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A Bioarchaeological Study of Prehistoric Populations from the Volga Region

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Introduction

Bioarchaeological research is a valuable methodology for studying the impact that large-scale socio-political, environmental and economic processes may have had on the health and well-being of past populations (Perry 2007, 486). This chapter presents the results of a detailed osteological and paleopathological examination of a corpus of 297 Eneolithic to Late Bronze Age human skeletons from the Samara Oblast and the neighbouring oblasts of the middle Volga-Ural region.

The 297 skeletons included in the analysis were assigned to five cultural groups (see Table 2). Syntheses of previous research have indicated that, in broad terms, Eneolithic (5200-3500 BC) steppe populations were largely hunters, gatherers and fishers, but had adopted sheep and cattle herding as an adjunct to their foraging-centered economy. Much of the information from this period in the middle Volga region has derived from the cemeteries of Khvalynsk I and II. Grave goods of a variety of materials were commonly associated with the burials and, of particular note, some 286 copper objects were recovered from the approximately 43 burials of the Khvalynsk II cemetery. Animal sacrifices and red ochre were also a feature of Khvalynsk burials (Anthony 2007, 182-185). All members of society are considered to be represented in Khvalynsk cemeteries (Vasil'ev *et al*. 2000 as quoted in Popova 2009, 301).

A transition to mobile pastoralism occurred during the Early Bronze Age (3500-2700 BC). Yamnaya-culture individuals (Pit-Grave) were generally buried lying on organic mats in grave pits beneath kurgans of a diameter of 15-60 m. The central burial was usually that of an adult, frequently a male. During the Middle Bronze Age (2700-2200 BC), this mobile economy was continued. Poltavka-culture burials generally involved the body having been placed in a single chamber, with a wide step, positioned beneath a kurgan surrounded by a circular ditch. The kurgan was usually erected for an adult male, although adult female central burials are also known from this horizon.

At the end of the Middle Bronze Age, Potapovka burials (2200-1800 BC) were also made beneath kurgans. It is thought that these kurgans may have been reserved for the ruling elite and their families (Popova 2009, 310). A rich array of grave goods, which generally comprised weaponry, vehicles and animal sacrifices, have been discovered within these burials (Anthony 2007, 372, 386). The Sintashta and Potapovka cultures are generally characterized by a major increase in demand for metal and they are believed to have been largely warrior societies (Anthony 2007, 391; see also Anthony 2009 and Chernykh 2009).

The transition from the Middle Bronze Age to the Late Bronze Age Srubnaya Culture witnessed a great increase in settlement sites as the population of the region generally became more settled at the beginning of the Srubnaya period, around 1900-1700 BC. The Srubnaya, or Timber Grave, culture is characterised by more modest burials within timber-lined pits beneath kurgans. The kurgans contain the remains of numerous individuals of all ages and both sexes and grave goods generally comprise domestic items or objects of adornment (Anthony *et al*. 2005, 410; Popova 2009, 315). It is considered that the Late Bronze Age is characterised by a lack of inter-societal conflict due to the acquisition of new resources. This is believed to have resulted in a change in societial structure from one which focused on status to one which may have had an emphasis on horizontal differentiation, such as kinship (Epimakhov 2009, 87).

The key objective of the human skeletal analysis was to gain information pertaining to the health, diet and lifestyle of these populations, thereby providing a background context which might help explain the development of the Late Bronze Age populations that were central to the overall Samara River Valley Project. The distribution of disease over ecological and socio-economic landscapes has been increasingly recognised as a vital component in the understanding of the human condition, past and present (Goodman 1991, 280). So that this might be achieved for the Volga populations a biocultural approach was adopted for the current study. Using this method emphasis is placed on the role of health in the interaction between a population, their associated culture, and their local environment. The information obtained from this form of analysis can then be used to gain an understanding of the effect that diseases would have had on the lives of both the overall population and individuals within the population. Previously a detailed osteological report which included full descriptions of all lesions was produced (Murphy and Khokhlov 2004) and this chapter represents an overview of the main findings of that research. One of the main limitations of the current study is a lack of comparative data for other prehistoric Eurasian populations but it is hoped that the current study will go some way towards addressing this lacuna.

Materials

Osteological and palaeopathological analysis of the 297 individuals was undertaken by the author in June-August 1999. The skeletons had originated from approximately 34 different sites and had been retrieved during the course of some 46 different excavations (Table 1).

Site name	N individuals	% individuals	Site name	N individuals	% Individuals
Alexseevsky	1	0.3	Nikolaevka III	9	3.1
Barinovka I	21	7.1	Nizhny Orleansky I	6	2.0
Chistyar I	11	3.7	Nizhny Orleansky II	6	2.0
Ekaterinovka	3	1.0	Nizhny Orleansky IV	6	2.0
Grachyovka I	2	0.7	Nizhny Orleansky V	2	0.7
Grachyovka II	5	1.7	Nizhny Orleansky ?	1	0.3
Kalach	1	0.3	Novoorlovsky	1	0.3
Kalinovka	5	1.7	Novosiolky	8	2.7
Khvalynsk II	26	8.8	Osinsky II	1	0.3
Kinel I	4	1.4	Podlesnaya	2	0.7
Krasnosamarskoe IV	31	10.4	Poplavskoy	2	0.7
Krutyenkova	1	0.3	Potapovka I	6	2.0
Kryazh	1	0.3	Rozhdestveno I	17	5.7
Kurmanaevsky III	2	0.7	Spiridonovka II	28	9.4
Kutuluk I	4	1.4	Spiridonovka IV	26	8.8
Kutuluk II	1	0.3	Studenzy I	9	3.1
Kutuluk III	3	1.0	Svezhensky	14	4.7
Leshyovsky I	2	0.7	Tryasinovka	1	0.3
Leshyovsky ?	2	0.7	Uranbash	1	0.3
Lopatino I	8	2.7	Uren II	2	0.7
Lopatino II	4	1.4	Utyervka II	2	0.7
Murzichinsky	1	0.3	Utyervka IV	1	0.3
Nadezhdnaya	1	0.3	Utyervka VI	6	2.0

Table 1: Details of the numbers of individuals from each site included in the study.

The numbers of individuals recovered from each excavation ranged from just one (0.3%) at 13 sites to 31 (10.4%) individuals recovered from three kurgans at Krasnosamarskoe IV excavated as part of the Samara Valley Project in 1999. Full records of the excavations at the majority of sites are unavailable, however, so it is not possible to know if all individuals recovered from a single site have been included in the study. As such, detailed analysis at site level will not be undertaken. The skeletons were assigned to five chronological phases as described in Table 2.

Period	Culture	Date	N individuals	% individuals
Eneolithic	Khvalynsk	5200-3500 BC	27	9.1
Early Bronze Age	Yamnaya	3500-2700 BC	19	6.4
Middle Bronze Age	Poltavka	2700-2200 BC	41	13.8
Middle Bronze Age	Potapovka	2200-1900/1800 BC	18	6.1
Late Bronze Age	Srubnaya	1900/1800-1300/1200 BC	192	64.6

Table 2: Details of the number of individuals from each period included in the study.

It is clear that the Srubnaya corpus of individuals was substantially larger than all of the other assemblages, representing 64.6% (192/297) of the individuals available for study. The remaining five corpuses were relatively small and ranged in size from 18 individuals (6.1%) for the Potapovka culture to 41 (13.8%) for the Poltavka group. The variations in sample size make comparison between the different population groups difficult and it is often not possible to be certain if trends are genuine or are simply a reflection of the small sample sizes of the earlier populations. In many cases the results derived from the smaller assemblages, however, were found to mirror those obtained from the analysis of the substantial Srubnaya corpus of material.

Methods

All skeletons were curated by Dr. Alexander Khokhlov in the Physical Anthropology Laboratory of the Institute for the History and Archaeology of the Volga, Samara. The cranial and post-cranial remains of the majority of individuals were not curated together and it was often necessary to analyse these two components of the body separately and then amalgamate the data at a later date. The sex, age-at-death, and basic post-cranial metrics were recorded for all adult individuals in the corpus. The only osteological feature of the non-adults to be methodically determined was the age-at-death. If an individual displayed an unusual or a prominent non-metric trait this was also recorded. All individuals were subjected to a rigorous macroscopic palaeopathological examination of both skeletal and dental remains. Cultural modifications, such as discoloration due to the association with metal artefacts or ochre, or cut marks due to secondary burial practices, were also recorded for all individuals. At the request of Dr. Khokhlov, the palaeopathological analysis of the Eneolithic Khvalynsk II individuals was restricted to the study of metabolic diseases and dental palaeopathology.

Sex was determined on the basis of a morphological analysis of the pelvis and skull following the recommendations of Ferembach *et al*. (1980) and Buikstra and Ubelaker (1994). In cases where neither the skull nor pelvis was present an attempt was made to determine sex using metrical data obtained from the long bones (Pearson 1917-1919; Stewart 1979; Krogman and Işcan 1986; Berrizbeita 1989).

The age-at-death of non-adults was determined from the state of epiphyseal fusion (Ferembach *et al*. 1980, 530-531; Brothwell 1981, 66), the diaphyseal lengths of the long bones, dental eruption (Ubelaker 1989, 64, 70-71) and dental calcification (Moorrees *et al*. 1963; Smith 1991, 161). It is thought that the tooth calcification method is the most accurate of the non-adult ageing techniques and most weight was given to the values derived from this method (Ferembach *et al*. 1980, 530). Age-at-death estimates for fetal and perinatal infants were determined using the linear regression equations of Scheuer *et al*. (1980). Each non-adult was allocated to one of the following age categories – Infant (< 2 years), Child (2-6 years), Juvenile (6-12 years) and Adolescent (12-18 years). Adult age-at-death estimates were largely determined from an examination of the morphology of the pubic symphysis (Brooks and Suchey 1990), the auricular surface (Lovejoy *et al*. 1985) and the sternal rib ends (Işcan *et al*. 1984; 1985). In cases where these bones were not present age-at-death was determined on the basis of the state of dental attrition (Brothwell 1981, 71). For younger adults the state of fusion of the sternal ends of the clavicles and the first and second sacral vertebrae was also observed in addition to an assessment of the state of eruption of the third molars (McKern 1970). Each adult was assigned to one of the following age categories – 18-35 years (young adult), 35-50 years (middle adult) and 50+ years (old adult). Khokhlov's age categories (this volume) were defined differently.

The research of Trotter and Gleser (1958, 121) has indicated significant differences between the relationship of stature to bone length between Europeans, Asians and Blacks. They considered the differences significant enough to warrant the development of different regression equations for each of the three major races. The application of inappropriate stature equations has been demonstrated to have the potential to over or under-estimate living stature (Feldesman and Fountain 1996). Since the population groups from the Volga region may have included some Asians after the Middle Bronze Age, the estimation of stature could be problematic (see Khokhlov, this volume). Krogman and Işcan (1986, 302-51) have demonstrated that the maximum length of the femur is related to living stature more closely than the maximum lengths of any of the other long bones. As such, the maximum length of the femur was used as a means of assessing growth for the Volga population groups (cf. Buzon and Judd 2008, 95).

When discussing the palaeopathological lesions the prevalence rates are reported based on the number of individuals with the appropriate element present as well as on the actual number of bone elements present. More weight is placed on the latter figures since they are considered to provide the most accurate prevalence rates. In instances where different types of lesions were amalgamated for the purposes of revealing general trends, crude prevalence rates based on the total number of individuals in each population group are used.

Results and Discussion

In the following sections the results of the osteological and palaeopathological analyses will be presented as a series of themes. This approach is considered to have the most potential to provide information on different social and cultural aspects of the populations through time.

Population profiles Details of the age and sex profiles of the dataset utilised for the palaeopathological study are provided in Table 3.

Culture	Adult			Non-adult
	Total	**Male**	**Female**	**Total**
Khvalynsk	92.6 (25/27)	80.0 (20/25)	20.0 (5/25)	7.4 (2/27)
Yamnaya	84.2 (16/19)	75.0 (12/16)	25.0 (4/16)	15.8 (3/19)
Poltavka	82.9 (34/41)	85.3 (29/34)	14.7 (5/34)	17.1 (7/41)
Potapovka	77.8 (14/18)	78.6 (11/14)	21.4 (3/14)	22.2 (4/18)
Srubnaya	67.2 (129/192)	52.3 (67/128)	47.7 (61/128)	32.8 (63/128)

Table 3: Details of the breakdown of adults and non-adults in the dataset included in the current study. Note that it was not possible to determine the sex of one of the Srubnaya adults.

It is clear that non-adults and adult females are generally under-represented in the dataset. Khokhlov's analysis (this volume) of 1350 individuals from the region revealed a different set of trends and, since his analysis has been based on a more representative sample, no further comment will be made concerning the palaeodemographic characteristics of the 297 individuals included in the current study.

Developmental defects

Axial skeleton

Developmental defects of the axial skeleton – skull, vertebral column, ribs and sternum – were recorded following the morphogenic approach advocated by Barnes (1994). Using this approach each defect can be traced and described as a consequence of disturbances which occurred during morphogenesis in the specific embryonic developmental fields (Barnes 1994, 3). Developmental malformations can arise from genetic or chromosomal abnormalities, as a consequence of environmental disturbances, such as maternal disease (e.g. diabetes mellitus or infection) or, in some instances, by the occurrence of rogue genes which only manifest themselves in particular environmental conditions (Potter and Craig 1975, 168).

It is usually the case that the majority of developmental disturbances evident in the skeleton are inherited defects (Potter and Craig 1975, 552). As such, similar patterns of developmental defects among skeletal populations from different sites may be an indication of population homogeneity, while dissimilar patterns of defects are suggestive of the occurrence of different gene pools (Barnes 1994, 5). The detailed recording of developmental defects is therefore of great importance for gaining an understanding of the genetic trends of a particular population. This in turn has significance for the study of past migration as well as kinship and marriage patterns (Barnes 2008, 331).

Some 81 different developmental defects of the axial skeletons were recorded in 64 individuals from the Yamnaya to Srubnaya populations. The majority of defects had affected the blastemal desmocranium (53.1%; 43/81) and paraxial mesoderm fields (39.5%; 32/81), with the sternal (6.2%; 5/81) and first branchial arch (1.2%; 1/81) developmental fields having only been sporadically affected. A summary of the crude prevalence rates of individuals to display developmental defects of the different fields is provided in Figure 1.

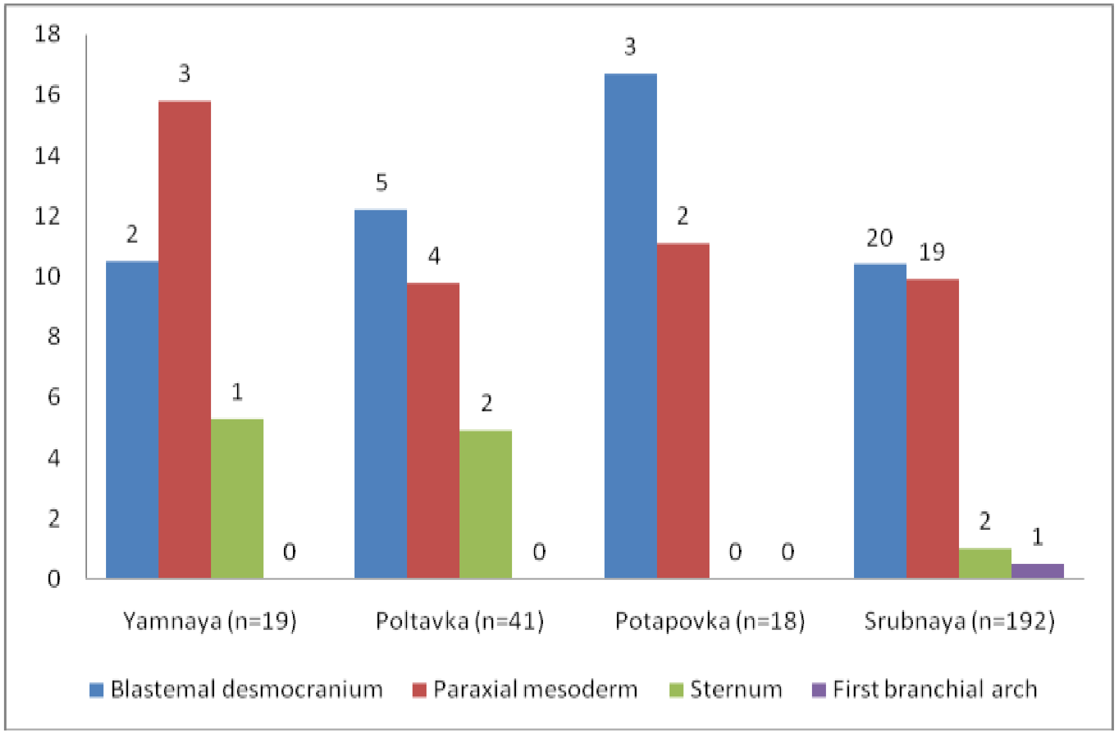

Figure 1: Crude prevalence rates (%) based on the numbers of affected individuals for developmental defects in the different fields for the Yamnaya to Srubnaya populations (adult and non-adult). The Khvalynsk population group was not included in the analysis.

The preponderance of defects of the blastemal desmocranium or paraxial mesoderm appears to have been a common trait amongst all Yamnaya to Srubnaya population groups. The small sample sizes of the earlier groups make it difficult to be certain that the results are reflecting genuine trends. Since this trend was clearly apparent for the larger Srubnaya population, however, the validity of the results is possible.

Blastemal desmocranium

The blastemal desmocranium is responsible for the development of the calvarium – the frontal, the parietals, the interparietal of the occipital, the squamosa of the temporals, the greater wings of the sphenoid, and the lamina of the pterygoid processes (Barnes 1994, 14). Some 33 individuals of the Khvalynsk to Srubnaya cultures displayed a total of 43 various developmental defects of the blastemal desmocranium (Table 4).

Culture	Site	Context	Age	Sex	Lesion	Adult prevalence by bone
Khvalynsk	Khvalynsk II	G 22	35-50	M	retention of the mendosa suture	4.3% (1/23)
Khvalynsk	Khvalynsk II	G 24	18-35	M	multiple interparietal bones	4.3% (1/23)
Khvalynsk	Khvalynsk II	G 25	7-9	-	obelion bone	-
Yamnaya	Kutuluk I	K3 G4	35-50	M	metopic suture	11.1% (1/9)
Yamnaya	Lopatino II	K3 G1	15-17	M	metopic suture	-
Yamnaya	Lopatino II	K3 G1	15-17	M	multiple interparietal bones	-
Poltavka	Krasnosamarskoe IV	K1 G3	18-35	F	metopic suture	5.0% (1/20)
Poltavka	Krasnosamarskoe IV	K3 G8	35-50	M	ossicle at lambda	11.1% (2/18)
Poltavka	Lopatino I	K30 G2	35-50	M	ossicle at lambda multiple interparietal bones	11.1% (2/18) 11.1% (2/18)
Poltavka	Nikolaevka III	K1 G3	35-50	M	multiple interparietal bones	11.1% (2/18)
Poltavka	Nikolaevka III	K3 G1	6-8	-	multiple interparietal bones	-
Potapovka	Grachyovka II	K3 G9a	50+	F	multiple interparietal bones	25.0% (3/12)
Potapovka	Utyevka VI	K6 G1	35-50	F	metopic suture multiple interparietal bones	16.7% (2/12) 25.0% (3/12)
Potapovka	Utyevka VI	K6 G5 Sk2	18-35	M	metopic suture retention of the mendosa suture multiple interparietal bones	16.7% (2/12) 8.3% (1/12) 25.0% (3/12)

Srubnaya	Barinovka I	K2 G41	18-35	M	retention of the mendosa suture multiple interparietal bones	11.6% (1/86) 12.8% (11/86)
Srubnaya	Chistyar I	K1 G2	35-50	F	metopic suture ossicle at lambda	4.5% (4/89) 5.8% (5/86)
Srubnaya	Kinel I	K5 G2	18-35	F	coronal suture ossicles multiple interparietal bones	1.1% (1/88) 12.8% (11/86)
Srubnaya	Krasnosamarskoe IV	K3 G1	18-35	F	metopic suture	4.5% (4/89)
Srubnaya	Krasnosamarskoe IV	K3 G14	15-17	M	multiple interparietal bones	12.8% (11/86)
Srubnaya	Krasnosamarskoe IV	K3 G17	35-50	M	lambdoid suture ossicles	1.2% (1/86)
Srubnaya	Nizhny Orleansky I	K13 G1	35-50	M	metopic suture multiple interparietal bones	4.5% (4/89) 12.8% (11/86)
Srubnaya	Nizhny Orleansky II	K4 G14	5-7	-	ossicle at lambda	5.8% (5/86)
Srubnaya	Nizhny Orleansky ?	K1 G7	18-35	M	multiple interparietal bones	12.8% (11/86)
Srubnaya	Novoorlovsky	K4 G1	18-35	M	multiple interparietal bones	12.8% (11/86)
Srubnaya	Poplavskoy	K1	18-35	F	premature fusion of sagittal suture	1.1% (1/88)
Srubnaya	Poplavskoy	K2	50+	M	ossicle at lambda	5.8% (5/86)
Srubnaya	Rozhdestveno I	K5 G11	18-35	F	ossicles at asterions	1.2% (1/86)
Srubnaya	Spiridonovka II	K10 G3	18-35	F	multiple interparietal bones	12.8% (11/86)
Srubnaya	Spiridonovka II	K11 G6	18-35	F	multiple interparietal bones	12.8% (11/86)
Srubnaya	Spiridonovka IV	K2 G13	18-35	F	ossicle at lambda multiple interparietal bones	5.8% (5/86) 12.8% (11/86)
Srubnaya	Studenzy I	K2 G3	18-35	F	ossicle at lambda	5.8% (5/86)
Srubnaya	Svezhensky	G73	35-50	F	multiple interparietal bones	12.8% (11/86)
Srubnaya	Svezhensky	Sk 74	6-7	-	multiple interparietal bones	12.8% (11/86)
Srubnaya	Svezhensky	G77	50+	F	metopic suture	4.5% (4/89)

Table 4: Details of individuals with defects of the blastemal desmocranium developmental field.

Nine different defects were evident, the most common of which were multiple interparietal bones (44.2%; 19/43), metopic sutures

(20.9%; 9/43), the presence of a solitary ossicle at the lambda (16.3%; 7/43) and the retention of the mendosa suture (7%; 3/43) – all of which were caused by the failure of the elements to coalesce. Multiple interparietal bones can arise along any parts of its border as they fail to coalesce and they are thought to be associated with retention of the mendosa suture (Barnes 1994, 143). All five of the populations had individuals with multiple interparietal bones. Again, the small sample sizes of the earlier groups hinders the analysis since it is not possible to reliably compare the frequencies of the lesions for the purposes of gaining insights about the gene pools in operation. Retention of the metopic suture arises as a result of developmental delay in the precursors of the frontal bone during the blastemal stage (Barnes 1994, 148). Metopism was observed among the Yamnaya, Poltavka, Potapovka and Srubnaya population groups. Research has indicated that in some cases metopism is hereditary, while in other instances it occurs sporadically (Torgersen 1951, 204). The presence of two Potapovka individuals from Kurgan 6 at Utyevka VI with both multiple interparietal bones and metopic sutures might provide a tantalising glimpse of familial relatedness at that site.

A number of the less frequent defects of the blastemal desmocranium are worthy of comment. Skeleton G25, a 7-9 year old juvenile from the Khvalynsk II cemetery, displayed an obelion bone in the posterior aspect of the sagittal suture. The ossicle is associated with the fetal sagittal fontanelle, which normally closes prior to birth, and is considered to be a relatively rare occurrence (Barnes 1994, 139, 142). Skeleton K5 G2, an 18-35 year old Srubnaya female recovered from the Kinel I burial ground, displayed two accessory ossicles in the right side of the coronal suture. The individual also displayed multiple interparietal bones as well as defects of the paraxial mesoderm developmental field.

The only field defect of the blastemal desmocranium present among the populations that was not due to a failure of the elements to coalesce was a case of sutural agenesis which is due to a failure of the elements to differentiate. If opposing cranial bone precursors fail to differentiate they become partially or completely coalesced into a single bone, and the suture between them fails to develop (Barnes 1994, 152). Sutural agenesis can occur within family groups, thereby indicating a genetic relationship, but external factors, such as birth trauma and metabolic disorders, can also result in craniosynostosis (Barnes 1994, 152). The posterior aspect of the sagittal suture in Skeleton K1 retrieved from the Srubnaya Culture Poplavskoy burial ground had been completely obliterated. The individual was an 18-35 year old female and the remainder of her sutures were clear and unfused. Unfortunately, only the skull of the individual was available for analysis and it is not possible to ascertain if the premature suture fusion had occurred as a result of a developmental or external factor.

<u>Paraxial mesoderm</u>

The paraxial mesoderm results in the production of the vertebral column, the ribs, the exoccipitals (lateral sections of the base of the occipital containing the condyles) and the supraoccipital (Barnes 1994, 13). A total of 28 individuals of Yamnaya to Srubnaya culture date displayed some 32 defects of the paraxial mesoderm developmental field (Table 5). The overwhelming majority of defects involved clefting or bifurcation of the sacral neural arches and a bifurcated LV5 was also evident (65.6%; 21/32). Sacralisation was the next most frequent lesion (18.8%; 6/32), followed by the occurrence of block vertebrae (6.3%; 2/32) and supernumerary vertebrae (6.2%; 2/32). A single individual displayed a rib defect (3.1%; 1/32).

Culture	Site	Context	Age	Sex	Lesion	Adult prevalence by bone
Yamnaya	Leshyovsky I	Flat grave 5	18-35	M	cleft neural arch (S)	33.3% (3/9)
Yamnaya	Nizhny Orleansky I	K1 G5	35-50	M	bifurcated neural arch (S)	33.3% (3/9)
Yamnaya	Nizhny Orleansky I	K4 G2	18-35	M	cleft neural arch (S)	33.3% (3/9)
Poltavka	Kalinovka	K1 G4	50+	M	bifurcated neural arch (S)	25.0% (3/12)
Poltavka	Kryazh	K2 G1	18-35	M	cleft neural arch (S)	25.0% (3/12)
Poltavka	Nizhny Orleansky I	K1 G4	35-50	M	bifurcated & cleft neural arches (S)	25.0% (3/12)
Poltavka	Lopatino I	K33	18-35	M	block vertebra (CV7/TV1) (Type II Klippel Feil Syndrome)	12.5% (1/8)

Potapovka	Lopatino II	K1 G1 Sk2	18-35	M	cleft neural arch (S)	20.0% (1/5)
Potapovka	Utyevka VI	K6 G6	18-35	M	irregular segmentation of a rib	-
Srubnaya	Chistyar I	K1 G2	35-50	F	bifurcated (LV5) cleft neural arch (S) sacralisation	2.8% (1/36) 28.3% (13/46) 13.0% (6/46)
Srubnaya	Ekaterinovka	K2 G1	18-35	M	bifurcated & cleft neural arches (S)	28.3% (13/46)
Srubnaya	Kinel I	K5 G2	18-35	F	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Nadezhdnaya	G9	18-35	M	bifurcated neural arch (S)	28.3% (13/46)
Srubnaya	Nizhny Orleansky I	K1 G8	18-35	F	bifurcated neural arch (S) sacralisation	28.3% (13/46) 13.0% (6/46)
Srubnaya	Rozhdestveno I	K5 G10	35-50	M	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Spiridonovka II	K1 G10	18-35	M	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Spiridonovka II	K10 G7	18-35	M	bifurcated neural arch (S)	28.3% (13/46)
Srubnaya	Spiridonovka II	K14 G10	18-35	F	sacralisation	13.0% (6/46)
Srubnaya	Spiriodonovka IV	K1 G8	35-50	M	sacralisation	13.0% (6/46)
Srubnaya	Spiriodonovka IV	K1 G6	18-35	F	Six lumbar vertebrae	6.9% (2/29)
Srubnaya	Spiridonovka IV	K1 G10	35-50	F	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Spiridonovka IV	K1 G13	35-50	M	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Spiridonovka IV	K2 G1a	35-50	F	block vertebra (CV2/3)	5.3% (1/19)
Srubnaya	Spiridonovka IV	K2 G12	50+	M	sacralisation	13.0% (6/46)
Srubnaya	Studenzy I	K1 G2	18-35	M	sacralisation Six lumbar vertebrae	13.0% (6/46) 6.9% (2/29)
Srubnaya	Svezhensky	G71a	18-35	M	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Svezhensky	G71b	35-50	M	cleft neural arch (S)	28.3% (13/46)
Srubnaya	Uren II	K2 G2	50+	F	cleft neural arch (S)	28.3% (13/46)

Table 5: Details of individuals with defects of the paraxial mesoderm developmental field (CV = cervical vertebra, TV = thoracic vertebra, LV = lumbar vertebra, S = sacrum).

If developmental delay results in hypoplasia or aplasia of either or both parts of the precursors of the pedicles, laminae or spinous process it can result in the failure of the two halves of the vertebrae to coalesce, and the formation of a bifid or cleft neural arch (Barnes 1994, 119). Bifid neural arches occur as a result of minor delay during growth, while completely cleft neural arches are caused by major delays. Clefting as a result of developmental delay is a relatively common phenomenon. In cases where the neural arch is cleft the underlying spinal cord would be exposed. Since the cleft area is bridged by cartilage or membrane, however, the lesion is clinically insignificant (Roberts and Manchester 2005, 55). Cleft neural arches are generally found in the border areas of the vertebral column, especially at the unstable lumbosacral border. The defects were observed in all of the Yamnaya to Srubnaya culture populations. Of particular interest was the occurrence of two Srubnaya individuals from Kurgan 1 at the Spiridonovka IV burial ground (G10 and G13) and a further two Srubnaya individuals with the defect at the Svezhensky burial ground (G71a and G71b). As was the case for the blastemal desmocranium field defects the presence of multiple individuals with the same developmental defects in the same burial grounds may provide evidence of relatedness.

The number of regional vertebrae can vary as a result of the shifting of differentiating features in border vertebrae. The most common sites for these shifts to occur are in the unstable occipitocervical and lumbosacral borders – in the latter instance cranial shifting results in sacralisation. The aetiology for the defect is uncertain, but it is thought to relate to a delay in the formation of the intervertebral disc space and the adjacent vertebral segments of the two bordering regions (Barnes 1994, 79-80). Studies have indicated that both cranial and caudal shifting at the lumbosacral border show variable frequencies between populations (Schmorl and Junghanns 1971, 61). All six cases of sacralisation were observed in individuals from the Srubnaya Culture (see Table 5).

Skeleton K6 G6, an 18-35 year old Potapovka male recovered from the Utyevka VI burial ground, displayed possible evidence for the irregular segmentation of a rib (Barnes 1994, 71). An oval-shaped facet, which measured 26.1 mm medio-laterally by 18 mm antero-posteriorly and had a depth of approximately 4 mm, was apparent on the superior margin of the right eighth rib at the point where the rib curves in an anterior direction. The corresponding seventh rib was not available for analysis. It is possible that the facet had been due to the partial articulation or bridging of the seventh and eighth right ribs. Only a small number of rib segmentation errors have been reported in the palaeopathological literature (Barnes 1994, 72).

Sternum

The sternebrae, part of the manubrium and the xiphoid process develop from the sternal plates (Barnes 1994, 14). A variety of defects of the sternal developmental field were evident (Table 6).

Culture	Site	Context	Age	Sex	Lesion	Adult prevalence by bone
Yamnaya	Nizhny Orleansky I	K4 G2	18-35	M	aplastic sternebra	20.0% (1/5)
Poltavka	Kalinovka	K1 G4	50+	M	cleft of sternal body	11.1% (1/9)
Poltavka	Lopatino I	K33	18-35	M	hyperplastic body (Type II mesosternum)	11.1% (1/9)
Srubnaya	Studenzy I	K1 G2	18-35	M	Fusion of xiphoid to body	6.2% (1/16)
Srubnaya	Studenzy I	K2 G4	35-50	F	Fusion of manubrio-mesosternal joint	6.2% (1/16)

Table 6: Details of individuals with defects of the sternal developmental field.

Of particular note was the occurrence of a relatively rare defect in the form of a cleft at the distal third of the body in a 50+ year old Poltavka male (K1 G4) recovered from the Kalinovka burial ground. This defect arises as a consequence of incomplete cohesion of the sternal bands. In this case, since the cleft was quite substantial, it was probably due to the complete failure of fusion of the last sternebra (Barnes 1994, 225). Another Poltavka individual, an 18-35 year old male (K33) recovered from the Lopatino I burial ground had a sternal body with an abnormally large caudal end. It is probable that delayed fusion had resulted in the development of bilateral ossification centres in the lower sternebrae. This type of mesosternum has been classed as Type II, and it is relatively common (Barnes 1994, 218). Interestingly, the individual also displayed Type II Klippel-Feil Syndrome and it is possible that the two defects were connected. Likewise, in an 18-35 year old Srubnaya male (K1 G2) recovered from the Studenzy I burial ground, the xiphoid was fused to the sternal body. This defect arises as a consequence of a failure of the fibrous lamina that separates the xiphoid process from the sternum to develop properly (Barnes 1994, 213). The individual also displayed an extra lumbar vertebra and sacralisation and again it is possible that the defects were somehow connected.

First branchial arch

The branchial arches become apparent in the embryo during the fourth week of gestation, with differentiation completed by the sixth to eighth week. The cartilage of the first branchial arch divides into two sections forming a maxillary and a mandibular part. The former develops into the maxilla and the zygomatic, the lateral area of the upper lip and cheek, and the inferior parts of the helix and the tragus of the ear (Feingold and Gellis 1968, 30).

Only a single individual in the corpus displayed a possible developmental defect of the first branchial arch. Skeleton K1 G3, an 18-35 year old Srubnaya male recovered from the Chistyar I cemetery, displayed a possible developmental fissural cyst. An oval perforation with smooth margins, which measured 8 mm antero-posteriorly by 4 mm medio-laterally, was situated immediately posterior to 4 3 2⌋. The location of the cyst would tend to suggest that it was a globulomaxillary cyst. This type of cyst generally arises at the lateral junction of the premaxilla and the maxilla between the lateral incisor and the canine (Barnes 1994, 178). Its origin is uncertain and it has been suggested that it is due either to the entrapment of epithelial tissue or derived from later odontogenic tissue (Barnes 1994, 178). The lesion had a prevalence rate of 1.2% (1/83) for the Srubnaya population.

Appendicular skeleton

Only four of the prehistoric Volga individuals displayed developmental defects of the appendicular skeleton. These comprised a single Yamnaya individual and three individuals from the Srubnaya Culture. In all four cases the lesions had affected the hips – in three cases only one joint was affected while in a single case the lesions were bilateral. All four of the individuals are likely to have suffered from gait disturbances, some of which may have been severe, and would have undoubtedly placed them at some disadvantage relative to unaffected members of their societies.

Slipped femoral capital epiphysis

An 18-35 year old adult male recovered from Flat Grave 5 of the Yamnaya Culture Leshyovsky I burial ground displayed probable slipped femoral capital epiphysis of his right femur (Plate 1). Both the right femur and acetabulum displayed extensive post-mortem damage, but the abnormalities of the hip were clearly apparent. The right femoral head had a flattened appearance with inferior displacement of the capital epiphysis so that it was positioned below the greater trochanter. It was difficult to assess the nature of the depression for the attachment of the ligamentum teres. Porosity and eburnation were visible on the head, while extensive marginal lipping was apparent, particularly at the margins of its inferior surface. The right acetabulum was hypertrophied and very shallow, and its articular surface displayed extensive porosity and eburnation. The secondary degenerative joint disease is indicative of the long-standing nature of the abnormalities.

The proximal half of the shaft of the right femur had a notably flattened antero-posterior appearance when compared to its left counterpart. This flattening was clearly apparent in the metrical analyses of the femora – the antero-posterior diameter of the midshaft of the affected right femur was 21.8 mm compared with 31.1 mm in its normal left counterpart. The midshaft medio-lateral diameters were both similar, with the right femur measuring 29 mm and the left femur having a diameter of 29.2 mm. The subtrochanteric antero-posterior diameter of the right femur was approximately 25 mm, while that for the normal left femur was 26.2 mm. The subtrochanteric medio-lateral diameters were 35.2 mm and 34.6 mm for the right and left femora respectively. The abnormal antero-posterior flattening may have been due to the abnormal gait that would have been induced by the femoral head deformities. It was not possible to ascertain the greatest length of the right femur due to post-mortem damage.

Slipped femoral capital epiphysis most typically occurs in children and adolescents, with a greater incidence among males. A number of factors have been proposed as possible aetiologies of the condition, and a link is generally accepted between it and adolescent growth spurts, as the growth plate is particularly vulnerable to shearing stresses during this period (Resnick *et al*. 1995, 2646). Associated with the adolescent growth period are the influences of a variety of sex hormones. The condition is common in adolescents who are overweight and have delayed sexual maturation. A greater amount of growth hormones relative to sex hormones are present in these individuals, and this may increase the period of time when the proximal epiphysis is vulnerable to slippage (Gruebel Lee 1983, 176). In some families there may be a notable history of slipped epiphysis, and the condition has been observed in monozygotic twins (Resnick *et al*. 1995, 2646).

There are a number of main characteristics of slipped femoral capital epiphysis. These include the crumbling of inadequately ossified metaphyseal bone positioned just inferior to the epiphyseal plate. This results in a chronic slippage in which the bones of the femoral neck gradually bend and deform. Acute slippage occurs as a result of sudden shearing separation of the epiphysis from the metaphysis (Gruebel Lee 1983, 175). Chronic slippage occurs in approximately 70% of cases, with acute slippage present among 30% of affected individuals (Apley and Solomon 1988, 172). The sequelae of the condition include severe varus deformity, broadening and shortening of the femoral neck, flattening of the femoral head, osteonecrosis, chondrolysis and degenerative changes (Resnick *et al*. 1995, 2647). In an individual with slipped femoral epiphysis the affected leg will be shortened and externally rotated. A loss of abduction, associated with increased adduction due to coxa vara, will be apparent. In addition, there is loss of internal rotation, increased external rotation and hyperextension with loss of flexion of the hip. The individual may also experience pain upon certain movements (Gruebel Lee 1983, 181).

The main differential diagnosis for the abnormalities apparent in the individual from Leshyovsky I is Perthes' disease. In Perthes' disease, however, one would expect the femoral head to have a mushroom-shaped appearance with notable porosity and a poorly defined depression for the attachment of the ligamentum teres. In addition, in Perthes' disease the centre of the femoral head is not markedly dislocated from the femoral neck and the neck has a generally normal appearance (Ortner 2003, 347), and no slippage of the head is expected (Aufderheide and Rodríguez-Martin 1998, 90). Other possible aetiologies for the abnormalities include dysplasia of the hip or developmental coxa vara.

This disabled adult male from the Leshyovsky I cemetery appeared to have suffered a violent death – his right thigh had been crushed by a heavy blow and his left leg and skull had been gouged to the bone (see below for full discussion). His body was reported to have been excavated not under the nearby Yamnaya-culture kurgan, but rather beside it in a grave (Grave 5) without a mound covering. He was reportedly buried in a prone position, face down and contorted and was referred to as "the prisoner" in casual conversation by the archaeologists, a speculation that is only one among many possible interpretations of this grave. A radiocarbon date on bone from the individual measured by the Arizona laboratory gave an age of approximately 2900-2800 BCE (AA47807 4254 ± 61 BP, 2909-2786 calBC, midline 2883 calBC), possibly contemporary with the burial of two Yamnaya individuals in one grave (1a and 1b) in the nearby kurgan. These comprised a young adult female (1a) and the poorly preserved remains of a perinatal infant. Presumably the woman was the mother of the baby but it is not possible to know if they had died during or after birth. No radiocarbon date is available for Grave 1. There is nothing to indicate any relationship between the individuals buried within Grave 1 and Grave 5, although evidence for the presence of ochre in both burials is suggestive that the mortuary rituals were similar. It seems likely that the male in Grave 5 was either killed in a violent encounter or that he had been intentionally tortured. It is interesting to speculate that this unusual treatment may have arisen because of his physical disabilities but this will be discussed later in the text.

Developmental dysplasia and congenital dislocation of the hip

Two Srubnaya individuals displayed possible cases of developmental dysplasia and dislocation of their hip joints. By the eleventh week *in utero* the basic morphology of the developed hip joint has been established. Consequently, dislocation of the hip is possible from this stage onwards. As such any defect which acts upon the embryo prior to the eleventh week will not cause a dislocation but will cause the occurrence of a malformation which results in abnormal and misshapen joints. At birth the hip joint is still cartilaginous in composition, but its associated ligaments are fully developed (Ferrer-Torrelles and Ceballos 1982, 21). Genetic, mechanical, hormonal and social factors have all been implicated as possible factors which are responsible for susceptibility to dislocation of the hip in the embryo. In the majority of cases the dysplasia arises as a result of abnormalities in the developmental processes, indicating that the abnormality is genetically controlled (Inman 1963, 250; Carter 1964, 308; Sartoris 1995, 4067). There is a marked preponderance of congenital dislocation of the hip in females, with a sex ratio of approximately 6:1 (Carter 1964, 308). The majority of congenital dislocations of the hip occur during the first two weeks following birth, although occasionally a dislocation will occur in individuals of up to one year of age. In general, however, late initial dislocations occur rarely during childhood (Sartoris 1995, 4068)

Cases of developmental dysplasia of the hip also occur sporadically, however, and it has been suggested that these cases arise due to an intra-uterine position of the foetus in which either the hips are flexed or the knees are incompletely flexed and the feet are externally rotated. This posture commonly occurs in breech births, especially among the first born. The practice of swaddling a baby with their hips extended and adducted probably also contributes to the occurrence of congenital dislocation of the hip, and prevents the spontaneous recovery of some of the milder forms of the defect (Carter 1964, 308). Developmental dysplasia of the hip is most common in Native Americans who swaddle their babies tightly with the hips fully extended, but it is uncommon in African tribes where the babies are carried across the back with the hips widely abducted (Apley and Solomon 1988, 163). Murphy (2000b, 63-65) described two cases of developmental dysplasia of the hip in the semi-nomadic Scythian period population from Aymyrlyg, South Siberia.

Clinical studies have indicated that approximately 0.3-1% of a population is born with a dysplastic hip (Gruebel Lee 1983, 102-103), with the defect bilateral in over 50% of cases (Inman 1963, 251). Individuals with congenital dislocation of the hip will generally display the Trendelenburg gait, a limp which is characterised by an even timing of the two legs, but with a tilt towards the normal hip. From a distance, unilateral examples of the limp are observed as a lateral movement of the shoulders towards the normal side, or as a movement of the shoulders from side to side if the condition is bilateral (Gruebel Lee 1983, 78). If the dysplasia of the hip has not been treated in individuals over the age of three years then the femoral head will become deformed and the acetabulum will have a triangular morphology (Inman 1963, 252).

In Skeleton K1 G8, a 35-50 year old male recovered from the Spiridonovka IV burial ground, the bones of the left leg had a markedly atrophied appearance and had abnormal morphologies. Unfortunately, the left innominate was not available for analysis and the femoral head had been subject to extensive post-mortem damage. The femoral neck was very thin, and a large articular facet, which displayed osteophytes and porosity, was visible in the region of the intertrochanteric line. The medio-lateral breadth of the shaft was notably atrophied (subtrochanteric diameter 16.4 mm (L), 33.6 mm (R); midshaft 17.6 mm (L), 30.7 mm (R)), although its antero-posterior dimensions were similar to its normal right counterpart (subtrochanteric diameter 21.1 mm (L), 26.1 mm (R); 26.9 mm (L), 24.9 mm (R)). The muscle markings on the posterior aspect of the femur were unpronounced. Only the proximal third of the left tibia was preserved but it also had a generally atrophied appearance relative to its normal right counterpart (bicondylar width c. 74 mm (L), 80.9 mm (R)). The left knee joint did not display any evidence for degenerative changes.

The abnormal morphology of the bones, and the lack of secondary degenerative joint disease suggests that the left leg, and presumably hip, was dysfunctional. The right innominate displayed slight marginal osteophytes of the acetabulum and enthesopathies of the gluteus medius and the tensor fasciae latae were apparent. The right femur was markedly robust with notable enthesopathies of the gluteal tuberosity (gluteus maximus), the lesser trochanter (psoas major and iliacus) and the greater trochanter (gluteus minimus, iliofemoral ligament and vastus lateralus). In addition, its antero-posterior dimensions were reduced giving it a notably flattened appearance. The right tibia had a normal appearance, although slight marginal osteophytes were apparent at its proximal articular surface.

It is possible that the robusticity of the right femur and the occurrence of enthesopathies had arisen as a consequence of the individual compensating for the loss of power in his atrophied left leg by developing an unusually strong right leg. Extensive degenerative joint disease was apparent in the lower thoracic and lumbar vertebrae, which may also have been secondary to the gait disturbance. Differential diagnosis for the abnormal left leg would include a fracture of the femoral neck and head region when the individual was a non-adult.

In Skeleton G1, a possible female adult recovered from the Novosiolky cemetery, the right femur had an atrophied appearance. Unfortunately, the right innominate and the remainder of the bones of the right leg were not available for analysis. The femoral head was notably atrophied and had a very flattened macroporotic appearance with marginal osteophytes at its posterior aspect. The medio-lateral breadth of the shaft was notably atrophied (subtrochanteric diameter 21.1 mm (R), 27.5 mm (L)) at the proximal end although it was more similar to its left counterpart at the midshaft (midshaft 24.5 mm (R), 25.4 mm (L)). The right proximal antero-posterior dimensions were slightly greater than those of the left bone (subtrochanteric diameter 28.1 mm (R), 24.5 mm (L)), although the midshaft dimensions were similar to its normal left counterpart (26.1 mm (R), 27 mm (L)). It was difficult to ascertain further information about this case due to the very incomplete nature of the skeleton.

Dysplastic proximal femur

In Skeleton K2 G37, an 18-35 year old Srubnaya male retrieved from the LBA Spiridonovka II burial ground, both femora had abnormal morphologies. The femoral necks were markedly short, with neck-shaft angles of approximately 90°. In addition, the proximal aspects of the femoral heads were positioned at the same level as the superior aspects of the greatest trochanters.

The term coxa vara is applied to any condition in which the neck-shaft angle of the femur is less than the normal figure of approximately 125° when viewed antero-posteriorly (Adams and Hamblen 1990, 313). In children, coxa vara can be secondary and develop as a result of rickets, bone dystrophies or Perthes' disease (Gruebel Lee 1983, 163). A primary developmental form of coxa vara also exists, however, although this is rare and is considered to be a manifestation of an autosomal dominant gene. The defect affects the neck of the femur. In infantile coxa vara a triangular portion of metaphyseal bone separates from the inferior aspect of the metaphysis just inferior to the growth plate, and this causes the epiphyseal plate to be positioned vertically. In developmental coxa vara both hips are generally affected (Gruebel Lee 1983, 166), as in Spiridonovka II K2 G37.

It does not seem likely that this individual suffered from proximal femoral focal deficiency (PFFD), also referred to as congenital hypoplasia of the upper femur and femoral hypoplasia with coxa vara. In these congenital conditions the proximal part of the femur is shortened or partially absent but they are generally unilateral (Resnick 1995a, 4284), as opposed to bilateral, which is the case for the individual from Spiridonovka II.

Health

Wood *et al*. (1992) warned that less healthy individuals die younger, while healthier individuals live for a longer period of time and therefore have a greater chance of developing palaeopathological lesions. To avoid being misled by this osteological paradox it is necessary to combine paleopathological and paleodemographical data with contextual information (Steckel and Rose 2002a, 586). Goodman and colleagues have emphasised the key role that the environment plays in the factors responsible for physiological stress

(Goodman *et al*. 1984; Goodman and Armelagos 1988; Goodman *et al*. 1988; Goodman 1991). Cultural systems can help buffer a society against stressors but some stressors can also be culturally induced. Depending on host resistance the stressors can then cause physiological disruption to the skeleton which is manifested in disruption to growth and the development of disease. Physiological stress can result in a decreased level of health, a reduced ability to undertake work, a suppressed reproductive capacity and general socio-cultural disruption. The potential indicators of physiological stressors recorded for the Volga populations were growth disturbances, cribra orbitalia, dental enamel hypoplasia and reactive new bone formation. All lesions were observed macroscopically and were generally recorded following the methods advocated by Buikstra and Ubelaker (1994) and Steckel and Rose (2002b).

Growth and Stature

Growth is controlled by a mixture of environmental and genetic factors (although see Goodman 1991, 33-5 for discussion). Stunting of growth can arise as a consequence of both nutritional deficiency and infectious disease processes (Pinhasi 2008, 365) and studies of living populations have demonstrated a clear relationship between physiological stress and stature (Larsen 1997, 14). Details of the greatest femoral lengths for each population group are provided in Table 7 and Figure 2.

Culture	**Male**			**Female**		
	N	Mean	Range	**N**	Mean	Range
Yamnaya	7	472.1	466-480	2	442.5	417-468
Poltavka	16	478	443-516	4	442	424-458
Potapovka	11	469.3	440-520	2	442	441-443
Srubnaya	67	457.7	160-187.5	63	422.1	373-463

Table 7: Summary of male and female femoral greatest lengths for the different cultures.

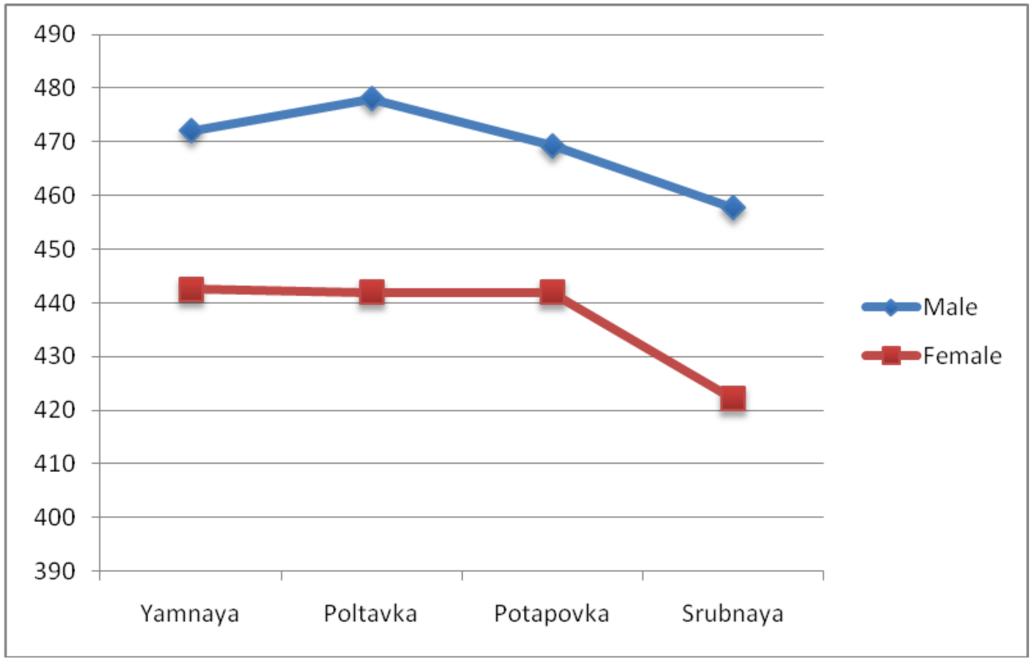

Figure 2: Male and female average greatest femoral lengths (mm) across the different time periods.

During the EBA Yamnaya period the average femoral greatest length for males was 472.1 mm, which then rose to 478 mm during MBA Poltavka times, declined to 469.3 mm during the late MBA Potapovka period, and declined even further to 457.7 mm for the LBA Srubnaya adult males. A different trend is apparent for females – their average greatest femoral length values were very similar (c. 442 mm) between the Yamnaya and Potapovka periods, but then decreased notably to 422.1 mm during Srubnaya times. The most obvious similarity between the two sexes is the decrease in femoral length, and therefore in stature, during the Srubnaya period. This decrease was markedly more dramatic for females than for males. Steckel (1995) and Larsen (1997, 14) have shown that a person's stature is directly related to the quality of their diet and their disease history, although the latter is of less importance. It appears to be the case that individuals with an adequate diet attain their genetic growth potential, but not individuals with a poor diet. The male trend would appear to indicate that there was a slight improvement in health from the Yamnaya to Poltavka periods followed by a gradual decline in health from the Poltavka to the Srubnaya periods. Female health appears to have been more static between Yamnaya and Potapovka times but then dramatically deteriorated during the time of the Srubnaya culture.

If Asian people composed a significant percentage of the Potapovka population, (see Khokhlov, this volume), this could account for part of the decline in stature during that period. Recent genetic studies have clearly demonstrated that adult height is significantly different for the three main geographical 'races'– Asian, White and Black (Feldesman and Fountain 1996; Lettre *et al*. 2008). As such, it is possible that racial differences, as well as health, had an influence on stature among Potapovka populations. But Khokhlov seems to suggest only a small influence of Asian cranial types in the Potapovka population, and did not report any Asian skull traits in the Srubnaya individuals.

Cribra orbitalia and porotic hyperostosis

Cribra orbitalia is the term used to refer to generally symmetrical lesions, with the morphology of small perforations of varying size and density, apparent in the cortical bone of the superior aspects of the orbit. The occurrence of lesions of similar morphology in the skull vault is referred to as porotic hyperostosis (Stuart-Macadam 1991, 101). The lesions have traditionally been interpreted as an indicator of iron deficiency anaemia acquired during childhood (e.g. Stuart-Macadam 1985). A recent study by Walker and colleagues (2009) has demonstrated that neither lesion can be physiologically caused by iron deficiency anaemia. They have suggested that porotic hyperostosis is due to haemolytic and megaloblastic anaemias which most commonly arise from deficiencies of vitamin B_{12} and vitamin B_9 (folic acid) (Walker *et al*. 2009, 6). They indicate the situation concerning cribra orbitalia is less clear cut and the lesions may have been caused by a multitude of conditions, which include chronic infections and deficiencies of vitamins B_{12}, C and D (Walker *et al*. 2009, 7, 11). They propose that a combination of poor diet, a lack of hygiene, infectious diseases and cultural practices associated with pregnancy and breastfeeding might explain the high levels of these lesions in many past populations (Walker *et al*. 2009, fig. 4). The degree of severity and extent of the surface affected were recorded (cf. Stuart-Macadam 1991, 109).

Cribra orbitalia occurred most frequently for the Yamnaya group, both in terms of numbers of individuals and numbers of orbits affected (Table 8). The reliability of this result is reduced, however, by the small number of Yamnaya individuals with observable orbits.

Culture	**Prevalence by individual (%)**			**Prevalence by bone (%)**
	Overall	**Male**	**Female**	**Overall**
Khvalynsk	13.0 (3/23)	5.3 (1/19)	50.0 (2/4)	11.1 (5/45)
Yamnaya	37.5 (3/8)	28.6 (2/7)	100.0 (1/1)	35.7 (5/14)
Poltavka	5.6 (1/18)	6.3 (1/16)	0 (0/2)	9.1 (2/22)
Potapovka	18.2 (2/11)	25.0 (2/8)	0 (0/3)	13.6 (3/22)
Srubnaya	17.6 (15/85)	13.6 (6/44)	22.0 (9/41)	15.7 (26/166)

Table 8: Prevalence rates (%) of the adults with cribra orbitalia for each culture. The numbers provided in brackets are the actual figures.

The prevalence of cribra orbitalia for the remaining groups was not dissimilar, with values ranging from 9.1% for the Poltavka population to 15.7% for Srubnaya. Except for the Yamnaya figure, the results from the Volga populations are lower than those obtained in a study of two Iron Age semi-nomadic populations from Aymyrlyg, South Siberia, in which it was found that cribra orbitalia had a prevalence of 18% by bone in the observable adult orbits of the Uyuk Culture and 28% in the Shurmak Culture (Murphy 2012). Due to the small sample sizes of the earlier populations it was only possible to compare male and female prevalence rates for the Srubnaya population. Some 12.2% of males and 25% of females with orbits present displayed cribra orbitalia. This finding would tend to suggest that Srubnaya females were more susceptible to low health and nutritional status during childhood than males, although the results were not statistically significant (χ^2 = 2.322; P = 0.127; df = 1).

Amongst the non-adults only the Poltavka and Srubnaya populations contained individuals with evidence for cribra orbitalia. The affected Poltavka individuals comprised a 0.5-1.5 year old infant retrieved from the Kalinovka cemetery and a 6-8 year old juvenile recovered from the Nikolaevka III burial ground. It was possible to examine one or both orbits in the crania of 26 Srubnaya non-adults, 38.5% (10/26) of which displayed cribra orbitalia. In total, 45 non-adult orbits were examined, 31.1% (14/45) of which displayed cribra orbitalia. This is a notably higher prevalence rate than the value of 15.7% (26/166) obtained for Srubnaya adult orbits. This finding would tend to suggest that a significantly lower proportion of children who developed cribra orbitalia survived to adulthood (χ^2 = 5.499; P = 0.019; df = 1). Details of the Srubnaya individuals with cribra orbitalia broken down by age and sex are provided in Table 9.

	<2	**2-6**	**6-12**	**12-18**	**18-35**	**35-50**	**50+**
Male					3	2	1
Female				2	6	3	
Unknown		1	6	1			
Total	**0**	**1**	**6**	**3**	**9**	**5**	**1**

Table 9: Numbers of Srubnaya individuals with cribra orbitalia broken down by age and sex (n=25).

Most of the Srubnaya non-adults with cribra orbitalia had died at the age of 6-12 years and a number of adolescents had also been affected. The majority of affected adults had an age-at-death of 18-35 years (60%; 9/15), a finding which would tend to suggest that adults with cribra orbitalia were more likely to die at a younger age. It is also interesting that the majority of affected adults were female (60%; 9/15). This finding may again indicate that female individuals were more susceptible to poor health and vitamin deficiencies during childhood than their male counterparts.

At a number of Srubnaya sites, particular kurgans contained multiple individuals with cribra orbitalia – Krasnosamarskoe IV (K3: G1, G12b, G16, G20), Nizhny Orleansky IV (K1: G2, G3, G8), Spiridonovka II (K11: G15, G21), Spiridonovka IV (K1: G4, G10, G16) and Svezhensky (G52, G55, G71a). These findings may indicate that a more comprehensive study, which analyses all individuals from particular kurgans, has the potential to yield information about differential health statuses at site level.

As noted above, porotic hyperostosis probably arose from deficiencies of vitamins B_{12} and B_9 (folic acid). The numbers of individuals with porotic hyperostosis in each group were low (Table 10).

Culture	**Prevalence by individual (%)**		
	Overall	**Male**	**Female**
Khvalynsk	0 (0/24)	0 (0/19)	0 (0/5)
Yamnaya	0 (0/8)	0 (0/7)	0 (0/1)
Poltavka	5 (1/20)	5.6 (1/18)	0 (0/2)
Potapovka	8.3 (1/12)	0 (0/9)	33.3 (1/3)
Srubnaya	1.6 (1/88)	0 (0/45)	2.3 (1/43)

Table 10: Prevalences (%) of adults with porotic hyperostosis based on the numbers of individuals with observable parietals and/or occipitals. The actual figures are provided in brackets.

Only single individuals were affected in the Poltavka, Potapovka and Srubnaya adult populations, with the prevalence ranging from 1.6% for the Srubnaya group to 5% for the Poltavka population and 8.3% for the Potapovka corpus. The spread of results from the Volga populations is not too dissimilar to those obtained from the Iron Age Uyuk Culture from Aymyrlyg, South Siberia, where the lesions had a prevalence of 8%. They are notably lower than the results obtained for the later Shurmak Culture from the same cemetery, however, where a prevalence of 16% was recorded (Murphy 2012). When the prevalences are examined on the basis of sex for the substantial Srubnaya population it would appear to be the case that females (2.3%) were more susceptible to the development of porotic hyperostosis than males (0%). This finding corresponds to the results obtained for cribra orbitalia discussed above.

Among non-adults, Skeleton K1 G5, a 0.5-1.5 year old infant retrieved from the Poltavka-Culture Kalinovka burial ground, displayed both porotic hyperostosis and cribra orbitalia. Two Srubnaya non-adults displayed evidence of porotic hyperostosis, both of whom were recovered from the Nizhny Orleansky IV burial ground – Skeleton K1 G8, a 6-7 year old juvenile and Skeleton K4 G3, a 15-17 year old male adolescent. In the former case cribra orbitalia was also observable but the lesions were unobservable in the latter individual.

Dental enamel hypoplasia

Dental enamel hypoplasia is one of the most common developmental defects of the tooth enamel. It arises as a consequence of ameloblast disturbance during enamel matrix production. The most common form of hypoplasia is Linear Enamel Hypoplasia in which the defect has the appearance of a groove, although the defects may also take the form of a sharp line, or as a band of pit-type defects (Hillson 1996, 166-7). Once a hypoplastic defect has occurred in the enamel it cannot be removed since enamel does not have the ability to remodel. Consequently, a hypoplastic defect on a permanent tooth acts as a memory to an incident of physiological stress which affected the ameloblast activity during childhood (Goodman and Armelagos 1988, 90; Dobney and Goodman 1991, 81; Goodman and Martin 2002, 23). This kind of stress can arise as a consequence of nutritional deficiencies and many childhood illnesses (Roberts and Manchester 2005, 75). Enamel hypoplastic defects were recorded on the basis of the methodology advocated by Goodman and colleagues (1980, 518-9). The severity of the hypoplastic lesions was categorised on the basis of the grading system of Brothwell (1981, 156). Details of the prevalence of adults to display enamel hypoplasia are shown in Table 11.

Culture	Prevalence by individuals (%)		
	N	Male	Female
Khvalynsk	57.0 (12/21)	52.6 (10/19)	100.0 (2/2)
Yamnaya	71.4 (5/7)	66.7 (4/6)	100.0 (1/1)
Poltavka	37.5 (6/16)	42.9 (6/14)	0 (0/2)
Potapovka	50.0 (5/10)	62.5 (5/8)	0 (0/2)
Srubnaya	37.8 (31/82)	31.1 (14/45)	45.9 (17/37)

Table 11: Prevalence (%) of adult individuals with dental enamel hypoplasia. The numbers in brackets provide the actual figures.

The overall prevalence rates ranged from 37.5% for the Poltavka population to 71.4% for the Yamnaya population but again the small sample sizes may be skewing the results. The spread of results from the Volga populations is not too dissimilar to those obtained from two Iron Age semi-nomadic populations from Aymyrlyg, South Siberia, in which it was found that dental enamel hypoplasia occurred amongst Uyuk Culture adult dentitions with a prevalence of 28%, while the dentitions of Shurmak Culture adults displayed hypoplastic lesions with a frequency of 42% (Murphy 2012). Lillie (1996, table 4) reported that 16.7% of Ukrainian Mesolithic individuals with teeth displayed hypoplastic lesions, while 11.4% of the corresponding Neolithic individuals were affected. These results are notably lower that those derived from the Volga or Aymyrlyg populations. The Ukrainian populations are considered to have followed a hunter-gatherer-fisher economy which was modified to include a pastoral component during Neolithic times (Lillie 1996, 137). It can be tentatively proposed that the more pastoral component of the economies of the Volga and Aymyrlyg populations had resulted in these groups being more susceptible to physiological stress. A major problem with this thesis, however, is that the Khvalynsk population would probably have followed a similar economy to the Ukrainian populations and it displayed relatively high levels of the lesions (57%). When the results for the substantial Srubnaya population are analysed by sex it is clear that females (45.9%) displayed hypoplastic lesions with a greater prevalence than males (31.1%), although the results were not statistically significant (χ^2 = 1.900; P = 0.168; df = 1).

Amongst the non-adults only the Khvalynsk, Poltavka and Srubnaya populations contained individuals with evidence for dental enamel hypoplasia. The Khvalynsk individual comprised Skeleton G23, a 13-15 year old possible female, while the affected Poltavka non-adult was Skeleton K2 G3, a 12-15 year old adolescent, recovered from Krasnosamarskoe IV. It was possible to examine the permanent dentitions of 32 Srubnaya non-adults for hypoplastic defects, 28.1% (9/32) of which displayed evidence of having been subject to one or more incidents of childhood physiological stress. Although this is a lower prevalence rate than the value of 37.8% (31/82) obtained from the Srubnaya adults the difference was not statistically significant ($\chi^2 = 0.947$; $P = 0.330$; df = 1). Details of the Srubnaya individuals with dental enamel hypoplasia broken down by age and sex are provided in Table 12.

	6-12	**12-18**	**18-35**	**35-50**	**50+**
Male		2	10	4	
Female		2	12	3	2
Unknown	3	2			
Total	**3**	**6**	**22**	**7**	**2**

Table 12: Numbers of Srubnaya individuals with enamel hypoplasia broken down by age (years) and sex (n=40).

Most of the non-adults with enamel hypoplasia died between the ages of 12-18 years and a number of juveniles also were affected. The relative paucity of younger children with the defects is probably due to a combination of two factors – the incomplete development of the teeth as well as the likelihood that younger individuals were generally less likely to survive an event which was severe enough to result in the development of a hypoplastic lesion. The majority of affected adults had an age-at-death of 18-35 years (55%; 22/40), a finding which would tend to suggest that adults with hypoplastic defects were more likely to die at a younger age.

In addition to the results included in Table 12, Skeleton K2 G2b, an 8-9 year old Srubnaya juvenile recovered from the Spiridonovka IV burial ground, displayed crinkling on the tips of the crowns of the mandibular deciduous molars. It is possible that the crinkled appearance was due to hypoplasia and that the individual had been subject to an incident of physiological stress when they were a fetus of approximately 5-9 months of age (cf. Ubelaker 1989, 64). The individual also displayed additional hypoplastic defects which indicated they had also been subject to physiological stress at an older age.

Non-specific infectious disease

Reactive new bone formation (periostitis) can occur as a result of inflammation in specific and non-specific infectious processes; it can arise as a result of direct trauma (Ortner 2003, 106); or it can occur as a consequence of other disease processes which cause physiological stress (Ribot and Roberts 1996, 70). Non-specific pathological bone changes are virtually identical to one another and result from infection by a variety of pyogenic bacteria including staphylococci, streptococci, pneumococci and the typhoid bacillus. In the modern world, *Staphylococcus aureus* is responsible for over 75% of cases of infection (Finch and Ball 1991, 208). The palaeopathological changes can involve the development of pits, striations and plaques of bone formation (Ortner 2003, 206-7). Following the guidelines of Lovell (2000, 237), the extent and location of the lesions were recorded, as was their state of healing (see Goodman and Martin 2002, 34). Details of the crude prevalence rates of individuals with infectious lesions are provided in Table 13.

Culture	**Overall**	**Male**	**Female**
Yamnaya	6.3 (1/16)	8.3 (1/12)	0 (0/4)
Poltavka	8.8 (3/34)	6.9 (2/29)	20.0 (1/5)
Potapovka	0 (0/14)	0 (0/11)	0 (0/3)
Srubnaya	1.6 (2/129)	1.5 (1/67)	1.6 (1/61)

Table 13: Crude prevalence rates (%) of individuals with infectious lesions. The numbers in brackets are the actual figures. One of the Srubnaya individuals was of indeterminable sex. The Khvalynsk population was not included in the study of infectious lesions.

No cases of infection were apparent among the Potapovka group. The crude prevalence rates ranged from 1.6% for the Srubnaya Culture to 6.3% for the Yamnaya group and 8.8% for the Poltavka Culture. Amongst the substantial Srubnaya group males and females appear to have been equally susceptible to the development of infections. Details of the frequencies of reactive new bone formation among adult bones for the Yamnaya, Poltavka and Srubnaya periods are provided in Table 14.

	Yamnaya % affected	**Poltavka % affected**	**Srubnaya % affected**
Mandible (body)	0 (0/7)	6.3 (1/16)	0 (0/78)
Humerus (shaft)	0 (0/22)	5.0 (2/40)	0 (0/157)
Ulna (shaft)	0 (0/19)	8.3 (3/36)	0 (0/143)
Radius (shaft)	0 (0/23)	7.9 (3/38)	0 (0/142)
Femur (shaft)	0 (0/20)	4.9 (2/41)	1.1 (2/175)
Tibia (shaft)	8.7 (2/23)	12.8 (5/39)	1.1 (2/174)
Fibula (shaft)	4.8 (1/21)	8.8 (3/34)	0.7 (1/135)
Ribs	0 (0/70)	5.1 (9/177)	0 (0/197)
Total	**1.5 (3/205)**	**6.0 (25/420)**	**0.4 (5/1201)**
Total long bones only	**2.3 (3/128)**	**7.9 (18/228)**	**0.5 (5/926)**

Table 14: Frequencies of reactive new bone formation by bone.

When the total numbers of long bones affected are examined, it was evident that the Poltavka population was affected to the greatest extent (7.9%), followed in frequency by the Yamnaya population (2.3%) and the Srubnaya group (0.5%). It is possible that the Poltavka individuals were genuinely subject to the development of lesions as a result of infectious disease processes with a greater frequency than the other groups. It also needs to be considered, however, that the results have been skewed by the occurrence of Skeleton K3 G9 of Poltavka date from the Krasnosamarskoe IV burial ground (see below). The majority of this individual’s bones displayed evidence for reactive new bone formation and it is considered probable that he had been suffering from an overwhelming systemic infection at the time of his death.

The frequency of infection is generally expected to rise in archaeological populations where there has been an intensification of sedentary agriculture, leading to a concomitant increase in population density and levels of nutritional stress. These subsistence factors are considered to provide an environment in which infectious diseases can flourish (Roosevelt 1984, 572). Analysis of the frequencies of infectious lesions at the Dickson Mounds, Illinois (AD 950-1300), revealed an increase in levels of infectious lesions from a frequency of 31% during periods of low-intensity agriculture to 67% during periods when more intensified agriculture was practised (Goodman *et al*. 1984, 291). Among prehistoric populations from the Ohio River Valley prevalence rates for periostitis of 10.8% were recorded for the later part of the Archaic period (8000-1000 BC), with a rate of 28.6% noted for the Middle Woodland period (1000-100 BC) and 13% by the time of the Mississippian Fort Ancient Culture (AD 700-1600) (Perzigian *et al*. 1984, 357). The earliest population group would have been hunter-gatherers, while the later groups would have been involved in gradually intensifying agriculture (Perzigian *et al*. 1984, 348-349).

A study of the frequencies of non-specific lesions among Japanese hunter-gatherer populations from the Neolithic period (unknown-3rd century BC) up until the Early Modern period revealed frequencies of lesions ranging from 9.6% to 12.3% (Suzuki 1991, 133). It is therefore evident that the frequencies of non-specific lesions among the Volga populations are generally lower than those recorded for either hunter-gatherer or agricultural population groups from different periods and various geographical locations throughout the world. Murphy (1998, 474) observed generally low levels of infection amongst the Iron Age populations from Aymyrlyg, South Siberia. Despite this fact evidence for tuberculosis, including the first definitive evidence for the bovine form of the disease in the archaeological record, was identified (Taylor *et al*. 2007; Murphy *et al*. 2009). No evidence for specific infective diseases was identified among any of the Volga populations.

The infectious lesions apparent in each individual were rather diverse and each case will now be described. An 18-35 year old male (K22) recovered from the Yamnaya-culture Lopatino I burial ground displayed tibio-fibular periostitis. Both tibiae and the left fibula displayed plaques of woven bone, in the process of remodeling, on their midshafts. The medial surfaces were affected in the tibiae, while the lateral surface was affected in the fibula.

Three Poltavka individuals displayed evidence of non-specific infectious disease, which in all cases took the form of reactive new bone formation. In all three cases the infectious processes appear to have been systemic since multiple skeletal elements were involved. Skeleton K33, an 18-35 year old male recovered from the Lopatino I burial site, displayed tibio-fibular periostitis and rib lesions. Plaques of striated bone in the process of remodeling were apparent on the lateral surfaces of the midshaft regions of the tibiae. Pitted woven bone was also visible on the medial surface of the right tibia. Plaques of grey, pitted woven bone were also evident on the medial surface of the midshaft of the right fibula. Thick plaques of grey woven bone were present on the visceral surfaces of the necks of the left second to tenth ribs. The right ribs were unaffected. The nature of the lesions was indicative that the individual would have had an active chest infection when he died. Skeleton K2 G2, a 35-50 year old female recovered from the Kalach burial site, displayed plaques of woven bone on a number of her bones. Thick plaques of grey woven bone in the early stages of remodeling were apparent on the medial and lateral surfaces of the distal third of the left tibia, while similar lesions were evident on all surfaces of the distal third of the left fibula. The right tibia was not available for analysis, but the right fibula appeared normal. Plaques of grey woven bone in the early stages of remodeling were also visible on the antero-lateral surfaces of the distal thirds of the right ulnae and on the medial surface of the distal third of the left radius. The left fifth metatarsal displayed thick plaques of woven bone on all of its surfaces. Skeleton K3 G9, an 18-35 year old male recovered from the Krasnosamarskoe IV burial ground, displayed thick plaques of grey woven bone on practically all of the bones of his skeleton – mandibular bodies, clavicles, scapulae, humeri, radii, ulnae, metacarpals, hand phalanges, ilia, femora, tibiae, fibulae, calcanei and metatarsals. The nature of the woven bone deposits would tend to suggest that the individual had been suffering from an active systemic infection when he died. Given the extent of the skeletal involvement in the infection in addition to the individual's young age it is highly feasible that the infection had contributed to his death.

Two Srubnaya individuals displayed evidence of possible non-specific infectious disease. Skeleton K1 G1, an 18-35 year old male recovered from the Krutyenkova burial site, displayed reactive new bone formation on his femora, tibiae and right fibula. Plaques of pitted and striated bone in the process of remodeling were apparent on the anterior surfaces of the proximal halves of the femora. The distal half of the left femur also displayed pitting of its cortical surface. Plaques of woven bone were present on the medial surface of the distal third of the right tibia, and the remainder of the medial surface displayed striations. The cortex of the entire medial surface of the left tibia displayed pitting and striations, while plaques of striated bone were evident on the lateral surface of the midshaft of the right fibula. The nature of the lesions would tend to suggest that, although the infection was still active when the individual had died, it was in the process of healing.

Skeleton K2 G36, a 50+ year old female recovered from the Barinovka I cemetery, displayed a possible case of extensive osteomyelitis on a metatarsal. In osteomyelitis the pathological process involves bone destruction and pus formation with concomitant bone repair. The bone may become enlarged, and bone destruction is apparent in the form of pitting on the bone surface, and in some cases the formation of a cavity within the bone. The cavity, which is an abscess and contains pus, may penetrate the cortex and discharge the pus into the adjacent body tissues (Roberts and Manchester 2005, 169). In addition, in osteomyelitis a sequestra may develop, which is a segment of necrotic bone separated from the living tissue by granulation tissue. In the process of bone repair an involucrum may develop, which is a layer of living bone formed around the dead bone. An opening in the involucrum is referred to as a cloaca, and granulation tissue and sequestra are discharged through this opening via sinuses to the surface of the bone (Resnick and Niwayama 1995a, 2326). The skeleton was in a poor state of preservation, with the small number of bones present in a fragmentary and eroded condition. It was not possible to identify which metatarsal was affected since the bone had been so extensively eroded as a consequence of the pathological processes. The proximal and distal ends and the shaft were all extensively eroded and the bone surface displayed a series of indentations and circular lytic lesions. It is difficult to be certain about the specific etiology of the lesions. Osteomyelitis is considered a feasible interpretation, although it is also possible that a seronegative arthropathy could have caused such bone changes. The latter interpretation is considered less likely, however, since none of the other metatarsals present displayed any pathological changes. The poor state of preservation of the skeleton also makes it feasible that the erosive activity was a pseudo-paleopathology and due to unusual taphonomic processes.

Osteoporosis

The remains of a 35-50 year old female (K1 G6) recovered from the Poltavka Kalinovka burial ground were considered to be abnormally light (osteopenic). Other lesions apparent in her remains included spondylolysis and extraspinal and spinal degenerative joint disease. The skeletal remains of a 50+ year old female (K3 G9a), recovered from the Poltavka period Grachyovka II burial ground, were also considered to be osteopenic. The remains were in a poor state of preservation and the only other lesions apparent were spinal degenerative joint disease and Schmorl's nodes. Given the ages and sex of both individuals it is considered feasible that they had suffered from osteoporosis.

The metabolic condition of osteoporosis is recognisable by the occurrence of qualitatively normal but quantitatively lacking bone. The cortex of the bone is thinner than usual, and there are fewer trabeculae than normal (Apley and Solomon 1988, 52). The condition is arbitrarily identified when the skeleton has lost at least 30% of its bone mass (Ortner 2003, 411). An individual with the condition will display diffuse osteopenia. In generalised osteoporosis the axial skeleton and the proximal areas of the long bones are predominantly affected. This form of osteoporosis can arise as a result of a variety of factors including old-age, the menopause, nutritional deficiencies, a high number of pregnancies, prolonged periods of lactation, and hormonal conditions such as hyperparathyroidism (Roberts and Manchester 2005, 243; Brickley and Ives 2008, 152-8). In modern populations osteoporosis is diagnosed in the majority of cases when the individual sustains a fracture, particularly in the wrist, hip or spine (Adams and Hamblen

1990, 63). Senile and postmenopausal osteoporosis are the most common aetiologies of generalised osteoporosis. In modern populations male skeletons begin to decrease in mass in the fifth or sixth decades of life, while those of females start to decrease in bone mass when the woman is in her thirties (Resnick and Niwayama 1995b, 1786). In archaeological cases the first sign that osteoporosis is present is the occurrence of bones of abnormally low mass (Ortner 2003, 413). Diagnosis of osteoporosis on the sole basis of the occurrence of abnormally light bone mass is hazardous, however, since diagenetic factors can affect the density of archaeological bone when it has been buried in the ground. As such, the identification of osteoporosis in these two individuals can only be considered as tentative.

Diet

Teeth recovered from archaeological population groups can provide valuable information about diet and subsistence economy. The frequencies of adults with dentitions and numbers of teeth and sockets by culture are provided in Table 15, while the frequencies by age and sex are listed in Table 16.

Culture	**Individuals**	**Teeth**	**Sockets**
Khvalynsk	92.0 (23/25)	66.7 (491/736)	88.5 (651/736)
Yamnaya	50.0 (8/16)	66.0 (169/256)	77.7 (199/256)
Poltavka	60.0 (18/30)	56.3 (324/576)	83.9 (483/576)
Potapovka	75.0 (12/16)	67.7 (260/384)	87.2 (335/384)
Srubnaya	68.2 (88/129)	61.5 (1732/2816)	90.0 (2536/2816)

Table 15: Details of the frequencies (%) of adults with dentitions and numbers of teeth and sockets by culture. Actual figures are provided in brackets.

	Khvalynsk		Yamnaya		Poltavka		Potapovka		Srubnaya	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
	Teeth/ Sockets	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**	**Teeth/ Sockets**
18-35	265/313	28/44	25/29	22/31	117/159	27/32	137/164	22/28	497/625	470/663
35-50	49/62	0/0	104/122	18/17	112/155	29/32	27/32	25/32	364/565	258/347
50+	135/199	14/33	0/0	0/0	29/105	0/0	31/47	18/32	63/171	80/165
Adult	0/0	0/0	0/0	0/0	0/0	10/0	0/0	0/0	0/0	0/0
Total	**449/574**	**42/77**	**129/151**	**40/48**	**258/419**	**66/64**	**195/243**	**65/92**	**924/1361**	**808/1175**

Table 16: Details of the numbers of teeth and tooth socket positions by age and sex for the adults of the different populations.

Teeth which were unerupted, or in the early stages of eruption, were excluded from the overall counts of teeth since it is unlikely that they would have been affected by the disease processes under study. In addition, impacted teeth were also excluded since they would have been retained within the jaw and not susceptible to disease processes, such as caries and calculus deposition. The positions of teeth which were unerupted, partially erupted or genetically absent were excluded from the counts of tooth sockets since these would not have been susceptible to disease processes, such as dental abscesses and periodontal disease. Sockets for impacted teeth, however, were included since impaction can contribute to the development of dental abscesses. Details of the frequencies for non-adult dentitions are provided in Table 17.

Culture	Individuals with dentitions	N deciduous teeth	N permanent teeth
Khvalynsk	100.0 (2/2)	100.0 (12/12)	87.5 (35/40)
Yamnaya	100.0 (2/2)	18.8 (3/16)	100.0 (28/28)
Poltavka	57.1 (4/7)	15.6 (5/32)	65.7 (44/67)
Potapovka	0 (0/3)	0 (0/0)	0 (0/0)
Srubnaya	50.8 (32/63)	42.2 (159/377)	64.0 (278/434)

Table 17: Details of the frequencies (%) of non-adults with dentitions and numbers of teeth and sockets by culture. Actual figures are provided in brackets.

Caries

Dental caries arise as a consequence of the destruction of the enamel, dentine and cement of a tooth as a result of acid production by the bacteria that live in dental plaque. The end result of the destructive action of the bacteria is the development of a cavity in the crown or root surface of the tooth (Hillson 1996, 269). The cariogenic qualities of a particular diet are determined by the proportion of readily metabolised carbohydrates it contains. Other variables involved in dietary cariogenicity include the textures of the foods and the population’s daily pattern of consumption. Clinical studies have indicated that the most cariogenic foodstuffs are those which are sticky in texture, contain high levels of simple sugars and are consumed frequently throughout the day. The presence of foods which have a rough texture, or the existence of abrasive particles in the diet, does not readily promote the development of caries since natural oral cleaning is stimulated (Powell 1985, 314).

Caries were notably rare amongst all of the Volga populations occurring with a frequency of 0.2% (1/491) for the Khvalynsk group and 0.2% (3/1732) for the Srubnaya population, while the lesions were absent among the adult teeth of all other cultures. The only non-adult to display caries was a member of the Srubnaya population (Table 18).

Culture	Site	Context	Age	Sex	Tooth	Size	Position
Khvalynsk	Khvalynsk II	G21	50+	M	7⌉	medium	buccal
Srubnaya	Nizhny Orleansky I	K13 G1	35-50	M	3⌉	medium	buccal
Srubnaya	Rozhdestveno I	K4 G4 Sk2	15-17	F	⌈5	small	distal
Srubnaya	Spiridonovka II	K14 G4	50+	F	⌊4	medium	mesial
Srubnaya	Spiridonovka IV	K1 G8	35-50	M	6⌉	medium	distal

Table 18: Details of the caries apparent in the population groups.

Cereal grains and starchy tubers can be cariogenic when consumed in large quantities, especially if prepared in soft, sticky porridge-like forms. Natural sugars present in honey, sugar cane, fruit and some vegetables are, however, also cariogenic (Powell 1985, 320). Agriculturists generally display greater frequencies of carious teeth than non-agriculturists or those relying on mixed economies (Leigh 1925, 195). In prehistoric South Asia, hunter-gather populations displayed carious teeth with a frequency of 0% to 5.3% (mean = 1.3%), individuals practising a mixed economy had a frequency of 0.4% to 10.3% (mean = 4.8%), and agricultural populations had a frequency of 2.3% to 26.9% (mean = 10.4%) (Lukacs 1989, 281). A large number of other studies have agreed that the frequencies of caries increased as agriculture was adopted. Perzigian *et al*. (1984, 355-356) found that the frequencies of carious teeth in hunter-gatherer populations of the Ohio River Valley in North America was 2.5%, for example, while the frequency of carious teeth in the same region's early agricultural groups were approximately 12.5%, and 24.8% for populations of developed agriculturists. In a study of a series of European populations Meiklejohn *et al*. (1984, 85) found that carious teeth occurred with a frequency of 1.9% among Mesolithic hunter-gatherer populations, and 4.2% among Neolithic agriculturists. In India, Iron Age sites revealed a frequency of 2.5-7.7% in a period thought to be characterized by a mixed economy of hunting-gathering and agriculture (Lukacs 1989, 279-280). Similarly, in two Iron Age semi-nomadic pastoralist populations from Aymyrlyg, South Siberia, carious teeth occurred with a frequency of 6.4% among the Uyuk culture adult dentitions, and 5.5% among the Shurmak culture adults (Murphy 1998, 498; Murphy et al. 2013). These frequencies were similar to the range expected for a mixed economy of agriculture and pastoralism. Interestingly, a small group of Hsiung-nu individuals from the cemetery of Naima Tolgoy, Mongolia, displayed no caries, a result said to be expected, because the diet of nomads would not have been cariogenic (Regöly-Mérei 1967, 407). In his study of Mesolithic (hunter-gatherer-fisher economy) and Neolithic (hunter-gatherer-fisher-pastoralist economy) Ukrainian populations Lillie (1996, 138) reported that caries were universally absent, similar to the Volga populations. The very low frequency rates for all Volga populations across the different periods are not indicative of populations that practiced crop-based agriculture (Fig. 3).

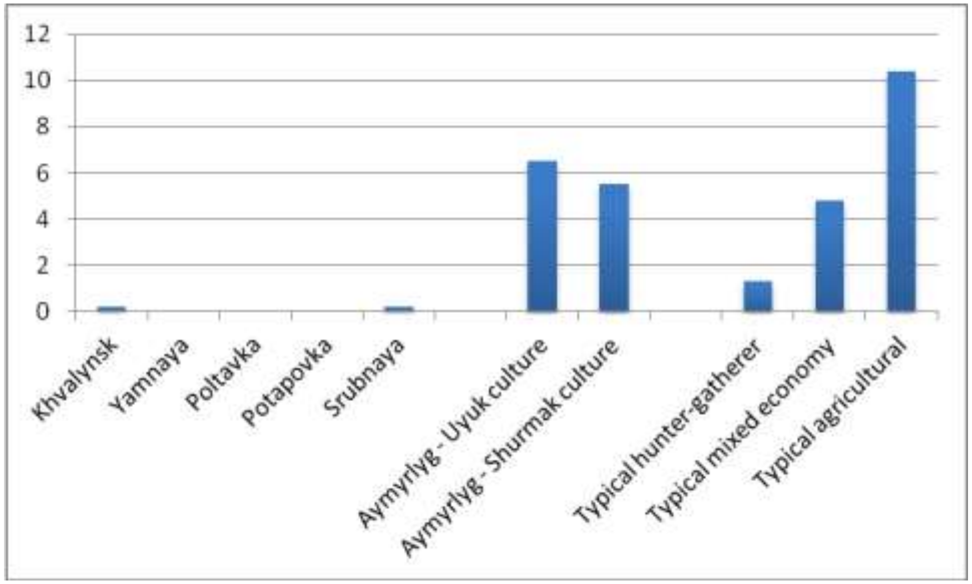

Figure 3: Caries prevalences (%) among the adult teeth of the Volga populations. Also included in the graph are the prevalences for two Iron Age populations from Aymyrlyg, South Siberia (Murphy 1998; Murphy et al. 2013) and mean typical caries frequencies for groups practicing hunter-gatherer, mixed or agricultural economies (cf. Lukacs 1989, 281).

Abscesses

The development of infection as a consequence of dental abscesses was one of the main potential causes of death among past societies (Rugg-Gunn 1993, 1). Dental caries, deposits of calculus, extensive attrition and periodontal disease can all predispose to the development of dental abscesses (Roberts and Manchester 2005, 70). Since the dentitions had not been subject to radiographic analysis, dental abscesses were classified as present only when the abscess fistula had produced a clearly discernible cavity in the alveolar bone, nasal cavity or maxillary sinus. The size of each abscess cavity was categorised as small (0-3 mm), medium (3-5 mm) or large (5+ mm). Details of the prevalences of abscesses apparent in the different adult population groups are presented in Table 19.

Culture	**Overall**	**Male**	**Female**
Khvalynsk	1.1 (7/651)	0.9 (5/574)	2.6 (2/77)
Yamnaya	0.5 (1/199)	0.7 (1/151)	0 (0/48)
Poltavka	0.8 (4/483)	1.0 (4/419)	0 (0/64)
Potapovka	3.3 (11/335)	4.1 (10/243)	1.1 (1/92)
Srubnaya	0.9 (24/2536)	1.4 (19/1361)	0.4 (5/1175)

Table 19: Details of the adult prevalences (%) of abscesses by tooth socket position for each population group. Actual figures are provided in brackets.

The middle Volga populations do not appear to have been particularly susceptible to the development of dental abscesses. The overall prevalences ranged from 0.5% (Yamnaya) to 3.3% (Potapovka). In general, the prevalences were markedly similar, with the only exception being the value of 3.3% attained for the Potapovka group. This figure appears to be notably higher than those of earlier or later groups and it is possible that individuals in this group were more susceptible to the development of abscesses. Murphy (1998, 501) found that dental abscesses occurred among Iron Age semi-nomadic adult individuals recovered from Aymyrlyg, South Siberia, with a frequency of 4.7% for the Uyuk culture group and 4.6% among the Shurmak culture population. It is difficult to reliably study the prevalence of abscesses over time by sex due to the small samples sizes. The results for the large Srubnaya corpus, however, would tend to suggest that males in this group were significantly more susceptible to the development of abscesses than females (χ^2 = 6.336; P = 0.012; df = 1).

Periodontal disease

Periodontal disease generally develops as a consequence of the bacteria contained in dental plaque producing substances, such as enzymes, which inappropriately trigger an immune response. Initially the periodontal disease involves the gingivae only and is referred to as gingivitis, but this can eventually develop into periodontitis in which the bone becomes involved (Hillson 1996, 262). Clinical studies have indicated that males are generally more frequently affected by the disease than females, but this may be related to habits of oral hygiene rather than biological factors (Hillson 1986, 312). In general, however, periodontal disease is multifactorial in origin and related to genetic predisposition, environment, diet and oral hygiene (Hillson 1996, 269). The identification of periodontal disease in archaeological skeletal remains is problematic, since the distance between the cemento-enamel junction and the alveolar crest increases in periodontal disease, but can also increase as a result of the teeth continuously erupting to compensate for extensive attrition (Hillson 1986, 312). Bearing these limitations in mind, the system for recording the extent of resorption of the alveolar bone devised by Brothwell (1981, 155) was followed during the current analysis (Table 20).

Culture	Overall	Males	Females
Khvalynsk	87.0 (20/23)	89.5 (17/19)	75.0 (3/4)
Yamnaya	75.0 (6/8)	83.3 (5/6)	50.0 (1/2)
Poltavka	76.5 (13/17)	80.0 (12/15)	50.0 (1/2)
Potapovka	50.0 (6/12)	55.6 (5/9)	66.7 (2/3)
Srubnaya	70.1 (61/87)	82.6 (38/46)	56.1 (23/41)

Table 20: Details of the prevalences (%) of periodontal disease by individual in each adult population group. Actual figures are provided in brackets.

Periodontal disease, predominantly of slight severity, appears to have been common in the middle Volga region, with the adult frequencies ranging from of 50% for the Potapovka population to 87% for the Khvalynsk group. It is possible that the preponderance of younger adults in the Potapovka group has contributed to the relatively low level of periodontal disease in this group. Murphy (1998, 501) found that periodontal disease occurred in 74% of Uyuk culture adult individuals, and 77.5% of Shurmak culture adults from the Siberian Iron Age site of Aymyrlyg. As stated before, it is difficult to compare the frequencies of affected males and female in each population group due to the small sample sizes. The results for the substantial Srubnaya group, however, would tend to suggest that males were statistically more susceptible to the development of periodontal disease than females ($\chi^2 = 7.271$; $P = 0.007$; $df = 1$).

Calculus

The bacteria which live on the surfaces of teeth are embedded into a matrix, partly developed by the bacteria themselves and partly formed from the proteins which occur in saliva. Together the matrix and the bacterial community form dental plaque (Hillson 1986, 284). Calculus may be defined as mineralised plaque which forms at the base of a living deposit of plaque. The mineral which forms calculus is derived from saliva, and consequently the surfaces of the teeth located nearest the salivary glands are most susceptible to plaque formation (Hillson 1996, 255). Calculus formation arises as a consequence of the factors which are responsible for the accumulation of plaque, including poor standards of oral hygiene and high levels of carbohydrate and/or protein consumption which result in the creation of an alkaline oral environment (Hillson 1996, 259; Roberts and Manchester 2005, 71). Details of the prevalence of calculus deposits for the adult teeth of each group are provided in Table 21.

Culture	**Overall**	**Male**	**Female**
Khvalynsk	74.5 (366/491)	75.5 (339/449)	64.3 (27/42)
Yamnaya	82.8 (140/169)	79.1 (102/129)	95.0 (38/40)
Poltavka	87.0 (282/324)	84.5 (218/258)	97.0 (64/66)
Potapovka	85.4 (222/260)	89.2 (174/195)	73.8 (48/65)
Srubnaya	77.3 (1339/1732)	78.2 (723/924)	76.2 (616/808)

Table 21: Details of the prevalences (%) of calculus deposits by teeth for each adult population group. Actual figures are provided in brackets.

Calculus occurred in relatively high frequencies among the Volga adult teeth of all periods, with a range of 74.5% in the Khvalynsk population to 87% for Poltavka. The prevalence among non-adults was similar to adults (Table 22).

Culture	**N deciduous teeth**	**N permanent teeth**
Khvalynsk	50.0 (6/12)	82.8 (29/35)
Yamnaya	0 (0/3)	100.0 (28/28)
Poltavka	60.0 (3/5)	38.6 (17/44)
Potapovka	0 (0/0)	0 (0/0)
Srubnaya	71.1 (113/159)	59.0 (164/278)

Table 22: Details of the prevalences (%) of calculus deposits by teeth for each non-adult population group. Actual figures are provided in brackets.

No statistically significant differences were observed in the levels of calculus on the teeth of Srubnaya males and females (χ^2 = 0.991; P = 0.319; df = 1). In the absence of caries, the high levels of calculus among the Volga populations would tend to suggest that all of the groups consumed high levels of protein (cf. Roberts and Manchester 2005, 71).

Similarly, Murphy (1998, 501) found that deposits of calculus were evident in 77.4% of Uyuk culture adult teeth, and 78.2% of Shurmak culture adult teeth from the Siberian Iron Age site of Aymyrlyg. Lillie (1996, table 3) reported a prevalence of 36.5% (299/820) for Ukrainian Mesolithic populations and 62.5% (915/1464) for Ukrainian Neolithic groups.

Calculus deposits for both adults and non-adults were invariably of slight or medium severity (cf. Brothwell 1981, 155). Details of the individuals to display heavy levels of calculus deposition on one or more teeth are presented in Table 23.

Culture	Site	Context	Age	Sex	Teeth	Cause
Poltavka	Lopatino I	K30 G2	35-50	M	7⌋⌊7	-
Poltavka	Lopatino I	K33	18-35	M	⌊8	Malalignment of tooth
Potapovka	Grachyovka II	K3 G9a	50+	F	8⌋⌊8, 7⌉	-
Potapovka	Utyevka VI	K6 G6	18-35	M	⌈8	-
Srubnaya	Barinovka I	K3 G7	35-50	F	⌊7	AM loss of ⌊8 & ⌈7 8; ⌊6 - abscesses
Srubnaya	Kras Samarskoe IV	K1 G2	35-50	M	⌊7 8, ⌈8	-
Srubnaya	Niz Orlean I	K13 G1	35-50	M	⌈8	AM loss of ⌊8
Srubnaya	Poplavskoy	Sk2	50+	M	⌊8	6⌋ & 6 5⌉ - abscesses
Srubnaya	Spiridonovka II	K14 G4	50+	F	⌈7	AM loss of ⌊5 6 7 & ⌈5; ⌊4 - caries
Srubnaya	Spiridonovka II	K14 G5	35-50	M	⌈8	AM loss of ⌈7
Srubnaya	Spiridonovka IV	K1 G8	35-50	M	⌈5	AM loss of ⌊8 & ⌈8
Srubnaya	Spiridonovka IV	K2 G1a	35-50	F	⌊7	-
Srubnaya	Studenzy I	K2 G4	35-50	F	⌈4	AM loss of ⌈5
Srubnaya	Svezhny	G71b	35-50	M	8⌋ ⌊8	AM loss of 8 7⌉ & abscess AM loss of ⌈7 8; ⌈7 - abscess

Table 23: Details of individuals with heavy deposits of calculus on one or more teeth.

The prevalence of heavy deposits of calculus by tooth over time ranged from 0% for the Khvalynsk and Yamnaya cultures, to 0.9% (3/324) for the Poltavka individuals, 1.2% (3/260) for the Potapovka corpus and 0.8% (13/1732) for the Srubnaya population. It can generally be concluded that, while calculus had a frequent occurrence amongst all the populations, usually the deposits were not heavy in nature. Pathological reasons can be found to account for the presence of the heavy deposits for nine of the 14 (64.3%) affected individuals thereby further supporting this assertion. None of the non-adult teeth displayed heavy deposits of calculus and in the majority of cases their teeth displayed only flecks or slight deposits (77.4%; 24/31).

Ante-mortem tooth loss

Ante-mortem tooth loss generally arises as a consequence of periodontal disease – as the loss of alveolar bone and tissue surrounding the tooth increases the tooth becomes loosened and is eventually avulsed (Hillson 1986, 309). Individuals with extensive ante-mortem tooth loss would have been at a disadvantage relative to those with more complete dentitions, since it would have been more difficult for edentulous, or near-edentulous, individuals to chew coarser foodstuffs. In addition, clinical studies have indicated that tooth loss predisposes some individuals to death from choking on inadequately masticated pieces of food (Rugg-Gunn 1993, 325). Details of the prevalence of ante-mortem tooth loss for the adults of each group are provided in Table 24.

Culture	Overall	Male	Female
Khvalynsk	4.0 (26/651)	2.4 (14/574)	15.6 (12/77)
Yamnaya	0.5 (1/199)	0.7 (1/151)	0 (0/48)
Poltavka	12.8 (62/483)	14.6 (61/419)	1.6 (1/64)
Potapovka	4.5 (15/335)	0.4 (1/243)	15.2 (14/92)
Srubnaya	5.2 (131/2536)	6.2 (84/1361)	4.0 (47/1175)

Table 24: Details of the adult prevalences (%) of ante-mortem tooth loss by tooth socket position for each population group. Actual figures are provided in brackets.

Ante-mortem tooth loss ranged in frequency from 0.5% for the Yamnaya group to 12.8% for Poltavka. The rates were similar for the Khvalynsk (4%), Potapovka (4.5%) and Srubnaya (5.2%) cultures. Rates were notably higher for the Poltavka corpus but this group contained a number of older adult males who were almost edentulous. Ante-mortem loss was associated with 9.1% of Uyuk culture adult tooth positions and 7.9% among their Shurmak culture counterparts at the Iron Age cemetery of Aymyrlyg, South Siberia (Murphy 1998, 501). The results for the large Srubnaya corpus would tend to suggest that males were statistically more susceptible to ante-mortem tooth loss than females ($\chi^2 = 6.072$; $P = 0.014$; $df = 1$).

Extensive attrition

Dental attrition generally arises as a result of neighbouring, or opposing, teeth coming into contact with one another, and wear facets may develop on the occlusal surfaces or at points of contact between the teeth (Hillson 1996, 231). Attrition of the occlusal surfaces may initially destroy the enamel and expose the underlying dentine, and further attrition may then expose the pulp cavity (Ortner 2003, 604). The study of tooth attrition can reveal a considerable amount of information on the use of teeth as tools in craftworking, diet and food preparation techniques (Molnar 1972, 511). Details of the frequencies of adult teeth with evidence of secondary dentine or pulp cavity exposure (classed as extensive attrition) from the different periods is provided in Table 25.

Culture	**Overall**	**Male**	**Female**
Khvalynsk	16.7 (82/491)	15.6 (70/449)	28.6 (12/42)
Yamnaya	4.7 (8/169)	6.2 (8/129)	0 (0/40)
Poltavka	26.2 (85/324)	28.7 (74/258)	16.7 (11/66)
Potapovka	25.0 (65/260)	20.5 (40/195)	38.5 (25/65)
Srubnaya	11.0 (190/1732)	14.9 (138/924)	6.4 (52/808)

Table 25: Details of the frequencies of adult teeth (%) with evidence of secondary dentine or pulp cavity exposure from the different periods. Actual figures are provided in brackets.

The frequencies of adult teeth with extensive attrition across the different periods ranged from 4.7% for Yamnaya to 26.2% for Poltavka. Adults appear to have been most susceptible to extensive attrition during the Poltavka and Potapovka periods. Extensive tooth attrition was associated with 13.8% of Uyuk culture adult teeth and 11.2% of Shurmak culture teeth at the Iron Age cemetery of Aymyrlyg, comparable to the Srubnaya frequency in the middle Volga (Murphy 1998, 499). The results for the large Srubnaya corpus would tend to suggest that males were statistically more susceptible to extensive tooth attrition than females (χ^2 = 31.884; P = 0.000;

df = 1). All teeth in the dental arc for all populations appear to have been susceptible to the development of extensive attrition and it is thought that it was probably mostly related to diet as opposed to the use of teeth as tools.

Correlations between dental attrition, diet and food preparation techniques have been observed in prehistoric population groups throughout the world (Larsen 1997, 248). The occurrence of heavy wear on both deciduous and permanent teeth has often been attributed to the use of stone grinders in the preparation of cereal grains into coarse flour (Powell 1985, 309), while research on early modern and modern Inuit populations has attributed the occurrence of heavy wear to occupational activities, including hide processing, and the consumption of large quantities of frozen meat (Powell 1985, 326). Larsen (1997, 250-251) reported that hunter-gatherers in prehistoric North America displayed more extensive wear patterns than later agriculturalists in the same region. The decrease in wear was explained by the shift in reliance from non-domesticated to domesticated plants or the more intensified use of domesticated plants which was associated with changes in food processing techniques. A similar difference has also been reported for hunter-gatherer and agricultural populations in Europe. It has also been suggested that the most important aetiological factor relating to dental wear is not the occurrence of a coarse gritty diet, but rather the need to chew long and strongly on tough food (Wells 1975, 741). Consequently, although fewer abrasive components are contained in meat relative to vegetable foods (Hillson 1979, 156), it is possible that tough meat, possibly dried, has the potential to result in the development of extensive dental attrition.

Activity patterns

Palaeopathological lesions can provide insights concerning lifestyles and day- to-day activities. These can occur as skeletal trauma, thought to be more characteristic of everyday accidents than deliberate violence; and as traits associated with joint disease.

Non-violence-related trauma

Fractures of the appendicular skeleton

Crude prevalence rates of adults with one or more fractured appendicular bones are provided in Table 26.

Culture	Adult	Male	Female
Yamnaya	6.3 (1/16)	8.3 (1/12)	0 (0/4)
Poltavka	14.7 (5/34)	17.2 (5/29)	0 (0/5)
Potapovka	7.1 (1/14)	9.1 (1/11)	0 (0/3)
Srubnaya	4.6 (6/129)	4.5 (3/67)	4.9 (3/61)

Table 26: Crude prevalence rates (%) of non-violence-related fractures based on the numbers of individuals affected in each population group. Counts in brackets. It was not possible to determine sex for one of the Srubnaya adults or to examine the Khvalynsk group for trauma.

The frequencies of individuals who displayed one or more fractured appendicular bones ranged from 4.6% (6/129) for the Srubnaya adults to 14.7% (5/34) for the Poltavka group. The high prevalence for the Poltavka group is of interest although it is difficult to be certain if this is a genuine trend or simply an artefact of the relatively small sample size. Although the numbers are small it is clear that for the Yamnaya to Potapovka populations males were more susceptible to non-violence-related appendicular fractures than females. The trend differed for the Srubnaya group in which males (4.5%) and females (4.9%) appear to have been equally susceptible to such injuries.

Details of the fractured appendicular bones present in the populations are provided in Table 27. The majority of the thirteen affected individuals were male (76.9%; 10/13). The prevalence rate of each fractured long bone by population is provided in Table 28.

Culture	Site	Context	Age	Sex	Bone	Type	Healing	Cause
Yamnaya	Lopatino I	K29 G1	35-50	M	R radius distal third	Simple oblique	Advanced	Fall on outstretched hand/direct blow
Poltavka	Grachyovka	K1 G2	50+	M	L radius prox third	Simple oblique	Advanced	Fall on outstretched hand/direct blow
Poltavka	Kalinovka	K1 G3	35-50	M	Tibia shaft	Simple oblique	Early-mid	
					R 4th MT distal third	-	-	
Poltavka	Lopatino I	K1 G1	18-35	M	L ulna prox third	Simple oblique	Advanced	Fall on outstretched hand
Poltavka	Tryasinovka	K2 G3	50+	M	R tibia distal third	Simple oblique	Advanced	
Potapovka	Grachyovka II	K2 G1	35-50	M	Prox hand phalanx	Simple oblique	Advanced	
Potapovka	Utyevka II	-	18-35	M	L radius & ulna dist thirds	Simple oblique	Advanced	Fall on outstretched hand
Srubnaya	Barinovka I	K1 G2b	35-50	M	L 1st prox foot phalanx dist	Simple oblique	Early	
Srubnaya	Nizhny Orleansky IV	K1 G2	50+	M	R tibia distal end	Compression	Advanced	
Srubnaya	Spiridonovka II	K11 G6	18-35	F	R femur shaft	Poss hairline	Advanced	
Srubnaya	Spiridonovka IV	K1 G10	35-50	F	L radius distal third	Simple oblique	Advanced	Fall on outstretched hand
Srubnaya	Spiridonovka IV	K2 G12	50+	M	R radius distal third	Simple oblique	Advanced	Fall on outstretched hand
Srubnaya	Uranbash	G88	18-35	F	R tibia midshaft	Simple oblique	Advanced	

Table 27: Details of the fractures of the appendicular skeleton apparent in the population groups.

	Yamnaya	**Poltavka**	**Potapovka**	**Srubnaya**
Radius (shaft)	4.3 (1/23)	2.6 (1/38)	4.8 (1/21)	1.4 (2/142)
Ulna (shaft)	0 (0/19)	2.8 (1/36)	5.0 (1/20)	0 (0/143)
Femur (shaft)	0 (0/20)	0 (0/41)	0 (0/25)	0.6 (1/175)
Tibia (shaft)	0 (0/23)	5.1 (2/39)	0 (0/23)	0.6 (1/174)
Tibia (distal end)	0 (0/20)	0 (0/39)	0 (0/22)	0.6 (1/164)

Table 28: Prevalence (%) of the different fractured long bones based on the numbers of right and left bones for each population group.

Again, the small sample sizes make it difficult to identify genuine trends but the radius seems to have been the bone most susceptible to fracture in the Yamnaya (4.3%) and Srubnaya (1.4%) groups, while the ulna and radius were almost equally likely to be fractured in the Potapovka population. The trend was somewhat different for the Poltavka group (5.1%) in which the tibia was most susceptible to fracture.

Amongst all of the populations the nature of the fractures to the forearm bones was mostly characteristic of falls on the outstretched hand although in a number of cases it was not possible to exclude the possibility that they had been caused by a direct blow to the arm (Hamblen and Simpson 2007, 172; Resnick and Goergen 1995, 2734). The 18-35 year old Poltavka male recovered from the Lopatino I cemetery (K1 G1) also displayed myositis ossificans traumatica on his left femur (see below) which would tend to suggest that his forearm fracture had been attained a result of a fall rather than a direct blow.

A 50+ year old Poltavka male (Tryasinovka, K2 G3) displayed a longstanding simple, oblique fracture to the distal end of his right tibia. A 35-50 year old Poltavka male (Kalinovka, K1 G3) displayed a simple oblique fracture in the early to mid stages of healing in a shaft fragment of one of his tibiae. The individual's right fourth metatarsal also appeared to have been fractured at the distal third of its shaft. An 18-35 year old Srubnaya female (Uranbash G88) displayed a long-standing simple, oblique fracture at the midshaft of her right tibia. There was only 50% apposition of the fracture parts and the proximal half was displaced anteriorly and slight medially. In addition, approximately 15 mm of overlap of fracture parts was apparent and it is probable that the bone would have been notably shorter than its left counterpart.

In all three cases of fractured tibiae the corresponding fibulae were not present so it was not possible to know if the injury had affected only the tibia or both lower leg bones, although it is known that the latter injury is more common among modern populations (Hamblen and Simpson 2007, 281). Fractures of the tibia and/or fibula shafts generally arise as a result of a direct blow to the leg, such as a kick (Hughes 1986, 130, 133). Perhaps the tibia shaft injuries sustained by the two Poltavka individuals had been due to kicks from livestock, although there are, of course, many other possible ways that the bones could have been injured. A 50+ year old Srubnaya male (Nizhny Orleansky IV, K1 G2) displayed a long standing compression fracture of his right distal tibia. The fracture appears to have affected the postero-lateral aspect of the articular surface where a series of small transverse fracture lines were apparent. The injury seems to have resulted in disruption to the associated soft tissue and bone growths were evident in the region immediately superior to the fracture lines and on the posterior margin of the tibio-fibular notch. This type of injury can be caused by a fall from a height (Hamblen and Simpson 2007, 292). Among the Srubnaya population an 18-35 year old female (K11 G6), recovered from the Spiridonovka II cemetery, displayed evidence for a possible long-standing hairline fracture at the proximal end of her right femur.

Details of the frequencies of fractured appendicular bones, in terms of the overall numbers of long bones available for each period, are provided in Table 29.

Culture	Overall	Male	Female
Yamnaya	0.8 (1/128)	1.2 (1/82)	0 (0/46)
Poltavka	1.8 (4/228)	2.3 (4/172)	0 (0/56)
Potapovka	0.8 (1/125)	1.1 (1/91)	0 (0/34)
Srubnaya	0.5 (5/926)	0.4 (2/475)	0.7 (3/451)

Table 29: Frequencies (%) of fractured appendicular bones as a proportion of the total number of adult long bones across the different time periods. Actual figures are provided in brackets.

The frequencies of fractured appendicular bones as a proportion of the total numbers of adult long bones were notably low, ranging from 0.5% (5/926) for the Srubnaya group to 1.8% (4/228) for the Poltavka population. It is interesting that the Poltavka population group displayed the greatest prevalence of fractured appendicular bones as well as the highest prevalence of adults with appendicular fractures, when compared to the other populations. This finding may indicate that the Poltavka adults were genuinely more susceptible to the occurrence of appendicular fractures relative to the other groups. For the substantial Srubnaya corpus, it is clear that males (0.4%) and females (0.7%) were almost equally susceptible to non-violence-related fractures. Murphy (2003a, 96) observed that fractures were present in 0.9% of all Uyuk culture and 0.8% of all Shurmak culture adult long bones from Iron Age

Aymyrlyg, South Siberia. A survey of six British Medieval sites indicated that fracture prevalences ranged from 0.3% to 6.1%. The 6.1% frequency observed in one of these samples was notably higher than the prevalences observed in the other studies, and it has been suggested that the results reflect a small sample size (Roberts and Manchester 2005, 99). The prevalences of fractures among the Volga populations, therefore, are well within the expected range for an archaeological population.

A small number of individuals displayed hand or foot fractures. Skeleton K1 G3, the 35-50 year old Poltavka male recovered from the Kalinovka burial site, with a fractured tibia (see above) also had a fracture of the distal third of the shaft of the right fourth metatarsal. A 35-50 year old male (Grachyovka II, K2 G1) also recovered from the Poltavka group displayed a long standing, simple, oblique fracture at the distal end of one of his proximal hand phalanges. A 35-50 year old Srubnaya male (Barinovka, K1 G2b) displayed a simple oblique fracture at the distal end of his left first proximal foot phalanx that was in the early stages of healing.

Fractures of the axial skeleton

Fractures of the ribs and vertebrae occurred only in the Srubnaya population. Rib fractures arose amongst the Srubnaya adults with a prevalence of 1% (2/197). The majority of fractures of the ribs occur as a result of direct injury, such as a blow to the chest or a fall against a hard object (Hamblen and Simpson 2007, 119). Skeleton K5 G2, an 18-35 year old female recovered from the Kinel I burial ground, displayed two fractured ribs. The left tenth and eleventh ribs displayed simple transverse fractures which occurred at the same regions of the midshafts and had probably been caused during a single incident. Both fractures were surrounded by extensive callus formation, suggesting they were in the early to mid stages of healing. No other examples of trauma were apparent in the remains of the individual, making it likely that she had suffered from a direct blow or fall against a hard object.

Two Srubnaya adults displayed compression fractures of their thoracic or lumbar vertebral bodies. The majority of fractures of the vertebral bodies of the thoracic or lumbar vertebrae are caused by vertical forces acting through the long axis of the spinal column. The forces can act from above, as in situations where heavy weights fall on top of the individual, or from below as a result of a heavy fall on the feet or the buttocks (Hamblen and Simpson 2007, 109). A compression fracture of the right side of TV12 was apparent in Skeleton K3 G17, a 35-50 year old male, recovered from the Krasnosamarskoe IV burial ground. The individual also displayed osteochondritis dissecans (see below), which may be a further indicator of a heavy physical lifestyle. A compression fracture was also evidence in the LV5 of Skeleton K1 G22, a 35-50 year old female, retrieved from the Spiridonovka IV cemetery. Spondylolysis was apparent in the LV4 (see below) of the individual, which may indicate that she had engaged in heavy physical activities. A total of 148 adult cervical, thoracic and lumbar vertebrae were examined for compression fractures, 1.4% (2/148) of which displayed the injuries. Of the thoracic vertebrae examined, 0.6% (1/163) displayed the lesions; and of the lumbar vertebrae, 0.7% (1/143).

Skeleton K11 G13, an 18-35 year old Srubnaya female recovered from the Spiridonovka II cemetery, displayed a hyperextension fracture at the anterior aspect of the superior body surface of LV4. An area of bone measuring 25.6 mm medio-laterally by 10 mm supero-inferiorly had chipped off the superior surface to expose the spongy bone beneath. Marginal osteophytes were associated with the affected area.

Spondylolysis

Spondylolysis is a vertebral defect in which a lack of bony continuity occurs at the pars interarticularis and the defective area is bridged by fibrous tissue (Adams and Hamblen 1990, 190). The lesion occurs in adults of modern populations with a frequency of 5-6% (Schmorl and Junghanns 1971, 88), although certain ethnic groups, such as the Japanese and Inuit, have a higher incidence of the defect. Up to 50% of Inuit may display spondylolysis, a finding that has been explained as a consequence of their difficult and strenuous lifestyle (Merbs and Wilson 1960, 160). The defect occurs with higher frequency among athletes, especially those involved in gymnastics, diving, weight-lifting, pole-vaulting and American football, and the majority of cases in modern populations occur in males (Resnick *et al*. 1995, 2597).

The aetiology of spondylolysis is uncertain, with genetic or traumatic causes both considered as possible aetiologies. It is generally accepted, however, that it is an acquired traumatic lesion which would have occurred at some stage between infancy and young adulthood. It has been suggested that it may arise as a result of a fatigue fracture as a consequence of repeated trauma, possibly due to bending and lifting in an upright position. An acute fracture at the pars interarticularis can also reflect a single incident of trauma, probably accounting for a proportion of the defects (Roberts and Manchester 2005, 106). It is likely that, to a certain extent, genetic factors are also involved, as 25% of individuals in some families display the lesion. The defect may be asymptomatic, but lumbar back pain, tenderness, gait abnormality and neurologic problems can occur (Resnick *et al*. 1995, 2599). Details of the individuals with spondylolysis among the Volga populations are provided in Table 30.

Culture	**Site**	**Context**	**Sex**	**Age**	**Vertebra**	**R**	**L**	**Other trauma/ vertebral DJD**	**Prevalence by bone**
Yamnaya	Kutuluk I	K1 G1	M	18-35	LV5	+	+	o	10.0% (1/10)
Poltavka	Kalinovka	K1 G6	F	35-50	LV5	+	+	+	7.7% (1/13)
Srubnaya	Chistyar I	K2 G10	F	35-50	LV5	+	+	o	11.1% (4/36)
Srubnaya	Krasnosamarsko e IV	K3 G1	F	18-35	LV5	+	+	+	11.1% (4/36)
Srubnaya	Nizhny Orleansky ?	K1 G3	M	35-50	LV5	+	+	o	11.1% (4/36)
Srubnaya	Spiridonovka II	K1 G6	M	35-50	LV5	o	+	o	11.1% (4/36)
Srubnaya	Spiridonovka IV	K1 G22	F	35-50	LV4	+	+	+	3.4% (1/29)

Table 30: Details of spondylolysis in the populations. (+ = present, o = absent, LV = lumbar vertebra).

The prevalence of spondylolysis ranged from 3.4% for Srubnaya LV4s to 11.1% for Srubnaya LV5s. Of the seven affected individuals four were female. Among the Srubnaya population the prevalence of spondylolysis amongst females was 11.8% (2/17) for LV5, while the frequency of occurrence in the LV5s of males was 10.5% (2/19). These results would tend to suggest that males and females were practically equally susceptible to the development of spondylolysis in Srubnaya times. Murphy (2003a, 96), reported that the injury occurred with a frequency of 13% among Uyuk culture lumbar spines and 5% among Shurmak culture lumbar spines at Aymyrlyg, South Siberia. In both populations females were more frequently affected than males. The occurrence of spondylolysis in a Poltavka female and three Srubnaya females suggests that both males and females in these cultures engaged in heavy physical activities which caused strain to the lower back.

Myositis ossificans traumatica

Myositis ossificans traumatica generally occurs as a sequela to trauma, and the sites most commonly affected are those most susceptible to trauma including the elbow, the thigh and the buttocks. Post-traumatic ossification of soft tissues generally arises after an incident of severe trauma, but it is also known to occur as a result of repetitive incidents of minor trauma which can be occupationally induced (Resnick and Niwayama 1995c, 4577). Details of the cases of myositis ossificans traumatica among the Volga populations are provided in Table 31.

Culture	Site	Context	Age	Sex	Bone	Muscles affected	Prevalence by bone part
Yamnaya	Lopatino I	K31	35-50	M	L ulna prox	flexor digitorum superficialis, pronator teres, brachialis, supinator muscles	5.0% (1/20)
Poltavka	Lopatino I	K1 G1	18-35	M	R femur shaft	vastus lateralis	2.4% (1/41)
Poltavka	Nikolaevka III	K1 G3	35-50	M	L femur dist	tibial collateral ligament	2.6% (1/39)
Poltavka	Nizhny Orleansky I	K1 G4	35-50	M	R tibia & fibula prox	interosseous ligament	2.9% (1/35 tib); 3.0% (1/33 fib)
Potapovka	Potapovka I	K5 G3	35-50	M	R tibia & fibula dist	tibial collateral ligament, interosseous ligament	4.5% (1/22 tib); 7.7% (1/13 fib)
Srubnaya	Barinovka I	K2 G15	35-50	M	R femur prox	iliofemoral ligament, gluteus minimus, vastus lateralis	0.6% (1/164)
Srubnaya	Spiridonovka IV	K2 G6	50+	M	L clavicle acromial	trapezoid and conoid ligaments, deltoid	1.1% (1/93)

Table 31: Details of the cases of myositis ossificans traumatica among the Volga populations (prevalence is calculated on R and L bones specific to the affected part).

The prevalence of the lesions by bone was generally low, ranging from 0.6% for Srubnaya proximal femora to 7.7% for Potapovka distal fibulae. Details of the frequencies of myositis ossificans traumatica, in terms of the overall numbers of long bones that were available for each period, are provided in Table 32.

Culture	Overall	Male	Female
Yamnaya	0.8 (1/128)	1.2 (1/82)	0 (0/46)
Poltavka	1.8 (4/228)	1.7 (3/172)	0 (0/56)
Potapovka	1.6 (2/125)	1.1 (1/91)	0 (0/34)
Srubnaya	0.1 (1/926)	0.4 (2/475)	0 (0/451)

Table 32: Frequencies (%) of myositis ossificans traumatica as a proportion of the total number of adult long bones across the different time periods. The actual figures are provided in brackets.

Myositis ossificans traumatica occurred among the Volga populations at a low frequency, ranging from 0.1% for the Srubnaya group to 1.8% for Poltavka. The elevated Poltavka frequency repeats the pattern for fractures of the appendicular skeleton discussed earlier, and would appear to confirm that the Poltavka adults were most susceptible to everyday injuries. This finding may suggest that the nature of their lifestyle made them more accident prone than individuals from the other periods, particularly Srubnaya times. In all populations, only males displayed myositis ossificans traumatica.

Ossified hematomas

Muscle contusion can arise as a consequence of direct trauma made by a blunt implement, which may result in the rupture of capillaries and the occurrence of bleeding between the fibres of the damaged connective tissue. This type of injury is generally followed by oedema and the development of an inflammatory mass (Resnick *et al*. 1995, 2673), and the resultant soft tissue swelling may become replaced by a smooth bone swelling known as an ossified haematoma (Baker and Brothwell 1980, 83).

Two Srubnaya adults and a Srubnaya non-adult displayed evidence of these injuries. Skeleton K1 G3, an 18-35 year old male recovered from the Chistyar I burial ground, displayed an oval-shaped smooth bony nodule, which measured 12 mm antero-posteriorly by 5 mm medio-laterally, on the inferior margin of the mandibular body in the region of the left second premolar and first molar. Skeleton K1 G7, an 18-35 year old male retrieved from the Spiridonovka IV cemetery, displayed a smooth oval-shaped bony nodule, which measured 23.2 mm supero-inferiorly by 4 mm antero-posteriorly, on the medial surface of the midshaft of the right tibia.

The injuries occurred on Srubnaya adult mandibles with a frequency of 1.3% (1/78), and on tibial midshafts at 0.6% (1/174). Skeleton K4 G4 Sk2, a 15-17 year old possible female recovered from the Srubnaya Rozhdestveno I burial ground, displayed a possible example of an ossified haematoma in the early stages of development. A smooth, raised area of bone was visible on the proximal third of the right tibia. The lesion was concentrated on the area immediately superior to the nutrient foramen on the lateral aspect of the posterior surface and was surrounded by finely pitted woven bone, which may indicate that it was still in the process of healing.

Os acromiale

Os acromiale is an anomaly in which a persistent ossification centre occurs at the most lateral part of the acromion of the scapula (McClure and Raney 1975, 27). It has been suggested that in populations with a high prevalence of os acromiale the anomaly may have been culturally, rather than genetically, induced. In the burials from the *Mary Rose*, a 16th century AD warship which sank off the south coast of England, for example, the prevalence of os acromiale was 12.5% and this was attributed to the long-term use of heavy longbows by the professional archers on board the ship (Stirland 1991, 44). Os acromiale generally occurs in 1-15% of shoulders (Resnick 1995b, 2960)

Os acromiale was apparent in the right scapula of Skeleton K3 G1, an 18-35 year old female, recovered from the Srubnaya Krasnosamarskoe IV burial ground. The lesion was only partial and had affected the superior half of the acromion. The left scapula was not available for analysis so it is not possible to ascertain if the anomaly was unilateral or bilateral. A total of 27 Srubnaya adult acromions were present and the lesion was found to have had a frequency of 3.7% (1/27). Since the individual recovered from Krasnosamarskoe IV displayed other indications of stress and strain to her skeleton in the form of Schmorl’s nodes (see below) and spondylolysis (see above) it is considered probable that the os acromiale had also arisen for this reason. An underlying developmental weakness of the acromions cannot, however, be entirely excluded as a causative factor.

Osteochondritis dissecans

Osteochondritis dissecans is a localised disorder which affects convex joint surfaces. An area of subchondral bone becomes avascular and, in conjunction with its associated articular cartilage, may slowly detach from the surrounding joint surface to form a loose body within the joint (Adams and Hamblen 1990, 125). The joints most commonly affected by the disorder are the knees and elbows, although in some cases the femoral heads and tali may display the lesions (Adams and Hamblen 1990, 126). Males are more likely to be affected by the disorder than females, and the lesion is more likely to be unilateral than bilateral (Resnick *et al*. 1995, 2616). In modern clinical cases the disorder is generally presented in adolescents or young adults. During the early stages of necrosis the individual may feel an aching sensation in the affected joint after use, and once the fragment completely separates from the articular surface the symptoms include recurrent sudden locking of the joint followed by sharp pain and effusion of a clear fluid into the joint (Adams and Hamblen 1990, 126).

Osteochondritis dissecans is generally considered to be the end result of an osteochondral fracture that was initially caused by shearing, rotatory or tangentially aligned impaction forces (Resnick *et al*. 1995, 2613). Wells (1974, 367) recorded that that the lesion occurred in the knee or foot in 95% of Romano-British and Anglo-Saxon populations. He observed that when using the feet for very heavy work – weight bearing, thrusting and turning movements – that the principal line of force is directed through the big toe, the first cuneiform, the navicular, and the head and trochlear surface of the talus to the distal articular surface of the tibia, the line along which the majority of osteochondritic dissecans lesions are observed. This observation supports the theory that trauma or stress is a major cause of the lesion (Wells 1974, 367) but modern studies have also indicated there is likely to be a genetic predisposition for the condition since it can occur throughout families, and an autosomal dominant mode of inheritance has been suggested. In addition, irregularities of ossification are considered as a third possible aetiology (Resnick *et al*. 1995, 2611). Another theory suggests that the lesion occurs as a result of ischemia, in which the blood supply to the affected area is cut off, possibly as result of thrombosis of an end-artery (Clanton and DeLee 1982, 51).

Five Srubnaya adults displayed lesions which were possibly indicative of osteochondritis dissecans (Table 33).

Site	Context	Sex	Age	Location	Bilateral/ unilateral	Other strains and activity-related trauma
Krasnosamarskoe IV	K3 G17	M	35-50	femur dist	unilateral (L)	Compression fracture TV12 Pitting MT4s
Krasnosamarskoe IV	K3 G23	M	35-50	tibia prox	unilateral (R)	Schmorl's nodes
Nizhny Orleansky II	K2 G1	M	35-50	femur prox	-	o
Spiridonovka II	K2 G37	M	18-35	femur dist	unilateral (R)	o
Spiridonovka II	K10 G7	M	18-35	talus prox	unilateral (L)	Schmorl's nodes

Table 33: Details of osteochondritis dissecans in the Srubnaya population (L = left, R=right, o = not present, TV=thoracic vertebra, MT = metatarsal) (vertebral osteophytosis and enthesopathies were not included in the 'other strains and trauma' category).

It is interesting to note that all five of the individuals with osteochondritis dissecans were male. In the four cases where it was possible to examine the corresponding right and left bones all lesions were found to be unilateral. Three of the individuals displayed other signs of stress and strain to their skeletons in the form of vertebral compression fractures and Schmorl's nodes. The occurrence of these lesions may indicate that the individuals had practised active lifestyles which had resulted in considerable physical stress to their skeletons. A summary of the prevalences of osteochondritis dissecans for the affected bones of the Srubnaya adults is provided in Table 34.

Bone	No. affected	No. present	% affected
Femur (prox)	1	164	0.6
Femur (dist)	2	168	1.2
Tibia (prox)	1	164	0.6
Talus (prox)	1	45	2.2

Table 34: A summary of the prevalences of osteochondritis dissecans in the affected bones of the Srubnaya population (both right and left bones are included).

The summary indicates that osteochondritis dissecans occurred among the Srubnaya adults with very low frequencies which ranged from 0.6% to 2.2%.

Enthesophytes

Enthesophytes can occur at the sites of musculotendinous and ligamentous attachments, and arise as a consequence of chronic repetitive irritation, bleeding and inflammation, periostitis or microavulsions (Pavlov 1995, 3246). Enthesophytes were apparent in the remains of three Srubnaya individuals. Skeleton K1 G1 Sk. 2, an 18-35 year old male recovered from the Ekaterinovka burial ground, displayed an enthesophyte at the proximal end of the left fibula. The lesion appeared to have affected the posterior talofibular ligament and measured approximately 10.5 mm supero-inferiorly by 1.4 mm antero-posteriorly. An enthesophyte was evident at the proximal end, immediately inferior to the tibio-fibular articular facet, of the right tibia of Skeleton K1 G2, an 18-35 year old male retrieved from the Studenzy I cemetery. The lesion appeared to have been related to the tibialis posterior muscle, and measured 10 mm medio-laterally by 8 mm antero-posteriorly. Post-mortem damage had resulted in its supero-inferior dimension remaining unknown. Skeleton K2 G4, a 35-50 year old female retrieved from the Studenzy I burial ground, displayed an enthesophyte on the medial surface of the distal third of the right ulna. The lesion measured approximately 11 mm supero-inferiorly by 4.3 mm antero-posteriorly and appeared to have affected the pronator quadratus muscle. The prevalence of enthesophytes amongst the affected Srubnaya long bones is provided in Table 35.

Bone	No. enthesophytes	No. bones	% enthesophytes
ulna (prox.)	1	151	0.7
tibia (prox.)	1	164	0.6
fibula (prox.)	1	87	1.1

Table 35: Prevalences of enthesophytes in the Srubnaya population.

Enthesophytes were found to have occurred amongst the Srubnaya adult long bones in very low frequencies, which ranged from 0.6% to 1.1%.

Summary of non-violent traumas

A wide variety of probable non-violent injuries was apparent. The Srubnaya population displayed the greatest variety of injuries, including appendicular and axial fractures, spondylolyis, myositis ossificans traumatica, ossified haematomas, os acromiale, osteochondritis dissecans and enthesophytes. Details of the crude prevalence rates of adults with one or more injuries considered likely to be related to lifestyle and activity rather than violence are provided in Table 36.

Culture	**Overall**	**Male**	**Female**
Yamnaya	25.0 (4/16)	33.3 (4/12)	0 (0/4)
Poltavka	20.6 (7/34)	20.7 (6/29)	20.0 (1/5)
Potapovka	14.3 (2/14)	18.2 (2/11)	0 (0/3)
Srubnaya	18.6 (24/129)	23.9 (16/67)	13.1 (8/61)

Table 36: Crude prevalence rates (%) of non-violence-related injuries. Actual figures are provided in brackets. It was not possible to determine the sex of one Srubnaya individual, or to examine the Khvalynsk group for trauma.

The crude prevalence rates are fairly similar ranging from 14.3% for the Potapovka population to 25% for Yamnaya. For males, these injuries were most prevalent among the Yamnaya (33.3%) and Srubnaya (23.9%) populations. Only the Srubnaya population had sufficient sample sizes for both sexes, showing that males (23.9%) were more frequently affected by non-violence-related injuries, but females (13.1%) were not immune and the difference was not statistically significant (χ^2 = 2.429; P = 0.119; df = 1). This finding suggests that both males and females engaged in physical activities that appear to have left them susceptible to injury.

Joint disease

In human skeletal remains it is possible only to identify degenerative processes which affected the bones and joints. The joint disease most common among archaeological population groups is osteoarthritis (Roberts and Manchester 2005, 136). Primary osteoarthritis is directly related to the ageing process and physiological wear and tear, while secondary osteoarthritis develops at an earlier age in structurally or functionally abnormal joints (Ortner 2003, 546-547). By examining the distribution of degenerative changes in the joints of different social groups culturally-related differences may become apparent. If, for example, males and females were each principally engaged in separate specific occupational activities a varying distribution pattern of degenerative changes may be apparent in their joints. Degenerative changes in the vertebrae are considered by many palaeopathologists and clinicians to be related to functional stress. Consequently, studies have been undertaken to determine the relationship between degenerative changes in the spine and known culturally patterned activities in population groups (Lovell 1994, 150). It is difficult to distinguish, however, between those extraspinal and spinal degenerative changes which are purely age-related and those which may have been occupationally induced. It is considered that degenerative changes with an apparent specific distribution and high prevalence among the younger members of a population group may indicate that the lesions were indeed occupationally induced (Roberts and Manchester 2005, 144).

Osteoarthritis is recognisable in skeletal material on the basis of several characteristic features, including the development of marginal osteophytes, subchondral bone reaction which includes eburnation, sclerosis and the development of cysts, porosity of the joint surfaces, and alterations in the contours of the joints (Rogers *et al*. 1987, 185). Eburnation is considered to be the most pathognomonic indicator of osteoarthritis (Rogers and Waldron 1995, 13), although it does not always need to be present in a joint to confirm that the individual suffered from osteoarthritis, and it is possible to make a diagnosis of osteoarthritis provided that at least two other characteristic degenerative changes can be recorded in the skeletal remains (Waldron and Rogers 1991, 49).

Extraspinal osteoarthritis

In modern clinical studies osteoarthritis occurs in bones other than the spine more frequently in the lower limbs than the upper limbs (Jurmain 1980, 148). The converse is generally true for archaeological populations, possibly indicating that the upper limbs were subject to greater functional stress in past groups compared to their modern counterparts (Jurmain 1980, 148). In a study of a 14th century population from London, for example, it was found that the shoulder (32.7%) was much more frequently affected by osteoarthritis than either the knee (4.1%) or the hip (3.1%) (Waldron 1992, 236).

Crude prevalence rates for extraspinal osteoarthritis in the middle Volga region are provided in Table 37.

Culture	**Overall**	**Male**	**Female**
Yamnaya	6.3 (1/16)	8.3 (1/12)	0 (0/4)
Poltavka	11.8 (4/34)	10.3 (3/29)	20.0 (1/5)
Potapovka	14.3 (2/14)	0 (0/11)	66.7 (2/3)
Srubnaya	16.3 (21/129)	22.4 (15/67)	9.8 (6/61)

Table 37: Crude prevalence rates (%) of extraspinal osteoarthritis based on the numbers of individuals present in each population group. Actual figures are provided in brackets. It was not possible to determine the sex of one Srubnaya individual or to examine the Khvalynsk group for osteoarthritis.

Prevalences ranged from 6.3% for the Yamnaya group to 16.3% for Srubnaya. In the Srubnaya group males (22.4%) displayed a higher level of extraspinal osteoarthritis than females (9.8%), although the results were not statistically significant (χ^2 = 3.668; P = 0.056; df = 1). This situation may have arisen because more males survived into middle and old age (see above). The extent of the difference, however, may also indicate that males engaged in physical activities which made them more susceptible to degeneration of the extraspinal joints. Details of the prevalences of osteoarthritis among the main extraspinal joints for the different populations are provided in Table 38 and Figure 4.

	Yamnaya % affected	**Poltavka % affected**	**Potapovka % affected**	**Srubnaya % affected**
Temporomandibular			10.5 (2/19)	5.9 (10/169)
Sternoclavicular		7.4 (2/27)		2.0 (2/98)
Acromioclavicular		14.8 (4/27)		7.5 (7/93)
Glenohumeral	5.0 (1/20)	11.1 (4/36)	14.3 (2/14)	9.1 (12/132)
Elbow		2.7 (1/37)	9.5 (2/21)	
Wrist		2.9 (1/34)		2.3 (3/128)
Sacroiliac				
Hip	7.7 (2/26)	8.1 (3/37)		3.0 (5/164)
Knee	4.5 (1/22)	2.6 (1/39)	9.1 (2/22)	4.2 (7/168)

Table 38: Prevalence rates of extraspinal osteoarthritis (the number of joints is based on the part of the joint with the highest number of bones present and includes right and left sides).

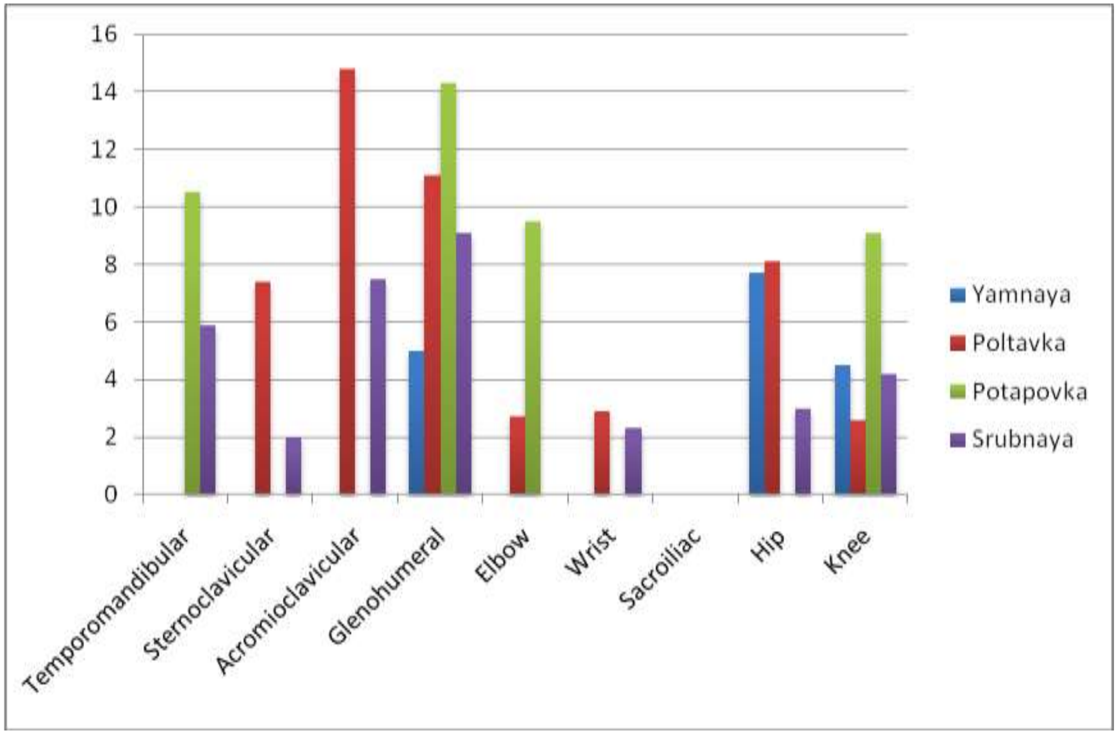

Figure 4: Prevalence rates (%) of extraspinal osteoarthritis (the number of joints is based on the part of the joint with the highest number of bones present and includes right and left sides).

Extraspinal osteoarthritis occurred with a relatively low frequency, ranging from 0% to 14.8%. The glenohumeral (shoulder) and knee joints were the only joints to be affected across all periods, while no individuals displayed osteoarthritis of the sacroiliac joint. The glenohumeral joint was the most frequently affected joint for the Potapovka (14.3%) and Srubnaya (9.1%) groups, while the acromioclavicular (upper shoulder) joint (14.8%) followed by the glenohumeral joint (11.1%) were most frequently affected for the Poltavka population. The acromioclavicular joint is used to raise the arm above the head, so perhaps the Poltavka population performed this action particularly often. The hip was most frequently affected during the Yamnaya (7.7%) period. These differences in the pattern of affected joints may indicate that a change in activity had occurred between the Yamnaya and later periods, with the principal stress shifting from the lower to the upper body. It should be noted, however, that the glenohumeral joint was also affected during the Yamnaya (5%) period, while the hip joints also displayed osteoarthritis during the Poltavka (8.1%) and Srubnaya (3%) periods. Murphy (1998, 475) found that the shoulder was the most frequently involved extraspinal joint in both Iron Age groups from Aymyrlyg, Siberia, having a frequency of 3.7% among the Uyuk culture population and 9.2% among the Shurmak culture group.

Temporomandibular joints displayed osteoarthritis only in the Potapovka (10.5%) and the Srubnaya (5.9%) populations. It is not surprising that the Potapovka individuals displayed osteoarthritis of their temporomandibular joints since relatively high numbers of their teeth were very worn (25%). It is perhaps surprising, however, that the Poltavka individuals were not affected by osteoarthritis of the temporomandibular joints since this group displayed the highest frequencies of extensive dental attrition (26.2%). Furthermore, the Srubnaya population displayed relatively low levels of attrition (11%). One would have expected a better correlation between high frequencies of extensive tooth wear and osteoarthritis of the temporomandibular joints, but that expectation is not met here.

The large Srubnaya sample made it possible to examine extraspinal osteoarthritis in further detail. A total of 21 Srubnaya individuals displayed apparently primary extraspinal osteoarthritis. Of the 20 individuals that could be assigned to specific age categories only two had age-at-death values of 18-35 years (10%), while ten (50%) had died at 35-50 years and eight (40%) had died at the age of 50+ years. This finding would tend to suggest that extraspinal osteoarthritis in the Srubnaya population was largely related to advancing age. When the frequencies of extraspinal osteoarthritis are analysed by sex some interesting trends are apparent (Table 39; Figure 5).

Joint	Overall	Male	Female
Temporomandibular	5.9 (10/169)	8.5 (8/94)	2.7 (2/75)
Sternoclavicular	2.0 (2/98)	0 (0/60)	5.3 (2/38)
Acromioclavicular	7.5 (7/93)	9.1 (5/55)	5.3 (2/38)
Glenohumeral	9.1 (12/132)	10.0 (7/70)	8.1 (5/62)
Elbow			
Wrist	2.3 (3/128)	4.3 (3/70)	0 (0/58)
Sacroiliac			
Hip	3.0 (5/164)	4.8 (4/83)	1.2 (1/81)
Knee	4.2 (7/168)	3.4 (3/88)	5.0 (4/80)

Table 39: Details of the prevalences (%) of osteoarthritis among the main extraspinal joints for Srubnaya males and females. Actual figures are provided in brackets.

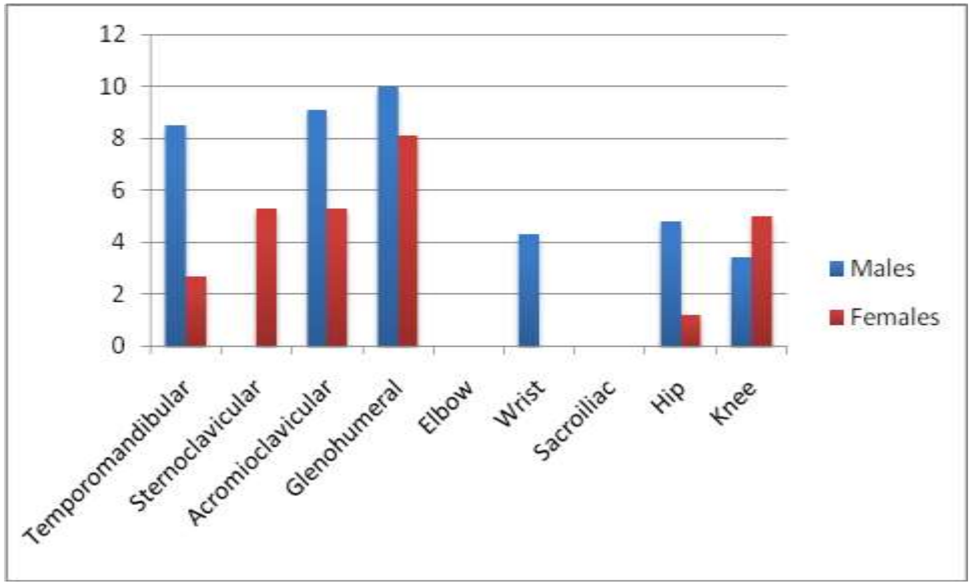

Figure 5: Details of the prevalences (%) of degenerative joint disease among the main extraspinal joints for Srubnaya males and females.

For both males and females the shoulder joint (glenohumeral) was most frequently affected. When it came to the lower limbs, however, the hip was more frequently affected in males, while the knee was slightly more frequently affected in females. Only males displayed osteoarthritis of the wrist. Notably higher frequencies of males displayed osteoarthritis of the temporomandibular joints. These findings would tend to suggest sex-related differentiation of physical activities in Srubnaya society.

<u>Spinal osteoarthritis</u>

A summary of the prevalences of osteoarthritis of the vertebrae is provided in Table 40.

Culture	Prevalence by individuals N	 Male	 Female	Prevalence by joint surface Apophyseal	 Bodies
Yamnaya	50.0 (6/12)	62.5 (5/8)	25.0 (1/4)	3.3 (15/458)	12.6 (28/223)
Poltavka	73.3 (11/15)	80.0 (8/10)	60.0 (3/5)	6.6 (72/1082)	18.9 (99/523)
Potapovka	66.7 (4/6)	60.0 (3/5)	100.0 (1/1)	1.1 (1/90)	4.7 (2/43)
Srubnaya	43.7 (31/71)	47.4 (18/38)	39.4 (13/33)	4.9 (85/1732)	20.0 (171/856)

Table 40: Summary of the prevalences of spinal osteoarthritis (%) based on the number of individuals, apophyseal joints (excluding costal and transverse facets) and body surfaces. The numbers in brackets are the actual figures.

The prevalences of spinal osteoarthritis among individuals with one or more vertebrae present were quite high, ranging from 43.7% for Srubnaya to 73.3% for Poltavka. Sex differences can be studied only in the large Srubnaya corpus, where males (47.4%) were more susceptible than females (39.4%), although the results were not statistically significant ($\chi^2 = 0.457$; $P = 0.499$; df = 1). The apophyseal joints were infrequently affected, ranging from 1.1% in the Potapovka group to 6.6% in the Poltavka group. The vertebral body surfaces were more frequently affected, but still had low values ranging from 4.7% for Potapovka to 18.9% for Poltavka and 20% for Srubnaya. The prevalences of osteoarthritis of the apophyseal joints of the different vertebrae are provided in Table 41.

Apophyseal joints	Yamnaya %	Poltavka %	Srubnaya %
CV1		11.1 (4/36)	6.5 (3/46)
CV2		8.3 (4/48)	6.5 (6/92)
CV3		9.1 (4/44)	1.8 (1/56)
CV4		15.0 (6/40)	6.3 (4/64)
CV5		5.6 (2/36)	1.7 (1/60)
CV6		7.1 (2/28)	2.1 (1/48)

CV7			5.6 (2/36)
TV1		2.5 (1/40)	
TV2			
TV3		5.6 (2/36)	
TV4		6.8 (3/44)	1.9 (1/52)
TV5		7.5 (3/40)	
TV6	12.5 (2/16)	8.3 (4/48)	
TV7	18.8 (3/16)	6.3 (3/48)	1.9 (1/52)
TV8	25.0 (4/16)		3.3 (2/60)
TV9	12.5 (2/16)		1.7 (1/60)
TV10		10.4 (5/48)	1.8 (1/56)
TV11		13.6 (6/44)	3.8 (2/52)
TV12		5.0 (2/40)	5.0 (3/60)
LV1	3.6 (1/28)	8.3 (4/48)	
LV2		6.3 (3/48)	8.0 (9/112)
LV3		7.1 (4/56)	5.6 (7/124)
LV4		13.5 (7/52)	7.8 (9/116)
LV5	7.5 (3/40)	3.8 (2/52)	16.0 (23/144)
S1		3.3 (1/30)	7.5 (8/106)

Table 41: Prevalence (%) of osteoarthritis in the apophyseal joints (excluding costal and transverse process facets) of each vertebra (CV = cervical vertebra, TV = thoracic vertebra, LV = lumbar vertebra, S = sacral vertebra). The actual figures are provided in the brackets. The Potapovka group is not included due to the very small numbers of vertebrae preserved.

During the Yamnaya period the mid-thoracic region (TV6-TV9) was most susceptible to osteoarthritis, while during Poltavka times the lower thoracic and lumbar (TV10-LV4) and the upper cervical (CV1-CV6) were the regions of the spine most prone to degeneration. Among the Srubnaya group the lumbar (LV2-S1) and the upper cervical (CV1-CV4) displayed the highest levels of osteoarthritis of the apophyseal joints. The lack of CV with osteoarthritis among the Yamnaya group was the most obvious difference between the three groups, and it may be an indication that these earlier individuals were not putting stress on their upper vertebrae to the same extent as the individuals of Poltavka and Srubnaya times. It is possible, however, that the Yamnaya results are anomalous due to the relatively small numbers of apophyseal joints preserved in this group. The occurrence of relatively high levels of osteoarthritis in the cervical vertebrae of the Poltavka and Srubnaya populations is interesting. Studies of other populations have interpreted this pattern of spinal osteoarthritis as an indication that they carried heavy loads on their heads (Larsen 1997, 176). The prevalences of osteoarthritis of the body surfaces of the different vertebrae are provided in Table 42.

Body	**Yamnaya %**	**Poltavka %**	**Srubnaya %**
CV2			4.3 (2/46)
CV3	25.0 (1/4)	13.6 (3/22)	3.4 (1/28)
CV4		25.0 (5/20)	9.4 (3/32)
CV5		27.8 (5/18)	6.7 (2/30)
CV6	25.0 (2/8)	20.0 (4/20)	12.5 (3/24)
CV7	25.0 (1/4)	7.1 (1/14)	5.6 (1/18)
TV1		15.0 (3/20)	
TV2			
TV3		11.1 (2/18)	7.1 (2/28)
TV4		13.6 (3/22)	3.8 (1/26)
TV5		15.0 (3/20)	16.7 (5/30)
TV6	25.0 (2/8)	12.5 (3/24)	15.4 (4/26)
TV7		20.8 (5/24)	26.9 (7/26)
TV8	12.5 (1/8)	25.0 (6/24)	16.7 (5/30)
TV9		25.0 (6/24)	23.3 (7/30)

TV10		29.2 (7/24)	25.0 (7/28)
TV11		9.1 (2/22)	19.2 (5/26)
TV12		10.0 (2/20)	23.3 (7/30)
LV1		25.0 (6/24)	25.0 (7/28)
LV2	12.5 (2/16)	12.5 (3/24)	25.0 (14/56)
LV3	28.6 (4/14)	28.6 (8/28)	40.3 (25/62)
LV4	35.7 (5/14)	26.9 (7/26)	34.5 (20/58)
LV5	45.0 (9/20)	38.5 (10/26)	41.7 (30/72)
S1	11.1 (1/9)	33.3 (5/15)	24.5 (13/53)

Table 42: Prevalence (%) of osteoarthritis in the vertebral body surfaces (CV = cervical vertebra, TV = thoracic vertebra, LV = lumbar vertebra, S = sacral vertebra). The actual figures are provided in the brackets. The Potapovka group is not included due to the very small numbers of vertebrae preserved.

The occurrence of osteoarthritis of the cervical vertebral bodies for the Yamnaya group suggests that the lack of osteoarthritis in the corresponding apophyseal bodies is likely to be an anomaly due to sample size rather than due to differences in physical activity between the three groups. The small sample size makes it difficult to identify general trends for the Yamnaya period but the lumbar bodies (LV3-LV5) would appear to be most susceptible to degeneration. During the Poltavka period osteoarthritis most frequently affected the bodies of the lower cervical (CV4-CV6), mid to lower thoracic (TV7-TV10) and lower lumbar (LV3-S1) regions, while the lower lumbar (LV3-LV5) were affected to the greatest extent among the Srubnaya individuals. The trends would tend to suggest that the vertebral bodies of the lower spine for all three cultures were most susceptible to stress and strain.

Schmorl's nodes

Schmorl's nodes are recognisable in the skeleton as indentations which occur on either the superior or inferior surfaces of the vertebral body, and are most common in the lower thoracic and lumbar regions of the spine (Rogers and Waldron 1995, 27). They arise as a result of intervertebral osteochondrosis in which the nucleus pulposus and the cartilaginous endplates of the vertebra simultaneously degenerate as part of the ageing process (Resnick and Niwayama 1995d, 1378). In addition, Schmorl's nodes can also occur as a result of other disease processes which disrupt the endplate or the subchondral bone, such as Scheuermann's disease, infection, metabolic and endocrine disorders, neoplastic conditions, or trauma (Resnick and Niwayama 1995d, 1421). Since there was no evidence of underlying disease among any of the individuals with Schmorl's nodes it is probable that they arose mainly as a result of degenerative processes or trauma. A summary of the prevalences of Schmorl's nodes in the vertebrae is provided in Table 43.

Culture	**Prevalence by individuals**			**Prevalence by body surface**
	N	**Male**	**Female**	**N**
Yamnaya	41.7 (5/12)	50.0 (4/8)	25.0 (1/4)	11.2 (25/223)
Poltavka	60.0 (9/15)	80.0 (8/10)	20.0 (1/5)	9.0 (47/523)
Potapovka	33.3 (2/6)	20.0 (1/5)	100.0 (1/1)	14.0 (6/43)
Srubnaya	32.4 (23/71)	31.6 (12/38)	33.3 (11/33)	18.8 (161/856)

Table 43: Summary of the prevalences (%) of Schmorl's nodes based on the number of individuals and body surfaces. The actual figures are provided in brackets.

The prevalence of individuals with Schmorl's nodes was quite high, ranging from 32.4% for the Srubnaya population group to 60% for the Poltavka adults. As was the case for osteoarthritis, it is difficult to be certain that the apparently higher prevalence for the Poltavka adults represents a real increase or is simply due to the small number of individuals included in the analysis. When the prevalences are calculated on the basis of the number of surfaces affected the results are slightly different with the Srubnaya (18.8%), Potapovka (14%) and Yamnaya (11.2%) groups having higher prevalence rates than the Poltavka (9%) population. The prevalence based on the number of bone surfaces is likely to be more reliable, suggesting that the Srubnaya group was most susceptible to the development of Schmorl's nodes. Murphy (1998, 481) found that Schmorl's nodes occurred with frequency of 17.8% among the body surfaces of the Uyuk culture population and 13.1% among the Shurmak culture population from Iron Age Aymyrlyg, South Siberia.

Among the Srubnaya adults, males (31.6%) and females (33.3%) were almost equally susceptible to the development of Schmorl's nodes ($\chi^2 = 0.025$; P = 0.875; df = 1). Some three Srubnaya males and seven females with age-at-death values of 18-35 years displayed Schmorl's nodes, a finding which indicates that both sexes were engaged in strenuous physical activities from a young age. The prevalences of Schmorl's nodes on the different vertebrae are provided in Table 44.

Body surfaces	**Yamnaya %**	**Poltavka %**	**Srubnaya %**
CV2			
CV3			
CV4			
CV5			
CV6			
CV7			
TV1			
TV2			
TV3			
TV4			3.8 (1/26)
TV5			10.0 (3/30)
TV6	12.5 (1/8)	8.3 (2/24)	15.4 (4/26)
TV7	25.0 (2/8)	16.7 (4/24)	15.4 (4/26)

TV8	12.5 (1/8)	20.8 (5/24)	20.0 (6/30)
TV9	25.0 (2/8)	20.8 (5/24)	43.3 (13/30)
TV10	20.0 (2/10)	16.7 (4/24)	42.9 (12/28)
TV11	25.0 (2/8)	4.5 (1/22)	53.8 (14/26)
TV12	20.0 (2/10)	10.0 (2/20)	63.3 (19/30)
LV1	14.3 (2/14)	20.8 (5/24)	64.3 (18/28)
LV2	6.3 (1/16)	8.3 (2/24)	33.9 (19/56)
LV3	14.3 (2/14)	14.3 (4/28)	41.9 (26/62)
LV4	28.6 (4/14)	19.2 (5/26)	19.0 (11/58)
LV5	10.0 (2/20)	19.2 (5/26)	11.1 (8/72)
S1	11.1 (1/9)	20.0 (3/15)	5.7 (3/53)

Table 44: Prevalence (%) of Schmorl's nodes in the vertebral body surfaces (CV = cervical vertebra, TV = thoracic vertebra, LV = lumbar vertebra, S = sacral vertebra). The actual figures are provided in brackets. The Potapovka group is not included due to the very small numbers of vertebrae preserved.

In all three groups the lower thoracic and lumbar spines were most susceptible to the development of Schmorl's nodes. A cluster of particularly high prevalences was evident for TV9-LV3 of the Srubnaya population. The findings indicate that the lower spine was most susceptible to damage as a result of strenuous physical activities.

Violence and Society

Evidence for deliberate violence occurred in generally small levels amongst the population groups and comprised possible weapon injuries and fractured nasal bones.

Weapon injuries

Since a variety of possible weapon injuries were observed they will each be described in turn. Skeleton K3 G1, a 15-17 year old Yamnaya male recovered from the Lopatino II cemetery, displayed an oval-shaped perforating injury on the posterior aspect of his right parietal. The perforation measured 38 mm antero-posteriorly by 6.5 mm medio-laterally at its anterior margin and 15 mm medio-laterally at its posterior margin. The anterior margin of the perforation had a beveled appearance, and a fracture line radiated from the lateral aspect of the anterior margin to the posterior part of the temporal bone. No evidence of healing was associated with the injury.

An 18-35 year old male recovered from Yamnaya Flat Grave 5 at the Leshyovsky I burial site displayed a series of unusual weapon injuries that appeared to have been made during the peri-mortem period. A large chop mark was apparent on the lateral surface of the proximal end of the right femur, in the area immediately inferior to the greater trochanter (Plate 2). The injury appears to have been made with a fairly heavy blunt implement that was wielded with substantial force. The blow had resulted in the detachment of a triangular segment of bone, which would have measured approximately 35 mm antero-posteriorly by 51 mm supero-inferiorly, and encompassed the entire medio-lateral diameter of the bone in that region. The remaining underlying bone had a splintered appearance. The location of the injury indicates that it was dealt to the side of the individual.

Multiple injuries that can best be described as scrape or gouge marks, as a consequence of their broad and shallow nature, were apparent on the cranium (Plates 3 and 4) and are summarized in Table 45.

Bone	Location	Morphology	Dimensions
L parietal	lateral	transverse	36.4 mm SI x 2 mm AP
	posterior	transverse	20.1 mm ML x 1.7 mm SI
R parietal (Plate 3)	posterior	transverse, slightly curved	27.5 mm AP x 2 mm SI
R parietal-occipital (Plates 3 and 4)	posterior (p) supero-lateral (o)	oblique	79.6 mm AP x 2.3 mm SI
	adjacent to lambda	oblique	36.1 mm AP x 2.8 mm SI
	adjacent to lambda	oblique	32.5 mm AP x 2.6 mm SI
Occipital (Plate 4)	external occipital protuberance	curved	29.4 mm ML x 2.1 mm SI
			28.6 mm AP x 2.1 mm SI
	L occipital condyle	transverse	4.1 mm AP x 2 mm ML

Table 45: Yamnaya individual – Details of the cranial injuries apparent in the individual recovered from Flat Grave 5 of the Leshyovsky I burial ground (L=left, R=right, p=parietal, o=occipital, AP=antero-posterior, SI=supero-inferior, ML=medio-lateral).

A total of eight scrape or gouge marks were apparent on the individual's cranium. It is evident that the majority of marks were located on the posterior aspect of the cranium, particularly on the occipital. All of the scrape marks had a similar breadth of around 2 mm, which may indicate that they had been made using a single implement or by a single individual. In a number of cases the marks had clearly been made using a serrated implement, which had the potential to leave a curved mark. The scrape marks do not appear to have been made for the purposes of scalping the individual since these marks are generally made in a very methodical manner which follows the circumference of the cranium (see Murphy *et al*. 2002). The more random nature of the scrape marks in the case of the individual from Leshyovsky I may suggest that they had been employed for the purposes of removing tufts of hair from the individual, as opposed to his scalp. It can be speculated that this may have been a means of torture. The only injury which cannot be explained in this manner is the short mark that was apparent on the left occipital condyle. This injury may have been made during the decapitation of the individual, although it is curious that no further marks were evident on the occipital condyles or the cervical vertebrae.

Two transverse conjoined scrape marks were apparent on the medial surface of the proximal end of the distal third of the left femur. Both marks appeared to have emanated from the same point but became forked as they advanced towards the anterior surface of the shaft. They measured approximately 25 mm antero-posteriorly by 1.5 mm supero-inferiorly. A further discrete transverse scrape mark was visible on the anterior surface of the distal aspect of the proximal half of the left femur. It measured approximately 10.5 mm antero-posteriorly by 1.5 mm supero-inferiorly. In addition, further possible scrape marks were present on the anterior surface of the left femur, but these were notably less pronounced than the marks already described.

It can be postulated that the chop mark on the right proximal femur represented the initial injury to the individual since he would have been largely incapacitated by this blow. It would then have been possible for the assailants to undertake the gouging injuries on the individual’s cranium and left femur. The individual also displayed probable slipped femoral capital epiphysis of his right femur and cleft neural arch defects (see above). In addition, it has been reported that he had been buried in a prone, contorted position in Grave 5, which was positioned adjacent to, but not beneath, a kurgan.

A single Poltavka individual displayed clear evidence for a depressed fracture of the cranium. The injury was apparent in the cranium of Skeleton K2 G3, a 50+ year old male, recovered from the Tryasinovka burial ground. It had been made to the superior aspect of the parietals, approximately 25 mm posterior to the bregma and comprised an oval-shaped perforation, which measured around 30 mm medio-laterally by 18 mm antero-posteriorly. The right side of the perforation had a beveled edge and two fracture lines radiated from the right corner of the posterior margin of the perforation. The first fracture line ran parallel to the posterior margin in a lateral direction, while the second fracture line, which measured approximately 38 mm, radiated in a posterior direction until it reached the sagittal suture. A further fracture line ran in a posterior direction from the midpoint of the aforementioned line and ran towards the lambdoid suture. The morphology of the injury suggests that it had been made with a small, rounded object, presumably an axe. The occurrence of the large radiating fracture lines is an indication that the blow had been dealt with a substantial amount of force. The location of the beveled margin suggests that it had been dealt by someone standing to the left of the individual. The left side of the cranium was poorly preserved, but one of the broken margins of the left parietal, located just beneath the injury described above, was notably curved. It is considered possible that this curved edge may have been due to a second blow having been dealt to the cranium. No signs of healing were associated with either of the injuries and it is probable that they had been responsible for the death of the individual. The individual also displayed a healed fracture of his right tibia (see above).

A single Potapovka individual – Skeleton K6 G6, an 18-35 year old male, recovered from the Utyevka VI burial ground – displayed two possible cranial fractures. An oval-shaped depressed area, which measured approximately 10 mm antero-posteriorly by 16 mm medio-laterally, was situated on the superior aspect of the left side of the frontal bone, just anterior to the coronal suture. The oval-shaped area was surrounded by a pronounced sclerotic margin. It is possible that the lesion was a well-healed depressed fracture, which had been made with a small blunt implement. A linear indentation, of similar dimensions, was apparent just anterior to the oval-shaped depression and may represent a second healed injury. The ectocranial surfaces of the superior aspect of the frontal bone and the parietals had a generally irregular and porotic appearance. This finding may have been due to the occurrence of inflammatory or infectious activity on the cranial surface, and could have been secondary to the possible injuries. It is difficult to be certain, however, that the lesions were traumatic in nature and it is also possible that they had been due to some form of localised infection. Possible depressed fractures occurred with a prevalence of 8.3% (1/12) on the frontal bones of the Potapovka adults.

Four Srubnaya individuals displayed possible evidence for weapon injuries to their crania. A possible injury was evident at the midpoint of the frontal bone, immediately superior to the supraorbital ridges of Skeleton K2 G41, an 18-35 year old male, recovered from the Barinovka I cemetery. The depression was sub-rectangular in shape and measured 14.1 mm medio-laterally by 3.6 mm supero-inferiorly, and had a depth of approximately 2 mm. No radiating fracture lines were apparent. The depressed area was not very distinct and it is probable that the injury was in an advanced state of healing. The morphology of the injury would tend to suggest that it had been made with a small, sharp object, possibly a blade.

Skeleton K2 G13, a 35-50 year old male, retrieved from the Srubnaya Chistyar I burial ground (Plate 5) displayed a very pronounced near-circular depressed area on the right side of the frontal bone, immediately anterior to the coronal suture. Its external diameter was approximately 41 mm, while the internal diameter measured approximately 36.5 mm medio-laterally by 31 mm antero-posteriorly. It had a very pronounced scelerotic margin which had a thickness of approximately 5 mm, and the depth of the depression was also around 5 mm. Bone was present in the interior of the depressed area, which appeared to derive from the inner vault table. No obvious fracture lines were visible around the margins and they were very smooth, features that would tend to suggest the trauma was long-standing and well healed. A possible fracture line was apparent in the new bone formation within the interior of the injury. A line was visible on the endocranial surface which demarcated the extent of the injury and no beveling was evident. It is considered probable that the trauma represented a long-standing, healed blunt force injury. The main indicator that the perforation may have represented a depressed fracture is the occurrence of the curved fracture line that affected the new bone formation in the interior of the circular area. If the depression had been due to blunt force trauma it is probable that it had been made using a rounded implement, with a diameter of around 40 mm, possibly a mace. The main differential diagnosis for the injury is that it was a healed trepanation. The features compatible with this diagnosis include the regularity of the shape of the trauma, the development of new bone that is restricted to the inner vault table in the interior of the circular area and the absence of beveling on the endocranial surface of the cranium. Numerous examples of ante-mortem trepanations are known from the palaeopathological record for the Eurasian steppes (e.g. Mednikova 2001; Murphy 2003b), with the earliest possible cases dating to Epipaleolithic times (Lillie 2003).

Despite extensive surface erosion a possible injury was apparent on the frontal bone of Skeleton K10 G7, an 18-35 year old male, retrieved from the Spiridonovka II burial ground. An oval-shaped depression, which measured 12 mm medio-laterally by 4 mm antero-posteriorly, was situated on the superior aspect of the frontal anterior to the bregma by some 12.5 mm. No radiating fracture lines were visible and the dimensions of the depressed area may indicate that it had been made by a sharp implement.

A possible healed depressed fracture was visible on the left temporal of Skeleton 2, a 50+ year old male, recovered from the Poplavskoy cemetery. A ridge associated with a smooth indented area, which measured approximately 30 mm antero-posteriorly, was situated immediately beneath the superior margin of the temporal. A further possible fracture line, which measured 19 mm antero-posteriorly, was apparent just superior to the mastoid process. The fractured area would have affected a region which measured approximately 30 mm supero-inferiorly and ran for the entire antero-posterior length of the temporal. It is considered probable that the injury would have been made with a blunt implement of similar dimensions. The individual also displayed fractured nasal bones (see below).

It was difficult to be certain of a definite etiology for any of the four Srubnaya cranial injuries. It is considered most probable, however, that the trauma represented two blade injuries and two blunt force trauma injuries. The cranial vault injuries were found to have affected the frontal bone with a prevalence of 3.4% (3/89), while the right temporal displayed injuries with a frequency of 1.2% (1/86). The locations of the injuries – three on the frontal bone and one on the left temporal bone – is in keeping well the expected positions of injuries obtained during face-to-face interpersonal violence. All four of the injuries appeared to have been long-standing and in advanced states of healing.

Skeleton G52, a 6-7 year old juvenile recovered from the Srubnaya Svezhensky burial ground, displayed a possible blade injury on his/her right scapula. A sharp injury, which measured 13.6 mm, ran in an antero-posterior direction through the central area of the spine. The margins of the injury were sharp and the exposed bone was of similar color to the remainder of the bone suggesting that it had occurred during the peri-mortem period. The cut appeared to have been made with an implement larger than a knife and was generally more extensive than cut marks considered indicative of defleshing or disarticulation apparent in other individuals (see below). If the trauma has been accurately identified as a blade injury it is probable that it was dealt from behind the individual. No other traumatic lesions were apparent on the skeleton. Differential diagnosis should also include damage attained through the use of a sharpened shovel during the excavation process, although the exposed surface was the same color as the remainder of the bone and not paler.

Fractured nasal bones

Details of the individuals with fractured nasal bones are provided in Table 46.

Culture	Site	Context	Age	Sex	R		L	
					Type	Healing	Type	Healing
Yamnaya	Nizhny Orleansky I	K1 G5	35-50	M	Simple transverse	advanced	Simple transverse	advanced
Srubnaya	Chistyar I	K1 G2	35-50	F	Simple transverse	unhealed	Simple transverse	unhealed
Srubnaya	Poplavskoy	Sk2	50+	M	Simple oblique	unhealed	Simple oblique	unhealed
Srubnaya	Rozhdestveno I	K5 G10	35-50	M	Simple oblique	advanced	Simple oblique	advanced

Table 46: Details of individuals with fractured nasal bones in the population groups.

It was not possible to obtain a reliable prevalence rate of the injuries for the Yamnaya group since only five nasal bones were preserved. The injuries occurred with a frequency of 4.5% (6/134) for the Srubnaya adults. Fractured nasal bones are common in archaeological populations and probably arise as a consequence of fist-fighting (Roberts and Manchester 2005, 109). It is interesting that both males and females displayed the injuries. In all cases the fractures had affected both nasal bones. The individual recovered from Poplavskoy also displayed a possible depressed cranial fracture (see above). Murphy (2003a, 97) reported that fractured nasal bones occurred with a frequency of 3.4% among the Uyuk culture population and 6% among their Shurmak culture counterparts from the Iron Age cemetery of Aymyrlyg, South Siberia.

Summary

Crude prevalence rates for probable violence-induced trauma are provided in Table 47.

Culture	Overall adult	Male	Female	Non-adult
Yamnaya	18.8 (3/16)	16.7 (2/12)	0 (0/4)	33.3 (1/3)
Poltavka	2.9 (1/34)	3.4 (1/29)	0 (0/5)	0 (0/7)
Potapovka	7.1 (1/14)	9.1 (1/11)	0 (0/3)	0 (0/4)
Srubnaya	3.9 (5/129)	5.9 (4/68)	1.7 (1/60)	1.6 (1/63)

Table 47: Crude prevalence rates (%) of probable violence-induced trauma based on the numbers of individuals present in the each population group. The actual figures are provided in the brackets. It was not possible to determine the sex of one Srubnaya adult or to examine the Khvalynsk group for trauma.

The lesions considered to be possibly indicative of deliberate violence comprised cranial and post-cranial weapon injuries and fractured nasal bones. The adult crude prevalences ranged from 2.9% for the Poltavka population to 18.8% for the Yamnaya group. The small numbers of individuals in the majority of groups probably result in the inflation of trauma prevalence. A further problem with the analysis of cranial injuries is that extensive reconstruction of many of the crania with wax precluded a detailed analysis of certain broken edges. In the majority of groups, only males displayed possible violence-related injuries. Although males (5.9%) had the highest crude prevalence of possible violence-related injuries amongst the substantial Srubnaya population, females (1.7%) and non-adults (1.6%) were not immune to such injuries.

Funerary Processes

Ochre

Some 50 individuals from the Volga region had bones that were stained with ochre during funerary rites (Table 48). It is highly probable that the frequency of individuals with this staining has been under-estimated due to taphonomic processes and post-excavation procedures, such as the cleaning of the skeletons. In the vast majority of cases the ochre staining was red, although a 35-50 year old Poltavka female (K2 G2) recovered during the excavations at Krasnosamarskoe IV was also associated with a black pigment. If the writer had not been involved in the excavation and post-excavation curation of this individual it is highly probable that the association with the black pigment would have been missed since the staining could have been interpreted as a normal taphonomic process. It is feasible that other individuals included in the study group had also been associated with a black pigment but that this is now invisible on their skeletal remains. The following discussion is largely specific to the use of red ochre during the funerary ritual. None of the Khvalynsk individuals displayed evidence for ochre staining, however, it should be remembered that in the majority of cases only the crania of these individuals were available for analysis, and there are several ochre stained ritual deposits found above graves in this cemetery (Anthony 2007, 184).

Culture	Site	Context	Age	Sex	Bones affected
Yamnaya	Kurmanaevsky III	K3 G2	35-50	F	Entire skeleton
Yamnaya	Kutuluk I	K3 G1	35-50	M	Mandible, entire skeleton, esp. feet
Yamnaya	Kutuluk I	K3 G4	35-50	M	Skull, entire skeleton
Yamnaya	Kutuluk I	K4 G1	18-35	M	Skull, entire skeleton, esp. feet
Yamnaya	Kutuluk II	K1 G1	18-35	F	Entire skeleton
Yamnaya	Leshyovsky ?	K1 G1a	18-35	F	L forearm, lower legs
Yamnaya	Leshyovsky ?	K1 G1b	8-9 lunar months	-	R femur

Yamnaya	Leshyovsky I	flat grave 5	18-35	M	L distal femur
Yamnaya	Lopatino I	K22	18-35	M	Entire skeleton, esp. lower legs
Yamnaya	Lopatino I	K31	35-50	M	Entire skeleton
Yamnaya	Lopatino I	K32	adult	M	Entire skeleton
Yamnaya	Lopatino II	K3 G1	15-17	M	Entire skeleton, esp. skull
Yamnaya	Nizhny Orleansky I	K1 G5	35-50	M	Entire skeleton, esp. skull
Yamnaya	Nizhny Orleansky I	K4 G2	18-35	M	Innominates (skeleton incomplete)
Poltavka	Grachyovka	K1 G2	50+	M	Entire skeleton
Poltavka	Grachyovka II	K2 G1	35-50	M	Entire post-cranial skeleton, esp. feet
Poltavka	Kalach	K2 G2	35-50	F	R humerus
Poltavka	Kalinovka	K1 G4	50+	M	Entire skeleton
Poltavka	Krasnosamarskoe IV	K1 G3	18-35	F	Entire skeleton esp. R arm, skull, lower legs
Poltavka	Krasnosamarskoe IV (Plate 6)	K1 G4	0-0.5	-	Entire skeleton (heavy)
Poltavka	Krasnosamarskoe IV	K2 G2	35-50	F	Entire skeleton
Poltavka	Kryazh	K2 G1	18-35	M	Entire skeleton
Poltavka	Kutuluk III	K1 central	18-35	M	Entire skeleton, esp. feet
Poltavka	Lopatino I	K1 G1	18-35	M	Distal lower legs
Poltavka	Lopatino I	K30 G2	35-50	M	Facial area of skull
Poltavka	Lopatino I	K33	18-35	M	Facial area of skull & feet
Poltavka	Nikolaevka III	K3 G2	adult	M	Entire skeleton
Poltavka	Nizhny Orleansky	K1 G4	35-50	M	Entire skeleton, esp. feet
Poltavka	Podlesnaya	K1 G6	18-35	M	Entire skeleton
Poltavka	Potapovka I	K5 G6	35-50	M	Feet
Poltavka	Tryasinovka	K2 G3	50+	M	Legs
Potapovka	Lopatino II	K1 G1 Sk 1	adult	M	Distal lower legs
Potapovka	Lopatino II	K2 G3	50+	M	L side skull, legs, arms, torso

Potapovka	Poptapovka I	K5 G4 Sk1	5.5-7.5	-	Entire skeleton
Potapovka	Poptapovka I	K5 G11 Sk3	7.5-8.5	-	Entire skeleton
Potapovka	Utyevka II	-	18-35	M	R shoulder
Potapovka	Utyevka VI	K6 G5 Sk 1	18-35	F	L lower leg
Srubnaya	Barinovka I	K2 G28	18-35	F	Entire skeleton
Srubnaya	Chistyar I	K1 G1	35-50	F	L humerus, legs
Srubnaya	Chistyar I	K1 G2	35-50	F	R foot
Srubnaya	Chistyar I	K2 G10	35-50	F	Skull (?)
Srubnaya	Nizhny Orleansky II	K4 G9	18-35	F	Entire skeleton (?)
Srubnaya	Novosiolky	K3 G7	18-35	F	Lower legs
Srubnaya	Rozhdestveno I	K1 G3	35-50	M	Arms, legs
Srubnaya	Rozhdestveno I	K5 G11	18-35	F	Entire skeleton
Srubnaya	Spiridonovka II	K10 G3	18-35	F	R side skull
Srubnaya	Spiridonovka II	K11 G8	18-35	F	L side skull
Srubnaya	Spiridonovka II	K11 G11	18-35	M	L side skull (?)
Srubnaya	Spiridonovka II	K14 G10	18-35	F	L side skull
Srubnaya	Uren II	K2 G2	50+	F	Entire skeleton

Table 48: Details of the individuals with red ochre staining from the different cultures.

A detailed analysis of the distribution by skeletal element was not undertaken. In general terms the results would tend to suggest that during Yamnaya and Poltavka times the entire skeleton was covered with ochre and deliberate concentrations appear to have been deposited on the skull or feet. No obvious trends are evident for the Potapovka adults but the fact that non-adults of this culture displayed generalized ochre distribution may indicate that this may also have originally been the case for the adults. A slightly different pattern of staining may be evident for the Srubnaya group although the results need to be interpreted with caution – it is difficult to be certain that the ochre staining on the bones accurately reflects its original deposition since taphonomic processes may have resulted in a lack of staining on certain bones. A number of skeletons displayed the generalized deposition observed for the previous cultures but for five individuals the ochre appeared to have been restricted to the skull. The prevalence rates of individuals with ochre are provided in Table 49.

Culture	Prevalence by individuals			
	Overall	Male	Female	Non-adult
Yamnaya	73.7 (14/19)	75.0 (9/12)	75.0 (3/4)	66.7 (2/3)
Poltavka	41.5 (17/41)	44.8 (13/29)	75.0 (3/5)	14.3 (1/7)
Potapovka	33.3 (6/18)	27.3 (3/11)	33.3 (1/3)	50.0 (2/4)
Srubnaya	6.8 (13/192)	3.0 (2/67)	18.0 (11/61)	0 (0/63)

Table 49: The prevalence rates of individuals (%) associated with ochre. The actual figures are provided in brackets. It was not possible to reliably examine the Khvalynsk population for the occurrence of ochre.

There appears to have been a general decline in the use of ochre from the Yamnaya (73.7%) through to the Srubnaya (6.8%) periods. Due to the paucity of females in the earlier groups it is difficult to ascertain any precise sex specific trends although adult males and females of all ages appear to have been accorded the funerary practice. Among the Srubnaya population, however, it is interesting to note that the prevalence of females (18%) with ochre staining was notably higher than for their male (3%) counterparts. It is possible that as the ritual declined it remained largely associated with females.

Non-adults also appear to have been accorded this funerary rite, at least during the Yamnaya, Poltavka and Potapovka periods. The affected individuals ranged from a perinatal infant through to a 15-17 year old adolescent, suggesting that non-adults of all ages were accorded this funerary treatment. It is possible that social status, or perhaps manner of death, rather than age was a determining factor concerning who was buried with ochre. Despite the relatively large number of non-adults of Srubnaya date (n=63) none displayed ochre staining. It is again possible that by the Srubnaya era the ritual was in decline.

The association of ochre with a young adult female and a perinatal infant from Yamnaya contexts at the Leshyovsky burial ground (K1 G1a and b) is of interest. It is possible that these skeletons represent a mother and her baby who had either died during or shortly after the baby's birth. A similar situation is evident for a pair of Poltavka burials from the Krasnosamarskoe IV burial ground. A young adult female recovered from the central burial of Kurgan 1 (G3) was covered in ochre. An adjacent burial of a young infant (G4 – 0-0.5 years) was covered in notably heavy deposits of ochre (Plate 6). It is feasible that the individuals in the two burials were linked – perhaps again being a mother and infant. The association of ochre with death is obvious from its location within the burials. The discovery of two possible mothers and young infants with deposits of the substance may also indicate that the red ochre was symbolic of life – perhaps blood. It may be the case that ochre was included within the burials as a symbol of the rebirth of the individuals in the afterlife.

Association with copper/bronze artefacts

A total of 24 individuals from all periods displayed green discoloration that was due to their association with copper or bronze artefacts (Table 50). Only those metal objects that came in direct contact with bone are represented in this count. As such, it is quite probable that the actual frequencies of individuals buried with metal objects were higher. Nevertheless, since the same situation applies to all of the populations it is still valid to determine if any trends are apparent.

Culture	Site	Context	Age	Sex	Bones affected	Poss object
Khvalynsk	Khvalynsk II	G 6	18-35	F	L mastoid & ext. aud. meatus	Earring
Khvalynsk	Khvalynsk II	G 13	18-35	M	R mastoid & mandible; L mastoid	Pair of earrings
Khvalynsk	Khvalynsk II	G 24	18-35	M	R & L mastoid & mandibular condyle	Pair of earrings
Yamnaya	Kutuluk I	K4 G1	18-35	M	L humerus dist; L ulna prox	Armlet
Poltavka	Grachyovka II	K3 G9a	50+	F	L mastoid; R temporal; L humerus dist;	Pair of earrings; armlet;
					L tibia dist; R calcaneus	pair of anklets
Poltavka	Kalinovka	K1 G6	35-50	F	L femur prox, anterior surface	Unid - object lying on hip
Potapovka	Utyevka VI	K5 G4 Sk1	5.5-7.5	-	L ulna & radius midshaft	Armlet or bracelet
Potapovka	Utyevka VI	K5 G11 Sk3	7.5-8.5	-	R tibia dist	Anklet
Potapovka	Utyevka VI	K6 G1	35-50	F	R & L ulna & radius dist	Pair of bracelets
Potapovka	Utyevka VI	K6 G2 Sk 1	18-35	M	L humerus prox, posterior surface	Armlet
		(Plate 7.6)			L maxilla	Part of head-dress
Potapovka	Utyevka VI	K6 G5 Sk 1	18-35	F	L humerus prox, anterior surface	Armlet
					R & L ulna & radius dist	Pair of bracelets
					Skull esp. R ext auditory meatus	Head-dress
Potapovka	Utyevka VI	K6 G5 Sk 2	18-35	M	R humerus dist, anterior surface	Armlet
					R ulna & radius prox	
Srubnaya	Chistyar I	K1 G2	35-50	F	R mandibular condyle; L mastoid process	Pair of earrings
					R & L ulna & radius dist	Pair of bracelets
Srubnaya	Chistyar I	K2 G10	35-50	F	L mastoid process	Earring
Srubnaya	Kinel I	K5 G2	18-35	F	R mandibular condyle, mastoid, occipital	Pair of earrings
					condyle; L mastoid process, asterion	
Srubnaya	Kinel I	K6 G2	50+	F	R ulna & radius dist; L ulna dist	Pair of bracelets
Srubnaya	Nizhny Orleansky I	K5 G3	18-35	F	R ulna & radius dist	Pair of bracelets
Srubnaya	Spiridonovka II	K1 G2 Sk1	13-16	-	R radius dist; L ulna midshaft	Pair of bracelets
Srubnaya	Spiridonovka II	K11 G12	35-50	F	R & L radius dist	Pair of bracelets
Srubnaya	Spiridonovka II	K11 G15	12-16	F	L ulna & radius patches	1+ bracelet/armlet
Srubnaya	Spiridonovka IV	K1 G16	18-35	F	R ulna dist; L ulna & radius dist	Pair of bracelets
Srubnaya	Spiridonovka IV	K2 G1	35-50	F	R ulna dist	Bracelet
Srubnaya	Spiridonovka IV	K2 G13	18-35	F	R & L ulna & radius dist	Pair of bracelets

Table 50: Details of the individuals with green discoloration on bones indicative of association with metal artefacts.

All three of the Khvalynsk individuals exhibiting green staining probably were buried wearing earrings. Two of the individuals were males, suggesting that adults of both sexes wore copper ear ornaments. The single Yamnaya individual with green discoloration was a young adult male who seems to have worn an armlet at his left elbow. Three Poltavka individuals were affected – an infant who was buried wearing a pair of bracelets, a middle adult female who had green discoloration at her hip and an old adult female who seems to have been buried with a pair of earrings, an armlet at her left elbow and a pair of anklets. It is possible that the green discoloration at the hip of the middle adult female represented some form of belt attachment that may have been functional rather than decorative. The baby with bracelets is interesting since it indicates that young children could be buried with metal jewellery which was presumably an indication of high status.

All six of the affected Potapovka individuals were from Kurgans 5 and 6 of the Utyevka VI burial ground, which are regarded as particularly high status kurgans. A juvenile wore an armlet or bracelet (K5 G4 Sk1), while another wore an anklet (K5 G11 Sk3). One middle adult female wore a pair of bracelets (K6 G1), while a young adult female seemed to have been associated with a head-dress, a pair of bracelets and an armlet (K6 G5 Sk1). A young adult male from the same burial wore an armlet (K6 G5 Sk2). Finally, a young adult male (K6 G2 Sk 1) wore an armlet and possibly a head-dress or earring (Plate 7).

The Srubnaya findings appear to be more uniform with all nine affected adults having been female. Six of these wore a single bracelet or a pair of bracelets, while a possible female adolescent from Spiridonovka II (K11 G15) wore at least one bracelet/armlet and another adolescent of unidentifiable sex from the same burial ground (K1 G2 Sk1) also wore a pair of bracelets. These 11 individuals derived from four sites and included adolescents as well as young, middle and old adults so it is possible that Srubnaya females in general wore bracelets. Two individuals were buried wearing one or more earrings, while a middle adult female from the Chistyar I cemetery (K1 G2) wore both a pair of earrings and a pair of bracelets.

The prevalence rates of individuals with green staining are provided in Table 51.

Culture	Prevalence by individuals			
	Overall	Male	Female	Non-adult
Khvalynsk	11.1 (3/27)	10.0 (2/20)	20.0 (1/5)	0 (0/2)
Yamnaya	5.3 (1/19)	8.3 (1/12)	0 (0/4)	0 (0/3)
Poltavka	4.9 (2/41)	0 (0/29)	40.0 (2/5)	14.3 (1/7)
Potapovka	33.3 (6/18)	18.2 (2/11)	66.7 (2/3)	50.0 (2/4)
Srubnaya	5.7 (11/192)	0 (0/67)	14.8 (9/61)	3.2 (2/63)

Table 51: The prevalence rates (%) of individuals with green discoloration due to their association with metal objects. The actual figures are provided in brackets.

The frequencies ranged from 4.9% for the Poltavka population to 33.3% for Potapovka. The high percentage for the Potapovka assemblage may have been largely due to the inclusion of the presumably high status site at Utyevka VI. A definite decline in green discoloration occurred between Potapovka and the Srubnaya culture, when only 5.7% of individuals displayed staining.

Although most of the sample sizes are too small for the results to be considered definitive, females seemed to display higher levels of green discoloration than males. The only exception was in the Yamnaya population in which the single affected individual was male. The definite female preponderance in the substantial Srubnaya group may indicate that this is a genuine trend throughout the different populations. Although the non-adult numbers are generally low, children and adolescents appear to have been buried wearing metal objects more frequently than adult males in the Poltavka, Potapovka and Srubnaya population groups.

Defleshing and disarticulation

Some 14 individuals displayed cut marks that were probably due to the disarticulation and/or defleshing of the body as part of a secondary burial process (Table 52).

Culture	Site	Context	Age	Sex	Bones affected	Location	Dimensions	Poss action
Yamnaya	Lopatino I	K22	18-35	M	LV2	Anterior surface	13 mm ML	Disembowelling
Yamnaya	Lopatino I	K29 G1	35-50	M	L femur	Supero-lateral aspect of head	17.6 mm SI	Disarticulation - detachment of leg
Poltavka	Nizhny Orleansky I	K1 G4	35-50	M	LV5	Anterior surface	18.2 mm ML	Disembowelling
Poltavka	Krasnosamarskoe IV (Plate 8)	K2 G1	18-35	M	All	-	-	No cut marks but body entirely disarticulated
Poltavka	Potapovka I	K5 G6	35-50	M	R tibia	Proximal, tibio-fibular articular facet	24.4 mm AP	Disarticulation - detachment of lower leg
Srubnaya	Barinovka I (Plate 9)	K1 G2b	35-50	M	R humerus	Distal third, anterior surface Capitulum, lateral margin	3-5 mm ML (x3) 7 mm ML	Disarticulation - detachment of lower arm
					L radius	Distal third, posterior surface	12.6 mm SM - IL	Disarticulation - detachment of hand
					R calcaneus	Superior surface	15 mm SP - IA	Disarticulation - detachment of foot
Srubnaya	Barinovka I	K2 G16	35-50	F	L humerus	Proximal, lesser tubercle	5.5 mm SI	Disarticulation - detachment of arm
					R tibia	Proximal, tibio-fibular articular facet	7 mm SI	Disarticulation - detachment of lower leg
					L tibia	Proximal, medial condyle	3 mm SI	Disarticulation - detachment of lower leg

Srubnaya	Nizhny Orleansky ?	K1 G3	35-50	M	L femur	Head, anterior surface Midshaft, anterior surface	18.3 mm & 7.9 mm SM - IL 5 mm ML	Disarticulation - detachment of leg Defleshing
Srubnaya	Nizhny Orleansky II	K4 G27	18-35	F	L femur	Lateral condyle, posterior surface Medial condyle, posterior surface	8 mm SL - IM 3 mm ML	Disarticulation - detachment of lower leg Disarticulation - detachment of lower leg
Srubnaya	Nizhny Orleansky V	K5 G1	18-35	M	L radius	Head, posterior surface Midshaft, medial surface Midshaft, posterior surface Distal third, medial surface	11 mm ML 6 mm ML 7.5 mm SM - IL 4.6 mm AP (x2)	Disarticulation - detachment of lower arm Defleshing Defleshing Defleshing
Srubnaya	Spiridonovka II	K2 G37	18-35	M	L femur	Proximal third, AL margin	7.2 mm SL - IM	Disarticulation - detachment of leg
Srubnaya	Spiridonovka II (Plate 10)	K10 G7	18-35	M	R femur	Greater trochanter, lateral surface Proximal third, lateral surface	26 mm AP 12 mm SM - IL 8.4 mm SL - IM 3-6 mm ML (x3)	Disarticulation - detachment of leg Disarticulation - detachment of leg Disarticulation - detachment of leg Disarticulation - detachment of leg

Srubnaya	Spiridonovka IV	K1 G10	35-50	F	R femur	Greater trochanter, AI surface Midshaft, lateral surface	13 mm SP - IA 4.2 mm AP 7 mm SP - IA	Disarticulation - detachment of leg Defleshing Defleshing
Srubnaya	Spiridonovka IV	K2 G2	18-35	F	R tibia	Proximal, tibio-fibular articular facet	15 mm SL - IM 5.6 mm SL - IM	Disarticulation - detachment of lower leg Disarticulation - detachment of lower leg

Table 52: Details of individuals with evidence of defleshing and/or disarticulation as part of the funerary process.

It is highly probable that the number of individuals processed in this manner is under-estimated since not all bodies treated in this manner will display the tell-tale cut marks. The skill of the processor, the size of the joint and the state of decomposition of the remains are all factors that would have an impact on whether or not cut marks would be visible in the skeleton. This situation was made particularly clear during the excavations at Krasnosamarskoe IV when a bundle burial (K2 G1) of Poltavka date was discovered (Plate 8). Despite a thorough examination by the author no cut marks were observed on the remains although it was clear that the individual had been fully disarticulated and buried within a small organic container which had since decomposed.

Two individuals derived from the Yamnaya culture displayed possible evidence of disemboweling and the detachment of the leg at the hip during disarticulation. Three Poltavka individuals displayed cut marks – one individual displayed possible evidence for disemboweling, the individual discussed above displayed evidence of having been entirely disarticulated, while cut marks on a third individual were indicative of the detachment of the lower leg at the knee during disarticulation. A total of nine individuals from the Srubnaya group displayed evidence of body processing. Of the 12 instances where different areas of the body had been disarticulated the majority had involved disarticulation of the leg at the hip (33.4%; 4/12; Plate 9), followed in frequency by detachment of the lower leg from the upper leg at the knee (25%; 3/12) and evidence for the separation of the lower arm from the upper arm at the elbow (16.7%; 2/12; Plate 10). Single cases of the detachment of the arm from the shoulder (8.3%), separation of the wrist from the lower arm (8.3%) and removal of the foot from the lower leg (8.3%) were also observed.

The preponderance of disarticulations at the hips and knees would appear to indicate that the main objective of the procedure was to reduce the corpse to a more manageable size. Murphy (2000a) undertook a detailed analysis of the defleshing and disarticulation cut marks that were apparent among Iron Age Uyuk culture individuals recovered from the cemetery of Aymyrlyg, South Siberia. The results indicated that, similarly to the Volga populations, the knee (26.1%) and the hip (23.9%) were the joints most frequently associated with disarticulation cut marks (n=29). Three bones from the Srubnaya group – two femurs and a radius – also displayed evidence of having been defleshed and indicate that not only were some corpses reduced in size through disarticulation but that in some instances efforts were made to skeletalize the bodies by removal of the flesh.

The prevalence rates of individuals with evidence of disarticulation and/or defleshing are provided in Table 53.

Culture	**Prevalence by individuals**			
	N	**Male**	**Female**	**Non-adult**
Yamnaya	10.5 (2/19)	16.7 (2/12)	0 (0/4)	0 (0/3)
Poltavka	7.3 (3/41)	10.3 (3/29)	0 (0/5)	0 (0/7)
Potapovka	0 (0/18)	0 (0/11)	0 (0/3)	0 (0/4)
Srubnaya	4.7 (9/192)	7.5 (5/67)	6.6 (4/61)	0 (0/63)

Table 53: The prevalence rates (%) of individuals with evidence of defleshing and/or disarticulation. The actual figures are provided in brackets. It was not possible to analyze the Khvalynsk population for cut marks.

The prevalence rates ranged from 0% for the Potapovka groups to 10.5% for the Yamnaya corpus. Apparently only a small proportion of individuals from each period were treated in this manner. As discussed above, however, the disarticulation of a dead body does not necessarily involve cutting the bone and the skill of the processor will also have an effect on whether the bones are marked with cuts. It is therefore highly probable that the number of Volga individuals whose bodies were disarticulated after death has been under-estimated. Adult males displayed evidence for this form of body processing in all three affected populations but only in the Srubnaya group were females treated in this manner. In this population, males (7.5%) and females (6.6%) exhibited similar frequencies. None of the non-adult individuals displayed evidence for cut marks and this might be due to the fact that their bodies are smaller than those of adults and did not require processing. The generally smaller size of adult females compared to their male counterparts may also account for the lack of females with evidence of processing in the earlier populations. Alternatively, it is possible that pastoral strategies determined the prevalence of male, female or non-adult disarticulations (see below).

Drawing on historical sources (e.g. the Chinese Annals) and archaeological and seasonality information derived from other excavations, including the Iron Age royal tombs at Pazyryk, South Siberia (Rudenko 1970), it has been postulated that the post-mortem dismemberment apparent in the populations at Aymyrlyg, Siberia, was due to the semi-nomadic lifestyle of these societies (Murphy 2000a). It has been suggested that the distribution of large tribal burial grounds in Tuva, including that of Aymyrlyg, indicates that cyclic migration with fixed routes and set winter camp sites would have existed amongst the steppe-mountain pastoralist tribes (Vainshtein 1980, 96). These regular repeated seasonal migrations would have been undertaken within the borders of a relatively well defined territory (Mandelshtam 1992, 193). Presumably, herds would have been pastured in the mountains during the summer and in the more low-lying land during the winter (Bokovenko 1995, 255). Consequently, since Aymyrlyg is located in the valley of the Ulug-Khemski River, it is probable that the Uyuk culture and Shurmak culture groups would have been living in relatively close proximity to their cemetery during the winter months, the season when burial would have been most difficult because the ground was frozen.

Rudenko (1970) developed a model of seasonal interment for the burials at Pazyryk which can help explain the presence of disarticulated bodies at the Aymyrlyg cemetery. Following this system it is possible that burials would have occurred in autumn immediately before the ground became frozen, or in spring as soon as the ground had sufficiently thawed. The corpses of individuals who had died during the winter period may have been temporarily preserved in the snow without need of artificial processing until the spring, when they would have been buried in a relatively undecomposed and intact condition. The cadavers of those who died during the later spring to early autumn months in the mountain areas would, however, have required some form of processing. It would have been both unhygienic and unpleasant for the remainder of the population if the corpses had been allowed to naturally decompose in the summer heat. It would, therefore, have been extremely practical for the bodies to have been defleshed and disarticulated and stored safely until the group returned to the main tribal cemetery at Aymyrlyg in the autumn (Murphy 2000a).

The Volga populations are extremely interesting because even as far back as Yamnaya times, they were actively disarticulating certain dead members of their society. Indeed, it would appear to be the case that throughout the Early, Middle and Late Bronze Age periods that secondary burial was a necessary procedure for the Volga populations. Given the pastoralist nature of these Bronze Age populations this finding is not unexpected. Frachetti (2008) has discussed the intricacies involved with the pastoral strategies utilised by particular groups and his work has demonstrated the existence of considerable variation among steppe populations depending on the nature of social and environmental conditions.

The occasional disarticulation of the corpse appears to be a recurring trait of Eurasian pastoralism that has been largely ignored. Analysis of these secondary burial practices has the potential to add to the growing body of literature which is providing a more nuanced understanding of the nature of steppe pastoralism. The necessity for such body processing has the potential to provide insights concerning the seasonality of pastoralism as well as the nature of the distances travelled by groups. The results of the current study perhaps indicate that the Yamnaya and Poltavka populations traveled further that the later Potapovka and Srubnaya groups and therefore needed to process a greater proportion of bodies. Perhaps only a few individuals, those with evidence of body processing, travelled the greatest distances. Although the numbers of females included in the study are admittedly small it is interesting that only males in the Yamnaya and Poltavka groups had been afforded body processing. By Srubnaya times, examples of males and females with body processing were about equal. Perhaps a change had occurred which saw individuals of both sexes travelling greater distances. This finding is particularly curious in light of the results of the seasonality analysis of the settlement at Krasnosamarskoe which indicated that the settlement was occupied all year round (Anthony *et al*. 2005, 403). One might have envisioned that women and children would have remained at this settlement while males went to the pastures with their herds but the occurrence of females with evidence of disarticulation would tend to suggest that this was not the case. The lack of non-adults with disarticulation cut marks may be an indicator that younger individuals were not required to travel as far as adults or, as discussed above, it may simply have been the case that these smaller bodies did not require processing to the same extent as their adult counterparts.

Conclusions

The Samara Valley Project applied a multidisciplinary approach to the study of the subsistence economy of the Late Bronze Age Srubnaya culture in the Samara River Valley. A great increase in settlement sites occurred at this time. Analysis of 297 prehistoric human skeletons was undertaken to see if these changes in settlement pattern had affected the bodies of these ancient peoples. While many insights concerning the lives and deaths of the populations have been gained, a major limitation of the study has been the small sample size of most of the earlier population groups which precluded a more detailed statistical analysis. In the following conclusion the main trends across time will be discussed, particularly within the context of the apparent economic changes that occurred by Srubnaya times. Very few palaeopathological studies of Eurasian steppe populations have been published to date and it is hoped that the results of the current study will demonstrate the potential of this approach.

Developmental defects

All of the population groups displayed a notable preponderance of defects of the blastemal desmocranium (33 of 297 individuals) or paraxial mesoderm (28/297). It is generally accepted that such similarities in developmental defects between skeletal populations are an indication of genetic relatedness (Barnes 1994, 5). The middle Volga populations might have derived from similar gene pools, although this finding would need to be confirmed by analyses of larger populations from the region. The occurrence of individuals with the same developmental defects within cemeteries, such as the Potapovka cemetery of Utyevka VI and the Srubnaya cemetery of Spiridonovka IV, might suggest that familial burials occurred within some cemeteries.

All of the Bronze Age Volga populations displayed developmental defects of the appendicular skeleton, all of which involved the hip joints and would have caused the affected individuals to suffer from gait disturbances. An adult male recovered from the Yamnaya Leshyovsky I burial ground with slipped femoral epiphysis was of particular interest. This individual also displayed evidence that a heavy blow had been dealt to his right thigh, possibly with an axe, as well as a series of scrape or gouge marks on the posterior aspect of his cranium and on his left femur. The scrape marks on the cranium appeared to have been made with a serrated implement and their random placement is not typical of scalping (see Murphy *et al*. 2002). It is possible that tufts of hair were removed from the individual, perhaps as some form of torture. The individual was reported to have been buried in a face-down prone position suggesting that he had been accorded a non-normative burial. Individuals with physical disabilities and non-normative forms of burial have been recovered from around the world (see e.g. Papadopoulos 2000; Murphy 2008). Indeed, subtle differences in burial rite appear to have been afforded to a Potapovka adult male (Kurgan 1, Burial 8) and a Srubnaya adult male (Kurgan 2, Burial 6) with potential physical disabilities recovered from the Spiridonovka IV kurgan cemetery (Popova *et al*. 2011, 300-301). It can be tentatively proposed that the apparent physical abuse and non-normative burial of the man from Leshyovsky I may in some way have been related to his physical disability.

Health

Health is not only an important factor in the quality of life but it is also closely related to “demographic, social, economic, and political change and with the outcomes of wars and other conflicts” (Steckel and Rose 2002a, 3). According to the World Health Organisation (2006), health may be defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. Anthropological studies of war torn populations have demonstrated a reduced state of well being amongst the civilians caught up in such conflicts. As such, the evidence for violence is presented alongside the data for physiological stress (Figure 6).

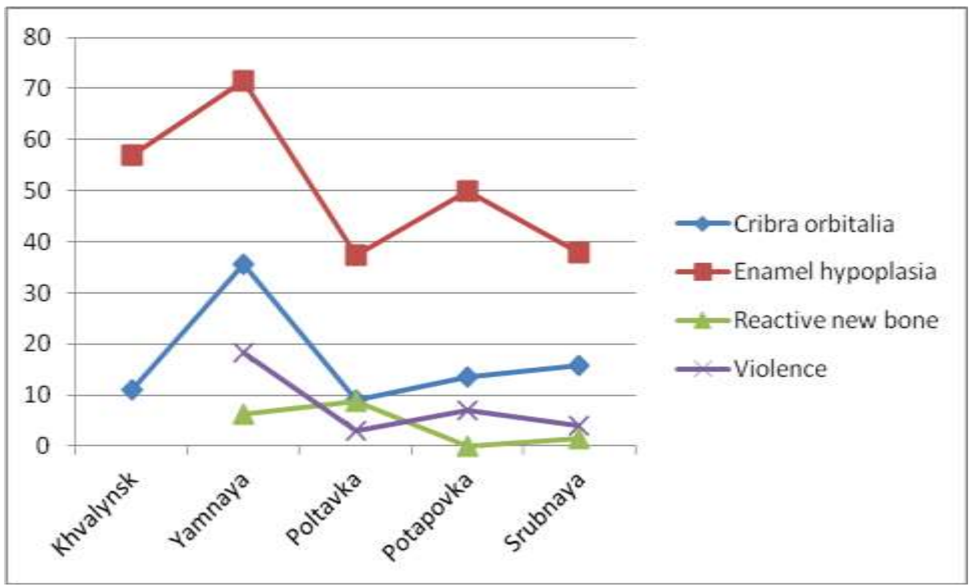

Figure 6: Summary of the prevalence rates (%) of cribra orbitalia (by bone), enamel hypoplasia (by individual), reactive new bone formation (crude) and violence (crude) for each culture based on the data contained in Tables 8, 11, 13 and 47. It was not possible to record the occurrence of reactive new bone formation or evidence for violence for the Khvalynsk group.

When interpreting the indicators of physiological stress it is important to remember the osteological paradox – a skeleton with no lesions may represent a healthy individual or, conversely, it may represent a person who was ill but whose immune system was too weak to react to the disease and who died before any changes had been caused to the skeleton (see Wood *et al*. 1992). Cribra orbitalia and enamel hypoplasia are both indicators of childhood physiological stress caused by nutritional deficiencies and childhood disease, whereas reactive new bone formation is indicative of the occurrence of an infection or inflammatory response during the time leading up to an individual's death – i.e. when they were an adult.

The results would tend to suggest that, with its low levels of cribra orbitalia, the Khvalynsk population was relatively healthy. This would correlate with the high prevalence of older adult males in the corpus and with the potentially high status nature of the Khvalynsk II burial ground as evidenced by the occurrence of a rich array of copper grave goods in the burials. The levels of enamel hypoplasia were relatively high, however, but given the other positive indicators of health it is possible that this is just a sign that those individuals who had been subject to ill health as a child had the ability to recover thereby enabling the hypoplastic defect to develop.

The standard of health appears to have dramatically declined between Khvalynsk (Eneolithic) and Yamnaya (EBA) times, when individuals had the highest levels of cribra orbitalia, enamel hypoplasia and violence-related injuries. None of the Yamnaya adult males survived into older adulthood which may be a further indicator of poor health. The Yamnaya culture appears to have been associated with a time of great change in Eurasia which saw major and sustained waves of migration and the first adoption of highly mobile pastoralism (Anthony 2007, 304). Although warfare is not thought to have facilitated the spread of the Yamnaya horizon across the Pontic steppes (Anthony 2007, 317) the results of the osteological analysis would tend to suggest that the Yamnaya people included in the current study were physiologically stressed and had a relatively high frequency of weapon injuries. It is possible that intensified social competition between pastoral nomadic groups (Anthony 2007, 317) would also have been a source of physiological stress to the members of successful and less successful herding groups alike and that violence occurred at least sporadically.

Health appears to have again improved by Poltavka (MBA) times, during which the levels of cribra orbitalia, enamel hypoplasia and violence-related injuries all markedly decreased. The average femoral length for Poltavka adult males had the greatest value of all Bronze Age populations, which again may be an indicator of good health. The highest levels of reactive new bone formation were apparent among the Poltavka population but, considering their low levels of other physiological stressors and tall stature, it is possible that this finding can be explained as evidence of an adult population that had sufficient resilience to fight and survive infection, enabling lesions to develop in the skeleton. Both cribra orbitalia and enamel hypoplasia were lower in the MBA than in the Eneolithic, suggesting that the Poltavka population may have enjoyed an even higher level of good health than the Khvalynsk population, which included many high-status individuals.

Health appears to have deteriorated significantly from Poltavka (MBA) to Potapovka (final MBA) times. Levels of cribra orbitalia, enamel hypoplasia and violence-related injuries rose, although they were still much lower than the high levels observed for the Yamnaya culture. Further evidence of stress was evidenced by notably high levels of death during young adulthood amongst the males. In addition, the average femoral length for adult males declined. Given the possible evidence for a slight Asian admixture in the Potapovka group (see Khokhlov, this volume), however, there is a possibility that the decline in stature was related to the changing genetics of the population. No individuals displayed evidence for reactive new bone formation but, in the context of poor health suggested by the other indicators of stress, it is possible that individuals who contracted an infection died quickly before any lesions had time to develop.

The Sintashta culture – and by extension the Potapovka culture – are generally associated with a major increase in demand for metal as well as being shaped by warfare (Anthony 2007, 391-393). The archaeological evidence suggests that a number of innovations occurred in Potapovka weaponry and grave goods frequently comprise weapons as opposed to items of adornment (Anthony 2007, 372). These included the development of the chariot as well as new types of projectile points, perhaps for use with spears and javelins, that might have been thrown from chariots (Anthony 2007, 395). It is also interesting to note that Potapovka graves were sometimes deliberately dug through Poltavka graves, while some Sintashta settlements appear to have been developed on top of Poltavka settlements (Anthony 2007, 386). It is possible that the Potapovka groups were deliberately destroying these sites as a way of asserting their authority over the herders of the region. As such, it is highly probable that a period of unrest and political tension was responsible for the general decrease in health status apparent amongst the Potapovka people.

The trends for the LBA Srubnaya culture are difficult to interpret. While the levels of enamel hypoplasia and violence-related trauma decreased from the preceding Potapovka era, the levels of cribra orbitalia rose slightly. The age-at-death profile for the adults was also somewhat conflicting since the majority of adult males survived until middle or old age whereas the majority of females died as young adults. Stature for both males and females underwent a dramatic decline during Srubnaya times, which may again be indicative of poor health. Since the health indicators are so inconclusive it is difficult to interpret the significance of the slight increase in prevalence of reactive new bone formation amongst the Srubnaya group. It would seem to be the case, however, that the Srubnaya people enjoyed a better standard of health than either the Yamnaya or Potapovka groups. Perhaps the increase in sedentarization resulted in an improvement in health.

Diet

As stated above, the principal goal of the Samara Valley Project was to document the nature of the subsistence economy of the LBA Srubnaya culture in the Samara Valley. The transition from the MBA to the LBA witnessed a great increase in settlement sites as the population of the region generally became more settled at the beginning of the Srubnaya period, around 1900-1700 BC. It has been proposed that this early Late Bronze Age sedentarization process was related to the adoption of agriculture, but the Samara Valley Project found no evidence for agriculture in Srubnaya settlements (see Anthony *et al*. 2005, 408). One of the most interesting aspects of the human skeletal record is that it does not display any evidence for a significant change in diet between the Eneolithic and the Srubnaya periods.

The overall trends for caries, abscesses, periodontal disease, supragingival calculus, ante-mortem loss and extensive tooth attrition did not differ greatly during from the Khvalynsk through to the Srubnaya Cultures in the Volga region (Figure 7).

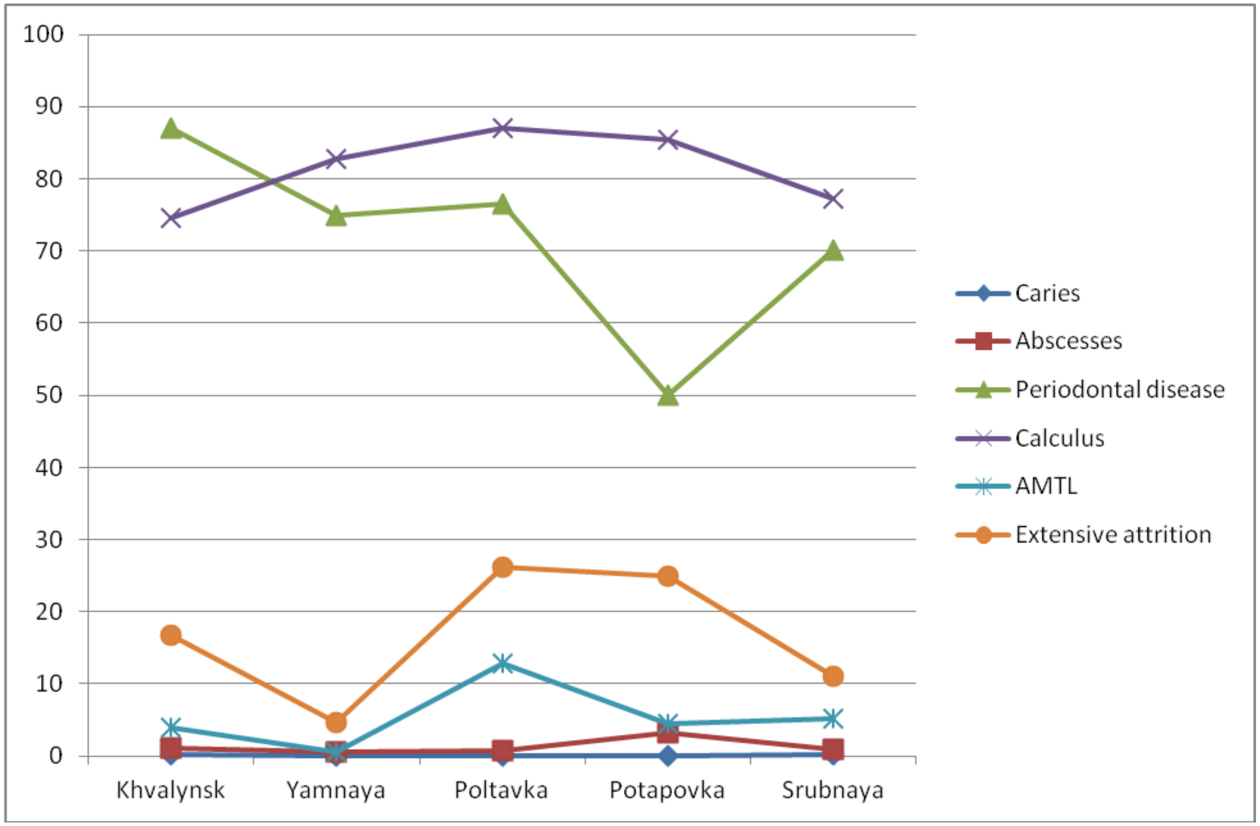

Figure 7: Summary of the dental palaeopathological lesions among the Volga adults across the different time periods, based on Tables 18-21, 24 and 25.

The dentitions of all groups were characterised by high levels (c. 50-100%) of periodontal disease and calculus, and generally low levels (0-30%) of extensive tooth attrition, ante-mortem loss, abscesses and caries. Previous studies have indicated that, although there can be a variety of aetiologies for the lesions, when studied at population level caries and calculus formation are particularly useful for palaeodietary reconstruction. The precise nature of the relationship between diet and calculus formation is not fully understood and high levels of calculus have been identified in populations that consumed both diets rich in protein and high in carbohydrates (Lieverse 1999, 226). When the frequencies of calculus and caries are compared, however, they can be used to assess the relative levels of proteins versus carbohydrates within a group's diet (Keenleyside 2008, 265). Lillie (1996; 2000) found, for example, that Mesolithic and Neolithic populations in Ukraine displayed no caries and high levels of dental calculus. He interpreted these findings as indicative of a protein-based diet that was low in carbohydrates, and therefore compatible with the hunting-fishing-gathering and, for the Neolithic, pastoralist form of economy expected for these early populations. These trends are very similar to those derived from the Volga populations where caries are practically absent and the calculus levels are even higher. It can therefore be concluded that all of the Volga populations from the Eneolithic through to Late Bronze Age times consumed a high protein diet in which cereals were largely absent. This conclusion finds support both in the stable isotope analyses of the populations (see Schulting and Richards, this volume) and in paleoenvironmental studies of the region (see Popova, this volume). It could be postulated that the dental palaeopathological characteristics of these early Volga populations may reflect a largely pastoral economy. It is interesting to note that the dental palaeopathological findings of the Volga populations, particularly in terms of caries prevalence, are very different from populations of Iron Age mobile pastoralists from the South Siberian steppe-lands where prevalences of 6.4% and 5.5% have been reported for Uyuk Culture and Hunno-Sarmatian Aymyrlyg respectively and a frequency of 1.9% was obtained for Tagar Culture Ai-Dai (Murphy 1998, 498; Murphy et al. 2013). It is probable that crop-based agricultural products formed a major component of their diet.

Other features that warrant comment are the relatively low levels of periodontal disease recorded for the Potapovka group. This could be ascribed to the high number of young adults that occurred in this population. Differing levels of extensive attrition were recorded, perhaps indicating that the Poltavka and Potapovka cultures had a greater tendency to eat course foodstuffs which caused wear to their teeth. One would imagine that the consumption of wild plants (see Popova, this volume) and tough, possibly dried, meat would have the potential to cause extensive tooth wear. A more in-depth analysis of the patterns of attrition would be required, however, to enable the trends to be explored further.

Activity patterns

Prevalence rates of the four main potential indicators of physical activity – non-violence related injuries, spinal and extraspinal osteoarthritis and Schmorl's nodes – are displayed in Figure 8.

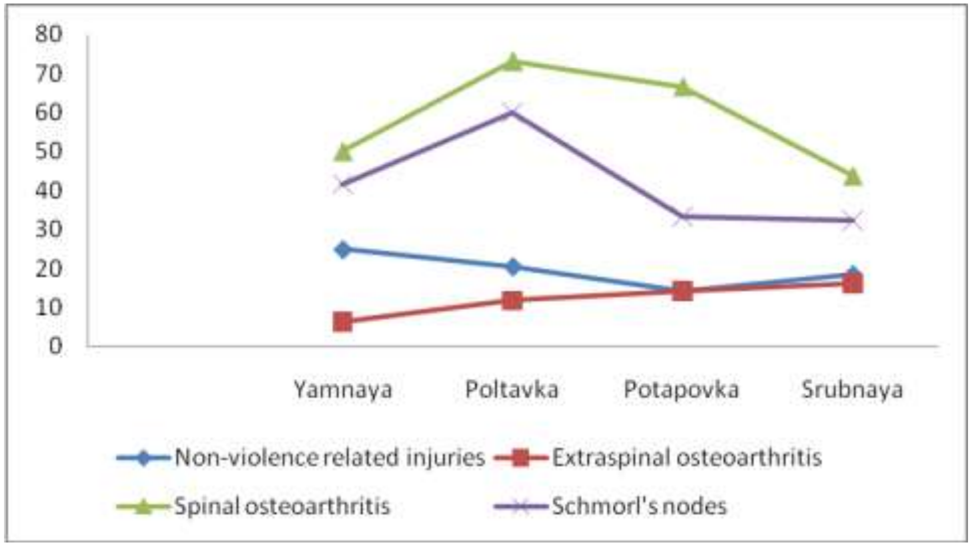

Figure 8: Summary prevalence rates of the potential indicators of physical activity derived from Tables 36 (crude), 37 (crude), 40 (individual) and 43 (individual).

No clear trends were apparent and it would appear that each population engaged in physical activities that placed stress and strain on the body in different ways. The prevalence of non-violence related injuries was highest during the Yamnaya period and appeared to decrease over time, only to rise for the Srubnaya population. The Poltavka group displayed the highest levels of spinal osteoarthritis and Schmorl's nodes which may indicate that their daily activities had placed particular stress and strain on the spine, while the Srubnaya corpus of individuals displayed the least stressed spines but the highest levels of extraspinal osteoarthritis. The Yamnaya to Potapovka populations would have been more mobile and nomadic than the later Srubnaya people, who demonstrably lived more settled lives. The diversity of trends for the activity patterns would tend to suggest that, even though they were all pastoralists, the Yamnaya, Poltavka and Potapovka groups engaged in a variety of different activities that focused strain and injury in different ways. This finding should not really be surprising, however, since recent research has demonstrated the existence of considerable variation in relation to the pastoral strategies that would have been utilized by steppe populations depending on the nature of social and environmental conditions (see Frachetti 2008).

The Srubnaya population displayed the least stressed spines, although they appeared to have been most susceptible to extraspinal osteoarthritis and displayed similar levels of non-violence related injuries to the Middle Bronze Age populations. The more settled Srubnaya residence pattern apparently did not depend on agricultural work (see Popova, this volume). It is known that seasonal mining activities were undertaken by the Srubnaya people and a copper mine dating to this period has been partly excavated at Mikhailovka Ovsianka, 24 kilometers to the south of the Samara River Valley. Mining activities are generally thought to have increased in the Late Bronze Age across the western and central steppes in Srubnaya and Andronovo contexts. It is thought that there may have been a move from the exploitation of central metallurgical centers to a more widespread utilisation of resources (Anthony *et al*. 2005, 414). It is possible that the change in activity patterns was somehow related to these activities. Although the prevalences were very low, only the Srubnaya population displayed rib and vertebrae fractures. Also of note was the relative diversity of injuries apparent among the Srubnaya people, including spondylolysis, ossified haematomas, myositis ossificans traumatica, os acromiale, osteochondritis dissecans and enthesophytes. Perhaps this diversity of injuries is evidence that the Srubnaya individuals were engaging in a greater range of activities than preceding populations.

The occurrence of five cases of osteochondritis dissecans in five males is also of interest. Although there may be a genetic component, the lesion is generally considered to be the end result of an osteochondral fracture that was initially caused by shearing, rotatory or tangentially aligned impaction forces (Resnick *et al*. 1995, 2613). One could imagine that digging activities associated with mining could potentially have caused such twisting injuries. Another interesting characteristic of the Srubnaya activity patterns was the relatively high levels of extraspinal osteoarthritis. The Srubnaya population displayed the lowest levels of spinal osteoarthritis and Schmorl’s nodes, however, and one would imagine that mining would potentially have caused major stress and strain to the spine. As such, it is possible that the interesting variety of injuries and relatively high levels of extraspinal osteoarthritis apparent in this group is not specifically related to mining but rather to a general change in activities that was associated with increasing sedentarization. Such activities may have included the construction of buildings. Perhaps the lower levels of lesions characteristic of spinal stress may be indicative of a decrease in herding activities, such as horse-back riding and presumably the loading of wagons with supplies.

Another interesting aspect of the injury pattern amongst the Srubnaya individuals was the occurrence of a relatively high level of injury amongst female individuals (13.1%) as well as males (23.9%). Some of the affected women displayed lesions, including os acromiale and spondylolysis, thereby suggesting that Srubnaya males and females both engaged in arduous physical activities. It is a pity that the female sample sizes for the earlier populations were not larger since this would have enabled one to ascertain if the nature of female activities had changed with the increasing sedentarization of the Srubnaya period.

Since these results are based on fairly small sample sizes and are partly derived from crude prevalence rates they can only be viewed in general terms. They do appear to be providing tantalising glimpses of the occurrence of differing activities between the Bronze Age groups, however, that may have been related to economic differences.

Funerary Processes

Three forms of funerary treatment were examined – the use of ochre in the burials, the presence of green discoloration on the skeletons as an indicator of the inclusion of metal objects and the presence of cut marks due to disarticulation and/or defleshing (Figure 9).

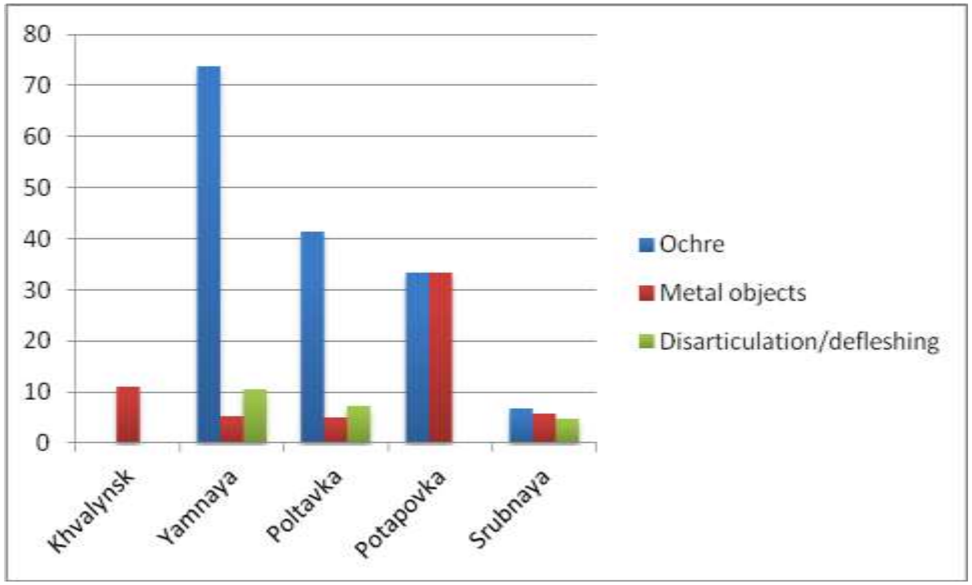

Figure 9: Summary of the prevalence rates for association with ochre and metal artefacts and evidence for disarticulation and/or defleshing based on the data contained in Tables 49, 51 and 53. It was only possible to examine the Khvalynsk group for their association with metal objects.

When interpreting the data it is important to bear in mind the problems associated with the small sample sizes of the earlier populations. All of the populations appear to have contained relatively low numbers of individuals with evidence of defleshing and/or disarticulation although, as discussed earlier, it is highly probable that the frequencies of such individuals are under-estimated. Nevertheless, it would appear that throughout the Early, Middle and Late Bronze Ages secondary burial was a necessary procedure. The disarticulation of the corpse appears to have been a recurring trait of Eurasian pastoralism that has been largely ignored. Perhaps this practise indicates that the Yamnaya and Potapovka populations were more mobile than the later Potapovka and Srubnaya groups and therefore needed to process a greater proportion of bodies. Although the numbers of females included in the study are admittedly small it is interesting that only males in the Yamnaya and Poltavka groups had been afforded body processing. By Srubnaya times, both males and females exhibited body processing. Perhaps a change had occurred which saw individuals of both sexes travelling greater distances, but this interpretation is complicated by the evidence for year-round settlements (Anthony *et al*. 2005, 403). One might have envisioned that women and children would have remained in the settlement while males went to the pastures with their herds but the occurrence of a few females with evidence of disarticulation would tend to suggest that this was not always the case.

The deposition of red ochre on the body appears to have been an important funerary rite for the Yamnaya population but its use seems to have declined by Srubnaya times. The frequencies of disarticulation and defleshing also gradually decreased from the Yamnaya to Srubnaya times. Among the Srubnaya population the prevalence of females (18%) with ochre staining was notably higher than for males (3%). It is possible that as this funerary ritual went into decline it remained largely associated with females. Perhaps it was the females of society who were more inclined to keep tradition alive, while the males were more open to new ideas and belief systems. The occurrence of two apparently related female and infant burials colored with red ochre – one Yamnaya and the other Srubnaya – may further attest to the particular significance of ochre for women. Both infants were very young and it is possible that they and their mothers had died during, or soon after, the birthing process. Perhaps red ochre was symbolic of life – perhaps blood – and was included within a funerary context as a symbol of the rebirth of the individuals in the afterlife.

All of the populations contained low numbers of individuals with green discoloration due to their association with metal artifacts, most of which appear to have been items of jewellery. A notably higher frequency of individuals with green staining was recorded for the Potapovka group. All of the affected individuals derived from a single kurgan – Kurgan 6 of the Utyevka VI burial ground – and, if we consider burial with jewellery to be a high status characteristic, it is possible that this result was influenced by the fact that this was a particularly high status kurgan. However, the increase in copper staining in the Potapovka sample correlates with a significant increase in the number of copper objects deposited in graves during the Potapovka period in general. At contemporary Sintashta settlement sites, located south-east of the Ural Mountains, copper-working occurred in every excavated structure. The increase in copper-stained human bones complements the evidence for increased numbers of metal artefacts in Potapovka and Sintashta graves and for a great increase in metal production in Sintashta settlements of the same era (Anthony 2007, 391). It is extremely interesting that despite this apparent wealth in metal, the Potapovka population had generally low levels of health which may have been related to increasing levels of violence at this time (see above). This is in contrast to the Khvalynsk population which was also associated with numerous copper grave goods but appeared to have enjoyed a relatively good standard of health.

Final remarks

The results would tend to suggest that subtle differences in health, diet, lifestyle, levels of violence and funerary practices were apparent amongst the Khvalynsk, Yamnaya, Poltavka, Potapovka and Srubnaya populations. Perhaps most surprisingly, the dental palaeopathological profile, with its very low levels of caries and high levels of calculus, did not provide evidence for the occurrence of a major economic change to correspond with the increased sedentarization of the Srubnaya culture. It would seem to be the case that all of the cultures included within the study were predominantly pastoralists. Evidence that the populations engaged in different forms of everyday physical activities was hinted in the distribution of osteoarthritis and non-violence related injuries, although it was impossible to be more specific about the nature of the tasks in which each group was engaged.

Analysis of a suite of health indicators would tend to suggest that the standards of health were poorest during the Yamnaya and Potapovka times, while the Khvalynsk and Poltavka populations enjoyed the highest levels of good health. The occurrence of a physically disabled male with an array of unusual signs of trauma, that may be indicative of torture, provides a glimpse into the darker side of life amongst the Yamnaya population. It is perhaps significant that this population appeared to have suffered from the poorest levels of health.

The osteological evidence has also provided insights concerning the funerary rituals afforded to individuals within each population. It would appear to be the case that certain individuals in all groups were buried with metal grave goods. The use of ochre and the practice of the disarticulation and defleshing of the body were used throughout the Bronze Age although, as time advanced, they appear to have declined. Perhaps this apparent decline was related to the increasing sedentarization of the Srubnaya population. Within the Srubnaya sample it is particularly interesting to note that although the frequencies were relatively low, cut marks were observed on both males and females. This may indicate that males and females were equally mobile at this time.

This study represents the first comprehensive palaeopathological analysis undertaken on the prehistoric populations of the Volga region – a key location at the cross-roads between Europe and Asia. While this general overview has provided significant insights concerning the people who lived and died in this region from Eneolithic through to Late Bronze Age times it is clear that a greater integration of site-specific mortuary data with osteological and palaeopathological findings has the potential to provide an even richer understanding of these populations (see e.g. Popova *et al*. 2011). The prehistoric Volga populations practiced a diverse array of complex burial rituals and an integrated bioarchaeological approach has the potential to greatly enhance our understanding of the social aspects of the burial record. The adoption of such an approach has the potential to enable a truer understanding of what these populations valued, their relationships and their belief systems – fundamental aspects of being human that lie at the heart of any society, past or present.

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PLATES 1-10

Plate 1: Posterior view of a probable case of slipped femoral capital epiphysis of the right femur apparent in an 18-35 year old male of Yamnaya date recovered from Flat Grave 5 of the Leshyovsky I burial ground.

Plate 2: Lateral view of a probable case of slipped femoral capital epiphysis of the right femur apparent in an 18-35 year old male of Yamnaya date recovered from Flat Grave 5 of the Leshyovsky I burial ground. A large chop mark was evident which is considered to possibly be peri-mortem.

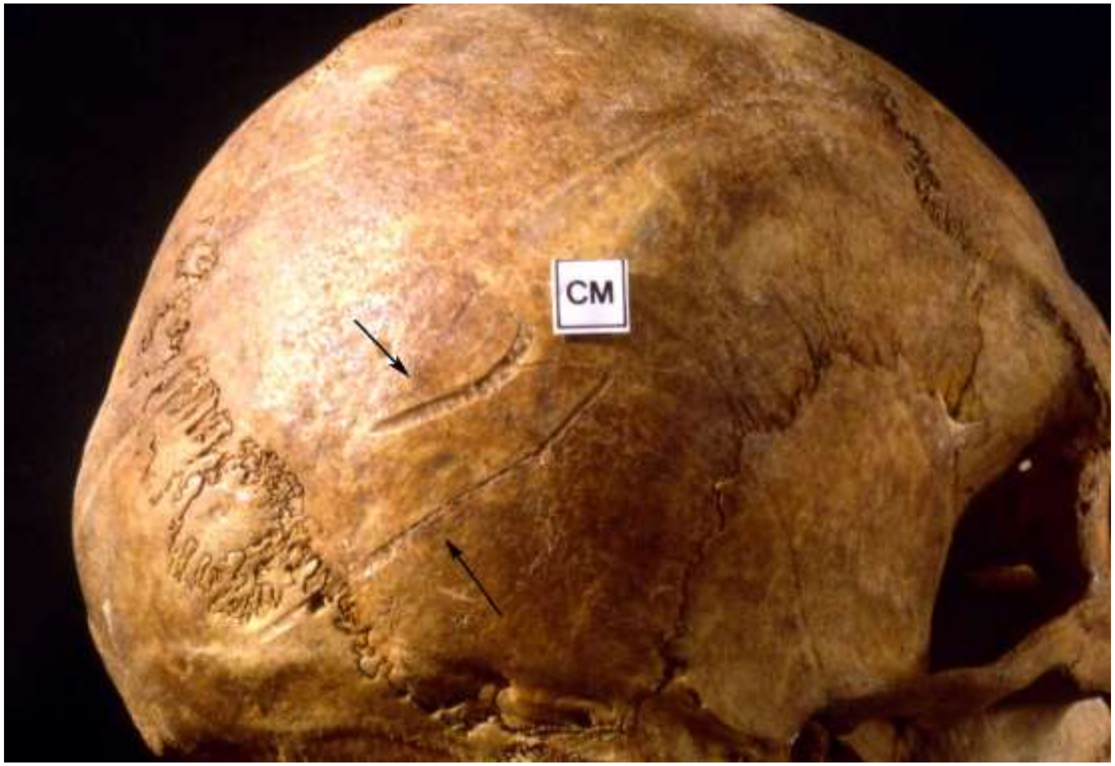

Plate 3: Peri-mortem gouge or scrape marks apparent on the postero-lateral aspect of the right parietal and occipital of an 18-35 year old male of Yamnaya date recovered from Flat Grave 5 of the Leshyovsky I burial ground. Note the serrated edge of the most superior mark.

Plate 4: Peri-mortem gouge or scrape marks apparent on the postero-lateral aspect of the right parietal and the superior aspect of the occipital of an 18-35 year old male of Yamnaya date recovered from Flat Grave 5 of the Leshyovsky I burial ground.

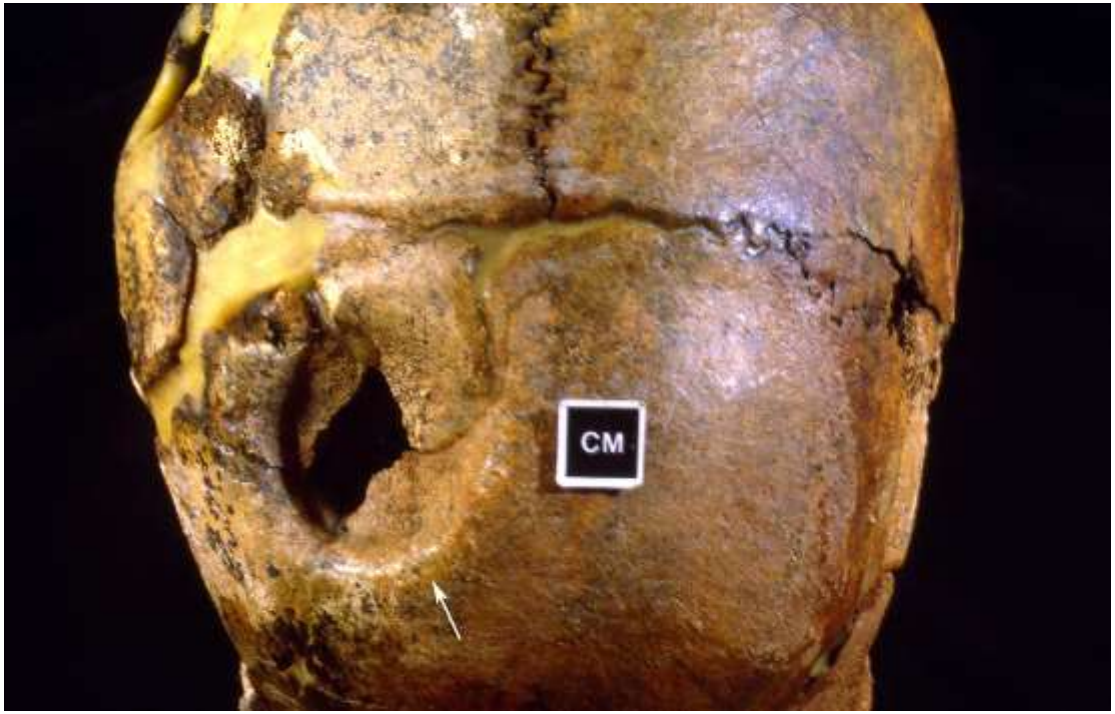

Plate 5: Probable longstanding depressed fracture on the right side of the frontal bone of Skeleton K2 G13, a 35-50 year old male of Srubnaya date, recovered from the Chistyar I burial ground.

Plate 6: *In situ* view of Skeleton K1 G4, a newborn-0.5 year old infant of Poltavka date, recovered from the Krasnosamarskoe IV burial ground. The entire skeleton was heavily covered with red ochre.

Plate 7: Green discoloration due to association with copper or bronze objects on the left maxilla of Skeleton K6 G2 Sk 1, an 18-35 year old male of Potapovka date, retrieved from the Utyevka VI burial ground.

Plate 8: *In situ* view of the disarticulated bundle burial of Skeleton K2 G1, an 18-35 year old male of Poltavka date, recovered from the Krasnosamarskoe IV burial ground.

Plate 9: Disarticulation cut marks on the right distal humerus of Skeleton K1 G2b, a 35-50 year old male of Srubnaya date, recovered from the Barinovka I burial ground.

Plate 10: Disarticulation cut marks on the proximal right femur of Skeleton K10 G7, an 18-35 year old male of Srubnaya date, recovered from the Spiridonovka II burial ground.