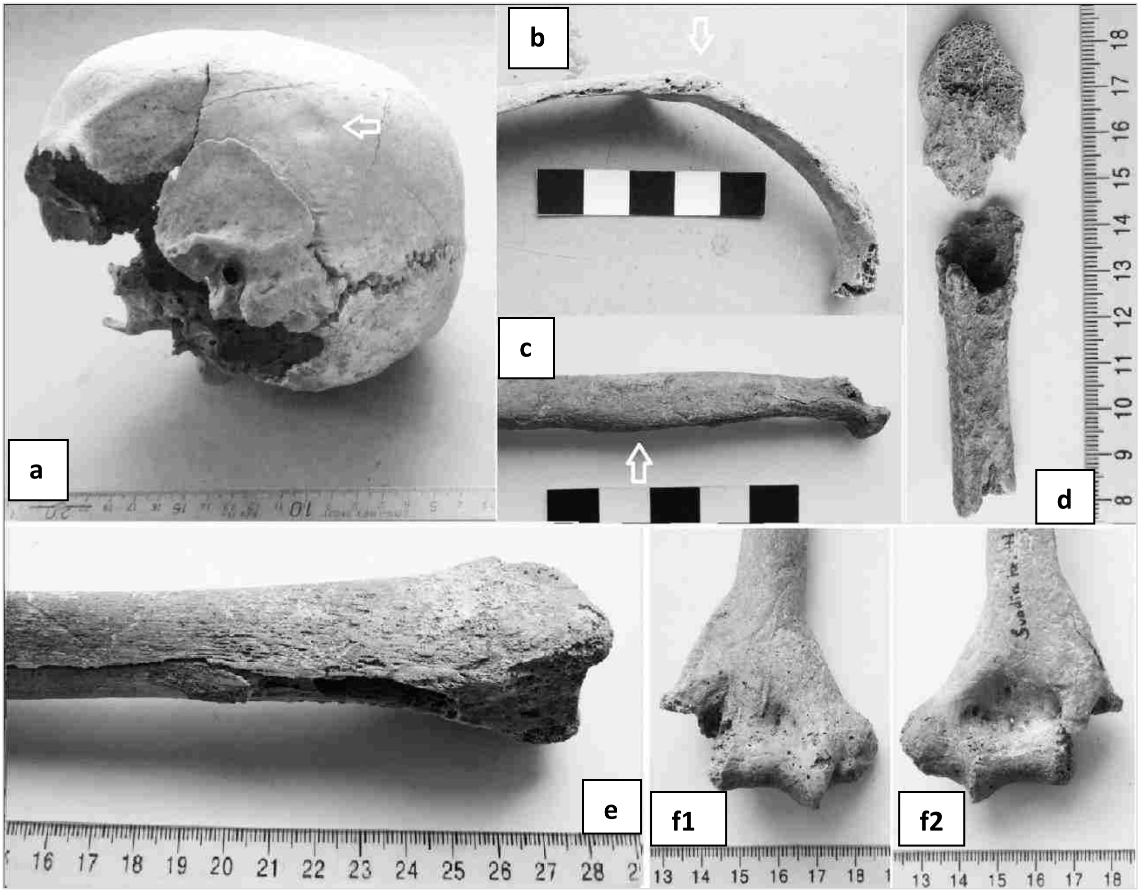


Figure 138. Traumatic and trauma-related lesions observed on the skeleton of an old female from Svodín (H41). a – healed blunt-force trauma on the skull; b – healed fracture of a rib; c – healed fracture of distal ulna; d – probable pseudarthrosis of distal fibula; e - periostitis on distal tibia; f – antemortem and perimortem trauma of distal humerus (1) anterior view, (2) posterior view.

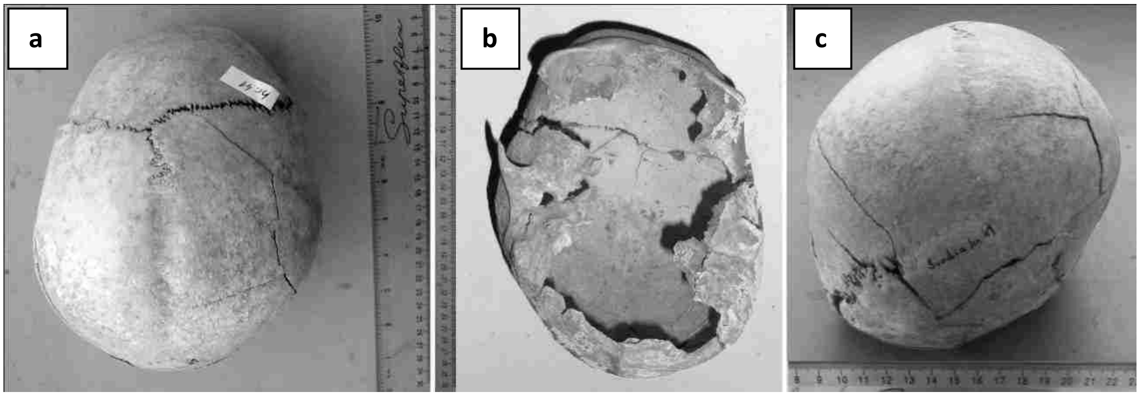


Figure 139. Plagiocephaly of an old female (H41) from Svodín. a – superior view, frontal bone is up; b – inferior view, frontal bone is up; c – posterior view.

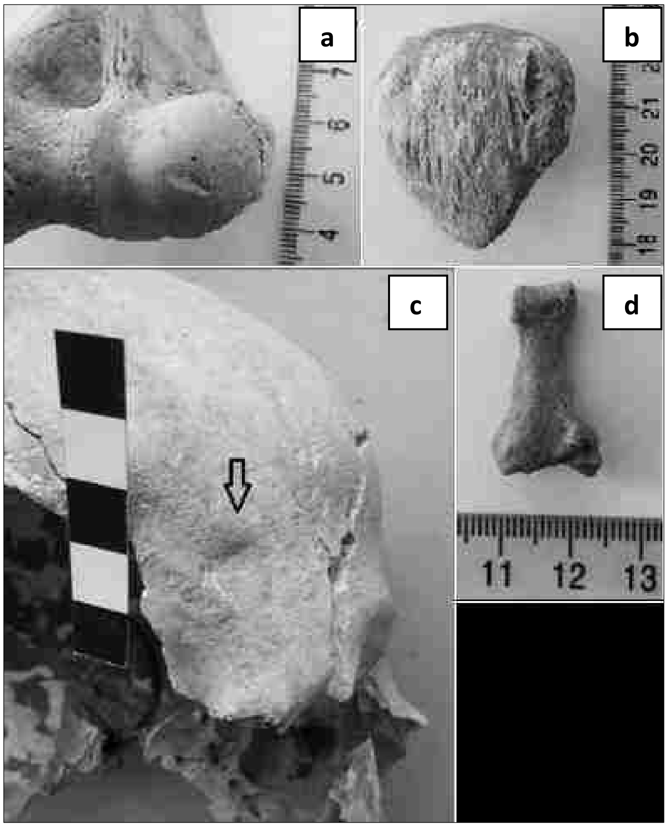


Figure 140. Traumatic lesions observed on the skeleton of a mature male from Svodín (H93). a – depression fracture on the capitulum of the distal humerus; b – defect on the patella; c – blunt-force trauma on the right frontal bone; d – fracture of a foot phalanx.

Figure 141. Lesions observed on the skeleton of a mature male from Svodín (H10). a – thickening of compact bone of the ulna; b – rib fracture; c – bone formation on vertebral bodies; d – healed fracture of the fifth metacarpal, e – fractures of foot phalanges; f, g – thickening of compact bone of the femur.

Figure 142. Perimortem trauma on the occipital of a young Chalcolithic female from Kněževes (767).

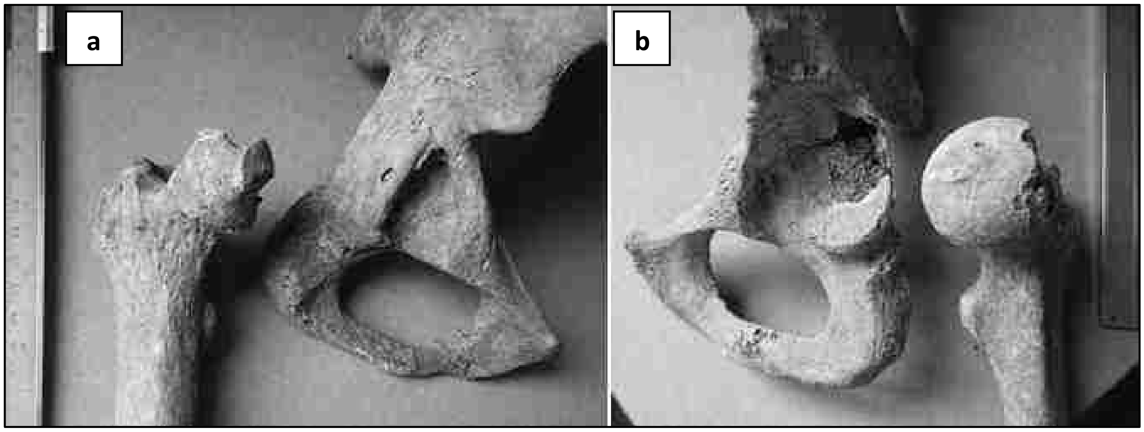


Figure 143. Hip dislocation including avascular necrosis of the femoral head observed in a male from Hulín (H66) aged 25-35 years. a – dislocated right joint; b – left joint.

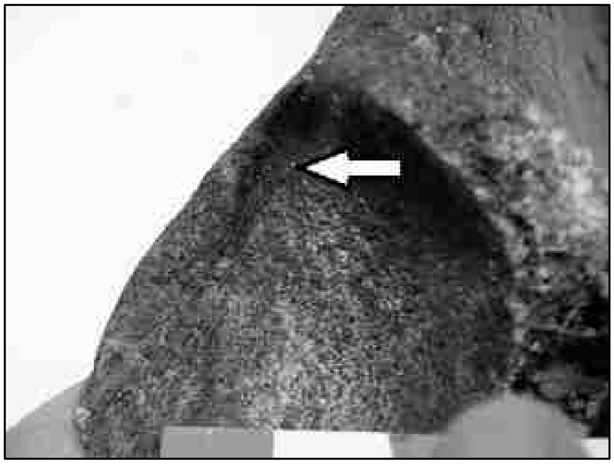


Figure 144. Perimortem perforation or a cut trauma to the superior acetabulum of a female from Praha – Malá Ohrada (8768) aged 25-35 years.

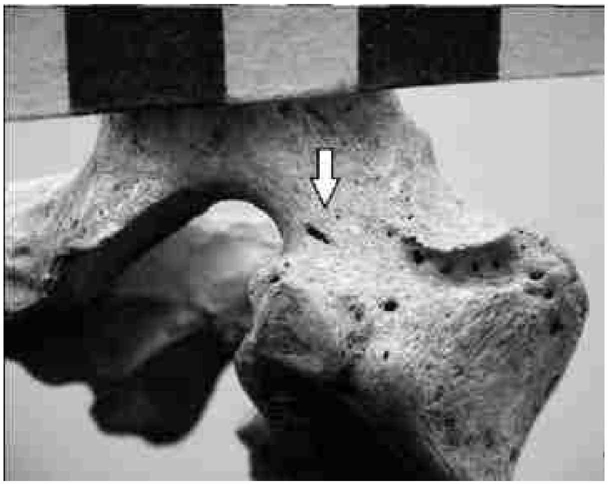


Figure 145. Perimortem trauma on the thoracic vertebra of a mature male from Nižná Myšľa (H215), possibly caused by an arrow.

Table 67. List of photographs with the examples of occupational tooth wear.

NEO	Svodín	H77
	Svodín	H159
	Svodín	H164
CHAL	Hulín	H66
	Stehelčeves	3839
EBA	Nižná Myšľa	H67
	Nižná Myšľa	H111
	Nižná Myšľa	H121
	Nižná Myšľa	H215
	Nižná Myšľa	H262
	Nižná Myšľa	H306
	Praha-Malá Ohrada	8772

Table 68. List of photographs with the examples of periodontal disease.

NEO	Svodín	H6
	Svodín	H41
	Svodín	H77
	Svodín	H93
	Svodín	H169
	Svodín	H174
CHAL	Kněževes	772B
	Kněževes	1169
	Lochenice	8383
	Lochenice	8400
	Lochenice	8404
	Tišice	634
	Želešice	8340
EBA	Nižná Myšľa	H213A
	Nižná Myšľa	H279

Table 69. List of photographs with the examples of non-specific stress indicators.

Periostitis	**NEO**	Svodín	H77
		Svodín	H163
		Svodín	H164
	CHAL	Kněževes	H772A
		Kněževes	H766
	EBA	Klučov	1154
		Nižná Myšľa	H35
		Nižná Myšľa	H53
		Nižná Myšľa	H80
		Nižná Myšľa	H234
		Praha-Malá Ohrada	8783B
		Praha-Podhoří	7892
Porotic hyperostosis	**NEO**	Svodín	H169
		Svodín	H174
	EBA	Nižná Myšľa	H31
		Stekník	2422

Table 70. List of photographs showing individuals with evidence of metabolic diseases.

Rickets	**NEO**	Svodín	H172
	CHAL	Brandýsek	1625
		Březno-Louny	7012
Scurvy	**NEO**	Svodín	H3
		Svodín	H27
		Svodín	H113
	EBA	Čičovice	9318 (subadult)
		Nižná Myšľa	H39
		Nižná Myšľa	H75
		Nižná Myšľa	H136
		Nižná Myšľa	H253
		Nižná Myšľa	H290

Table 71. List of photographs with the examples of joint diseases.

Extra-spinal OA	**NEO**	Svodín	H41
		Svodín	H83
	CHAL	Lochenice	8383
		Lochenice	8400
	EBA	Nižná Myšľa	H19
		Nižná Myšľa	H279
		Praha-Čimice	7437

Table 72. List of photographs of trauma in the Neolithic.

Site	Context	Trauma
Svodín	H10	AM fractured metacarpal
		AM fractured rib
		PeM fractured femur with signs of a systemic condition
		PeM fractured ulna with signs of infection - detail
		PeM fractured ulna with bone thickening
Svodín	H27	Healed shaft of the fibula
		Healed shaft of the fibula - detail. Distal end on the left
Svodín	H41	AM fracture of distal humerus (anterior view)
		AM fracture of distal humerus (posterior view)
		AM fractured distal ulna
		Healed blunt-force trauma to the cranium
		Pseudojoint of distal fibula
Svodín	H83	Compression fractures of thoracic vertebrae
Svodín	H93	AM blunt-force trauma on the capitulum of the left humerus - detail
		AM blunt-force trauma on the capitulum of the left humerus
		AM blunt-force trauma on the left side of the frontal bone
		Healed fracture of a foot phalanx
Svodín	H107	Healed avulsion of the left 3rd metacarpal
Svodín	H113	Healed fracture of the left humerus
Svodín	H125	Healed blunt-force trauma on the left side of the frontal bone
		PeM fractured femur (a)
		PeM fractured femur (b)
		PeM fractured shin (a)
		PeM fractured shin (b)
		PeM fractured tibia (c)
Svodín	H182	Healed rib fracture
Svodín	H183	Healed blunt-force trauma(s) on the cranium

Table 73. List of photographs of trauma in the Chalcolithic.

Site	Context	Trauma
Březno-Louny	7012	Healed fracture of the clavicle
Hulín	H66	Comparison of the left (a) and right (b) femoral heads
		Left hip joint
		Right hip joint
		Left os coxa with enlarged acetabulum (arrow)
		Right femoral head with signs of bone necrosis - anterior view
		Right femoral head with signs of bone necrosis - posterior view
		Right os coxa with the signs of hip dislocation. Arrow points to the acetabulum
Kněževes	766	PeM sharp-tool injury on the 1st metatarsal - detail
		PeM sharp-tool injury on the 1st metatarsal
Kněževes	767	PeM fracture of the occipital - inner table
		PeM fracture of the occipital - outer table
Kněževes	772A	AM fracture of the proximal femur
Malé Březno	8880	Healed fracture of the humerus - anterior view
		Healed fracture of the humerus - lateral view
		Healed fracture of the humerus - superior view
		Healed fracture of the ribs
Mochov	4070	PeM fractured skull - inner table
		PeM fractured skull - outer table
Plotiště	6100	Bone formation at the spinal canal
		Healed fracture of distal fibula
		Healed fracture of distal ulna - detail 1
		Healed fracture of distal ulna - detail 2
		Healed fracture of distal ulna - detail 3, inferior view
		Healed fracture of distal ulna
		Healed fracture of the metacarpal
Stehelčeves	3840	OD proximal radius
		OD tibia
Sulejovice	1820	Healed metacarpal fracture
		Perimortem fracture of the left distal ulna
Tišice	633	PeM blunt-force injury on the left parietal - detail
		PeM blunt-force injury on the left parietal
Tišice	634	AM blunt-force trauma on the cranium - inferior-posterior view
		AM blunt-force trauma on the cranium - inner table
		AM blunt-force trauma on the cranium - lateral view
Žabovřesky	2293	Healed fracture of the clavicle - medial end is on the left
Želešice	8340	AM fracture of the scapula - inferior view
		AM fracture of the scapula - lateral view
		AM fracture of the scapula - superior view
		PeM cutmark on the capitulum of the humerus - detail
		Perimortem cutmark on the capitulum of the humerus

Table 74. List of photographs of trauma in the Early Bronze Age.

Site	Context	Trauma
Čičovice	9318	AM fracture of the left scapula - anterior view, detail
		AM fracture of the left scapula - anterior view
		AM fracture of the left scapula - posterior view, detail
		AM fracture of the left scapula - posterior view
Nižná Myšľa	H6	AM fracture of the right tibial plateau - anterior view
		AM fracture of the right tibial plateau - comparison with the left bone
		AM fracture of the right tibial plateau - superior view detail a
		AM fracture of the right tibial plateau - superior view detail b
		AM fracture of the right tibial plateau - superior view
Nižná Myšľa	H34(35)	AM fracture of the acetabulum - detail with periostitis (superior is up)
		AM fracture of the superior acetabulum
Nižná Myšľa	H53	AM sharp-tool trauma to the face - detail
		AM sharp-tool trauma to the facial area
		Healed fracture of the hand phalanx - inferior view
		Healed fracture of the hand phalanx - lateral view
		Healed minor fracture of distal humerus - anterior view
		Healed minor fracture of distal humerus - detail
		Healed minor fracture of distal humerus - lateral view
		Healed minor fracture of distal humerus - posterior view
Nižná Myšľa	H67	Healed rib fracture - inferior view
		Healed rib fracture - lateral view
		Healed rib fracture - superior view
		Healed rib fracture - view from visceral side
Nižná Myšľa	H71	PeM cutmark on the lumbar vertebra
Nižná Myšľa	H82	PeM fractured capitulum of the distal humerus
Nižná Myšľa	H94	PeM fracture of the anterior atlas
Nižná Myšľa	H121	PeM fracture of the skull - anterior view
		PeM fracture of the skull - lateral view
		PeM fracture of the skull - superior view
		PeM fractured mandibular ramus
Nižná Myšľa	H141	PeM fractured long bones (a)
		PeM fractured long bones (b)
Nižná Myšľa	H143	Healed fracture of the metatarsal - lateral view
Nižná Myšľa	H148	Healed blunt-force trauma on the skull
		Healed blunt-force trauma on the skull - detail
Nižná Myšľa	H200	OD right talus
Nižná Myšľa	H213A	AM fracture of the acetabular margin - anterio-lateral view
		AM fracture of the acetabular margin - lateral view
		Healed fracture of the femoral shaft - anterior view
		Healed fracture of the femoral shaft - medial view
		Healed fracture of the femoral shaft - posterior view
Nižná Myšľa	H215	AM trauma to the vertebral body

		Healed fracture of a rib PeM trauma to the right maxilla
Nižná Myšľa	H253	Healed rib fracture
Nižná Myšľa	H257	PeM fractured shaft of the fibula
Nižná Myšľa	H262	PeM fracture of the anterior vertebral body - anterior view PeM fracture of the anterior vertebral body - lateral view
Nižná Myšľa	H273	AM fracture of distal humerus - anterio-lateral view AM fracture of distal humerus - anterior view Dislocation-related changes on the radius Dislocation-related changes on the ulna.
Nižná Myšľa	H279	PeM fractured right parietal bone
Nižná Myšľa	H290	OD 1st foot phalanx OD 1st metatarsal
Nižná Myšľa	H299	AM fractured distal epiphysis of the humerus
Nižná Myšľa	H310	AM fracture of the vertebra - posterior view AM fracture of the vertebra - superior -posterior view AM fracture of the vertebra - superior view
Praha-Libeň	2298	AM healed rib - inferior view AM healed rib - superior view
Praha-Malá Ohrada	8750	AM fracture of the proximal humerus - detail AM fracture of the proximal humerus Healed rib fracture
Praha-Malá Ohrada	8751	AM bone formation on the lunate AM fracture of the hand phalanx - prone position AM fracture of the hand phalanx - supine position AM trauma at the proximal metacarpals AM trauma to the distal radius - detail AM trauma to the distal radius
Praha-Malá Ohrada	8752	AM fracture of 1st foot phalanx Healed 5th metatarsal fracture - inferior view Healed 5th metatarsal fracture - lateral view Healed 5th metatarsal fracture - medial view Healed 5th metatarsal fracture - superior view Healed fracture of the shaft of the fibula - lateral view Healed fracture of the shaft of the fibula - medial view PeM fracture of the 1st metatarsal PeM fracture of the humerus - anterior view PeM fracture of the humerus - medial view PeM fracture of the humerus - posterior view PeM fracture of the right coronoid process of the mandible - superior view PeM fracture of the right cranium PeM fractured forearm
Praha-Malá Ohrada	8759	PeM blunt-force trauma on the skull PeM blunt-force trauma to the skull - inner table PeM fractured humeral shaft - detail

(Table 74 continued).

		PeM fractured humeral shaft - proximal is right
		PeM fractured maxilla
		PeM traumas on the skull
Praha-Malá Ohrada	8763	Healed clavicle fracture - inferior view
		Healed clavicle fracture - posterior view
		Healed clavicle fracture - superior view
		OD femur
		PeM cutmark on the thoracic vertebra
		PeM fracture of tibial shaft - detail
		PeM fracture of tibial shaft
Praha-Malá Ohrada	8768	AM trauma to the posterior acetabulum
		Healed fracture of the clavicle - inferior view
		Healed fracture of the clavicle - superior view
Praha-Malá Ohrada	8778	PeM fractured jaws and a tooth
		PeM fractured left parietal - inner table
		PeM fractured left parietal - outer table
		PeM fractured left parietal
Praha-Malá Ohrada	8781	AM compression fracture of the vertebra - inferior view
		AM compression fracture of the vertebra - lateral view
		AM compression fracture of the vertebra - superior view
		AM fracture of the upper acetabular margin
		Healed avulsion of medial condyle of the humerus
		Healed blunt-force trauma on the occipital bone
		Healed rib fracture - superior view
		Healed rib fracture - visceral side
		Location of the fractured vertebra
		OD distal femur
Praha-Malá Ohrada	8783A	AM fracture of the lateral end of the clavicle
		AM fracture of the rib - anterior view
		AM fracture of the rib - visceral side detail
		AM fracture of the rib - visceral side
		PeM cutmark of the humeral head
		Possible AM trauma of the ilium - detail (a)
		Possible AM trauma of the ilium - detail (b)
		Possible AM trauma of the ilium
Praha-Malá Ohrada	8783B	AM cutmark on the rib
Praha-Malá Ohrada	8783C	Healed blunt-force trauma on the top of the skull and the depressed area (arrows)
		Healed blunt-force trauma on the top of the skull -lateral view
		Posterio-inferior margin of the trepanation
		Probably a healed trepanation (a) and a blunt-force trauma (b) - superior view
		Probably a healed trepanation (a) and a blunt-force trauma (b)
		Probably a healed trepanation (a) and possibly another blunt-force trauma (b)
		Probably a healed trepanation, posterior is right - inner table
		Probably a healed trepanation, posterior margin

(Table 74 continued).

		Superior anterior margin of the trepanation
Praha-Malá Ohrada	8792	Healed fracture of the clavicle - anterior view
		Healed fracture of the clavicle - inferior view
		Healed fracture of the clavicle - posterior view
		Healed fracture of the clavicle - superior view
		Healed fracture of the clavicle
		Healed fracture of the rib - superior view
		Healed fracture of the rib
		PeM fractured skull
		Rib-shaft with an embedded arrowhead
Praha-Malá Ohrada	8794	AM fracture of the shaft of the radius - medial view
		AM fracture of the shaft of the radius - detail
Stekník	2422	AM trauma of the rib
Vraný	1006	AM false joint sternum
		PeM fractured scapulae
		PeM fractured skull
Vraný	1589	PeM fracture of the mandible
		PeM fracture of the skull

(Table 74 continued).

Table 75. List of photographs of developmental anomalies.

Pigeon chest	**NEO**	Svodín	H18
		Svodín	H184A
	EBA	Nižná Myšľa	H306
Plagiocephalism	**NEO**	Svodín	H41
	CHAL	Bradýsek	1674
		Bradýsek	1677
Hypoplasia of femoral necks	**NEO**	Svodín	H164
	EBA	Nižná Myšľa	H136
		Nižná Myšľa	H82
Nasal cleft	**NEO**	Svodín	H176
Crowded teeth	**NEO**	Svodín	H184A
	EBA	Nižná Myšľa	H195
		Nižná Myšľa	H215
Rotated teeth	**NEO**	Svodín	H184A
Cervical rib	**EBA**	Nižná Myšľa	H84
Additional tooth cusp	**CHAL**	Lochenice	7897
		Mochov	8403
	EBA	Nižná Myšľa	H214
Dental pearl	**EBA**	Nižná Myšľa	H75
Cleft of neural arch	**EBA**	Brodce	1138
Sternal cleft	**EBA**	Brodce	1138
Supracondylar process	**EBA**	Klučov	1153
Improperly fused vertebra	**EBA**	Nižná Myšľa	H253
Additional tooth	**EBA**	Nižná Myšľa	H214
Calcaneus secundarius	**EBA**	Praha-Malá Ohrada	8783B
Os trigonum	**EBA**	Vraný	1589

Appendix 8
DVD

Enclosed.