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

Stature of the Great Moravian Population in Connection with Social Status

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Stature is one of the basic anthropometric information relating to man. It reflects very sensitively a number of factors such as e.g. living conditions, sex, age, ethnicity, etc. We were mainly interested in the relationship between stature and living conditions that in each historical period are significantly influenced by social class. We compared the skeletons from the Mikulčice highest social class with skeletons from the area below the castle and from distant areas that represented the background of the first two groups. Subsequently, we compared the Great-Moravian population with recent statures acquired at the end of the 20th century.

Key words: stature – social status – Great-Moravian population – recent population

1. Introduction

Determination of stature in living persons as well as its calculation from skeletal remains has long been enticing thanks to the fact that height very sensitively reflects a number of factors such as sex, age, ethnicity, social standings, etc. Stature aids in assessing the medical condition, body proportions and body dimensions in association with living conditions in the widest sense of the word. Height, together with weight form part of the basic parameters used to estimate population nutritional and health status. Thus stature becomes one of the important signs that enable the characterisation of both individuals as well as whole populations. Determination of stature is one of the most basic anthropometric figures. This also holds for the Great-Moravian populations that are the subject of our research.

Stature is defined as the perpendicular distance between the vertex anthropometric point and the ground (Martin/Saller 1957). The definition is simple, but the interpretation of concrete assessments is not without pitfalls. It is commonly known that stature changes during the day; it is greatest immediately following a night's rest and decreases rapidly. This decrease is chiefly due to the compression of inter-vertebral discs and the soft sections of the heel. During the day, man loses around 2 cm of his height, and this loss is greatest 6-7 hours following the assumption of the permanent or long-lasting position. A two-hour rest period, though, can again increase stature by one centimetre. Other changes in height are associated with age. Approximately from the age of 30, height gradually decreases due to the influence of "wear and tear", ageing of the organism (Ousley 1995). Nonetheless, the daily fluctuation of height may be greater than the loss associated

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with age (Sjøvold 1990). Deliberations regarding measurement and changes in height with daily fluctuation and fluctuation during the life cycle become important when attempting to estimate the stature of a living human being from its skeletal remains, as the validity of the data acquired when creating a reference group may significantly influence precision of the estimate.

The important components of stature diversity in individuals as well as populations include genetic differences, yet living conditions also play an important role. Silventoinen et al. (2003) when comparing eight populations (Australia, Denmark, Finland, Italy, Holland, Norway, Sweden and Great Britain) found the shortest stature to be associated with Italians, i.e. height was associated with a specific population in which certain family affiliations existed. Overall stature is the sum of the length (height) of body segments and the inter-population differences in height may be affected by the various relationships between them (Kozak 1996). The issue of the degree of influence of climate and thermoregulation on physical proportionality has also not been resolved. The results of studies published to-date are rather conflicting (Feldesman/Fountain 1996).

Living conditions have a significant effect on stature, as shown e.g. by Maat (2005). Capitularies from the Maastricht basilica (1070-1521) were 3.4 cm taller than the rest of the population whose life was probably less comfortable than that of the capitularies. Maat also mentions the work of Zeeman (1861) who studied the height of military recruits over a period of 27 years and found that fluctuation of their height copied with some delay the "evolution" of the price of the main foodstuff of that period, rye. Similar results regarding the relationship between stature and economic cycles were also published two years earlier by Woitek (2003) or Cole (2003). Gunnell/Rogers/Dieppe (2001) states that the length of bones and thus stature is also associated with the risk of premature death; the taller the individual, the lower the risk is. It has been shown that for death before the age of 30, extension of bones by a single standard deviation from the average length is associated with a 10-20% decrease in the risk of premature death. Many such examples can be found in literature.

Calculations are also complicated by the secular trend, either positive or negative. To date, the question whether changes in stature are proportional or whether they are more affected by changes in the proportions of body segments, e.g. the length of the femur or tibia has not been resolved.

Regression formulas are usually calculated independently for each specific population and separately for males and females. Differences between reference groups are usually statistically conclusive and thus it is not suitable to apply the calculated formulas for another population than for that for which they were calculated. These differences are given, as mentioned before, by genetic factors, living conditions, age distribution as well as techniques of measurement, methods of statistical processing etc. And if we have skeletal remains of unknown origin, the differences between regression formulas are misleading. Sjøvold (1990) has attempted to avoid this by formulating a method for determining height that is applicable regardless of sex and ethnicity. This is based on the fact that all formulas for calculation of stature include information relating to the height: length ratio of long bones and that this ratio is practically independent of sex and ethnic origin. Despite Sjøvold's precise mathematical reasoning, his method has not as yet come to be widely used in concrete cases for various reasons.

The long bones of the limbs are considered to be the most reliable components of the skeleton for the calculation of height. Kurth (1954) in his work recommends that stature be calculated as the arithmetic average of measurements of the humerus, radius, femur and tibia from both sides of the body. This procedure cannot be applied in many cases, as the given bones have not, simply put, been preserved.

Along with the length of long bones, stature has been determined with the aid of other components or fragments of the skeleton. For example, we can mention the work of Steele (1970) and Steele/McKern (1969) relating to fragments of long bones of lower limbs, Musgrave (1978) relating to the length of metacarpal bones, Mysorekar/Verma/Mandedkar (1980) relating to fragments of the femur and radius, Dobisíková/Urban/Strejc (1988) relating to the length and width of the skull, Holland (1992, 1995) relating to fragments of the tibia, calcaneus and talus Jacobs (1992) relating to fragments of the tibia and femur, Meadows/Jantz (1992) relating to the length of the metacarpal bones, Jason (1995) relating to vertebral segments and others. Similar works though are mainly used in forensic practice; for historical skeletal remains they are used only as auxiliary methods in the identification of concrete persons when long bones have not been preserved. For population studies, they are not useful due to the smaller correlation of dimensions with length. Currently, formulas based on the length of the femur are most widely used as this has a direct effect on stature and is frequently preserved.

Correctness of the calculation of "live" height is also significantly affected by whether the values of the reference group were acquired from measurements of living persons or measurements taken during autopsy. In a dead body, the muscle tone changes and curvature of the spine straightens. Thus the body extends by approximately 2-2.5 cm (Černý 1961). It must be remembered that "body height" is calculated using methods with a reference group represented by living persons, while methods using a reference group consisting of autopsy data provide information regarding "body length". When selecting methods, we must thus respect the means by which the reference group was obtained and conduct eventual corrections.

Attempts at scientific determination of stature from skeletal remains date to the first half of the 19th century. In 1831, M. Orfila drew up the first tables based on the length of the long bones of limbs. Among his successors, we could name Humphry in England in 1858 (Černý 1961), Langer in Austria in 1872 (Černý 1961) and Toldt from 1882 (Černý 1961). More precise results than the works of the aforementioned authors were based on the coefficient of the relationship between the height and length of long bones, calculated by Topinard in 1885. He respected the differences between males and females. The regressive formula for the calculation of stature from the length of the femur was created in 1888 by Beddoe (1888). Though these and other works tried to resolve this problem, they were mostly based on a small amount of material and thus they were greatly imprecise.

The turning point in the development of methods for the reconstruction of stature from skeletal material was represented by the work of Rollet from 1889. Rollet created on the basis of the examination of the skeletons of 50 males and 50 females so-called synoptic tables, according to which stature could be determined. In his work, though, he made the same mistake as his predecessors. He determined the average length of the long bones of persons with the same height. Bertillon (Telkkä 1950) though found in a group of 150 males and females of the same height, that equally tall people need not have lower limbs of the same length. Moreover Rollet conducted measurements on bones without maceration, and thus 2 mm must be added to the measured length of the dry bone. This correction was introduced following the discovery that upon desiccation, the length of bone shortens by this precise extent. Many other authors of further calculations based their work on Rollet's material, Manouvrier (1892, 1893), Pearson and Lee (1897) and Pearson alone (1899). Pearson's and chiefly Manouvrier's tables were still recommended and used by certain researchers in the second half of the 20th century.

The length of bones of Rollet's group was assigned to the length of the dead body measured at autopsy. This fact was later criticised, especially for the specificity of the autopsy material that did not guarantee random selection. It included to a large extent lower social ranks whose height is usually lower than that of social ranks living in comfort. Moreover, the group was drawn up from southern France whose inhabitants are not of great height. Another problem was the relationship between the actual height of the live body and the length of the long bones of the limbs from which the height was calculated. As mentioned previously, after the age of 30, stature decreases due to wear and tear affecting mainly the inter-vertebral discs and joint cartilage and the ratio between stature and bone length changes. This fact, though, was not respected. Nor is the change in muscle tone of the dead body and the straightening of the spine's curvature negligible. Though this was resolved by Manouvrier by subtracting 2 cm from the calculated stature and eliminating persons over the age of 60 from the reference group, methodical deficiencies of his method were still criticised. Dissatisfied with the tables of Rollet and Manouvrier, more and more researchers attempted to calculate stature using their own methods.

In the 1930s, Breitinger (1937) devised anew formula for calculating height, based on measurement of living persons and of the length of long bones determined with the aid of X-rays. This method too, has its pitfalls, as the determination of bone length in this manner cannot be as precise as direct measurement. This imprecision, though, was outweighed by the size of the group that included 2428 German athletes and students as well as by the fact that the true height of living persons was determined as opposed to the length of corpses. This method, unfortunately though, related only to the males section of the population. Formulas for females were not worked out, and the underlying data were burnt during the II[nd] World war (Černý 1961). Formulas for females were completed by Bach (1965) using a group of female students from Jena. Both Bach's and Breitinger's tables included groups of young people in whom height did not decrease with age or this decrease was only minimal. Calculations according to the formulas of these two authors thus illustrate the true stature of adults who have reached the end of their growth period.

For the taller northern populations, Telkkä (1950) drew up his formulas on the basis of Finnish autopsy material. For the Afro-American and Caucasian American populations, Dupertius and Hadden drew up theirs in 1951. The material of the latter was based on the measurement of the "height" of dead bodies, hung on rods inserted into their ears. They assumed that this height would be identical to that of the live body, and they could thus avoid the issue of differences between the height of the body (stature) and the length of the body. In 1959, though, on revising this methodology Valšík pointed out that not only do the differences between live and dead bodies not decrease, but they actually increase, so that the difference is not the usually contemplated 2-2.5 cm, but greater by another 2.57 cm.

In 1952, Trotter and Gleser drew up a regression formula based on the measurement of great quantities of material from skeletons of American soldiers who died during the II[nd] World War. This group already reflects the change in stature during life by subtracting the factor f=0.06 (age in years-30), which was included in the formula. In 1958, these authors reconstructed their formulas for men on the basis of material from skeletons from the Korean War. Trotter's and Gleser's formulas for the calculation of stature are most probably the most widely used worldwide. Nonetheless, especially those formulas drawn up for women have been criticised recently (e.g. Jantz 1992) for their unreliable results.

An interesting selection of bones was incorporated in the formulas of Fully (1956, 1960), who included the height of vertebral bodies as an important component of stature. Acquiring data for Fully´s method is quite difficult, though, as it presumes that the vertebral bodies are intact and this is not too frequent the case in historical material. Moreover, the measurement itself demands great experience.

We could continue in this enumeration of works dealing with stature, including both newer (e.g. Porter 1999, Medonca 2000) as well as older publications (e.g. Lorke/Munzner/Walter 1953-1954; Rother 1978; Olivier et al. 1978; Boldsen 1984), that are more or less known.

In Czech literature, by the end of the 20th century, only Černý and Komenda (1982) worked out a method for determining height from the bones of the Czech population. Their reference group, though, is burdened by the same mistake as that of Rollet. The authors based their data on autopsy material that was gathered mainly at the beginning of the 20th century and consisted chiefly of the population of poor districts of Prague.

This flaw was avoided by the authors (Dobisíková/Velemínský/Zocová 2000; Dobisíková et al. 2000) in their second study relating to the calculation of stature and height using the long bones of limbs in the population of the Czech region and by putting together a group of femur and humerus from both sexes using material from forensic laboratories. In view of the indications of forensic autopsies, these bones may be considered to be a randomly selected sample of the population. The length of the body was measured at autopsy, once the body was placed in a natural position, as the distance to the vertex from the intersection of the tangent of the heel protuberance and the posterior section of the plantar side of the planta pedis. The result of these measurements is not stature but body length.

In 2002, Porter summarised the requirements for a method to determine height/stature as follows:

- The method is described in detail so that it may be used by others
- The reference group is structured according to age, sex and ethnicity
- The size and structure of each subject is measured correctly (either alive or post mortem)
- The method enables one to estimate deviations in the calculation
- Measurement of distances is defined; measurements are conducted on intact bones with closed epiphyses
- A measured side is selected (either one or the average from both)
- Mesurement inaccuracy and the correct choice of statistical measurements are counted.

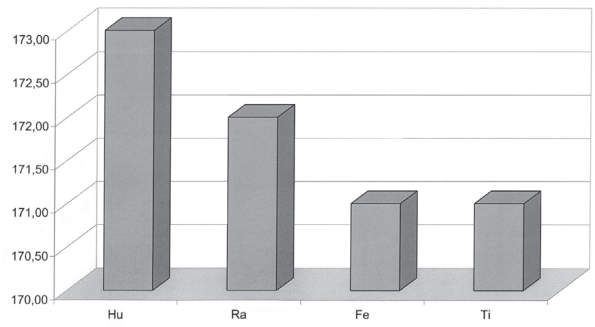
According to the author, these requirements are best met by the methods of Fully (and Fully and Pineau), Breitenger and Bach, Trotter and Gleser and Feldesman (Porter 2002).

From the text above, it is clear what an important role is played by the reference group in the calculation of stature. Such a group may be formed only by a population about which we have sufficient information and basically, without exception, must include a current population. Application of regression formulas drawn up on the basis of recent groups is hampered by the impossibility of verifying the reliability of the calculated data on a historical population. Interpretation of the acquired data may thus be controversial. Thus, e.g. use of Trotter's and Gleser's formulas drawn for use in Palaeolithic skeletons is not met with understanding (Formicola 2003). According to Rösing (1988) various methods of calculation should be applied to various social and economic groups. He recommends Pearson's method (1899) for groups of the lowest economic development, methods of Olivier et al. (1978) for the middle groups and Trotter's and Gleser's method for the group with the best conditions.

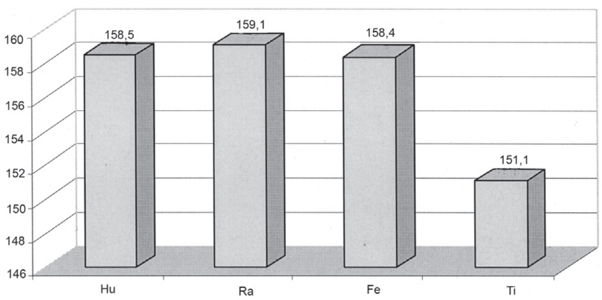
In our opinion, though, the point is not to acquire exact, absolute yet unverifiable figures, but to illustrate the relationships between populations.

2. Materials and methods

We were mainly interested in the relationship between stature and living conditions that in each historical period are significantly influenced by social class. The limiting factor was partly the accessibility and quantity of skeletal remains and partly the abundance of archaeological findings according to which it would be possible to stratify the society. These conditions were met by the Great-Moravian population from Mikulčice and its surroundings. We compared the skeletons from the Mikulčice highest social class concentrated around the IInd church (castle) with skeletons from the sub-castle (Mikulčice IXth church, Mikulčice-Kostelisko) and from distant areas that represented the hinterland of the first two groups (Josefov, Prušánky). Subsequently, we compared the Great-Moravian



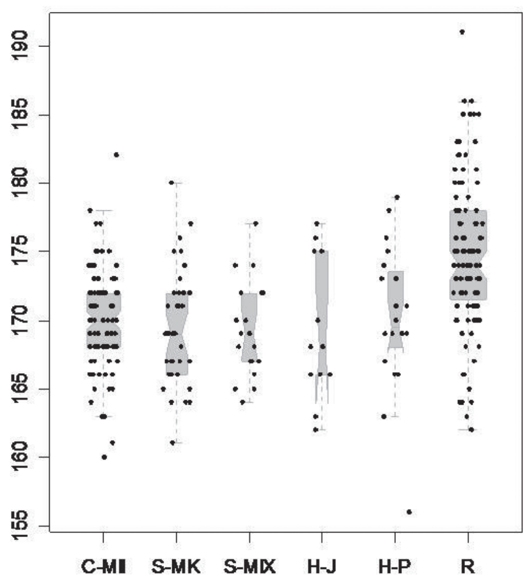
Graph 1. The stature' values of the male from the burial ground Mikulčice-Kostelisko (No. 1821) calculated on the basis different long bones.



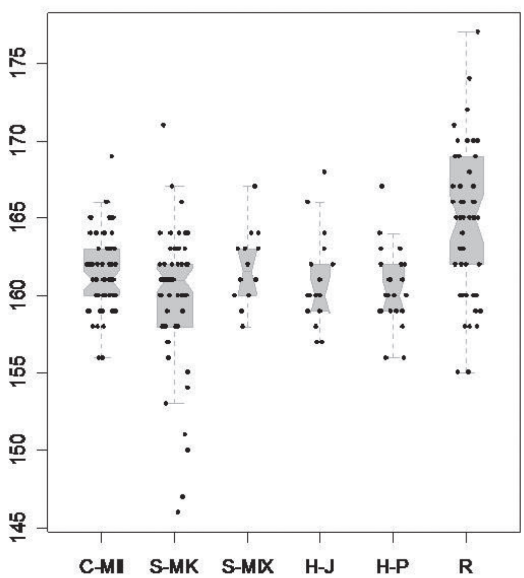
Graph 2. The stature' values of the female from the burial ground Mikulčice-Kostelisko (No. 1899) calculated on the basis different long bones.

population with recent statures acquired at the end of the 20th century (Dobisíková/Velemínský/Zocová 2000; Dobisíková et al. 2000). We used the following abbreviations to designate the individual groups:

In males, stature was calculated using Breitinger's formulas for the femur (Breitiger 1937), while in females, Bach's formula was used (Bach 1965). We chose Breitinger and Bach because since the foundation of the anthropology department at the National Museum, these methods were applied to all groups processed there. At the time, these methods were selected on the basis of testing (Hanáková/Stloukal 1976) and the authors of these tests claimed that Breitinger's and Bach's tables yielded more reliable results then Manouvrier's tables that were used up till then. Although many, e.g. Kurth (1954), Dupertius/Hadden (1951) claim that calculation of stature using a single long bone is less reliable than that using a combination of two or more bones, we kept to the comparison of results using just a single bone. We found this procedure more objective, in view of the various state of bone preservation, despite the fact that Hanáková/Stloukal (1976) claim that the differences in the calculated heights are slightly different using Breitinger's method, while in the case of Bach's method the situation,



Graph 3. Boxplots of stature (in cm), males.



Graph 4. Boxplots of stature (in cm), females.

except for calculations using the tibia that they do not recommend using, is similar.

We chose the femur because its length has the closest correlation with stature (Dobisíková et al. 2000), not only because it is directly involved in stature, but because acquiring its dimensions is easier than measuring other bones whose shapes are more complicated (e.g. the tibia) and they are easily damaged.

For illustration, we include examples of comparisons of stature calculations using various parts of the skeleton for concrete individuals in Graph 1 (males) and Graph 2 (females), with differences for the whole group from Kostelisko in Table 1.

Table 1. Comparison of stature calculations using various long bones of the limbs (S-MK).

	Males	Females
Humerus	171,3	158 ,2
Radius	170,6	159,5
Femur	169,4	160,1
Tibia	170,9	153

3. Results

Statistical evaluation was realised on the base the study Venables/Ripley (2002) and Wilcox (2004), graphical evaluation on the base Murrell (2005). In our study, we tested three basic questions, or more precisely, we verified three zero hypotheses:

Zero hypothesis 1: the stature of the populations from the **castle** (C-M-II), the **sub-castle** (S-M-K, S-M-IX) and the **hinterland** of the Mikulčice agglomeration (H-J, H-P) does not differ from the aspect of sex

Zero hypothesis 2: stature of the **early Middle Age – Great-Moravian population** (Mikulčice, Prušánky, Josefov) does not differ from the stature of the **recent population**

Zero hypothesis 3: there exist no differences in stature between males and females, either in the Middle Ages or today.

The following Table 2 includes the basic characteristics of the individual groups.

The distribution of stature for the individual burial grounds is shown in Graph 3-4. At first glance, it is apparent that the average height of all Great-Moravian groups is well balanced and that they all differ from the recent group. This, though, is not surprising. The Great-Moravian age is situated in a period of a negative secular trend that occurred in Europe approximately from Roman times until approximately the middle of the 19th century. The recent group is situated in a period of a positive secular trend that began in the second half of the 19th century.

Neither here do we see any significant differences. Only in females are the numerical

Table 2a. Basic statistical data of stature according to burial grounds (males).

	C-M-II	S-M-K	S-M-IX	H-J	H-P	Recent
N	89	37	19	12	20	107
minimum	159,530	161,260	164,470	162,330	156,490	162
C minimum	163,000	161,000	164,000	162,000	163,000	162,000
1. quartil(Q)	168,000	166,000	167,000	166,000	168,000	171,500
median	170,000	169,000	169,000	168,000	169,500	174,000
AA	169,876	169,432	169,263	169,333	170,150	174,785
3. quartil(Q)	172,000	172,000	172,000	175,000	173,500	178,000
C maximum	178,000	180,000	177,000	177,000	179,000	186,000
maximum	182,480	180,010	177,220	176,560	178,530	191
SD	3,677	4,180	3,509	5,211	5,294	5,575
LB	169,330	167,442	167,188	163,895	167,557	173,007
UB	170,670	170,559	170,812	172,105	171,443	174,993

Table 2b. Basic statistical data of stature according to burial grounds (females).

	C-M-II	S-M-K	S-M-IX	H-J	H-P	Recent
N	63	61	14	17	23	53
minimum	155,930	146,470	158,230	156,580	155,800	155
C minimum	156,000	153,000	158,000	157,000	156,000	155,000
1.quartil (Q)	160,000	158,000	160,000	159,000	159,000	162,000
median	161,000	161,000	161,500	160,000	160,000	165,000
AA	161,459	160,115	161,786	160,941	160,522	164,943
3.quartil (Q)	163,000	162,000	163,000	162,000	162,000	169,000
C maximum	166,000	167,000	167,000	166,000	164,000	177,000
maximum	168,790	170,960	167,090	167,610	166,560	177
SD	2,507	4,329	2,392	2,989	2,466	4,688
LB	160, 393	160,191	160,233	158,850	159,012	163,481
UB	161,607	161,809	162,767	161,150	160,988	166,519

The statistical analysis used values of the corrected (C) maximum and minimum statures in order to eliminate distant observations (outliers):

N = simple size
AA = arithmetic average
SD = standard deviation
LB = lower limit 95% of interval confidence for the median confidence interval
UB = upper limit 95% of interval confidence for the median confidence interval

C minimum = 1.Q-1,5(3.Q-1.Q)
C maximum = 3.Q+1.5(3.Q-1.Q)

Table 3a. Characteristics of the population groups according to social structure (males). The values used in this table are the same as in the previous one.

	Castle	Subcastle	Hinterland
N	89	56	32
minimum	159,480	161,260	156,490
C minimum	160,000	163,000	161,000
1. quartil	167,000	167,000	168,000
median	169,000	169,000	171,000
AA	169,483	169,839	170,125
3. quartil	172,000	172,500	173,000
C maximum	178,000	180,000	177,000
maximum	182,480	180,010	178,530
SD	3,934	4,455	3,687
LB	168,163	167,839	169,604
UB	169,837	170,161	172,397

Table 3b. Characteristics of the population groups according to social structure (females).

	Castle	Subcastle	Hinterland
N	61	75	40
minimum	155,930	146,470	155,80
C minimum	157,000	155,000	156,00
1. quartil	160,000	159,000	159,500

	Castle	Subcastle	Hinterland
median	161,000	161,000	161,000
AA	161,525	160,080	161,250
3. quartil	163,000	162,000	163,000
C maximum	167,000	164,000	166,000
maximum	168,790	170,960	167,610
SD	2,675	3,972	2,519
LB	160,393	160,453	160,126
UB	161,607	161,547	161,874

Table 4a. Statistical expression of the difference in stature between social classes (males).

	AA diff	LB	UB	TS	SE	p-val	GTS	gp-val
castle-subcastle	0,064	-2,507	2,634	0,058	1,100	0,953		
castle-hinterland	0,812	-1,914	3,538	0,696	1,166	0,509		
subcastle-hinterland	0,748	-0,831	2,328	1,107	0,676	0,280	0,646	0,464

AA diff difference of the arithmetic averages (estimate of the differences of the median values)
LB lower limit 95% of interval confidence for the median confidence interval
UB upper limit 95% of interval confidence for the median confidence interval
TS Yuen-Welch t-statistics for testing the difference of mean values (based on trimmed means and winsorized variances)
SE standard error
GTS global Yuen-Welch t-statistics (TS for 2 and more differences)

Table 4b. Statistical expression of the difference in stature between social classes (females).

	AA diff	LB	UB	TS	SE	p-val	GTS	gp-val
castle-subcastle	-0,881	-2,103	0,342	-1,714	0,514	0,092		
castle-hinterland	-0,606	-1,793	0,582	-1,213	0,499	0,230		
subcastle-hinterland	0,275	-1,004	1,554	0,512	0,538	0,614	1,585	0,210

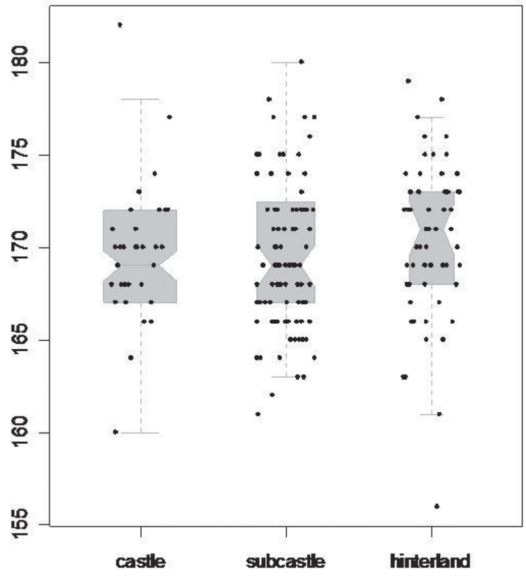
Table 5. Comparison of the Great-Moravian population and recent population on the basis of stature.

		AA diff	LB	UB	TS	SE	p-val
middle age-recent	males	-4,944	-6,256	-3,631	-7,442	0,664	< 0,001
	females	-4,041	-5,555	-2,525	-5,195	0,778	< 0,001

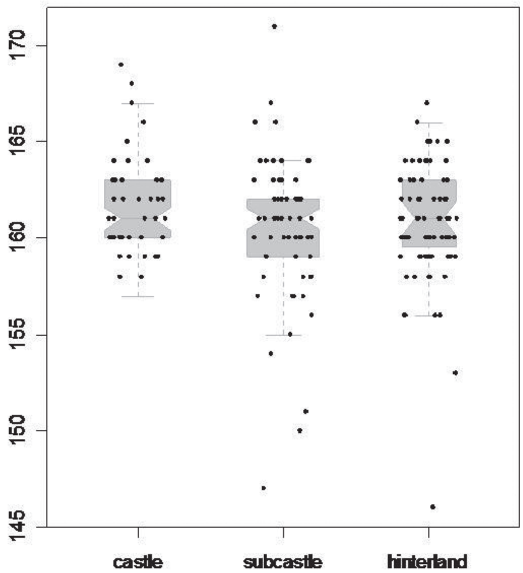
Table 6. Statistical differences in stature between the sexes.

	AAdiff	LB	UB	TS	SE	p-val
middle age(m-f)	8,589	7,827	9,351	22,363	0,384	< 0,001
recent (m-f)	9,493	7,614	11,372	10,015	0,948	< 0,001

AAdiff difference of the arithmetic averages
LB lower limit 95% of interval confidence for the median confidence interval
UB upper limit 95% of interval confidence for the median confidence interval
TS Yuen-Welch t-statistics for testing the difference of mean values (based on trimmed means and winsorized variances)
SE standard error



Graph 5. Boxplots of stature (in cm), males.



Graph 6. Boxplots of stature (in cm), females.

Table 7. Categorisation of the stature range (males, females).

Males		Females
130-149,9	very small	121-139,9
150-159,9	small	140-148,9
160-163,9	below medium	149-152,9
164-166,9	medium	153-155,9
167-169,9	above medium	156-158,9
170-179,9	tall	159-167,9
180-199,9	very tall	168-186,9

values of height smaller than in males, their distribution is narrower and thus the height is more homogenous. The statistical expression of the relationship between social class and stature is shown in Table 4. The graphical depiction of the comparison of stature between the highest social rank, the area below the castle and the background is illustrated in Graph 5-6.

If we compare the Great-Moravian population, where there is no significant difference either between the various locations or between the social groups, with the recent population, we get at the level of $\alpha = 0.01$ very significant differences, in both sexes. This is shown in Table 5 and Graph 7-8.

Another studied parameter was the comparison of the height of males and females. As no differences were found between the Great-Moravian groups, we include an overall comparison of males and females from the Great-Moravian period with the recent population in Table 6 and Graph 9-10.

The statistically significant difference between the height of males and females is at the level of $\alpha=0.01$ both in the Middle Ages and in the recent population.

To compare the distribution of height in the individual groups, we used the method of height categorisation devised by Martin and Saller (1957). We include this traditional distribution despite the fact that we currently have different ideas about "tall" stature thanks to the positive secular trend. This classification has long been used and it can thus be applied when comparing older groups, where no valid statistical parameters are mentioned.

In males and females of all groups, the category of tall stature is represented most frequently. The differences in the representation of the other categories are not great, with the exception of the recent population where very tall stature is significantly represented.

When looking at the table showing the representation of individual stature categories in three different social classes, the previously stated more homogenous height in females is clear. We can say that the majority of females of the studied Great-Moravian population were tall. Most of the tall females were found among the highest social class. The fewest number of tall females was among the group from below the castle. In males, this trend is practically similar, although it is less pronounced given the wider range of stature. The possible explanation is that the inhabitants of the background, mainly agriculturists who include a larger proportion of tall statures compared to the craftsmen from below the castle, may have had easier access to food that they cultivated and thus had less problems with nutrition.

Table 8a. Representation of the stature categories in the individual groups according to burial grounds (males).

	C-M-II		S-M-K		S-M-IX		H-J		H-P		Recent	
	n	%	n	%	n	%	n	%	n	%	n	%
very small	-	-	-	-	-	-	-	-	-	-	-	-
small	-	-	-	-	-	-	-	-	1	5,0	-	-
below medium	4	4,5	1	2,7	0	0	2	16,7	1	5,0	2	1,9
medium	11	12,4	9	24,3	4	21,1	3	25,0	2	10,0	6	5,6
above medium	25	28,1	11	29,7	7	36,8	2	16,7	6	30,0	6	5,6
tall	48	53,9	15	40,5	8	42,1	5	41,7	10	50,0	71	66,4
very tall	1	1,1	1	2,7	-	-	-	-	-	-	22	20,6

Table 8b. Representation of the stature categories in the individual groups according to burial grounds (females).

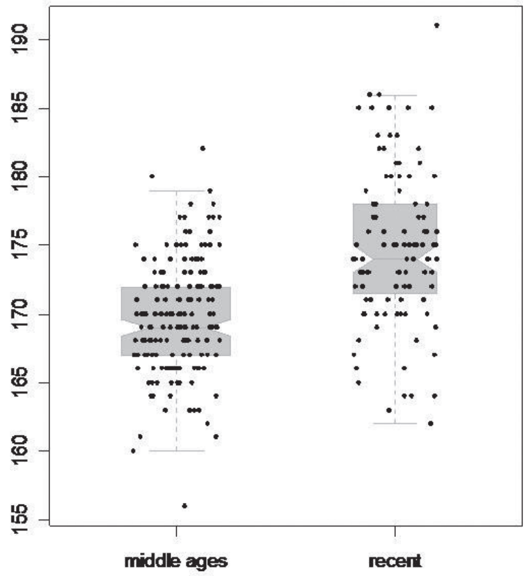
	C-M-II		S-M-K		S-M-IX		H-J		H-P		Recent	
	n	%	n	%	n	%	n	%	N	%	n	%
very small	-	-	-	-	-	-	-	-	-	-	-	-
small	-	-	2	3,3	-	-	-	-	-	-	-	-
below medium	-	-	2	3,3	-	-	-	-	-	-	-	-
medium	-	-	3	4,9	-	-	-	-	-	-	2	3,8
above medium	5	8,2	9	14,8	1	7,1	3	17,6	3	13,0	3	5,7
tall	55	90,2	44	72,1	13	92,9	13	76,5	20	87,0	33	62,3
very tall	1	1,6	1	1,6	-	-	1	5,9	-	-	15	28,3

Table 9a. Representation of the stature categories according to social class (males).

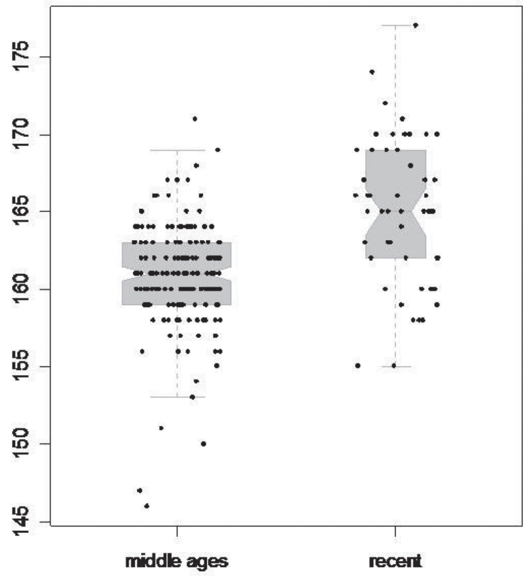
	Castle		Subcastle		Hinterland	
	n	%	n	%	n	%
very small	-	-	-	-	-	-
small	-	-	-	-	1	3,1
below medium	4	4,5	1	1,8	3	9,4
medium	11	12,4	13	23,2	5	15,6
above medium	25	28,1	18	32,1	8	25,0
tall	48	53,9	23	41,1	15	46,9
very tall	1	1,1	1	1,8	-	-

Table 9b. Representation of the stature categories according to social class (females).

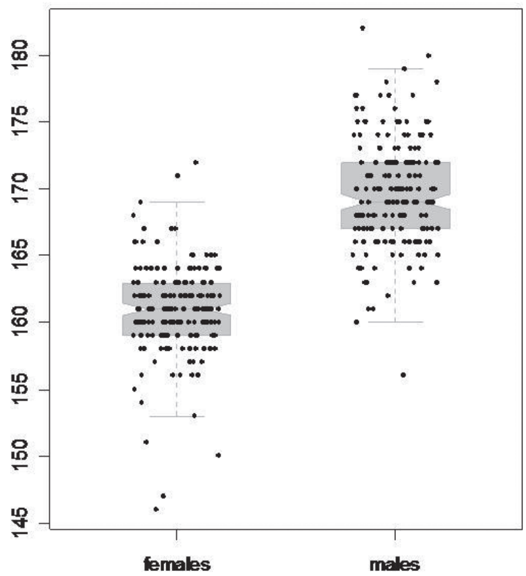
	Castle		Subcastle		Hinterland	
	n	%	n	%	n	%
very small	-	-	-	-	-	-
small	-	-	2	2,7	-	-
below medium	-	-	2	2,7	-	-
medium	-	-	3	4,0	-	-
above medium	5	8,2	10	13,3	6	15,0
tall	55	90,2	57	76,0	33	82,5
very tall	1	1,6	1	1,3	1	2,5



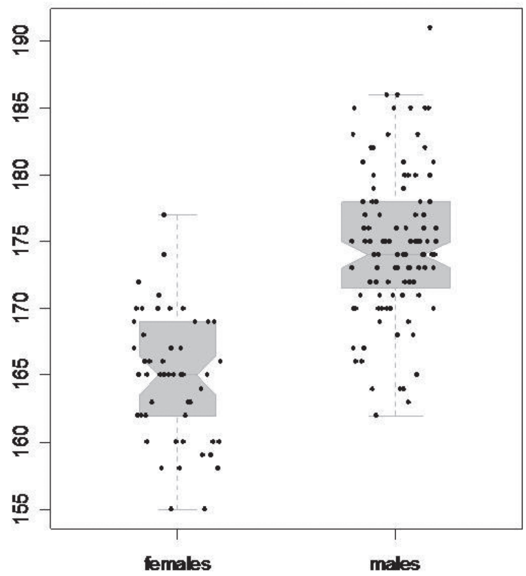
Graph 7. Boxplots of stature (in cm), males.



Graph 8. Boxplots of stature (in cm), females.



Graph 9. Boxplots of stature (in cm), Middle Age.



Graph 10. Boxplots of stature (in cm), recent.

Table 10a. Representation of height (stature) categories in the Great-Moravian and recent populations (males).

	Middle age		Recent	
	n	%	n	%
very small	-	-	-	-
small	1	0,6	-	-
below medium	8	4,5	2	1,9
medium	29	16,4	6	5,6
above medium	51	28,8	6	5,6
tall	86	48,6	71	66,4
very tall	2	1,1	22	20,6

Table 10b. Representation of stature categories in the Great-Moravian and recent populations (females).

	Middle age		Recent	
	n	%	n	%
very small	-	-	-	-
small	2	1,1	-	-
below medium	2	1,1	-	-
medium	3	1,7	2	3,8
above medium	21	11,9	3	5,7
tall	145	82,4	33	62,3
very tall	3	1,7	15	28,3

When comparing the Great-Moravian and recent populations, it may be said that tall stature dominate in both populations. The difference is in the representation of adjacent "height" categories. While in the Great-Moravian population we find greater representation on the left from the category of tall statures, i.e. in the above-average category; in the recent population there is a greater representation on the right, in the category of very tall individuals.

4. Conclusion

These results show that the studied Great-Moravian population was, according to the classical categorisation of Martin and Saller (1957) a population of tall and above-average stature, which is especially apparent in females. As mentioned before, this is a classification created using a population from the first half of the 20th century. Today, we have different ideas about "tall" stature thanks to the positive secular trend. The average stature of males in Great Moravia was approximately 170 cm, while females were approximately 161 cm tall. It must be stressed that these are average values, i.e. it does not mean that the population did not include individuals taller than 180 cm or on the other hand shorter than 160 cm. The minimum for males from the whole group from Great Moravia was 156.5 cm (H-P), the maximum 182.5 cm (C-M-II). For females, the minimum was 146.5 cm (S-M-K) and the maximum 171 cm (S-M-K). No statistically significant difference in stature was found among the various social classes, either in males or females. The fact that can be traced is that in the highest social classes, there was a trend towards greater percentage representation of individuals in the category "tall stature", especially among the female population. When comparing all three social classes, the population from below the castle included the least number of tall individuals, and this applied to both genders. This fact was again more marked in females than in males.

Compared to the recent population, the Great-Moravian population was statistically significantly shorter, and this applied to both genders.

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