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Anthropological and epidemiological characterization of Great-Moravian population in connection with the social and economic structure

Estimation of Biologically Related Groups of Individuals at the Mikulčice-Kostelisko Burial Site on the Basis of Morphological Similarities, Topography of the Burial Site and Archaeological Data

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The goal of this paper was to verify, whether the incidence of non-metric traits at the Mikulčice-Kostelisko (sub-castle) burial site differs in individuals with rich and poor grave equipment i.e. whether it differs between two, socially quite probably dissimilar groups. We then compared the morphological similarity of individuals in relation to the topography of the burial site. We divided the individuals on the basis of the character of grave inventory in accordance with two classifications (Hrubý 1955; Stloukal 1970). Comparison of the smaller group of individuals from graves with rich equipment defined according to Hrubý's criteria yielded more favourable results, as it showed statistically significant differences in the incidence of several traits, which may represent "ancestral" hereditary non-metric traits. Most of the differences, though, were due to sexual dimorphism. Finally, we placed the morphological similarity and grave equipment in relation to the topography of the burial site, and we tried to find groups of individuals in whom a biological relatedness could be expected. Some of the comparisons suggested certain ties. We must keep in mind, though, that with the aid of non-metric morphological traits we can only determine that the probability of biological relatedness between certain individuals is greater/smaller than between other individuals.

Key words: Early Medieval period – Mikulčice – non-metric traits – socio-economic status – grave equipments – topography of burial ground

1. Introduction

If we visit a cemetery today, walking through its alleys and lanes we pass tombs, where usually biologically related persons are buried. The tendency to concentrate biologically related individuals near each other may be presumed to have taken place in the past as well, that is in the case of burial sites dating from the Great Moravian period. Thus, it would not be surprising if, for example, members of one clan were buried at the same burial site. If one considers, for example, that the settlement agglomeration of Mikulčice was inhabited in the second half of the ninth century by one to two thousand persons (e.g. Stloukal/Vyhnánek 1976), then it is very probable that a number of biologically related individuals is buried at the Mikulčice burial site. For example, the smaller burial site at the IV[th] Mikulčice church is often cited as the possible ancestral burial ground of the ruling class (e.g. Poulík 1975). The biological relatedness between members

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of the ruling class is very likely. The burials of biologically related individuals may thus be logically expected also at the Kostelisko burial site. In view of its size, character and grave findings, it is presumed that artisans, peasants, as well as members of the military retinue or persons of a socially higher rank were buried there, i.e. that this is a burial site of "general" character. This, after all, has also been suggested by the results of the palaeo-demographic analysis of the burial site (Velemínský et al. 2005).

Naturally, the means and possibilities of demonstrating the biological relatedness of individuals in prehistoric burial sites are quite limited. The absence of soft tissue precludes the application of current routine forensic medicine genetic methods. Partly, one may conduct the morphological or metric comparison of the skeletons, or one may attempt to demonstrate relatedness genetically, on the basis of bone DNA. In the first case, which we applied in this work, so-called non-metric morphological traits are most frequently used.

Generally, these involve slight anatomical deviations from the common bone structure, which have a certain degree of heritability (the common state most often refers to the most frequently recorded situations within the relevant human population). Traits are predominantly determined genetically. External (environmental) and internal (physiological) factors affect their incidence, but their contribution is not deemed to be decisive. The validity of the aforementioned is only presumed for a number of traits, but it has not been verified. This mainly relates to traits localised on the post-cranial parts of the skeleton. Although the genetic basis also plays a role, the relationship between the incidence of such traits and other, "non-genetic" factors (the development of the muscle apparatus, skeleton robustness, sex) is apparent in a number of cases. Specific examples of this are traits in the region of ligament/muscle attachments.

The morphological resemblance of individuals naturally only indicates a probability, but does not definitely establish biological relatedness.

The goal of this paper was to verify, whether the incidence of non-metric traits differs in graves with rich and poor grave equipment, i.e. whether it differs in two most probably socially different groups. We compared the morphological similarity of individuals also in relation to the topography of the burial site, which may also indicate the biological relatedness of individuals.

2. Material and methods

The burial site at Kostelisko, where 425 graves have been uncovered, is the largest burial site in the sub-castle area of the Mikulčice settlement agglomeration. The burial site has not been dug completely. The skeletal remains of around 456 individuals have been found in the graves. Based on the grave equipment, it may be presumed that higher echelons of society were buried there. From a demographic aspect, female and non-adult individuals are more frequently represented (Velemínský et al. 2005). Based on the incidence of non-metric traits, we compared two population groups with a defined grave equipment character. We divided the individuals on the basis of the character of grave inventory in accordance with two classifications. The first study we took as our basis was that of Hrubý (1955), which defined five categories. We included in the group with rich grave equipment those individuals who met the criteria of the first and second group according to Hrubý's classification. We also applied Stloukal's (1970) more general proposal, designated for osteological purposes, and which differentiates only two groups- graves with rich equipment and graves with poor equipment.

The classification according to Hrubý (1955)

1. graves with very rich equipment – with a sword, two or more pairs of gold earrings
2. rich graves – axes , spurs, a pair of gold earrings or several pairs of gold-plated earrings, vessels of a Byzantine character
3. graves with average posthumous equipment – with a knife, razor, sharpening steel, studs, necklaces, several pairs of silver or bronze

earrings, pails etc
4. poor graves – with a knife, one pair of silver or bronze earrings, a stud, bead or cup
5. graves without equipment

The classification according to Stloukal (1970)
1. graves with swords, spurs, axes; graves with gold, silver or bronze objects
2. graves without equipment; graves with knives or other fine objects from gold, ceramics or glass.

Fifty graves met the criteria for rich graves according to Hrubý's classification (group 1-2), and 134 individuals met the criteria using Stloukal's more general proposal.

We evaluated the incidence of roughly one hundred fifty non-metric traits on the skeletons, of which ninety were located on the skulls and sixty-two on the bones of the post-cranial skeleton. Our methodology was based on the work of Finnegan/Faust (1974), Reinhard /Rösing (1985), Czartnetzki et al. (1985), Hauser/DeStefano (1989) and Velemínský (1999). For purposes of subsequent evaluation, we divided the traits into several groups, according to their character or function. This distribution cannot be taken in complete strictness, as the classification of certain traits is problematic. These traits related to:

A – Skull sutures (Epigenetic variants).
B – Presence, absence or nature of foramens – vascular outlets or nerve routes.
C – Presence, absence or nature of joint facets and their alterations.
D – Disorders of ossification, non-junction of the ossification centres or their absence.
Ea – Hyperostotic activity, with the presence of osseous tori, tubercles, spines or bridges.
Eb – Changes in the region of muscle/ligament attachments – loss of bone tissue or fibrous ossification resulting in the genesis of osseous prominences (enthesopathies). This is associated with marked long-term stress acting upon relevant muscle groups. According to Ossenberg (1977) these are termed hypostotic traits.

To verify the differences in the incidence of non-metric traits among individuals with rich and poor grave equipment, we used tests that compare nominal traits in independent selections (e.g. Zvára 1999, Statistica (STATISTICA 5.0 for Windows, StatSoft, Inc.) and the so-called Measure of Divergence (MD) or Mean Measure of Divergence (MMD) (e.g. Sjøvold 1973). This basically entails determining the degree of dissimilitude of the probabilities measured (Zvára 1999). The starting premise, null hypothesis (H_0), was that the relevant trait occurs with the same probability in both groups. We used the aforementioned tests only to determine whether a concurrence in the incidence does or does not exist, not to determine how great the eventual difference (dependence) of trait frequency is in the groups compared.

We used cluster analysis to find individuals who show greater concurrence in the incidence of non-metric traits. The principle of this method is the attempt to separate within a group of objects those that are in some way close, similar. In the case of the Kostelisko burial site, we attempted to identify individuals/groups (clusters) of individuals among whom a more significant degree of concurrence of non-metric traits exists. Cluster analysis ranks among the subjective methods of multivariate analysis. It searches for similarities between evaluated objects and clusters together similar elements, while it classifies mutually different elements into various groups (Havránek 1983). It does not take into consideration the possible random character of data, which is why it is not considered to be a statistical method (Zvára 1999). We based our evaluations on the procedure described in the work of Unzeitigová (2000). A matrix was created for each pair of skeletons, where the columns represented traits and the rows represented individuals, i.e. the matrix consisted of twos (presence of trait) and ones (absence of trait). We then determined the number of cases, where the incidence of a given trait differed in the group of compared individuals. The distance between individuals was taken as the percentage of such "divergences".

This calculation does not include situations, whereby the trait is absent in both compared individuals. In the case of traits with a low population incidence, the predictive value regarding the similarity of skeletons is nearly zero. This way, only the mutual distances of all individuals are determined. The distance between two groups (clusters) of individuals was defined as the Euclidean average of the distances between all individuals of both these groups (clusters) – weighted pair-group centroid (median) – or as the distance between the most distant elements-individuals (complete linkage). The graphical output of such an evaluation is the dendogram.

The algorithm of cluster analysis is as follows: first, the mutual distances between all individuals are calculated. Next, the two closest individuals are separated and classified into one group. Then, the new distances between this group and the remaining individuals are calculated. In the next step, the closest individuals (or group) are again separated, etc. This sequence is repeated until all individuals have been classified (Unzeitigová 2000).

A completed matrix is a pre-condition for the calculation itself. If we wish to compare, for example, twenty individuals on the basis of ten traits, only those individuals in whom all ten traits can be evaluated can be compared. The individual with a single, non-evaluable trait must be excluded from the comparison. The presence of missing values pre-conditions the reduction in the number of individuals compared or of the number of traits on who basis the given individuals are to be clustered.

We strove to conduct comparisons always in a group of traits with the same character or function.

3. Results and Discussion

The primary goal was to determine the incidence of selected non-metric morphological traits in the skeletal remains of individuals buried at Kostelisko and to determine the average population frequency of these traits. In the case of statistically significant dependence on sex, the given trait was excluded from the comparison, or this fact was taken into consideration when interpreting results (see Velemínský et al. this book, pp. 265-304)

Further calculations focused on predicting individuals whom we could presume to be biologically related. We focused only on the group of graves with rich grave equipment. In the pagan or early Christian era, the grave inventory may be seen as a source of information regarding the social rank of an individual. Moreover, it may be presumed that individuals of higher rank were often biologically related. If we also take into consideration the size of the Mikulčice settlement agglomeration and the estimated number of its inhabitants, we may expect that within the group of graves with rich equipment at the Kostelisko burial site there is a higher representation of biologically related skeletons. Thus, on the basis of the incidence of non-metric traits, we first compared the group of individuals from rich graves with the remaining population of Kostelisko. We worked with two groups of rich graves. The first, more specific, was selected according to Hrubý's criteria (1955) (group I) and the second, less definite, was selected according to Stloukal's criteria (1970) (group II). We attempted to determine, whether certain non-metric traits have a statistically different incidence in the group of individuals with rich grave equipment. If the premises detailed above hold, such traits could be considered, with some exaggeration, to be ancestral traits. We used the measure of divergence, mean measure of divergence and the Chi-square test to verify this.

In order to identify individuals at the burial site in whom biological relatedness could not be excluded, we basically took the following two approaches:

- we selected individuals with "ancestral" non-metric traits and compared the position of their graves. We thus started from the premise that the graves of blood-relatives could neighbor on each other or could be located in the same section of the burial site

- we selected individuals with non-metric traits whose population frequency within the group of rich graves was less than twenty percent, and we compared the mutual position of the graves of individuals with such traits, i.e. we again focused on the topography of the graves
- we compared individuals on the basis of groups of non-metric morphological traits of similar character with the aid of cluster analysis. This comparison was limited by the missing values, i.e. those cases where the given trait could not be evaluated due to damage or absence of the relevant part of the bone.

3.1 Non-metric traits in individuals with rich grave equipment

We tested the concurrence in the incidence of non-metric traits between individuals from "rich" and "poor" graves with the aid of the four-field table, Yates' modification of the chi-square test and by calculating the measure of divergence. We worked with two groups of individuals with a rich grave inventory – group I (Hrubý 1955) and group II (Stloukal 1970).

3.1.1 Graves with rich grave equipment I

We first focused on the smaller group of individuals with rich grave equipment, selected using the criteria of Hrubý (1955). For each non-metric trait, we calculated its average incidence in the given group and in the rest of the burial site. In the case of bilateral traits, we compared their frequency expressed as the average for a non-specific side. We then verified the differences in incidence between both groups with the aid of appropriate tests.

Table 1 lists the traits with a statistically significant different incidence in both groups when using the chi-square test. Statistically significant differences were demonstrated in the case of twenty two traits. The different incidence, though, was most often probably due to the demographic structure of the group of rich skeletons with male predominance, or more specifically to the sexual dimorphism in the incidence of non-metric traits at Kostelisko. In view of the poor state of skeleton preservation, the number of evaluated cases was usually low.

In individuals with graves with a rich inventory, it was often noted that two isolated facets participated in the communication between the calcaneus and talus (*facies articularis calcanea anterior et medialis*), while in the remaining population of Kostelisko these facets were more often fused (*facies articularis calcanea anterior et media communis*). A similar situation was found in the case of the analogical articular facets on the calcaneus – *facies articularis talaris anterior et media* (more frequent incidence in rich graves statistically not demonstrated) and the *facies articularis talaris anterior et media communis* (more frequent in graves with poor equipment). Yet, if we look at the demographic structure of the group of individuals with rich grave equipment (I), where males

Table 1. Non-metric traits (NMT) with a statistically different incidence in groups of individuals with rich grave equipment I (Hrubý 1955) at the Mikulčice-Kostelisko burial site.
Explanatory notes: attained level of significance of the chi-square test: p=0.5 ….. *; p=0.01 ….. **; p=0.001 ….. ***

More Frequently Incidence at the Group with Rich Grave Equipment I			Less Frequently Incidence at the Group with Rich Grave Equipment I
sutura supranasalis*	proc. pariet. sq.temp.*	torus maxillaris**	fac. art. tal. ant. et med. com.*
fac. art. trochl. partita*	for. Vesalii***	spina suprameatica*	fac. art. calc. ant. et med. com.**
facies Charles*	pont.interclinoideus*	torus acusticus*	for. hypogl. part.*
fac. art. calc. ant. et med.*	taenie interclinoidea**	torus mandibularis***	for. spin. incompl.**
fossa Alleni*	pont. atlantis*	fossa costoclavicularis***	tub. zygomaxillare*
for. infraorbitale part.****	pont. atlantis post.**		sutura incisiva

Table 2. Comparison of the incidence of non-metric traits in individuals from graves with rich equipment I (Hrubý 1955) and the other individuals buried at Kostelisko with the aid of the measure of divergence.
Explanatory notes: statistically significant values at p=0.05 are in bold italics; statistically significant values at p=0.05 and p=0.01 according to Sjovold´s criteria (1973) are in italics

trait	Mikulčice-Kostelisko - the Graves with Rich Goods			Mikulčice-Kostelisko - the Graves with Poor Goods			Measure of Divergence					
	N	Incidence	%	N	Incidence	%	MD	p=0,05	p=0,01	S^2 MD	Left Endpoint of 95% Confidence Interval	Right Endpoint of 95% Confidence Interval
sutura supranasalis absens	26	5	19,2	190	79	41,6	*0,19996*	0,13117	0,26235	0,12079	-0,48124	0,88116
sutura incisiva	48	3	6,3	398	160	40,2	*0,73039*	0,07004	0,14008	0,17566	-0,09109	1,55187
os epiptericum	27	1	3,7	146	24	16,4	*0,15647*	0,13166	0,26332	0,23737	-0,79845	1,11139
proc.pariet. os. sphen.	28	7	25,0	153	20	13	0,05221	0,12675	0,25350	0,00752	-0,11779	0,22220
f.ac. Charles+f.ac. cond. media	18	15	83,3	254	98	38,6	*0,86231*	0,17848	0,35696	0,34685	-0,29200	2,01663
fac. art. tal.ant.et med. (Ta)	29	9	31,0	242	35	14,5	*0,12259*	0,11584	0,23169	0,00299	0,01534	0,22984
fac. art.t al. ant.et med. com absens (Ta)	30	10	33,3	242	35	14,5	***0,16568***	0,11240	0,22479	0,00373	0,04600	0,28536
fossa Alleni	11	2	18,2	176	3	1,7	***0,2868***	0,28977	0,57955	0,01962	0,01220	0,56133
incisura supraorbitalis	57	2	3,5	439	-	-	*0,12220*	0,05947	0,11893	0,02725	-0,20136	0,44576
for.infraorbitale partitum	30	5	16,7	262	7	2,7	***0,2257***	0,11145	0,22290	0,00626	0,07062	0,38078
proc.pariet. sq.tempor.	23	2	8,7	195	1	0,5	*0,1587*	0,14582	0,29164	0,03069	-0,18465	0,50207
can. tympanicum	44	1	2,3	388	40	10,3	*0,09795*	0,07591	0,15183	0,13397	-0,61945	0,81534
for. hypogl. bipart.	39	1	2,6	320	54	16,9	*0,24686*	0,08630	0,17260	0,18275	-0,59101	1,08474
for. spin. incompletum	22	-	-	163	41	25,2	*1,0525*	0,15477	0,30954	0,71441	-0,60419	2,70911
for. Vesalii	22	7	31,8	253	23	9,1	***0,29407***	0,14822	0,29644	0,00940	0,10401	0,48414
ponticuli sellae	15	4	26,7	154	19	12,3	*0,06187*	0,21948	0,43896	0,01274	-0,15939	0,28313
ponticuli atlantis posterior	26	4	15,4	170	4	2,4	***0,20377***	0,13303	0,26606	0,01023	0,00548	0,40206
torus maxillaris	51	3	5,9	394	2	0,5	*0,09850*	0,06644	0,13288	0,02481	-0,21023	0,40723
torus acusticus	46	11	23,9	430	51	11,9	*0,07752*	0,07219	0,14439	0,00371	-0,04182	0,19687

trait	Mikulčice-Kostelisko - the Graves with Rich Goods			Mikulčice-Kostelisko - the Graves with Poor Goods			Measure of Divergence					
	N	Inci-dence	%	N	Inci-dence	%	MD	p=0,05	p=0,01	S^2 MD	Left Endpoint of 95% Confi-dence Interval	Right Endpoint of 95% Confi-dence Interval
torus mandibularis	57	3	5,3	479	2	0,4	*0,09168*	0,05889	0,11779	0,02431	-0,21389	0,39724
fossa costaclavic.	28	13	46,4	219	35	16,0	***0,41774***	0,12084	0,24168	0,03276	0,06299	0,77249
fossa pector.maj.	24	-	-	281	17	6,0	*0,20181*	0,13568	0,27135	0,39085	-1,02354	1,42716
fossa teres	28	-	-	284	12	4,2	*0,13221*	0,11771	0,23541	0,31223	-0,96298	1,22741
fossa bicipitis	13	3	23	159	18	11,3	0,01656	0,24964	0,49927	0,02448	-0,29010	0,32322
fossa hypotroch.	33	3	9,1	327	26	8,0	-0,03169	0,10008	0,20017	0,05838	-0,50527	0,44188
crista hypotroch.	22	10	45,5	225	75	33,3	0,01200	0,14970	0,29939	0,00746	-0,15733	0,18133
fossa solei	21	2	9,5	232	41	17,7	0,00581	0,15579	0,31158	0,15090	-0,75556	0,76718

clearly predominate, and at the results of verification of the sexual dimorphism of the incidence of these traits at Kostelisko, it is quite probable that the differences between the rich and poor group were mainly due to the different representation of traits in both sexes. The different incidence in males and females may also explain the differences in the incidence of other traits, *sutura supranasalis, torus acusticus, spina suprameatica, fossa costoclavicularis, fossa bicipitis* and *foramen hypoglossalis partitus*. The demographic structure and sexual dimorphism to a certain extent affect the fact that traits of a hyperostotic character occur more frequently in individuals with rich graves, while traits of a hypostatic character occur more frequently in individuals from poor graves. Both groups differ, for example, in the incidence of all traits associated with sites of muscle attachments. Apart from the *fossa costoclavicularis*, the *fossa bicipitis, crista hypotrochanterica* and *crista solei* occur more often in the group of "rich" skeletons (this difference was not statistically proven). In poor graves, the *fossa pectoralis major, fossa teres, fossa solei, fossa gastrocnemica* and *linea nuchae suprema* are developed more often. The *fossa pectoralis major*, whose incidence at Kostelisko was shown to be statistically greater in men, was not found at all in the group of individuals from rich graves. A similar situation also applies in the case of the *fossa gastrocnemica.* Also, the *fossa teres*, which in Kostelisko showed more or less the same incidence in both sexes, did not occur in any skeleton from rich graves. The influence of the difference in incidence in both sexes may be also be ruled out in the case of the *tuberculum zygomaxillare, foramen Vesalii*, *ponticulus atlantis, facies articularis trochlearis partita* and more or less also of the *foramen infraorbitale partitum* and *torus mandibularis*. In view of their possible ancestral heredity within the group of individuals with a rich grave inventory, these six traits have the highest predicative value. The *fossa Alleni* was evaluable only in several individuals (11/2), which is why we do not consider the significant difference in its case to be conclusive.

Table 3. Comparison of the graves with rich equipment I (Hrubý 1955) with the other individuals buried at Kostelisko on the basis o the group of non-metric traits using the mean measure of divergence.
Explanatory notes: statistically significant values are in bold italics

Trait Group	MMD	S^2mmd	MDD-1,96 S^2mmd	MDD+1,96 S^2mmd
cranial sutures	0,28476	0,03383	-0,07577	0,64528
articular facets	***0,47912***	0,04147	0,08	0,87823
vessel and nervous foramina	***0,25795***	0,01948	0,01948	0,49642
hyperostotic traits	0,08923	0,00587	-0,06092	0,23939
areas of muscle/fibrous insertions	0,10778	0,01994	-0,16899	0,38455
Total	***0,21926***	0,00431	0,09056	0,34797

Table 4. Non-metric traits with statistically different incidence in individuals with rich equipment II (Stloukal 1970) and the remaining part of the burial site at Kostelisko.
The stars characterise the level of significance reached using the chi-square test: p=0.5 ….. *; p=0.01 ….. **; p=0.001 ….. ***

More Frequently Incidence at the Group with Rich Grave Equipment II			Less Frequently Incidence at the Group with Rich Grave Equipment II
proc. temp. os. front.*	facies Charlesi***	for.condylaris*	sutura incisoiva***
oss. sut. lambdoideae*	fac. art. tal. ant. et med.*	for. proc. trans. part. C1-7***	fac. art. tal. ant. et med. com.***
		crista solei*	for. hypogl. part.*
			fossa solei*

In the next step, we verified in both groups the difference in the incidence of traits, which were statistically significant when applying the chi-square test, by calculating the measure of divergence (MD). We also included in the calculation those traits, in which the chi-square test values were not statistically significant but exceeded the value of two. These results are listed in Table 2. A different incidence at the 5% level of significance was found in the case of the *facies articularis calcanea anterior et medialis, facies articularis calcanea anterior et media communis, fossa Alleni, foramen infraorbitale partitum, foramen Vesalii, ponticulus atlantis posterior* and *fossa costoclavicularis*. This means that the number of traits with a different incidence in both compared groups significantly decreased when using the MD. If we take into consideration sexual dimorphism, we may consider the existence of "ancestral traits" only in the case of the *foramen infraorbitale partitum*, *foramen Vesalii* and *ponticulus atlantis posterior*.

Table 3 then lists the values of the mean measure of divergence for the groups of non-metric traits of similar character. Both groups had a statistically proven different incidence of those traits involving vascular and nerve outlets and the character of articular surfaces. No difference was shown, though, in the incidence of traits associated with the sites of muscle insertions. The total MMD value was 224.5.

3.1.2 Graves with rich grave equipment II

We proceeded analogically in the case of the group of individuals with rich grave equipment, selected according to the criteria of Stloukal (1970). For each non-metric trait, we calculated its average incidence for this group and for the rest of the burial site, and we compared both values using the four-field table and Yates correction. The non-metric traits for which we demonstrated statistically significant differences are listed in Table 4.

In view of the situation in the case of the previous comparison, we took into consideration the difference in the incidence of each trait in both sexes. Sexual dimorphism most probably lay behind the determined statistically significant difference in the incidence of the *ossicula suturae lambdoidea*, *facies articularis talaris anterior et media communis* and *foramen hypoglossalis partitus*. The other traits may be associated with ancestral heredity within the group of individuals with a rich grave inventory. The *foramen processus transversi partitum* of cervical vertebrae was evaluated in a small number of individuals. The statistically most significant difference was shown in the incidence of the *sutura incisiva* and *facies Charlesi.*

The group of „the rich" derived from Stloukal's criteria (N=153 individuals) is nearly three times larger than the group derived from Hrubý's classification. The demographic structure, representation of males and females, is in this case similar to that of the whole Mikulčice-Kostelisko burial site, i.e. females clearly predominate (e.g. Velemínský et al. 2005). It is thus natural that the group of individuals with a rich grave inventory differs from the other individuals at Kostelisko in a smaller number of traits.

Table 5 lists the results of the verification of the different incidence of non-metric traits in both groups with the aid of the measure of divergence. This test criterion did not show any difference in the incidence of any trait, nor of any group of traits. The total mean measure of divergence lies on the 5% level of significance – 111.4.

The following is a summary of the aforementioned attempts to find "ancestral" traits within the group of individuals with rich grave equipment:

1. More favourable results were yielded when comparing group I of rich graves selected according to Hrubý's criteria, which demonstrated statistically significant differences in the incidence of more traits. On the other hand, the demographic structure of this group was clearly different from the situation in the rest of the burial site, and sexual dimorphism probably played a significant role in the incidence of several traits. Nonetheless, a number of traits within the group of individuals with a rich grave inventory may still represent ancestral heredity.
   - both statistical criteria showed a difference in the incidence of: *foramen infraorbitale partitum, foramen Vesalii a ponticulus atlantis posterior*, or *fossa Alleni*
   - statistically significant values using only the χ^2- test were further demonstrated in the case of: *tuberculum zygomaxillare, facies articularis trochlearis partita* and *torus mandibularis*
2. Group II of individuals with rich grave equipment derived using the classification of Stloukal (1970) was too extensive in relation to the population group buried at Kostelisko. Its demographic structure more or less corresponded to the situation in the whole burial site. The statistically significant differences demonstrated by the smaller group I, which is practically part of this group, were not demonstrated in this case.
   - using the χ^2- test, a statistically significant difference in incidence was shown in the case of the following traits: *sutura incisiva, processus temporalis ossis frontalis, foramen condylaris, facies Charlesi, facies articularis talaris anterior et media, crista solei* and *fossa sole.*
   - another test criterion, the measure of divergence, did not confirm any one of the aforementioned differences.

3.2 Morphological similarity of individuals at the Mikulčice-Kostelisko burial site

In the last phase of this work, we attempted to find groups of individuals in whom biological relatedness could be expected, based on the incidence of selected non-metric traits. We focused mainly on individuals buried with rich grave equipment. We proceeded basically using two approaches. The first was based on the premise that the graves of family members could neighbor on each other, or were located

Table 5. Comparison of the graves with rich equipment II (Stloukal 1970) with the other individuals buried at Kostelisko using the measure of divergence.
Explanatory notes: statistically significant values at p=0.05 are in bold italics; statistically significant values at p=0.05 and p=0.01 according to Sjøvold's criteria (1973) are in italics

traits	Mikulčice-Kostelisko - the Graves with Rich Goods			Mikulčice-Kostelisko - the Graves with Poor Goods			Measure of Ddivergence					
	N	Incidence	%	N	Incidence	%	MD	p=0,05	p=0,01	S^2 MD	Left Endpoint of 95% Confidence Interval	Right Endpoint of 95% Confidence Interval
sutura incisiva	137	35	25,5	309	128	41,4	*0,10413*	0,03161	0,06321	0,01543	-0,13935	0,34762
proc. temp. os. front.	70	3	4,3	171	-	-	*0,15380*	0,06040	0,12080	0,02266	-0,14127	0,44887
os. sut. lambdoid.absens	70	17	24,3	234	88	37,6	*0,06537*	0,05568	0,11136	0,02625	-0,25220	0,38294
fac. Charles+f.ac. cond. media	33	24	72,7	239	89	37,2	*0,49834*	0,10346	0,20692	0,10200	-0,12764	1,12431
fac.art. tal. ant. et med. (Ta)	62	15	24,2	209	29	13,9	0,04935	0,06274	0,12548	0,00409	-0,07600	0,17470
fac. art. tal. ant. et med. com absens(Ta)	63	15	23,8	209	30	14,4	0,03807	0,06197	0,12395	0,00480	-0,09769	0,17383
for. supratrochleare	46	11	23,9	180	24	13,3	0,04796	0,08188	0,16377	0,00561	-0,09878	0,19470
sulcus frontalis	77	34	44,2	232	74	31,9	0,04688	0,05189	0,10378	0,00124	-0,02214	0,11590
os zygomaticum absens	112	3	2,7	280	21	7,5	*0,03858*	0,03750	0,07500	0,05419	-0,41768	0,49483
can. condylaris absens	31	5	16,1	57	19	33,3	0,11375	0,14941	0,29881	0,13638	-0,61007	0,83757
for. hypogl. bipart.	97	7	7,2	262	48	18,3	*0,10192*	0,04238	0,08476	0,05323	-0,35029	0,55414
for. suprascap.	42	4	9,5	165	4	2,4	0,06922	0,08961	0,17922	0,02539	-0,24307	0,38151
fossa pharyng.	185	44	23,8	53	24	45,3	*0,18498*	0,07282	0,14564	0,05064	-0,25608	0,62604
fossa costaclavic.	60	15	25,0	187	33	17,6	0,01043	0,06604	0,13209	0,00616	-0,14345	0,16431
fossa pector.maj.	62	0	-	243	17	7,0	*0,26637*	0,06073	0,12147	0,18042	-0,56616	1,09891
fossa teres	67	0	-	284	12	4,2	*0,15300*	0,05534	0,11068	0,14603	-0,59598	0,90199
fossa hypotroch.	86	3	3,5	274	26	9,5	*0,04748*	0,04583	0,09167	0,06432	-0,44959	0,54455
crista hypotroch.	49	22	44,9	198	63	31,8	0,04741	0,07638	0,15275	0,00273	-0,05497	0,14980
fossa solei	70	6	8,6	183	37	20,2	*0,09483*	0,05925	0,11850	0,06909	-0,42035	0,61002
crista solei	40	16	40,0	149	35	23,5	*0,09608*	0,09513	0,19027	0,00356	-0,02082	0,21298

Table 6. Comparison of skeletons from the graves with rich equipment II (Stloukal 1970) with the other individuals at Kostelisko on the basis of the group of non-metric traits using the mean measure of divergence. Explanatory notes: statistically significant values are in bold italics

Trait Group	MMD	S^2mmd	MDD-1,96 S^2mmd	MDD+1,96 S^2mmd
cranial sutures	0,10777	0,00715	-0,05796	0,2735
articular facets	0,15843	0,00728	-0,00882	0,32567
vessel and nervous foramina	0,7407	0,01082	-0,12978	0,27792
areas of muscle/fibrous insertions	0,11257	0,00817	-0,0646	0,28975
Total	***0,1114***	0,00244	0,01467	0,20813

in the same section of the burial site. This means that we based ourselves on the topography of the Kostelisko burial site. In the second phase, we used cluster analysis to determine the degree of morphological similarity of the skeletons from Kostelisko.

3.2.1. Morphological similarity of individuals in relation to the topography of the burial site and grave equipment

The topography of the burial site may also to some extent reflect structure, social hierarchy, previous societies or it may testify to the biological ties of the buried individuals. Naturally, one cannot expect that the position of the grave of each individual was strictly given and that we could be capable according to this position of determining the specific social position of the buried individual. The chronological succession of the death of individuals naturally always played an important role. The burial site was extended in a certain direction or certain directions.

On the other hand, ethnological studies indicate that the position of graves within the burial site was also determined by other facts. Socially important persons were usually buried at "special locations" within the burial site. We often find their graves in the centre of the burial site – the further a grave was located from the centre, the lower the expected social rank of the deceased. Once Christianity prevailed, such persons were often buried within church objects. The age of the deceased could also play an important role; children were more often buried at the edge of burial sites. The location of the grave could have also been selected with regards to the family or clan relationships of the deceased. The orientation of the graves could have also been affected for example by the season, position of the sun, i.e. previous faith, religion (e.g. Aries 2000).

The validity of some of these presumptions is not unrealistic even in the case of the Mikulčice burial sites. Which is why, out of interest, we focused on the relationships between the incidence of non-metric traits, the character of grave equipment and the grave position within the burial site. If we look at the map of the Kostelisko burial site with the graves with rich equipment according to Hrubý and Stloukal marked, we find the following:

- if a narrower selection according to Hrubý's criteria is used, then it is apparent that rich graves are concentrated in a wider cluster in the western and central section of the burial site. This is definitely not the case of a concentration into a single smaller place, as if we connect the "marginal" rich graves we get a more or less wider "oval" cluster of graves. Graves No 1778, 1890 are situated apart in the southern section, as are graves no. 1975 and 1980 in the western sector. At the edges of the burial site, we find exclusively graves with poor equipment or graves lacking equipment. This situation may be interpreted in several ways:
  - socially important individuals were buried in the centre of the burial site; family ties could also play a role.

- this state is contingent to the embracing of Christianity; older, pagan graves are in the centre, younger burials around these are in the spirit of Christian customs.
- this is a random state, burials were conducted only according to the chronological succession of death
- using the wider selection (Stloukal 1970), graves with rich equipment are found more or less throughout the burial site (Z-V), although they are yet again localised mainly in the western and central section of the burial site. The cluster of rich graves is not as apparent, significantly more graves "deviate". Nonetheless, "centralisation" of the rich graves, enclosed by graves without equipment is apparent.

We must also take into consideration that the burial site at Kostelisko has not been completely explored, its boundaries have not been determined. Certain graves with rich equipment thus need not have been detected by archaeological research.

In view of the aforementioned, we placed the incidence of non-metric traits i.e. the morphological similarities of individuals in the context of the topography of the burial site at Kostelisko. We focused only on individuals from graves with rich equipment according to Hrubý´s criteria (1955). The reason for this was the fact that this group differed in the incidence of several traits. Some of these may, despite the atypical demographic composition of the group, represent ancestral heredity. We proceeded as follows:

- we selected individuals in whom non-metric traits that could be, with some exaggeration, taken to be "ancestral" occurred and we compared the mutual position of their graves
- similarly, we also compared the incidence of other non-metric traits in individuals with rich equipment according to Hrubý, i.e. the mutual position of the graves of individuals with a concordant incidence of non-metric traits.
- we selected individuals with a concordant incidence of several non-metric traits, regardless of the mutual position of their graves.

The following list includes for each non-metric trait the number of the graves/skeletons, in which the relevant trait occurred as well as information whether there existed a "topographic" relationship between the cited graves. First, we list the morphological traits in whose incidence the group of "rich" individuals differed statistically (medium bold-type, italics), followed by traits with a low population incidence occurring in individuals from more distant graves.

- ***foramen infraorbitale partitum***
  grave 1705, 1711, 1752, 1778; in the vicinity of 1711 and 1752
- ***foramen Vesalii***
  graves 1750, 1766, 1908, 1952; in the vicinity of *1908* and *1952*, 1750 and 1766 in the same sector
- ***ponticulus atlantis posterior***
  graves 1809, 1902, 1903; in the vicinity of 1902 and 1903
- ***facies articularis trochlearis partita***
  graves 1616, 1705, 1908, 1980; different position of graves
- ***torus mandibularis***
  graves 1665, 1778; different position of graves
- **facies articularis talaris anterior absens**
  graves 1662, 1766; lie in the vicinity
- **foramen supraorbitale**
  graves 1752, 1840, 1975; in the relative vicinity of *1752* and *1840*
- **torus acusticus**
  graves 1677, 1711, 1748, 1778, 1879, 1952; in the vicinity of *1711* and *1748*
- **ponticuli sellae**
  graves 1616, 1665, 1879; next to each other *1616* and *1665 /*
- **tuberculum praecondylare**
  graves 1665, 1908, 1912; in the vicinity of *1908* and *1912 !*
- **spina trochlearis**
  graves 1702, 1750, 1759, 1879, 1952; graves in the same sector (1702, 1750, 1759)
- canalis condylaris
  graves 1742, 1752, 1766, 1778, 1809, 1908; in the vicinity of *1742* and *1752*, *1778* and *1809*,
- fossa bicipitis
  graves 1705, 1746, 1903; in the relative vicinity of 1705 and 1746
- torus maxillaris
  graves 1662, 1665; graves in the same sector
- trochanter tertius
  graves 1952, 1980; graves in the same sector

- fossa solei
  graves 1752, 1912; different position of graves
- crista solei
  graves 1908, 1980; different position of graves
- incisura faciei lunatae
  graves 1702, 1742, 1759, 1879; different position of graves
- facies articularis sacralis accessoriae
  graves 1809, 1903; different position of graves
- facies Charlesi (this is not a population rare trait)
  graves 1711, 1742, 1778, 1809, 1908, 1912, 1975, 1980; graves located in the vicinity of 1778 and 1809; 1908 and 1912
- facies articularis condylaris media (this is not a population rare trait)
  graves 1705, 1742; located in one sector
- facies articularis tibialis accessoriae lateralis (this is not a population rare trait)
  graves 1742, 1766, 1908, 1912, 1952, 1980; group 1908, 1912 and 1952
- facies articularis talaris anterior et media (this is not a population rare trait)
  graves 1655, 1677, 1689, 1711, 1746, 1778, 1809, 1908, 1912, 1952; certain graves in the vicinity e.g. group 1908, 1912, 1952
- facies articularis talaris anterior et media communis (this is not a population rare trait)
  graves 1616, 1742, 1746, 1752, 1759, 1975, 1980; in the vicinity of group 1742, 1752, 1759 ?
- sulcus frontalis (this is not a population rare trait)
  graves 1662, 1675, 1730, 1750, 1809, 1879, 1975
- foramen frontale
  1677, 1702, 1711, 1730, 1752, 1759, 1809, 1840, 1980; different position of graves, in the vicinity only 1752 and 1840
- foramen parietale absens (this is not a population rare trait)
  graves 1616, 1752, 1759, 1766, 1778, 1902, 1908, 1952, 1980; in the vicinity of 1908 and 1912

Thus, there are not many cases where a population rarer non-metric trait occurred in the vicinity of the buried individuals.

- individuals from graves 1711 and 1752 concur in the incidence of *foramen infraorbitale partitum*
- individuals from graves 1908 and 1952 concur in the incidence of *foramen Vesalii* (1750 and 1766)
- individuals from graves *1902* and *1903* concur in the incidence of *ponticulus atlantis posterior*
- individuals from graves 1662 and 1766 concur in the incidence of *facies articularis talaris anterior absens*
- individuals from graves 1752 and 1840 concur in the incidence of *foramen supraorbitale*
- individuals from graves 1711 and 1748 concur in the incidence of *torus acusticus*
- individuals from graves *1616* and *1665* concur in the incidence of *ponticuli sellae*
- individuals from graves *1908* and *1912* concur in the incidence of *tuberculum praecondylare*
- individuals from graves 1742 and 1752 , 1778 and 1809 concur in the incidence of *canalis condylaris*
- individuals from graves 1705 and 1746 concur in the incidence of *fossa bicipitis*

3.2.2 Groups of morphologically similar individuals derived by cluster analysis

There are not many statistical methods that may help separate individuals with the same incidence of non-metric traits. Of the classical statistical procedures, previous research used the modification of Bayes´ calculation of a posterior probability (Alt/Vach 1992; Alt/Vach 1998), cluster analysis (Wiltschke-Schrotta 1988; Coppa et al. 1998), logistic regression (Iregren/Isberg1991) and the modification of the "correlation" coefficient (Heinrich/Teschler-Nicola 1991). We did not take into consideration directly for these goals the procedure proposed by Sjøvold (1976-77) and Ullrich's method (e.g. 1969). We would apply Sjøvold's procedure if we could compare individuals on the basis of the same non-metric traits. This though was not possible due to the state of preservation of the skeletons. The interpretation of the results of analogical works is not unequivocal as a rule, the conclusions are easily disputed hypotheses. The error naturally need not involve the applied statistical method, but also the selection of traits. It also cannot be ruled out that the eventual concurrence represents a random phenomenon. Very often, the average incidences of the compared

traits in the studied population are also not verified. Thus, from the aspect of this issue, series of skeletons with corroborated genealogical data are extremely valuable (e.g. Bouquet-Appel 1984; Sjøvold 1986; Carson 2006).

For the reasons cited in the methodology, we compared only groups of certain individuals according to the incidence of certain traits. We did not compare all the individuals on the basis of all monitored traits. When selecting the traits, we proceeded according to their character and function or according to their localisation. In the first phase, we focused only on the group of individuals with rich grave equipment (Hrubý 1955), and in the next phase on the whole population buried at Kostelisko. We mention the results only of some comparisons.

3.2.2.1 Group of individuals with rich grave equipment (Hrubý 1955)

- comparison according to hyperostotic non-metric traits (*torus palatinus, torus maxillaris, torus mandibularis, trochanter tertius*/N=12)
  similarity is demonstrated by graves No:
  - 1677, 1952
  - 1746, 1752, 1759

3.2.2.2 The Mikulčice-Kostelisko population group

- comparison according to non-metric traits related to sites of muscle attachment (loss of bone tissue) (*fossa pectoralis major, fossa teres, fossa costoclavicularis, fossa hypotrochanterica, fossa solei*/N=24)
  similarity is demonstrated by graves no.:
  - 1679, 1784, 1908, 1980
  - 1680, 1912, 1939, 1963b, 2001
  - 1892, 1945
  - 1918, 1954, 1989,
- comparison according to hyperostotic traits (*torus palatinus, torus occipitalis, torus maxillaris, torus mandibularis, trochanter tertius*/ N=49)
  similarity is demonstrated by graves no.:
  - 1861 and 1938;
  - 1837 and 1918;
  - 1576, 1578, 1598, 1765, 1778,1909
  - 1596, 1728, 1831, 1907, 1913, 2003, 2005
- comparison according to non-metric traits of the pterion region (*os epiptericum, sutura frontotemporalis, processus frontalis ossis temporalis, processus temporalis ossis frontalis, processus parietalis ossis sphenoidalis*/N=59)
  similarity is demonstrated by graves No:
  - 1765, 1835, 1999;
  - 1777a, 1967;
- comparison according to non-metric traits relating to interposed ossicles in the cranial sutures (*ossiculum bregmaticum, ossiculum suturae sagittalis, ossiculum lambdae, ossiculum suturae lambdoidae, ossiculum asterii*/N=28)
  similarity is demonstrated by graves No:
  - 1578, 1637, 1708
  - 1963b, 1985, 1989

Most comparisons turned out to lack any great predicative value – the number of individuals (and traits) compared was usually low. This applied especially to the group of individuals with rich grave inventory. A slightly more ideal situation was when we included all the individuals at the burial site. The dendograms thus acquired do not allow for any general conclusions. The morphological similarity of certain graves suggested by one group of non-metric traits was not confirmed by another group of traits. Individuals who feature in one comparison often could not be compared according to the incidence of other traits. The poor preservation of skeletons turned out to be a greater limiting factor than initially presumed. The selection of another procedure, or resolution of the problem of missing bones, is thus necessary. The results of the comparison using cluster analysis nearly did not concur with the conclusions of the evaluation of relationships between morphological concurrence and burial site topography.

4. Summary and conclusion

Thanks to the aforementioned procedure, we were able to find within a group of rich graves traits that had a different incidence in view of the average population incidence at Kostelisko

and then of setting apart individuals with greater morphological concurrence, i.e. with a greater probability of being biologically related. A more favourable result was obtained when comparing smaller groups of individuals from graves with rich equipment as defined by Hrubý's criteria (Hrubý 1955), and which showed statistically significant differences in the incidence of several traits that may represent ancestral hereditary non-metric traits (*foramen infraorbitale partitum, foramen Vesalii* a *ponticulus atlantis posterior*, eventually *fossa Alleni*). If we presume that more than one family is buried at Kostelisko, it is more realistic to contemplate that the cumulation of common, population rare traits here need not be so great as in the case of a small ancestral burial site. This means that in the case of an "ancestral" trait, we may also expect a low average population incidence due to the amount of individuals (families) at the burial site. Thus, we need not detect such traits when comparing average population frequencies of these traits. From this aspect, the situation at a large burial site is not as "optimal" as in the case of a smaller "ancestral" burial site, where the morphological similarity should be theoretically greater. Although we showed in the group of individuals from graves with rich equipment (Hrubý 1955) statistically significant differences in the incidence of several traits, none of these may be unequivocally considered to be ancestral. The reason for this is also the small number of evaluated individuals for each trait within this group of "rich" individuals.

According to the incidence of selected non-metric traits (possible "ancestral" traits), we then attempted to find groups of individuals who would be expected to be biologically related. Our premise was that the graves of biologically related persons could neighbor on each other, or could be located in the same sector of the burial site. For the same purposes, we also used cluster analysis. The results of both comparisons almost did not concur.

One must take into consideration that with the aid of non-metric morphological traits we may only determine that the probability of biological relatedness between certain individuals is greater or smaller than between other individuals. A more ideal situation is in the case of smaller groups, where kinship is also indicated by the archaeological findings situation. This is why it is suitable also to use other methods for the verification of biological relatedness in the case of anonymous skeletal material. Mainly, attempts should be made to isolate bone deoxyribonucleic acid and subsequently compare specific nucleotide sequences (TRNP).

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