ANTHROPOLOGIE • XXXIX/2–3 • pp. 133–152 • 2001

VÁCLAV VANČATA, MARTINA CHARVÁTOVÁ

POST-PALAEOLITHIC *HOMO SAPIENS* EVOLUTION IN CENTRAL EUROPE: CHANGES IN BODY SIZE AND PROPORTIONS IN THE NEOLITHIC AND EARLY BRONZE AGE

ABSTRACT: There has been a number of human remains studies of the Upper Palaeolithic to Neolithic transition in recent decades, associated with the transition to food producing and increased sedentism. However, human biological change did not cease with the advent of village agriculture and pastoralism, but it may well have continued through the Neolithic, the epi-Neolithic and into the early Bronze Age. In order to assess these potential human microevolutionary trends, we have studied the femora, tibiae, humeri and radii of three Neolithic samples with early agriculture and mixed pastoral / early agriculture types of economy (Jena, Germany – Linear Band Pottery Culture – 32 individuals, Zlota, Poland – Corded Ware Culture – 62 individuals, Praha, Czech Republic – Bell Beaker Culture – 15 individuals) and Únětice early Bronze Age Culture, Bajč, Slovak Republic (28 individuals). The data on Lengyel Culture and three Bronze Age Cultures from the Carpathian Basin published by Éry (1998) have also been included into our study. We have analysed the bones lengths and various measurements of lower and upper limb long bones, enabling to perform a detailed analysis of the lower and upper limb long bones robusticity. The Early Bronze Age population from Bajč is similar to other Bronze Age groups with the exception that the tibia is significantly longer in the Bajč sample. One of the important questions is which changes, if any, in body build and proportions emerged after the Neolithic to Bronze Age transition. Early Bronze Age population males are relatively tall and robust, while the females are significantly smaller than the males but still are relatively tall and robust in comparison to the females of the Linear Band Pottery Culture and Lengyel Culture. We have found marked similarities among Únětice early Bronze Age Culture, Bell Beaker Culture and Corded Ware Culture populations with the exception of Corded Ware Culture females that are somewhat more gracile. All the three populations differ significantly from both Linear Band Pottery Culture and Lengyel Culture population, where the males are relatively short and very robust and the females are very small and gracile. The most probable explanation of those differences is a different way of life among early agricultural and mixed pastorals / early agriculturist populations. They probably differed in their use of natural resources, environmental zones and reproductive strategies. It is worth noting that the Únětice early Bronze Age Culture, Bell Beaker Culture and Corded Ware Culture populations are also similar to Mesolithic humans in many features of body build, proportions and bone morphology. Consequently it may be supposed that microevolutionary trends, ecology and the adaptive strategy of non-agricultural populations were rather conservative from the Mesolithic until the early Bronze Age.

KEY WORDS: Body size – Proportions – Homo sapiens *– Únětice Culture – Neolithic – Bronze Age – Microevolution*

INTRODUCTION

The number of studies concerning the Upper Palaeolithic to Neolithic transition important for the study of human microevolution has increased during the past decades (Ammermann, Cavalli-Sforza 1994, Anthony 1994, Formicolla, Franceschi 1996, Formicolla, Giannecchini 1999, Gamble 1995, Piontek, Marciniak 1990 a, b, Piontek, Vančata 1999, Frayer 1980, 1981, 1984, Frayer, Wolpoff 1985, Jacobs 1985 a, b, 1992, 1993, Piontek 1993, 1999, 2001, Piontek, Vančata 1999, Vančata 1988, 1997, etc.). Recent comparative studies have shown that this process was quite complicated (Gamble 1995) and that the understanding of population and microevolutionary variability of Palaeolithic and post-Palaeolithic populations is necessary. The evolution of human populations in the early post-Palaeolithic period was regionally and chronologically variable and very probably strongly depended also on the economy and culture of a given ethnic group and population (Ammermann, Cavalli-Sforza 1994, Barbujani *et al.* 1994, Barbujani, Bertolli 2001, Bogucki 1982, 1988, 1999, Buchvaldek 1985, Jankowska *et al.* 1999, Marciniak 1992, Meiklejohn *et al.* 1984, Kruk, Milisauskas 1999, Milisauskas, Kruk 1989, Piontek, Martiniak 1990 a, b, 1992, Pečírky *et al.* 1989, Pleiner *et al.* 1978, Podborský 1993, Tabaczynski 1970).

However, human biological change did not cease with the advent of village agriculture and pastoralism, but may well have continued through the Neolithic, the epi-Neolithic and into the early Bronze Age period (see Bogucki 1999). To learn more about the major trends and ecological and microevolutionary changes during this early post-Palaeolithic period, it is necessary to assess changes through the Neolithic, epi-Neolithic and early Bronze Age periods. This includes reconstruction of the body size, body shape and body proportions of Palaeolithic and post-Palaeolithic populations, which related to their ecology and basic features of their adaptive strategies.

Unfortunately, anthropological studies of late Neolithic and namely early Bronze Age populations in Central Europe are not very common, and they concentrate mainly on cranial morphology, address specific features of life in this period, or deal with relatively short time periods (e.g. Dočkalová *et al.* 1988, Hanáková, Stloukal 1973, Charvátová 1999, Chochol 1964, Pavelková 1988, Strouhal 1967).

Usually the beginning of the Bronze Age period is connected with an advance in technology, and it is taken to be distinct from the stone age periods (Buchvaldek 1985, Meiklejohn *et al.* 1984, Kruk, Milisauskas 1999, Milisauskas, Kruk 1989, Piontek, Marciniak 1990 a, b, 1992, Pečírky *et al.* 1989, Pleiner *et al.* 1978, Podborský 1993). Therefore, one of the important questions is which changes in body build and proportions, if any, had appeared after the Neolithic – Bronze Age transition.

Two basic adaptive strategies in the Neolithic populations have been described by various authors (Bogucki 1982, 1988, Jankowska *et al.* 1999, Marciniak 1992, Piontek 1993, 1999, 2001, Piontek, Marciniak 1990 a, b, 1992, Piontek, Vančata 1999, in prep., Vančata 1997) reflecting a different ecology, economy, lifestyle and basic cultural features of the two groups.

The first one is an early agriculturalist strategy typified by a relatively small territory on rich agricultural land in lowland regions (Bogucki 1982, 1988, 1999, Grigiel, Bogucki 1997, Kruk, Milisauskas 1999, Milisauskas, Kruk 1989, Marciniak 1992) and a sedentary way of life. The second one is a pastoralist / horticulturalist strategy with a larger territory and a more nomadic way of life in more highland territories (Bogucki 1982, 1988, 1999, Kruk, Milisauskas 1999, Milisauskas, Kruk 1989, Marciniak 1992).

We suppose that there were significant body size and shape differences among the groups with different adaptive strategies. We presume a marked shift from K-strategy to r-strategy sensu Pianka (1995, see Piontek 1999, 2001 for the details) in early agriculturalist populations that resulted in accelerated reproduction rate, higher fertility, shorter weaning period, accelerated puberty and changes in body size, proportions and sexual dimorphism in those populations (Piontek 1989, 1993, 1999, Piontek, Vančata 1999, in prep., Vančata 1997). In this sense (Piontek 1999, Piontek, Vančata 1999, Vančata 1997) we have suggested that early agricultural populations should have lower stature with shorter limbs, namely short tibia and radius, and longer trunks with higher fertility rate, while pastoralist / horticulturalist populations in early post-Palaeolithic age, i.e. Neolithic populations and perhaps also Bronze Age ones, should have higher stature with longer limbs, namely tibia and radius. Early agriculturalist males are supposed to be smaller but relatively more robust in comparison to the pastoralist ones.

To learn more about the relations of early Bronze Age and Neolithic prehistoric populations it is necessary to characterise their body size and body shape to establish their basic biological characteristics with respect to their ecology, social structure and adaptive strategy in general (see Piontek 1989, 1993, 1999, 2001, Piontek, Vančata 1999).

Therefore, one of the important goals of this study is to investigate variability of body size and proportions of a representative Early Bronze Age population and several late Neolithic populations. These are then compared with typical Neolithic agricultural populations. Fortunately, there are several well-represented skeletal samples like Bajč – early Bronze Age Únětice Culture, Zlota – Corded Ware Culture and Mittel-Elbe-Saale Gebiet collection of Linear Band Pottery Culture that provide relatively large, chronologically well determined and probably genetically homogeneous samples (see Material for the details).

Early Bronze Age Únětice Culture is represented by a relatively large homogeneous population from Bajč. Due to the homogeneity, this post-Palaeolithic sample is a very good object for the testing of degree of biological changes of the Neolithic – Bronze Age transition (Charvátová 1999). However, this sample has also its problems. The skeletons are very fragmentary and, for example, there is no complete upper limb skeleton of male sex.

Furthermore, we have used data on Neolithic Lengyel Culture and three Bronze Age cultures from the Carpathian basin published by Éry (1998) to expand the data set for the comparative analysis of Neolithic and Bronze Age ancient populations.

Consequently, the most important tasks for the analysis of basic body shape and ecological features of the examined Únětice Culture skeletons is to study not only the individual skeletal samples and their variability, but also the relations of the body size and shape and bone proportions of the Early Bronze Age skeletal sample from Bajč to the Neolithic and other Bronze Age samples. From this analysis microevolutionary trends in body size and proportions in the post-Palaeolithic period can be assessed.

MATERIAL

We have studied the femora, tibiae, humeri and radii (*Table 1*) of three Neolithic and one Early Bronze Age populations with early agricultural and pastoralist / horticulturalist types of economy: Jena, Germany (Bach 1978, Bach and Bach 1981, Behrens 1973, Vančata 1988, 1989, 1993, 1997) – Linear Band Pottery Culture – 32 individuals, Zlota, Poland (Krenz-Niedbala 2000, Krzak 1976, 1989, Vančata 1988, 1993, 1997) – Corded Ware Culture – 62 individuals, Praha, Czech Republic – Bell Beaker Culture – 15 individuals, Vančata 1997, partially unpublished data for Bell Beaker Culture) and Bajč, Slovak Republic (Hanáková, Stloukal 1973) – Únětice early Bronze Age Culture (28 individuals, Charvátová 1999). Only the lower limb bones were examined for the Linear Band Pottery Culture and Corded Ware Culture samples. Consequently, the available upper limb measurements were taken from literature (Jena – Bach and Bach 1981, Zlota – Krenz-Niedbala 2000).

The individual lengths of long bones for Neolithic Lengyel Culture (see Bogucki 1982, 1988, Grygiel, Bogucki 1997, Kruk, Milisauskas 1999 for the descripion of Central European Lengyel Culture) and three Bronze Age cultures from Hungary, Vatya (25 individuals), Maros – Perjámos (133 individuals without tibias), Tumulus (282 individuals) (see *Table 1* for the details) were taken from the database published by Éry (1998) to have comprehensive comparative samples for the Neolithic and Bronze Age periods.

Comparative material from the Mesolithic period was partially taken from Holliday (1995) and partially from Vančata's studies (1988, 1997, unpublished data).

METHODS

The selection of material and data has been made according to the ongoing program focussed on the reconstruction of

TABLE 1. Central European Neolithic and early Bronze Age populations included in the study.

Population, *Period* Country	**Culture**	**No.**	**Males**	**Females**	**Studied bones**	**References**
Jena *Neolithic* Germany	Linear Band Pottery Culture	32	13	19	femur, tibia *humerus, radius*	Vančata 1988, 1989, 1993, 1997 Bach and Bach 1981
Zlota *Neolithic* Poland	Corded Ware Culture	62	33	29	femur, tibia *humerus, radius*	Vančata 1988, 1989, 1993, 1997, Krenz-Niedbala 2000
Praha *Neolithic* Czech Republic	Bell Beaker Culture	16	10	6	Femur, tibia, humerus, radius	Vančata 1997, unpublished data
Bajč *Early Bronze Age* Slovak Republic	Únětice Culture	28	16	12	Femur, tibia, humerus, radius	Charvátová 1999
Carpathian Basin *Neolithic* Hungary	Lengyel Culture (LC)	84	37	47	Femur, tibia, humerus, radius, *Lengths only*	Database by Éry, 1998
Carpathian Basin *Bronze Age* Hungary	Vatya Culture	25	11	14	Femur, tibia, humerus, radius, *Lengths only*	Database by Éry, 1998
Carpathian Basin *Bronze Age* Hungary	Maros – Perjámos Culture	133	65	68	Femur, humerus, radius, *Lengths only*	Database by Éry, 1998
Carpathian Basin *Bronze Age* Hungary	Tumulus Culture	282	181	101	Femur, tibia, humerus, radius, *Lengths only*	Database by Éry, 1998

body size and body shape of fossil *Homo sapiens* (Vančata 1996, 1997, Charvátová 1999). We have studied the lengths of the bones and various measurements of lower and upper limb long bones enabling to conduct a detailed analysis of robusticity and biomechanical structure of the lower and upper limb long bones.

Together with the body size parameters (Vančata 1996, 1997), the lengths of bones, selected metrical traits (46 in an optimal case) and 27 indexes on the femur, tibia, humerus and radius were examined (see Vančata 1981, 1988, 1991, 1997, Knussmann 1988, Holliday 1995 for the definitions of measurements).

One of the main goals of the study is a reconstruction of body height, body mass and other body shape parameters of the Neolithic and Bronze Age populations. Accordingly, several important problems should be explained. Body height and body mass are reconstructed as integral parameters representing a basic pattern of the long bones growth on the one hand and basic physiological and biomechanical properties of the organism and its parts on the other hand. Stature cannot be fully represented by the long bones, because there are different long bone proportions between different human populations (e.g. Formicolla 1993, Formicolla, Giannecchini 1999, Piontek 1999, Ruff *et al.* 1997, Vančata 1988, 1991, 1993, 1997). Similarly there are specific allometric differences in proportions of individual epiphyses of long bones (McHenry 1992, Vančata 1988, 1991, 1993, 1997).

Body height and body mass were computed for each examined individual by various regression methods (e.g. Feldesman *et al.* 1990, Sjøvold 1990, McHenry 1992, Ruff and Walker 1993). Our approach has, however, several specific methodological features based on the statement that there is no ideal formula for computing body height and body mass and the preciseness of estimates cannot be consistently checked in prehistoric hominid samples (cf. also Vančata 1996, 1997): 1) The body height and body mass reconstruction use a stochastic approach and body height, i.e. more than one formula is used for the estimate of body height or body mass; 2) Body height and body mass should be computed for any examined skeleton together with their relation that is best expressed by skeletal ponderal indexes (Rohrer's index and Body mass index have been used); 3) All body size parameters should be examined also in relations to limb proportions.

As follows from the above mentioned principles and unlike other studies (see Formicolla 1983, 1993, Formicolla, Franceschi 1996, Formicolla, Giannecchini 1999, Sjøvold 1990 for reviews) we have computed the body parameters as mean values of several of the most reliable equations and they were computed by the same methods for each individual. There are the following main reasons why we do not prefer selection of one optimal equation for the estimates of stature and body mass: 1) The incompatibility of basic statistical parameters of a sample (mean, standard deviation, skewness, kurtosis and distribution of data) that served as a basis for computing the equations with those of an examined fossil population; 2) Different biological character of the data – recent skeletons used for the computing of equations are mainly randomly chosen and basically complete, while fossil skeletons are of unknown origin, frequently non-randomly selected (depending of the character of a fossil site or cemetery), and fragmentary; 3) Different proportions of the long bones should be taken into account (see e.g. Sjøvold 1990 for the discussion) that can be very distinct in phylogenetically different groups or in groups with different adaptive strategies; 4) Sufficiently robust methods for the estimates must be selected because there is a very limited feedback checking of the estimates of body size parameters in fossil human populations (see Formicolla, Franceschi 1996, Formicolla, Giannecchini 1999, Sjøvold 1990 for the discussion of stature estimates).

This approach can be in some cases not optimally precise for the body height and body mass estimates of an individual, but it should be free of unpredictable errors and it should also eliminate the presence of systematic biases in the estimates of body size for the individual; therefore, it is much more appropriate for the description of population body size variability. However, we are not able to state with sufficient certainty which method is the best for an individual, also, different methods are relatively precise for some populations only (see e.g. Feldesman *et al.* 1989, 1990, Feldesman and Fountain 1996, Formicolla 1983, 1993, Formicolla, Franceschi 1996, Formicolla, Giannecchini 1999, Scieulli, Giesen 1993, Sjøvold 1990, Vančata 1996, 1997 for the discussion) and we have really no exact guideline for fossil human populations. Furthermore, the data computed by our method are fully statistically comparable because they all originated using an identical method and, consequently, such data are statistically very appropriate for any kind of comparative or evolutionary study.

We have estimated body height and body mass of each individual by various regression equations, published by other authors (see *Tables 2, 3*). Body height has been computed by MA and RMA formulas published by Feldesman and colleagues (Feldesman *et al.* 1989, 1990, Feldesman, Fountain 1996), Jungers (1988), Olivier (1976) and Sjøvold (1990). We computed mean values from six equations based on femoral length and two formulae for humeral length. Humeral formulae are less precise (see Sjøvold 1990), but they decrease the influence of random errors connected with unexpected values of femoral length in any individual.

For the body mass estimate we use 22 formulae computed from the femoral head, the subtrochanteric product, the distal femoral product, and the proximal tibial and distal tibial products (McHenry 1988, 1991, 1992). Four formulae based on correlation of body height and body mass (Jungers, Stern 1983, Ruff, Walker 1993, Wolpoff 1983) are also included to decrease the influence of random errors. Body mass is then computed as an average value of the equations.

Ponderal indexes have been computed from the estimated body height and body mass. They can be taken as integral parameters expressing relations of body linearity and body volume and body mass as well as general body shape (cf. Vančata 1996, 1997, 2000 for the discussion). For this study, skeletal Body mass index and skeletal Rohrer's index were computed (s-BMI = body mass [g] / height [cm]^2, s-Rohrer = body mass [g] /height [cm]^3) for all studied specimens. In our opinion, the s-Rohrer's index is more suitable for the estimate of body robusticity, because it is less sensitive to random fluctuations of body mass estimates.

The methods for the estimating of body shape parameters have been published in detail elsewhere (Vančata 2000).

RESULTS

Early Bronze Age Culture males are relatively tall and robust, but smaller than average males from recent Central Europe. Females from Bajč are significantly smaller than the males (*Table 4, Figure 1*). The analysis of metrical traits shows that there is a marked sexual dimorphism in the Bajč sample (*Tables 4, 6, 10, Figures 1–7*). Both males and females are relatively tall but not very robust for the sample from the early post-Palaeolithic (*Figures 1, 2, 7*). Morphological analysis shows a marked relief of the muscle insertions in both males and females, which suggest habitual powerful muscular work (Charvátová 1999).

Both the male and female skeletons from Bajč Únětice Culture site have longer lower limbs with significantly

TABLE 2. Selected equations for estimates of body height in fossil *Homo sapiens*.

Reference	Parameter	Equations
Feldesman *et al*. 1989, 1990	Length of femur	BH = 3.745*Femur
Feldesman, Fountain 1996	Length of femur	BH = 3.01939*Femur + 31.26332
Sjøvold 1990	Length of femur	BH = 3.10*Fem2 + 28.82
	Length of humerus	BH = 4.74*Hum2 + 15.26
	Length of femur	BH = 3.01*Fem2 + 32.52
	Length of humerus	BH = 4.62*Hum2 + 19.00
Olivier 1976	Length of femur	BH = 3.420*Fem2 + 17.1
Jungers 1988 b	Length of femur	BH = 3.8807*Fem – 51.0

TABLE 3. Selected equations for estimates of body mass in fossil *Homo sapiens.*

Reference	Parameter	Equations
Ruff and Walker 1993	Stature	BM = 0.689*Stat – 53.1
Jungers and Stern 1983	Stature	BM = 0.00013*Stat^2.554
Wolpoff 1983	Stature	BM = 0.00011*Stat^2.592
	Stature	BM = 0.00062*Stat^2.241
McHenry 1988	subtrochanteric product	logBM = 0.624*log*Subtroch – 0.0562
McHenry 1991	femoral head	logBM = 1.7125*logHead – 1.048
	subtrochanteric product	logBM = 0.7316*logSubtroch – 0.4527
	distal femoral product	logBM = 0.960*logDistFem – 1.5678
	proximal tibial product	logBM = 1.0583*logProxTib – 1.9537
	distal tibial product	logBM = 0.9005*logSubtroch – 0.8790
McHenry 1992	femoral head	logBM = 1.7125*logHead – 1.0480
		logBM = 1.7754*logHead – 1.1481
		logBM = 1.7538*logHead – 1.1137
	subtrochanteric product	logBM = 0.7927*logSubtroch – 0.5233
		logBM = 0.8069*logSubtroch – 0.5628
		logBM = 0.8107*logSubtroch – 0.5&33
	distal femoral product	logBM = 0.9600*logDistFem – 1.5678
		logBM = 0.9919*logDistFem – 1.6754
		logBM = 0.9921*logDistFem – 1.6762
	proximal tibial product	logBM = 1.0583*logProxTib – 1.9537
		logBM = 1.0689*logProxTib – 1.9903
		logBM = 1.0683*logProxTib – 1.9880
	distal tibial product	logBM = 0.9005*logDistTib – 0.8790
		logBM = 0.9227*logDistTib – 0.9418
		logBM = 0.9246*logDistTib – 0.9473

longer tibiae and higher body heights in comparison with the other three Bronze Age samples (*Tables 5, 6*). However, with the exception of the shorter tibia, the body sizes and shapes of all the Bronze Age samples are not very different.

Early Bronze Age females are relatively tall and robust in comparison with females of the Linear Band Pottery Culture (*Figures 1, 2, 5, 6, 7, Tables 4, 7, 10*). There are many significant differences between the Únětice early Bronze Age population and Linear Band Pottery Culture populations in both males and females. Linear Band Pottery Culture males are significantly smaller and more robust than Early Bronze Age males, and the females are also significantly smaller than those from the early Bronze Age. However, they are significantly more gracile than the Early Bronze Age females. The comparison of lengths of long bones and stature of the Bajč sample with the same parameters of another early agriculturalist Neolithic population, the Lengyel Culture skeletal collection from the Carpathian basin, gives very similar results to the previous analysis (*Table 10*).

Summarising the results of the comparisons, significant differences in body size and character of sexual dimorphism have been found between the Únětice Culture population and those of Linear Band Pottery Culture and Lengyel Culture. The character of differences in the body size and sexual dimorphism suggests differences in the ways of life of the two post-Palaeolithic groups.

We have found numerous marked similarities in body size and proportionality among Únětice early Bronze Age culture, Bell Beaker Culture and Corded Ware Culture populations in both males and females (*Figures 1–7, Tables 4, 8, 9, 10*). Males from the early Bronze Age sample from Bajč and males from the two Neolithic populations are almost identical in most of the examined body parameters. They were relatively tall and not very robust. Also females of the three populations are very similar with some exceptions among the Corded Ware Culture females that are relatively more gracile.

Following a detailed analysis of the postcranial skeleton metrical traits, it may be concluded that the Únětice early Bronze Age Culture males and those of Neolithic Bell Beaker Culture are almost identical in body height, body mass, body robusticity and in a similar degree of sexual dimorphism in their populations, as well as in the character of the postcranial skeleton in general (*Figures 1–7, Tables 4, 9, 10*).

The Únětice early Bronze Age Culture, Bell Beaker Culture and Corded Ware Culture populations differ significantly from the Linear Band Pottery Culture and Lengyel Culture populations, where the males are relatively short and very robust and females are very small and gracile. The differences have been found in body height, body mass, body robusticity and in the pattern of sexual dimorphism (*Figures 2–7, Tables 4–10*). The three above mentioned populations differ from the Linear Band Pottery Culture and Lengyel Culture ones in both limb proportions and bone robusticity (*Figures 3–6, Tables 4–10*).

TABLE 4. Bajč Únětice Culture – basic data for long bones and body size and shape for males and females and T-test of sexual differences (AP subtroch. diam. – antero-posterior subtrochanteric diameter, ML subtroch. diam. – medio-lateral subtrochanteric diameter, AP misdhaft diam. – antero-posterior midshaft diameter, ML misdhaft diam. – medio-lateral midshaft diameter, biom. – biomechanical, biom. neck – biomechanical neck length, *P = 0,0000 is really P < 0,0001*).

	Mean ***Males***	**Mean** ***Females***	**t-value**	**p**	**Valid N** ***Males***	**Valid N** ***Females***	**Std. Dev.** ***Males***	**Std. Dev.** ***Females***
Head breadth	48.2	41.3	8.69	0.0000	7	7	1.72	1.20
Femur length	445.3	411.4	5.36	0.0001	9	8	16.42	7.48
Tibia length	378.3	349.8	3.26	0.0086	8	4	14.59	13.60
AP subtroch. diam.	27.8	26.5	1.15	0.2651	12	10	2.00	3.41
ML subtroch. diam.	31.7	28.2	2.85	0.0099	12	10	2.84	2.94
AP midshaft diam.	28. 0	24.2	4.82	0.0001	10	10	1.39	2.01
ML midshaft diam.	25.8	24.500	1.84	0.0821	10	10	1.56	1.65
Neck length	53.2	48.1	2.07	0.0531	11	9	6.85	2.98
Neck length biom.	60.8	84.7	–1.39	0.1941	5	7	46.03	5.22
Humerus length	316.7	292.9	2.80	0.0233	3	7	20.13	8.23
Radius length	241.0	221.5	2.17	0.0820	3	4	13.89	10.08
Head/Femur	1.048	1.021	1.85	0.1019	5	5	0.03	0.01
Head/Neck	0.860	0.870	–0.22	0.8330	7	6	0.10	0.06
Neck/Femur	1.185	1.180	0.09	0.9294	8	7	0.13	0.06
Neck. biom/Femur	1.432	2.090	–1.63	0.1474	3	6	1.06	0.11
Crural index	0.841	0.866	–2.29	0.0617	6	2	0.01	0.02
Brachial index		0.754			0	3		0.02
Humerus/Femur	0.714	0.726	–0.68	0.5357	2	4	0.01	0.02
Radius/Tibia	0.643	0.662	–5.93	0.1064	2	1	0.00	0.00
Body height	168.4	156.5	5.39	0.0001	8	7	5.34	2.46
Body mass	63.8	53.3	5.47	0.0000	12	10	4.42	4.36
BMI index	21.873	21.926	–0.09	0.9299	8	7	0.74	1.49
Rohrer's index	1.301	1.402	–2.13	0.0528	8	7	0.08	0.10

TABLE 5. Length of long bones, proportions and body height for Únětice Culture from Bajč. Lengyel Culture and three Bronze Age Cultures from the Carpathian Basin (Éry 1998).

	Femur			Tibia			Humerus			Radius		
	Means	N	Std. Dev.	Means	N	Std. Dev.	Means	N	Std. Dev.	Means	N	Std. Dev.
Neolithic H LC – males	430.8	27	18.41	347.6	24	16.49	308.8	29	13.78	234.0	25	13.15
Neolithic H LC – females	400.1	31	17.39	320.4	30	15.07	282.6	37	13.60	211.3	31	9.79
Early Bronze Age Bajč – males	445.3	9	16.42	378.2	8	14.59	316.7	3	20.13	241.0	3	13.89
Early Bronze Age Bajč – females	411.4	8	7.48	349.8	4	13.60	292.9	7	8.23	221.5	4	10.08
Bronze Age H Vatya – males	438.2	11	25.17	358.9	9	19.67	317.7	11	13.42	246.3	10	13.00
Bronze Age H Vatya – females	403.1	13	15.04	330.7	12	17.55	294.8	13	11.83	220.3	12	12.19
Bronze Age H Maros – males	443.5	49	19.39		0		315.9	31	14.80	247.1	18	13.47
Bronze Age H Maros – females	404.4	54	20.31		0		288.7	29	12.06	217.3	26	11.75
Bronze Age H Tumulus – males	442.8	79	23.69	362.0	63	22.88	318.2	52	14.84	242.0	56	14.41
Bronze Age H Tumulus – females	410.8	78	15.16	337.8	57	14.49	294.9	55	12.45	220.7	66	10.42
	Crural index			**Brachial index**			**Humerus/Femur**			**Body height**		
	Means	N	Std. Dev.	Means	N	Std. Dev.	Means	N	Std. Dev.	Means	N	Std. Dev.
Neolithic H LC – males	0.806	22	0.0235	0.760	23	0.0227	0.720	23	0.0131	162.0	33	6.20
Neolithic H LC – females	0.803	27	0.0207	0.748	26	0.0235	0.714	25	0.0232	150.5	43	6.03
Early Bronze Age Bajč – males	0.841	6	0.0126	0.779	1	0.0000	0.704	3	0.0201	168.4	8	5.34
Early Bronze Age Bajč – females	0.858	3	0.0171	0.754	3	0.0216	0.726	4	0.0222	156.5	7	2.46
Bronze Age H Vatya – males	0.821	9	0.0274	0.772	10	0.0152	0.726	11	0.0296	165.4	11	7.56
Bronze Age H Vatya – females	0.819	12	0.0283	0.747	12	0.0228	0.731	12	0.0184	153.8	14	4.79
Bronze Age H Maros – males		0		0.774	15	0.0226	0.722	23	0.0171	166.9	57	6.50
Bronze Age H Maros – females		0		0.749	19	0.0261	0.719	22	0.0251	153.6	61	6.63
Bronze Age H Tumulus – males	0.821	47	0.0283	0.766	37	0.0218	0.720	38	0.0228	0.674	33	0.0224
Bronze Age H Tumulus – females	0.826	48	0.0176	0.752	41	0.0235	0.720	45	0.0194	0.650	32	0.0177

DISCUSSION AND CONCLUSIONS

We can conclude that the studied Únětice Early Bronze Age Culture males and females are very similar to those of Neolithic Corded Ware Culture and Bell Beaker Culture, but very different from those of Neolithic Linear Band Pottery Culture and Lengyel Culture (see *Tables 4–10, Figures 1–7*). A preliminary analysis shows that the other examined Bronze Age populations are in some features similar to the pastoralist / horticulturalist populations, but intermediate between the two groups in other features (*Tables 5, 10*). However, any more detailed ecological interpretation of these results would be premature without more detailed palaeoecological information and more advanced analysis of skeletal material.

These differences are in both body size and shape, as well as in bone morphology and proportions, and our analysis supports the suggested marked differences in ecology, social structure and adaptive strategy of the two groups (see also Marciniak 1992, Piontek 1999, Piontek, Marciniak 1990 a, b, 1992). Microevolutionary trends in the Bronze Age period should be analysed in a separate detailed study.

According to our general hypothesis (Piontek 1999, Piontek, Vančata 1999, Vančata 1997), the most probable explanation of those contrasts is a different way of life among early agricultural populations and pastoralist / horticulturalist ones. There is some evidence (Jankowska *et al.* 1999, Krenz-Niedbała 2000, Marciniak 1992, Piontek 1999, Piontek, Marciniak 1990 a, b, 1992) that they differed

TABLE 6. Comparison of length of long bones, proportions and body height for Únětice Culture from Bajč and three Bronze Age Cultures from the Carpathian Basin (Éry 1998); *t-test was computed for groups with unequal number of individuals. P = 0.0000 is really P < 0.0001.*

Males – Bajč Únětice Culture vs. Vatya Bronze Age Culture	Mean *Bajč*	Mean *Vatya*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Vatya*	Std. Dev. *Bajč*	Std. Dev. *Vatya*
Femur length	445.3	438. 2	0.764	0.4552	9	11	16.424	25.167
Tibia length	378.3	358. 9	2.321	0.0348	8	9	14.587	19.669
Humerus length	316. 7	317.7	–0.086	0.9368	3	11	20.133	13.417
Radius length	241.0	246.3	–0.588	0.5978	3	10	13.892	12.996
Crural index	0.841	0.821	1.972	0.0721	6	9	0.013	0.027
Brachial index	0.779	0.772	0.434	0.6742	1	10	0.000	0.015
Humerus/Femur index	0.704	0.726	–1.527	0.1873	3	11	0.020	0.030
Body height	168.4	165.4	1.004	0.3296	8	11	5.339	7.562
Females – Bajč Únětice Culture vs. Vatya Bronze Age Culture	Mean *Bajč*	Mean *Vatya*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Vatya*	Std. Dev. *Bajč*	Std. Dev. *Vatya*
Femur length	411.4	403.1	1.680	0.1103	8	13	7.482	15.041
Tibia length	349.8	330. 7	2.251	0.0592	4	12	13.598	17.552
Humerus length	292.9	294.8	–0.440	0.6656	7	13	8.235	11.831
Radius length	221.5	220.3	0.190	0.8558	4	12	10.083	12.190
Crural index	0.858	0.819	3.036	0.0289	3	12	0.017	0.028
Brachial index	0.754	0.747	0.547	0.6222	3	12	0.022	0.023
Humerus/Femur index	0.726	0.731	–0.440	0.6826	4	12	0.022	0.018
Body height	156.5	153.8	1.688	0.1077	7	14	2.462	4.791
Males – Bajč Únětice Culture vs. Maros – Perjámos Bronze Age Culture	Mean *Bajč*	Mean *Maros*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Maros*	Std. Dev. *Bajč*	Std. Dev. *Maros*
Femur length	445.3	443.5	0.297	0.7714	9	49	16.424	19.390
Tibia length	378.3				8	0	14.587	
Humerus length	316. 7	315.9	0.064	0.9548	3	31	20.133	14.804
Radius length	241.0	247.3	–0.742	0.5121	3	26	13.892	14.438
Crural index	0.841				6	0	0.013	
Brachial index	0.779	0.774	0.208	0.8384	1	15	0.000	0.023
Humerus/Femur index	0.704	0.722	–1.479	0.2773	3	23	0.020	0.017
Body height	168.4	166.9	0.736	0.4786	8	57	5.339	6.499
Females – Bajč Únětice Culture vs. Maros – Perjámos Bronze Age Culture	Mean *Bajč*	Mean *Maros*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Maros*	Std. Dev. *Bajč*	Std. Dev. *Maros*
Femur length	411.4	404.4	1.831	0.0786	8	54	7.482	20.313
Tibia length	349.8				4	0	13.598	
Humerus length	292.9	288.7	1.078	0.3007	7	29	8.235	12.062
Radius length	221.5	218.4	0.567	0.6013	4	29	10.083	11.954
Crural index	0.858				3	0	0.017	
Brachial index	0.754	0.749	0.365	0.7391	3	19	0.022	0.026
Humerus/Femur index	0.726	0.719	0.571	0.5926	4	22	0.022	0.025
Body height	156.5	153.6	2.308	0.0324	7	61	2.462	6.628
Males – Bajč Únětice Culture vs. Tumulus Bronze Age Culture	Mean *Bajč*	Mean *Tumulus*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Tumulus*	Std. Dev. *Bajč*	Std. Dev. *Tumulus*
Femur length	445.3	442.8	0.416	0.6844	9	79	16.424	23.695
Tibia length	378.3	362.0	2.748	0.0177	8	63	14.587	22.879
Humerus length	316. 7	318.2	–0.126	0.9113	3	52	20.133	14.838
Radius length	241.0	242.0	–0.123	0.9131	3	56	13.892	14.413
Crural index	0.841	0.821	3.159	0.0075	6	47	0.013	0.028
Brachial index	0.779	0.766	0.582	0.5642	1	37	0.000	0.022
Humerus/Femur index	0.704	0.720	–1.371	0.3041	3	38	0.020	0.023
Body height	168.4	166.6	0.857	0.4115	8	93	5.339	7.482
Females – Bajč Únětice Culture vs. Tumulus Bronze Age Culture	Mean *Bajč*	Mean *Tumulus*	t separ. var. est.	p 2-sided	Valid N *Bajč*	Valid N *Tumulus*	Std. Dev. *Bajč*	Std. Dev. *Tumulus*
Femur length	411.4	410.8	0.172	0.8661	8	78	7.482	15.164
Tibia length	349.8	337.8	1.698	0.1881	4	57	13.598	14.494
Humerus length	292.9	294.9	–0.565	0.5847	7	55	8.235	12.453
Radius length	221.5	220.7	0.149	0.8913	4	66	10.083	10.421
Crural index	0.858	0.826	3.186	0.0860	3	48	0.017	0.018
Brachial index	0.754	0.752	0.173	0.8783	3	41	0.022	0.023
Humerus/Femur index	0.726	0.720	0.515	0.6420	4	45	0.022	0.019
Body height	156.5	155.5	0.898	0.3884	7	88	2.462	5.448

TABLE 7. Neolithic LPBC – Jena – basic data for long bones and body size and shape for males and females and t-test of sexual differences. (AP subtroch. diam. – antero-posterior subtrochanteric diameter. ML subtroch. diam. – medio-lateral subtrochanteric diameter. AP misdhaft diam. – antero-posterior midshaft diameter. ML misdhaft diam. – medio-lateral midshaft diameter. biom. – biomechanical. biom. neck – biomechanical neck length. *P = 0.0000 is really P < 0.0001. Numbers in italics were taken from Bach and Bach 1965*.)

	Mean *Males*	Mean *Females*	t-value	p	Valid N *Males*	Valid N *Females*	Std. Dev. *Males*	Std. Dev. *Females*
Head breadth	47.2	40.2	7.50	0.0000	13	19	2.275	2.832
Femur length	431.0	393.4	5.48	0.0000	13	19	14.860	21.397
Tibia length	354.4	319.4	5.02	0.0000	13	18	13.727	22.208
AP subtroch. diam.	29.0	25.2	4.20	0.0002	13	19	2.238	2.646
ML subtroch. diam.	29.9	26.6	5.20	0.0000	13	19	1.757	1.766
AP midshaft diam.	28.7	23.6	8.03	0.0000	13	19	1.940	1.615
ML midshaft diam.	26.5	23.6	4.78	0.0000	13	19	1.376	1.808
Neck length	53.8	48.5	3.38	0.0020	13	19	4.838	3.911
Neck length biom.	91.2	77.2	6.91	0.0000	13	19	5.895	5.475
Humerus length	*309.4*	*282.6*			*25*	*25*	*13.000*	*17.400*
Radius length	*233.0*	*211.0*			*24*	*29*	*12.300*	*14.500*
Head/Femur	1.097	1.021	3.83	0.0006	13	19	0.058	0.053
Head/Neck	0.883	0.830	2.30	0.0288	13	19	0.068	0.061
Neck/Femur	1.248	1.234	0.45	0.6528	13	19	0.102	0.073
Neck. biom./Femur	2.117	1.961	4.25	0.0002	13	19	0.125	0.083
Crural index	0.823	0.812	1.00	0.3244	13	18	0.039	0.020
Brachial index	*0.753*	*0.747*						
Humerus/Femur	*0.713*	*0.708*						
Radius/Tibia	*0.678*	*0.672*						
Body height	162.9	150.2	5.48	0.0000	13	19	4.997	7.195
Body mass	64.1	49.2	10.30	0.0000	13	19	3.579	4.294
BMI index	24.194	21.790	5.36	0.0000	13	19	1.443	1.097
Rohrer's index	1.488	1.455	0.75	0.4576	13	19	0.122	0.122

TABLE 8. Neolithic CWC – Zlota – basic data for long bones and body size and shape for males and females and t-test of sexual differences. (AP subtroch. diam. – antero-posterior subtrochanteric diameter. ML subtroch. diam. – medio-lateral subtrochanteric diameter. AP misdhaft diam. – antero-posterior midshaft diameter. ML misdhaft diam. – medio-lateral midshaft diameter. biom. – biomechanical. biom. neck – biomechanical neck length. *P = 0.0000 is really P < 0.0001. Numbers in italics were taken from Krentz-Niedbala 2000*.)

	Mean *Males*	Mean *Females*	t-value	p	Valid N *Males*	Valid N *Females*	Std. Dev. *Males*	Std. Dev. *Females*
Head breadth	46.8	41.8	7.52	0.0000	33	29	2.764	2.384
Femur length	448. 0	409.5	7.55	0.0000	33	29	20.220	19.797
Tibia length	375.1	338.6	7.36	0.0000	31	31	20.499	18.451
AP subtroch. diam.	28.1	25.3	4.22	0.0001	33	29	3.131	1.804
ML subtroch. diam.	31.2	28.4	4.06	0.0001	33	29	2.668	2.690
AP midshaft diam.	27.8	24.9	4.69	0.0000	33	29	2.701	2.200
ML midshaft diam.	27.4	25.6	3.28	0.0017	33	29	2.219	2.199
Neck length	51.5	46.5	5.65	0.0000	33	29	3.517	3.457
Neck length biom.	92.4	83.7	6.03	0.0000	33	29	6.645	4.364
Humerus length	*328.3*	*308.5*			*10*	*10*	*10.970*	*15.240*
Radius length	*247.0*	*223.1*			*11*	*10*	*16.740*	*17.700*
Head/Femur	1.045	1.023	1.88	0.0650	33	29	0.045	0.049
Head/Neck	0.911	0.903	0.53	0.6008	33	29	0.061	0.061
Neck/Femur	0.507	0.500	1.40	0.1654	33	29	0.024	0.015
Neck. biom./Femur	1.151	1.135	0.80	0.4255	33	29	0.081	0.068
Crural index	0.835	0.830	0.81	0.4226	30	25	0.024	0.019
Brachial index	*0.7524*	*0.7232*						
Humerus/Femur	*0.7328*	*0.7534*						
Radius/Tibia	*0.6585*	*0.6589*						
Body height	168.6	155.6	7.55	0.0000	33	29	6.799	6.657
Body mass	61.5	48.2	7.66	0.0000	34	35	5.334	8.617
BMI index	21.571	20.981	1.78	0.0809	33	29	1.288	1.325
Rohrer's index	1.283	1.352	–2.43	0.0181	33	29	0.105	0.120

TABLE 9. Neolithic BBC – Praha – basic data for long bones and body size and shape for males and females and T-test of sexual differences. (AP subtroch. diam. – antero-posterior subtrochanteric diameter. ML subtroch. diam. – medio-lateral subtrochanteric diameter. AP misdhaft diam. – antero-posterior midshaft diameter. ML misdhaft diam. – medio-lateral midshaft diameter. biom. – biomechanical. biom. neck – biomechanical neck length. *P = 0.0000 is really P < 0.0001*)

	Mean *Males*	Mean *Females*	t-value	p	Valid N *Males*	Valid N *Females*	Std. Dev. *Males*	Std. Dev. *Females*
Head breadth	47.7	41.3	3.49	0.0058	7	5	2.352	3.990
Femur length	451.3	417.8	1.90	0.0833	8	5	20.872	42.991
Tibia length	377.4	363.3	0.91	0.3884	7	3	23.565	18.448
AP subtroch. diam.	27.6	25.1	2.14	0.0559	8	5	2.001	2.084
ML subtroch. diam.	31.6	28.6	2.47	0.0312	8	5	1.745	2.719
AP midshaft diam.	28.1	25.3	2.20	0.0497	8	5	2.340	1.981
ML midshaft diam.	28.0	25.9	1.74	0.1105	8	5	1.979	2.271
Neck length	55.9	45.4	5.28	0.0005	6	5	3.185	3.417
Neck length biom.	96.2	82.9	3.57	0.0061	6	5	5.845	6.528
Humerus length	326.1	292.0	3.08	0.0105	8	5	16.392	23.843
Radius length	242.9	230.8	1.11	0.2931	7	5	13.018	24.631
Head/Femur	1.056	0.991	2.11	0.0606	7	5	0.042	0.066
Head/Neck	0.853	0.909	–1.92	0.0869	6	5	0.052	0.043
Neck/Femur	1.230	1.093	2.59	0.0292	6	5	0.072	0.103
Neck. biom./Femur	2.118	1.994	1.38	0.2007	6	5	0.148	0.150
Crural index	0.831	0.830	0.01	0.9902	7	3	0.032	0.047
Brachial index	0.745	0.753	–0.56	0.5886	6	4	0.023	0.019
Humerus/Femur	0.734	0.701	1.43	0.1826	7	5	0.037	0.042
Radius/Tibia	0.649	0.641	0.81	0.4503	5	3	0.013	0.015
Body height	169.5	157.3	2.36	0.0363	9	5	6.502	13.260
Body mass	63.6	51.8	4.78	0.0005	9	5	3.302	6.115
BMI index	22.163	20.982	1.61	0.1331	9	5	1.155	1.586
Rohrer's index	1.311	1.349	–0.43	0.6720	9	5	0.109	0.222

by the use of various natural resources, environment and reproduction strategy. It is worth noting that the Únětice early Bronze Age Culture, Bell Beaker Culture and Corded Ware Culture populations are similar in many features of body build, proportions and bone morphology also to the examined Mesolithic populations (*Figure 7*, Vančata 1997, in prep., Piontek, Vančata 1999, in prep.). The ecological and cultural differentiation and population continuity during the Late Palaeolithic, Mesolithic, Neolithic and the early Bronze period have been discussed recently (e.g. Barbujani, Bertolli 2001, Barbujani *et al.* 1994, Bogucki 1999, Kruk, Milisauskas 1999, Piontek 2001), showing the possibility of at least partial local continuity and specific features of early agriculturalists in central Europe during the Mesolithic, Neolithic, Early Bronze periods.

Consequently we can suppose that microevolutionary trends, ecology and the adaptive strategy of non-agricultural populations were rather conservative since the Mesolithic until the Early Bronze Age periods. Some of the microevolutionary conservative trends can be supposed also on the basis of archaeological and palaeoecological records (Bogucki 1999, Kruk, Milisauskas 1999), because of the non-continuous character of Early and Middle Neolithic agricultural populations.

It is very probable that the two life history patterns had existed in the early post-Palaeolithic period. The first one was a conservative pattern with prevailing adaptive K-strategy, keeping some features of hunter-gatherer's body built, ecology and social structure that originated probably early in the Mesolithic period. This life history pattern was connected predominantly with the pastoralist-horticulturalist cultural groups in the Neolithic and Early Bronze Age. The second life history pattern with r-strategy, features typical changed body built and proportions, ecology and social structure; it was connected with the origin and development of early agricultural system in the Neolithic period (see also Piontek 1999, Vančata 1987, Piontek, Vančata 1999).

ACKNOWLEDGEMENTS

We would like to thank the following colleagues for the discussions and remarks (alphabetically): Jaroslav Brůžek, Míla Dobisíková, Marta Dočkalová, Trent Holliday, Jan Jelínek, Alexander Kozintzev, Arkadeusz Marciniak, Vladimír Novotný, Jaroslava Pavelková, Janusz Piontek, Vladimír Přívratský, Vladimír Sládek, Milan Stloukal, Jiří Svoboda, Petr Škrdla, Erik Trinkaus, Petr Velemínský.

This research has been supported by the Grant Agency of the Czech Republic – grant project No. 206/96/0166 and 206/99/1697 and Grant Project of the Ministry of Education – Research Program No. 21-313-0041.

TABLE 10. Comparison of length of long bones, proportions and body height for three Neolithic Lengyel Cultures from the Carpathian Basin (Éry 1998) with Únětice Culture from Bajč, Praha BBC, Jena LBPC and Zlota CWC; *t-test was computed for groups with unequal numbers of individuals.*

Males – Lengyel Culture vs. Bajč Únětice Culture	Mean ***Lengyel H***	Mean ***Bajč***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***Bajč***	Std. Dev. ***Lengyel H***	Std. Dev. ***Bajč***
Femur length	430.8	445.3	–2.227	0.0417	27	9	18.406	16.424
Tibia length	347.6	378.3	–4.980	0.0003	24	8	16.490	14.587
Humerus length	308.8	316. 7	–0.662	0.5763	29	3	13.777	20.133
Radius length	234.0	241.0	–0.825	0.4963	25	3	13.148	13.892
Crural index	0.806	0.841	–4.919	0.0002	22	6	0.024	0.013
Brachial index	0.760	0.779	–0.815	0.4239	23	1	0.023	0.000
Body height	162.0	168.4	–2.946	0.0122	33	8	6.201	5.339
Females – Lengyel Cult. vs. Bajč Únětice Culture	Mean ***Lengyel H***	Mean ***Bajč***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***Bajč***	Std. Dev. ***Lengyel H***	Std. Dev. ***Bajč***
Femur length	400.1	411.4	–2.755	0.0102	31	8	17.390	7.482
Tibia length	320.4	349.8	–4.006	0.0161	30	4	15.071	13.598
Humerus length	282.6	292.9	–2.664	0.0195	37	7	13.600	8.235
Radius length	211.3	221.5	–1.918	0.1275	31	4	9.794	10.083
Crural index	0.803	0.858	–5.144	0.0142	27	3	0.021	0.017
Brachial index	0.748	0.754	–0.441	0.6894	26	3	0.023	0.022
Body height	150.5	156.5	–4.575	0.0002	43	7	6.033	2.462
Males – Lengyel Culture vs. BBC Praha	Mean ***Lengyel H***	Mean ***BBC Praha***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***BBC Praha***	Std. Dev. ***Lengyel H***	Std. Dev. ***BBC Praha***
Femur length	430.8	451.3	–2.497	0.0316	27	8	18.406	20.872
Tibia length	347.6	377.4	–3.135	0.0139	24	7	16.490	23.565
Humerus length	308.8	326.1	–2.736	0.0210	29	8	13.777	16.392
Radius length	234.0	242.9	–1.580	0.1451	25	7	13.148	13.018
Crural index	0.806	0.831	–1.889	0.0956	22	7	0.024	0.032
Brachial index	0.760	0.745	1.336	0.2182	23	6	0.023	0.023
Body height	162.0	169.5	–3.111	0.0090	33	9	6.201	6.502
Females – Lengyel Cult. vs. BBC Praha	Mean ***Lengyel H***	Mean ***BBC Praha***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***BBC Praha***	Std. Dev. ***Lengyel H***	Std. Dev. ***BBC Praha***
Femur length	400.1	417.8	–0.909	0.4148	31	5	17.390	42.991
Tibia length	320.4	363.3	–3.906	0.0597	30	3	15.071	18.448
Humerus length	282.6	292.0	–0.858	0.4391	37	5	13.600	23.843
Radius length	211.3	230.8	–1.752	0.1547	31	5	9.794	24.631
Crural index	0.803	0.830	–0.979	0.4309	27	3	0.021	0.047
Brachial index	0.748	0.753	–0.469	0.6590	26	4	0.023	0.019
Body height	150.5	157.3	–1.124	0.3240	43	5	6.033	13.260
Males – Lengyel Culture vs. LBPC Jena	Mean ***Lengyel H***	Mean ***LBPC Jena***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***LBPC Jena***	Std. Dev. ***Lengyel H***	Std. Dev. ***LBPC Jena***
Femur length	430.8	431.0	–0.034	0.9731	27	13	18.406	14.860
Tibia length	347.6	354.4	–1.338	0.1912	24	13	16.490	13.727
Crural index	0.806	0.823	–1.418	0.1741	22	13	0.024	0.039
Body height	162.0	162.9	–0.502	0.6199	33	13	6.201	4.997
Females – Lengyel Cult. vs. LBPC Jena	Mean ***Lengyel H***	Mean ***LBPC Jena***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***LBPC Jena***	Std. Dev. ***Lengyel H***	Std. Dev. ***LBPC Jena***
Femur length	400.1	393.4	1.147	0.2597	31	19	17.390	21.397
Tibia length	320.4	319.4	0.165	0.8699	30	18	15.071	22.208
Crural index	0.803	0.812	–1.472	0.1493	27	18	0.021	0.020
Body height	150.5	150.2	0.156	0.8768	43	19	6.033	7.195
Males – Lengyel Culture vs. CWC Zlota	Mean ***Lengyel H***	Mean ***CWC Zlota***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***CWC Zlota***	Std. Dev. ***Lengyel H***	Std. Dev. ***CWC Zlota***
Femur length	430.8	448. 0	–3.435	0.0011	27	33	18.406	20.220
Tibia length	347.6	375.1	–5.509	0.0000	24	31	16.490	20.499
Crural index	0.806	0.835	–4.306	0.0001	22	30	0.024	0.024
Body height	162.0	168.6	–4.112	0.0001	33	33	6.201	6.799
Females – Lengyel Cult. vs. CWC Zlota	Mean ***Lengyel H***	Mean ***CWC Zlota***	t separ. var. est.	p 2-sided	Valid N ***Lengyel H***	Valid N ***CWC Zlota***	Std. Dev. ***Lengyel H***	Std. Dev. ***CWC Zlota***
Femur length	400.1	409.5	–1.946	0.0567	31	29	17.390	19.797
Tibia length	320.4	338.6	–4.236	0.0001	30	31	15.071	18.451
Crural index	0.803	0.830	–4.864	0.0000	27	25	0.021	0.019
Body height	150.5	155.6	–3.313	0.0016	43	29	6.033	6.657

FIGURE 1. Body height and body mass in males and females in studied Neolithic and early Bronze Age populations. (LBPC – Linear Band Pottery Culture; Mittle-Elbe-Saale Gebiet, Jena, Germany. CWC – Corded Ware Culture; Zlota, Poland; Prague. BBC – Bell Beaker Culture; Bohemia and Moravia, Czech Republic. Bronze Age – Únětice early Bronze Age Culture; Bajč, Slovakia. SD – standard deviation. SE – standard error of mean.)

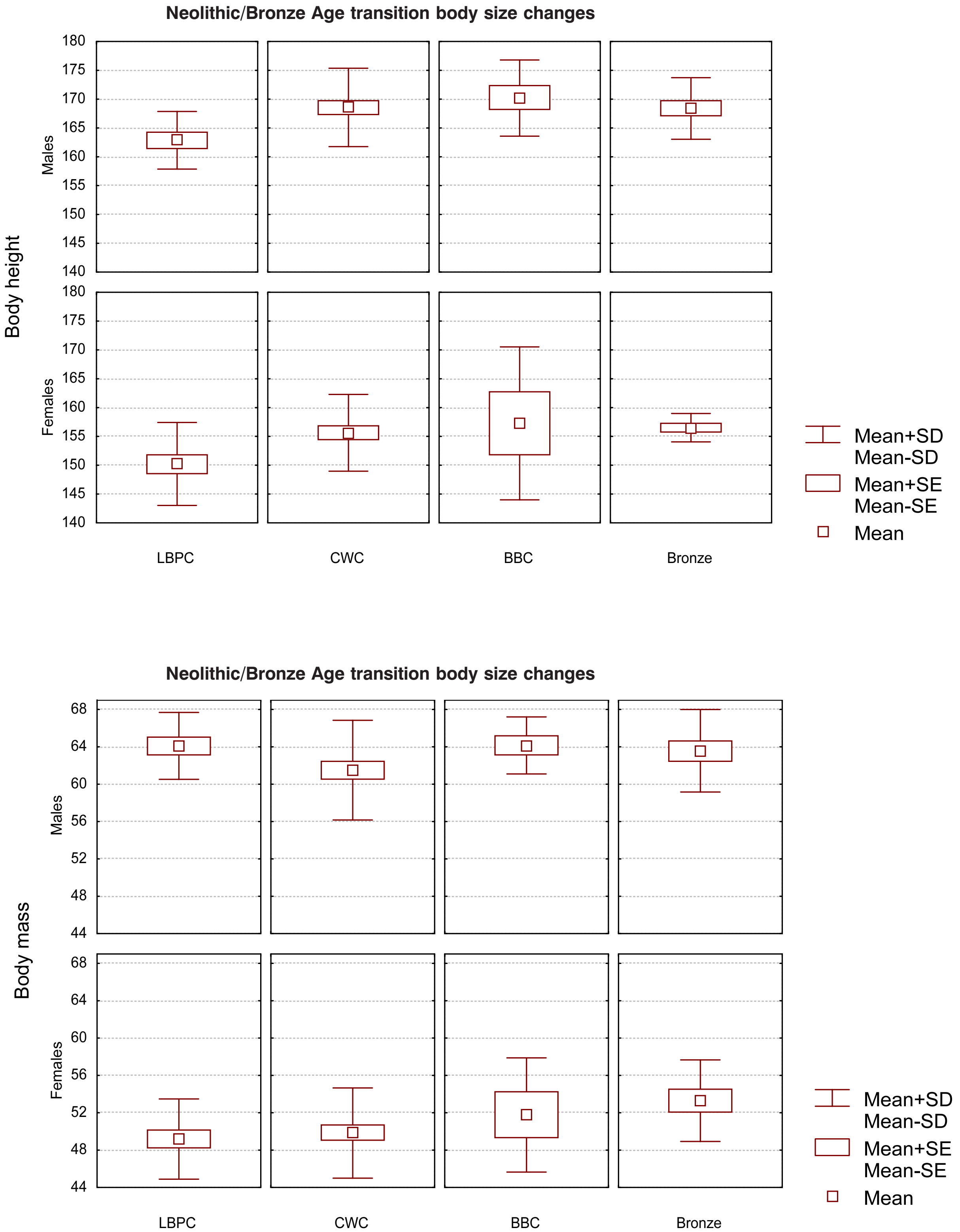
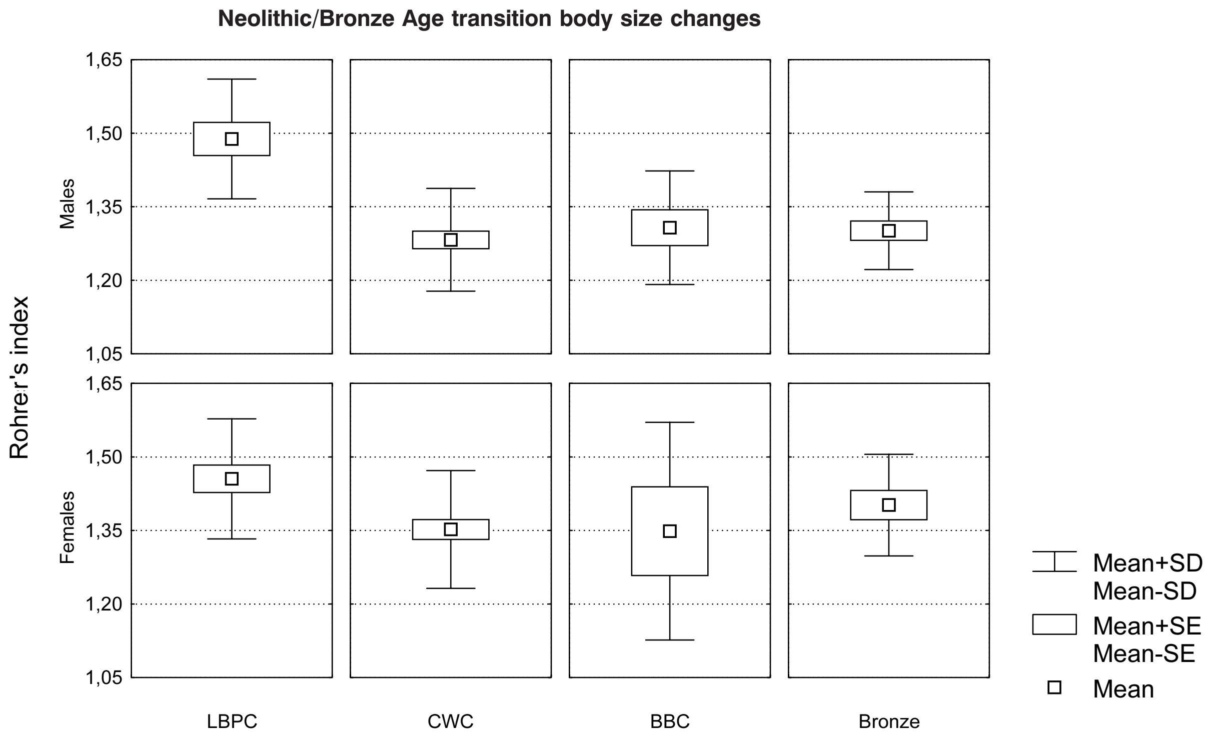


FIGURE 2. Body robusticity in males and females in studied Neolithic and early Bronze Age populations represented by Rohrer's index and vertical head breadth. Note that head breadth basically corresponds in sexual differences to the body mass (*Figure 1*), but the Rohrer's index makes a specific pattern.



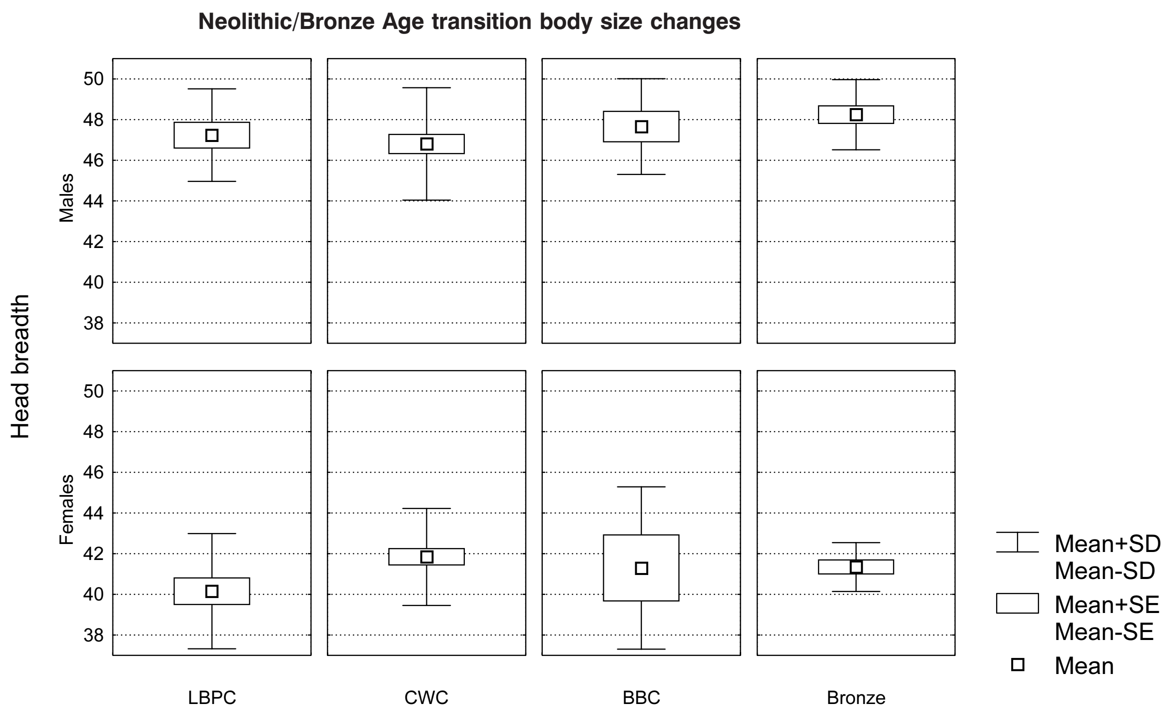
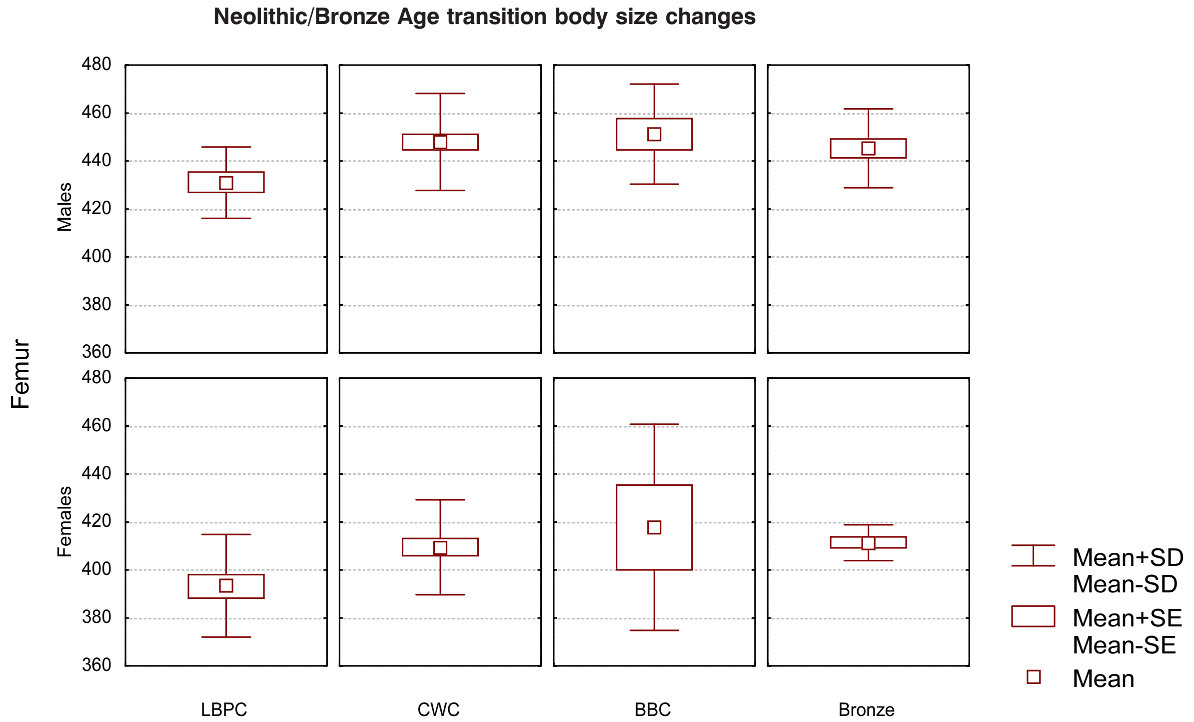


FIGURE 3. Length of femur and tibia in males and females in studied Neolithic and early Bronze Age populations.



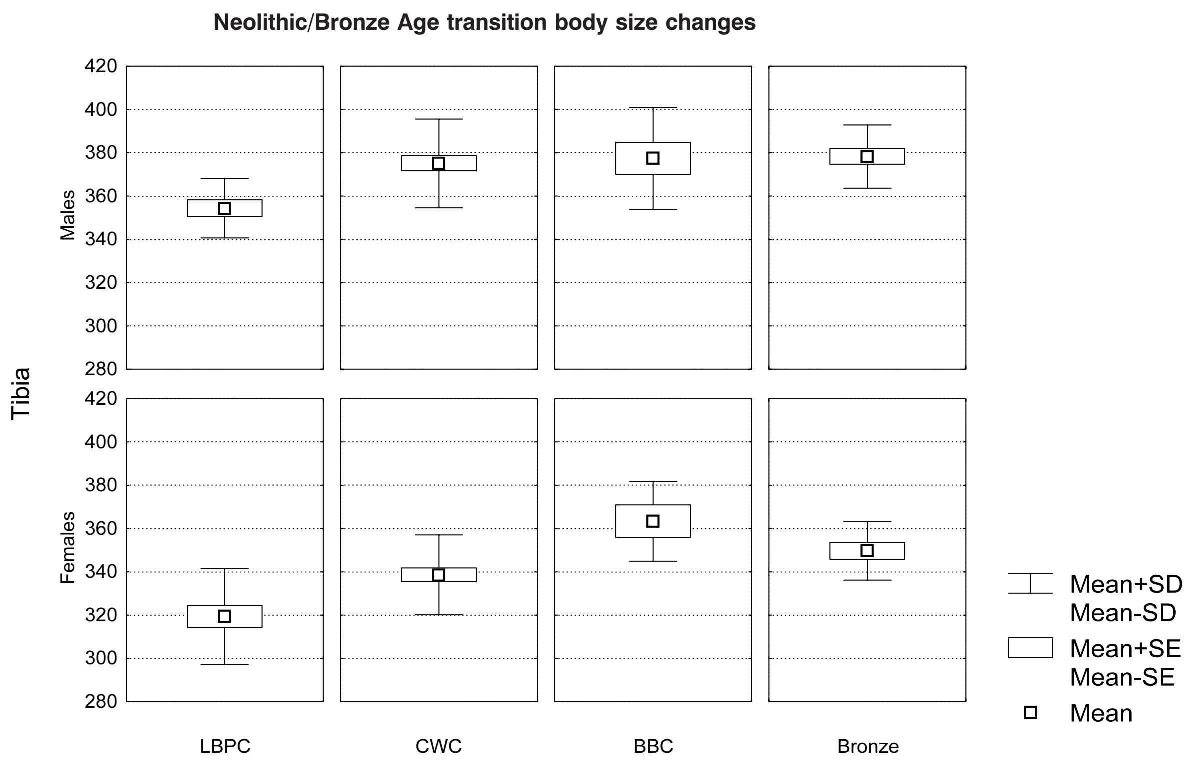
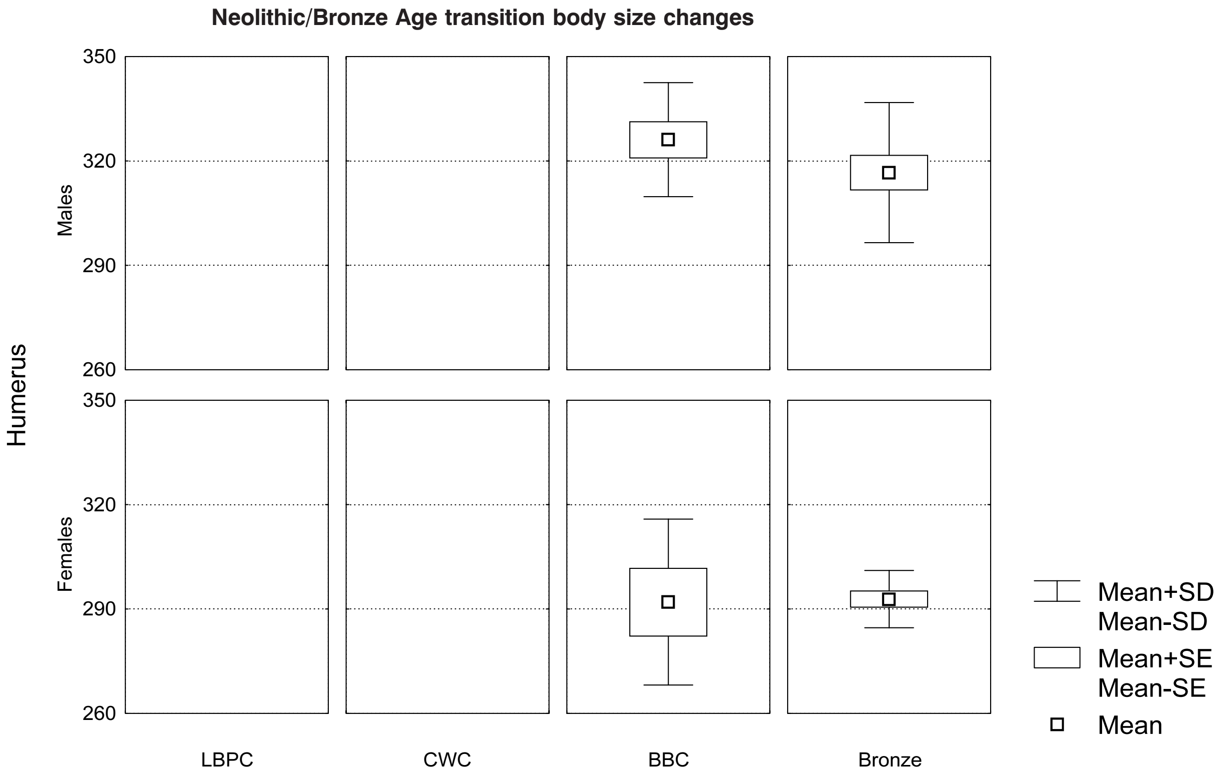


FIGURE 4. Length of humerus and radius in males and females in studied Neolithic and early Bronze Age populations. The humerus and radius of Linear Band Pottery Culture and Corded Ware Culture were not measured by the authors and therefore they cannot be included into the statistical analysis. However, the lengths of bones are available in literature (Bach 1978, Bach, Bach 1981, Vančata 1997, *Figure 7*).



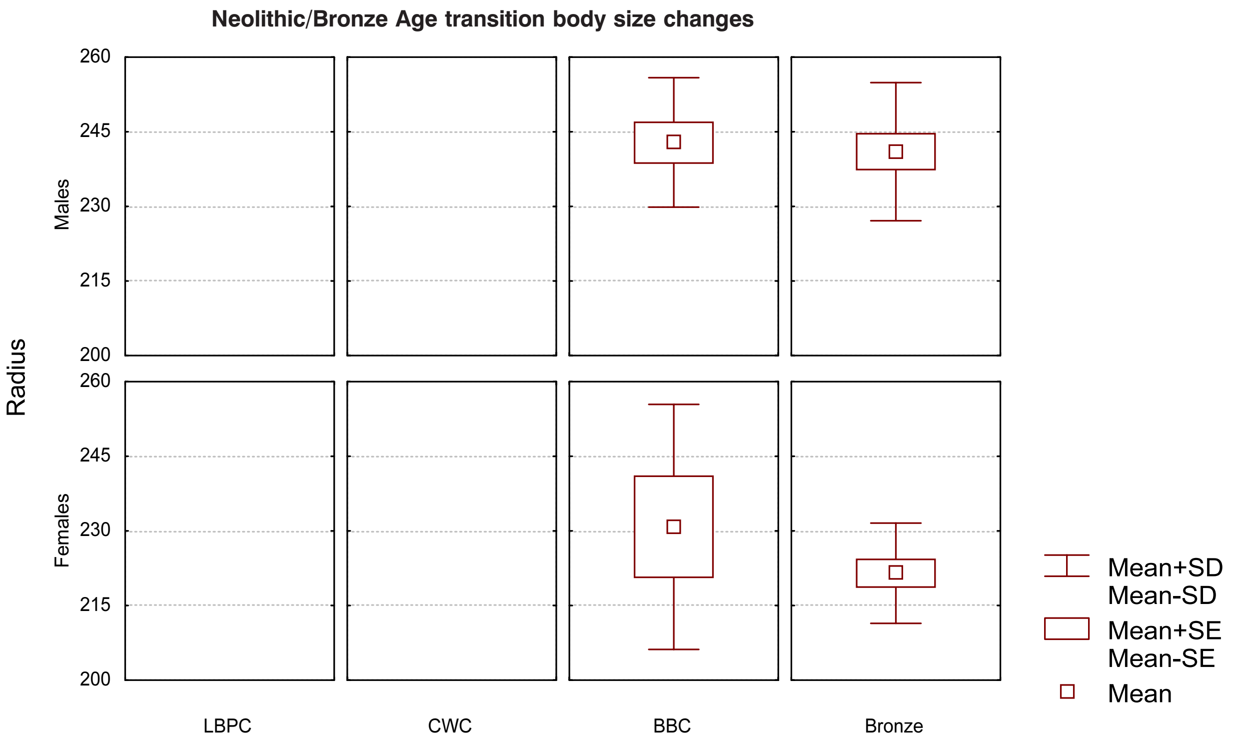


FIGURE 5. Shape and robusticity of subtrochanteric region of femur in males and females in studied Neolithic and Early Bronze Age populations represented by medio-lateral and antero-posterior subtrochanteric diameters.

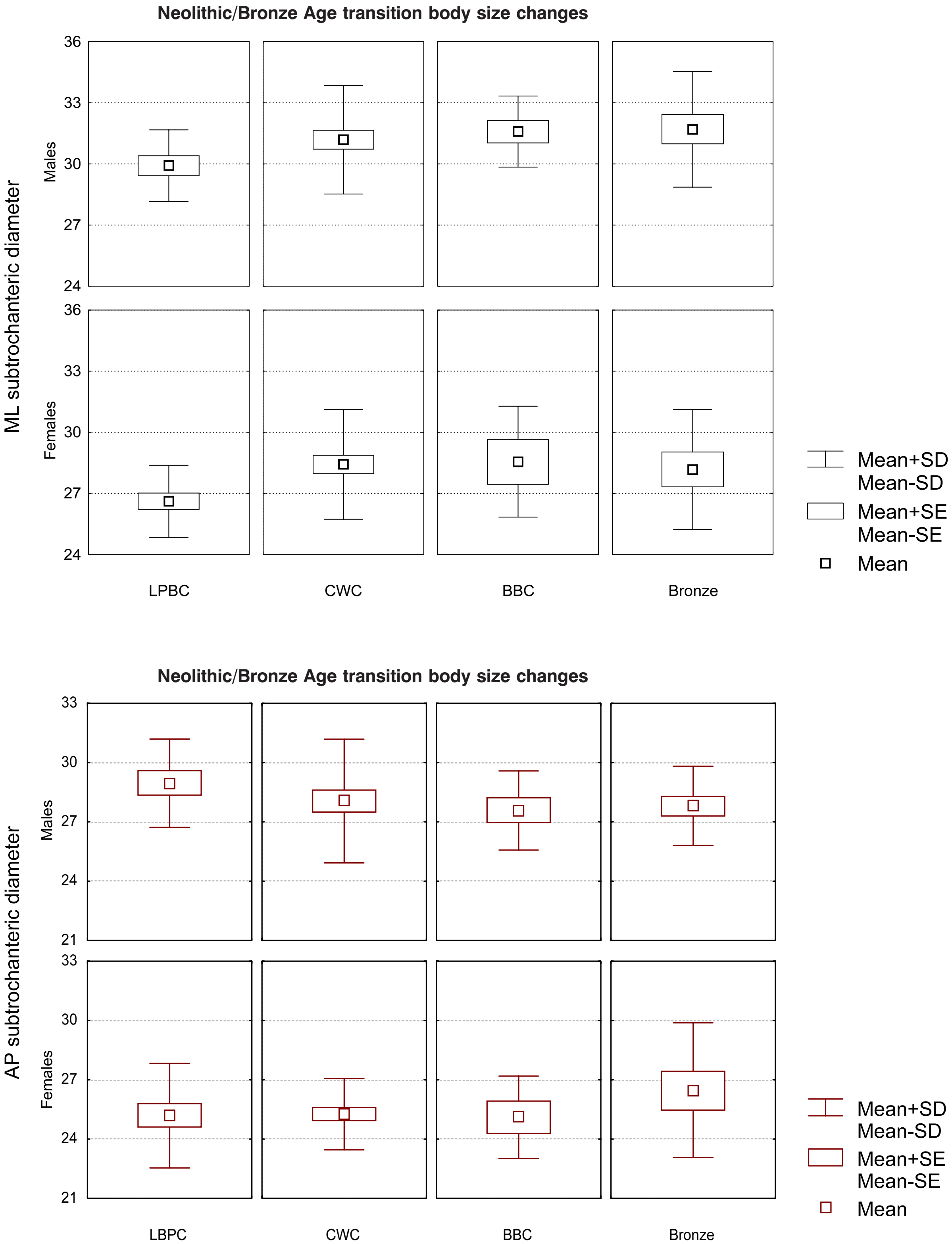
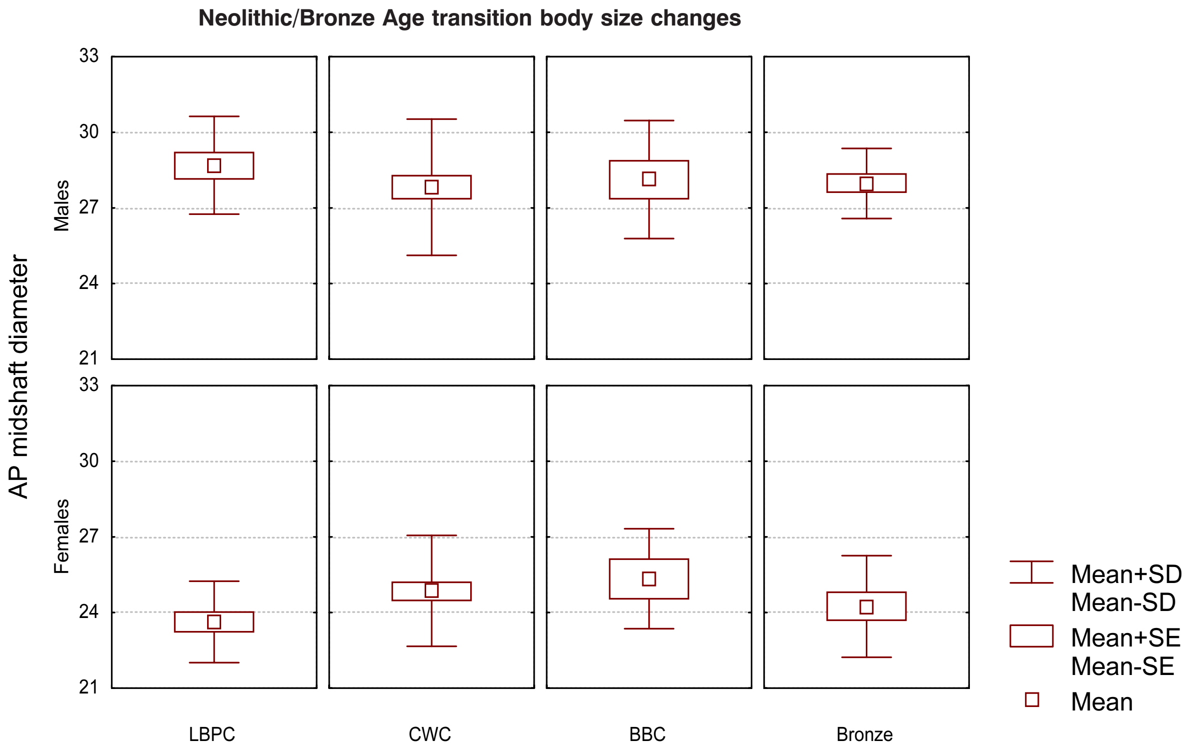


FIGURE 6. Shape and robusticity of midshaft region of femoral diaphysis in males and females in studied Neolithic and Early Bronze Age populations represented by medio-lateral and antero-posterior midshaft diameters.



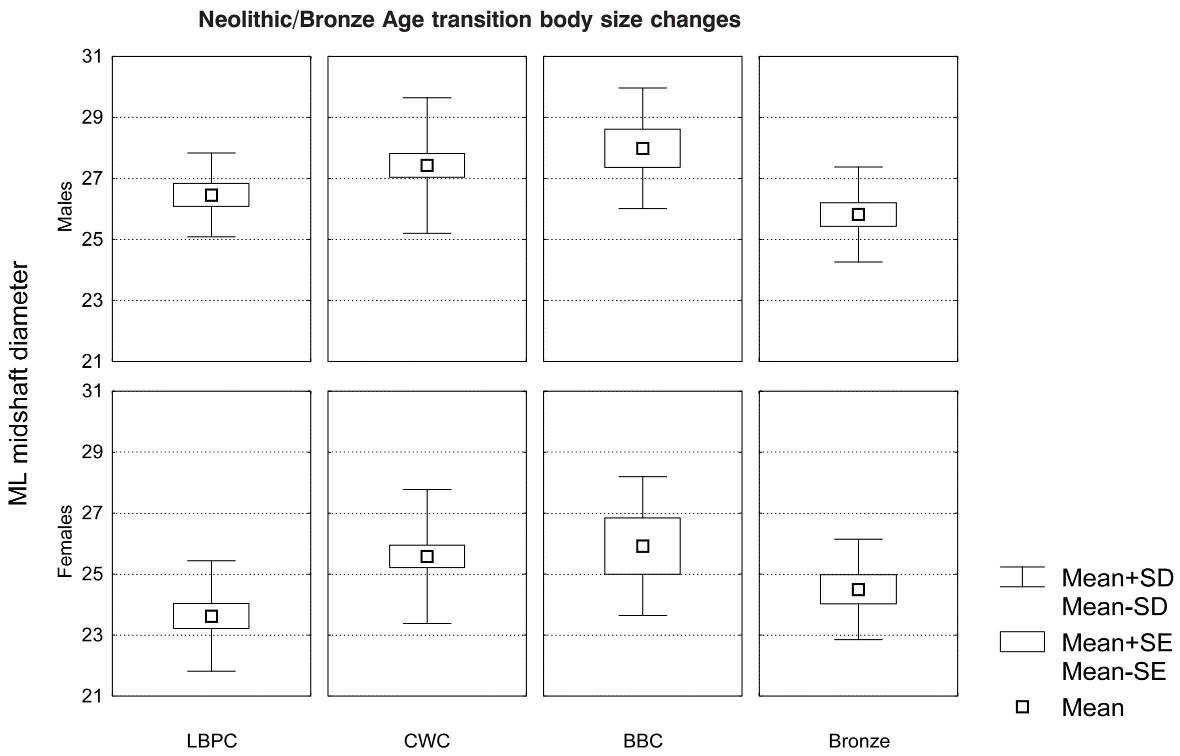
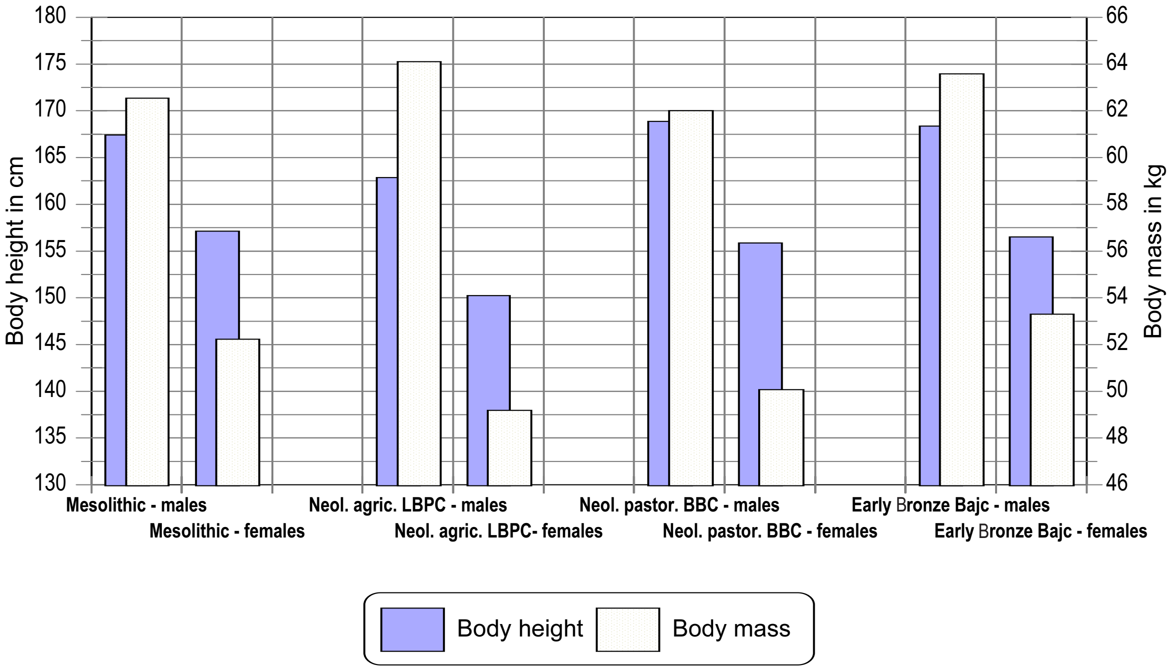
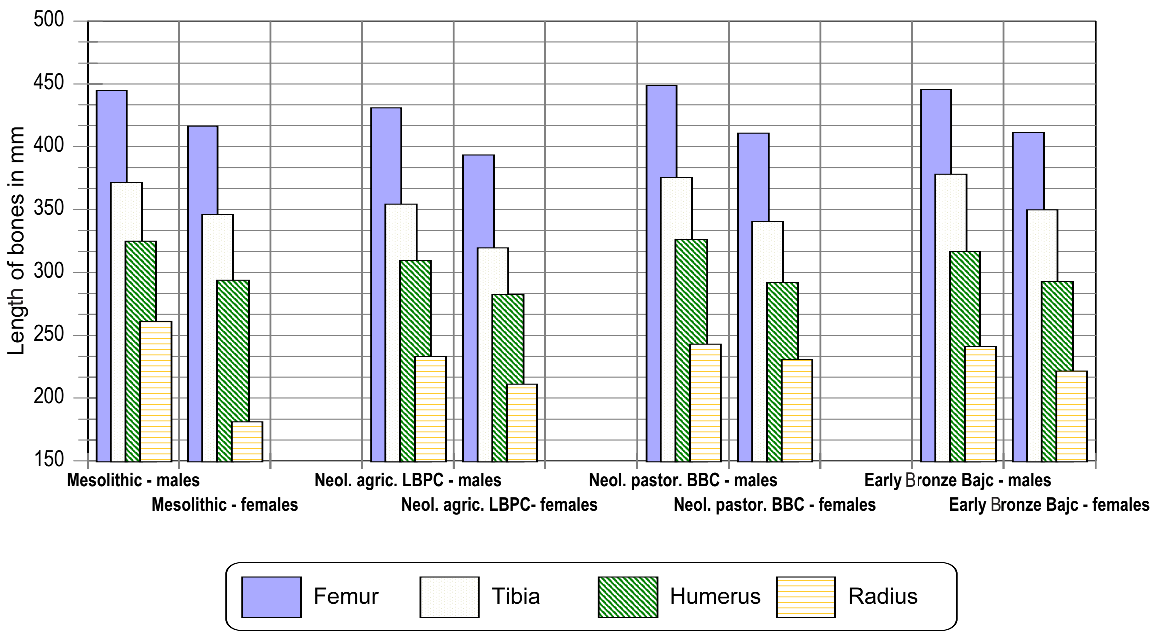


FIGURE 7. Body height, body mass and length of long limb bones for Mesolithic, Neolithic and Early Bronze Age human populations (Neol. – Neolithic, agric. – agriculturalists, pastor. – pastoralist / horticulturalist economy).





REFERENCES

AMMERMANN A. J., CAVALLI-SFORZA L., 1984: *The Neolithic Transition and the Genetics of Populations in Europe.* Princeton University Press, Princeton, NJ.

ANTHONY D. W., 1994: On subsistence change at the Mesolithic-Neolithic transition. *Curr. Anthrop.* 35: 49–58.

BACH A., 1978: *Neolitische Populationen in Mittelelbe-Saale-Gebiet.* Weimar Monographien zur Ur- and Frühgeschichte, Weimar.

BACH H., BACH A., 1981: Robustizitätverhältnisse und Körperhöhenentwicklung bei Neolithischen and Frühbronzezietlichen Bevölkerungen des Mittelelbe-Saale-Gebietes. *Beiträge zur Ur- und Frühgeschichte I,* 16: 185–195.

BARBUJANI G., BERTOLLI G., 2001: Genetics and the population history of Europe. *Proceedings of the National Academy of Science* 98: 22–25.

BARBUJANI G., PILASTRO A., DE DOMENICO S., RENFREW C., 1994: Genetic variation in North Africa and Eurasia: Neolithic demic diffusion vs. Paleolithic colonisation. *Amer. J. of Phys. Anthrop.* 95: 137–154.

BEHRENS H., 1973: Die Jungsteinzeit im Mittelelbe Saale Gebiet. Berlin.

BUCHVALDEK M. *et al.*, 1985: *Dějiny pravěké Evropy*. SPN, Praha (in Czech).

BOGUCKI P., 1982: *Early Neolithic Subsistence and Settlement in the Polish Lowlands.* Oxford: British Archaeological Reports (International Series 150).

BOGUCKI P., 1988: *Forest Farmers and Stockherders: Early Agriculture and its Consequences in North-Central Europe*. Cambridge University Press, Cambridge.

BOGUCKI P., 1999: *The Origins of Human Society*. Blackwell Publishers, Malden, Oxford.

ÉRY K., 1998: Length of limb bones and stature in ancient populations in the Carpathian Basin. *Humanbiologia Budapestinensis* 26: 1–86.

DOČKALOVÁ M. *et al.*, 1988: *Antropofagie a pohřební ritus doby bronzové*. Supplementum Sborníku Čs. společnosti antropologické při ČSAV, Brno.

FELDESMAN M. R., FOUNTAIN R. L., 1996: "Race" specifity and the femur stature ratio. *Amer. J. of Phys. Anthrop.* 100: 207–224.

FELDESMAN M. R., KLECKNER J. G., LUNDY J. K., 1990: The femur/stature ratio estimates of stature in mid- and late-Pleistocene fossil hominids. *Amer. J. of Phys. Anthrop.* 83: 359–372.

FELDESMAN M. R., LUNDY J. K., KLECKNER J. G., 1989: The femur/stature ratio estimates of stature in mid- and late-Pleistocene fossil hominids. *Amer. J. of Phys. Anthrop.* 78: 219–220.

FORMICOLLA V., 1983: Stature in Italian prehistoric samples with particular references to methodological problems. *Homo* 34: 33–47.

FORMICOLLA V., 1993: Stature reconstruction from long bones in ancient population samples: An approach to the problem of its reliability. *Amer. J. of Phys. Anthrop.* 90: 351–358.

FORMICOLLA V., FRANCESCHI M., 1996: Regression equations for estimating stature from long bones of Early Holocene European samples. *Amer. J. of Phys. Anthrop.* 100: 83–88.

FORMICOLLA V., GIANNECCHINI M., 1999: Evolutionary trends of stature in Upper Paleolithic and Mesolithic Europe. *J. of Hum. Evol.* 36: 319–333.

FRAYER D. W., 1980: Sexual dimorphism and cultural evolution in the Late Pleistocene and Holocene of Europe. *J. of Hum. Evol.* 9: 399–415.

FRAYER D. W., 1981. Body size, weapon use and natural selection in the Upper Paleolithic and Mesolithic Europe. *Amer. Anthrop.* 83: 57–73.

FRAYER D. W., 1984: Biological and cultural change in the European Late Pleistocene and Early Holocene. In: F. H. Smith, F. Spencer (Eds.): *The Origins of Modern Humans. A World Survey of Fossil Evidence*. Pp. 211–250. Alan R. Liss, Inc., New York.

FRAYER D. W., WOLPOFF M. H., 1985: Sexual dimorphism. *Annual Review of Anthropology* 14: 429–473.

GAMBLE C., 1995: *Timewalkers. The Prehistory of Global Colonization*. Penguin Books, London (first published by Allan Sutton Publishing 1993).

GRYGIEL R., BOGUCKI P., 1997: Early farmers in north-central Europe: 1989–1994 excavations at Oslonki, Poland. *J. of Field Archaeology* 24: 161–178.

HANÁKOVÁ H., STLOUKAL M., 1973: Pohřebiště ze starší doby bronzové v Bajči. *Časopis Národního muzea, odd. přírodovědný* 142(1/4): 58–88.

HOLLIDAY T. W., 1995: *Body size and proportions in the Late Pleistocene western old world and the origins of modern humans*. Ph.D. Thesis, University of New Mexico, Albuquerque.

CHARVÁTOVÁ M., 1999: *Postcranial skeleton of selected European Bronze Age and late Neolithic Populations (in Czech).* Diploma Thesis, Charles University, Prague.

CHOCHOL J., 1964: *Antropologické materiály z nových výzkumů neolitu a doby bronzové v Čechách.* Crania bohemica 1. AÚ ČSAV, Praha.

JACOBS K. J., 1985 a: Evolution in the postcranial skeleton of late Glacial and Postglacial European hominids. *Zeitschrift für Morphologie und Anthropologie* 75: 307–326.

JACOBS K. J., 1985 b: Climate and the hominid postcranial skeleton in Würm and Early Holocene Europe. *Curr. Anthrop.* 26: 512–514.

JACOBS K. J., 1992: Estimating femur and tibia length from fragmentary bones: an evaluation of Steele's (1970) method using a prehistoric European sample. *Amer. J. of Phys. Anthrop.* 89: 321–332.

JACOBS K. J., 1993: Human postcranial variation in the Ukrainian Mesolithic-Neolithic transition. *Curr. Anthrop.* 34: 311–324.

JANKOWSKA D., KRENZ-NIEDBAŁA M., PIONTEK J., WIERZBICKI J., 1999: *Biological and cultural consequences of the transition to agriculture in central Europe.* Monografie Instytutu antropologii UAM, 4, Poznañ.

JUNGERS W. L., 1988b: Lucy's length: Stature reconstruction in *Australopithecus afarensis* (A.L.288-1) with implications for other small-bodied hominids. *Amer. J. of Phys. Anthrop.* 76: 227–231.

JUNGERS W. L., STERN J. T., 1983: Body proportions, skeletal allometry and locomotion in the Hadar hominids: a reply to Wolpoff. *J. of Hum. Evol.* 12: 673–684.

KNUSSMAN R., 1988: *Anthropologie. Handbuch de vergleichenden Biologie des Menschen. Band 1: Wesen und Methoden der Anthropologie*. Gustav Ficher Verlag. Stuttgart, New York.

KRENZ-NIEDBAŁA M., 2000: *Biologiczne i kulturowe skutki neolityzacji w populacjach ludzkich na ziemiach polskich.* Ph.D. thesis, Institute of Anthropology, University of Poznań.

KRUK J., MILISAUSKAS S., 1999: *The Rise and Fall of Neolithic Societies (Rozkwit i upadek spoleczenstw rolniczych neolitu – full version in Polish)*. Institut archeologii i etnografii PAN, Krakow.

KRZAK Z., 1976: *The Złota Culture.* Ossolineum, Wrocław-Warszawa-Kraków-Gdańsk.

KRZAK Z., 1989: Złota Culture. Złota near Sandomierz, woj. Tarnobrzeg. Sites "Grodzisko I" and "Nad Wawrem", Cemeteries. *Przegląd Archeologiczny* 36: 255–269.
MARCINIAK A., 1992: Cultural adaptive strategies in the Neolithic in Central Europe within the context of palaeodemographic studies. *J. of European Archaeology* 1: 141–151.
McHENRY H. M., 1988: New estimates of body weight in early hominids and their significance to encephalization and megadontia in "robust" australopithecines In: F. E. Grine (Ed): *Evolutionary History of the "Robust" Australopithecines.* Pp.133–148. Aldine de Gruyter, New York.
McHENRY H. M., 1991: Sexual dimorphism in *Australopithecus afarensis*. *J. of Hum. Evol.* 20: 21–32.
McHENRY H. M., 1992: Body size and proportions in early hominids. *Amer. J. of Phys. Anthrop.* 87: 407–431.
MEIKLEJOHN C., SCHENTAG C., VENEMA A., KEY P., 1984: Socioeconomic change and patterns of pathology and variation in the Mesolithic and Neolithic in Western Europe: Some suggestions. In: M. N Cohen, G. J. Armelagos (Eds.): *Paleopathology at the Origins of Agriculture.* Pp. 75–100. Academic Press, Orlando.
MILISAUSKAS S., KRUK J., 1989: Neolithic economy in Central Europe. *J. of World Prehistory* 3: 403–446.
OLIVIER G., 1976: The stature of australopithecines. *J. of Hum. Evol.* 5: 529–534.
PAVELKOVÁ J., 1988: *Anthropology of Czech population of Bell Beaker Culture group (in Czech).* Ph.D. (CSc.) Thesis. Institute of Archaeology Prague, Czechoslovak Academy of Science, Prague.
PEČÍRKY J. *et al.*, 1989: *Dějiny pravěku a starověku*. SPN, Praha.
PIANKA E. R., 1995: *Evolutionary Ecology (fifth edition).* Harper Collins College Publishers, New York.
PIONTEK J., 1989. Biological consequences of the "Neolithic revolution": The case of the Middle European populations. In: I. Herzhkovitz (Ed.): *People and Culture in Change*. Pp. 177–195. BAR International Series 508, Tel Aviv.
PIONTEK J., 1993: Srodowisko a populacje ludskie w paleolicie i czasach postpaleolitycznych: Dwa modele adaptacji. In: J. Gladykowska-Rzeczycka (Ed.): *Czlowiek w czasie i przestrzeni.* Pp. 301–308. University of Gdańsk, Gdańsk.
PIONTEK J., 1999: Patterns of adaptive strategy in the Upper Paleolithic and post-Paleolithic populations: Evidence from Central Europe. In: H. Ullrich (Ed.): *Human Evolution and Environment.* Pp. 187–204. Humboldt Universität, Berlin.
PIONTEK J., 2001: Culture as a human adaptive system: Human ecology and culture. In: F. Tobias *et al.* (Eds.): *Humanity from African Naissance to Coming Millennia*. Pp. 47–54. Firenze University Press, Firenze.
PIONTEK J., MARCINIAK A., 1990 a. *Struktura antropologiczna a kulturowe strategie adaptacyjne populacji neolitycznych w Europie srodkowej.* Wydanwnictwo naukowe UAM, Poznan.
PIONTEK J., MARCINIAK A., 1990 b. *Biocultural Perspectives on Ecology of the Prehistoric Population from Central Europe.* Wydawnictwo SGGW-AR, Warszawa.
PIONTEK J., MARCINIAK A., 1992: Anthropological structure and culture adaptive strategies of the Neolithic populations in Central Europe. *Internat. J. of Anthropology* 7: 71–86.
PIONTEK J., VANČATA V., 1999: Evolutionary trends of body build changes in Upper Paleolithic – Neolithic transition. In: D. Šabík, J. Vigner, M. Vigner (Eds.): *IVth International Anthropological Congress of Aleš Hrdlička – Abstracts.* Pp. 120. Set Out, Praha.
PLEINER R. *et al.*, 1978: *Pravěké dějiny Čech*. SPN, Praha.
PODBORSKÝ V., 1993: *Pravěké dějiny Moravy*. UJEP, Brno.
RUFF C. B., WALKER A., 1993: Body size and body shape. In: A. Walker, R. E. Leakey (Eds.): *The Nariokotome* Homo erectus *Skeleton*. Pp. 234–265. Harvard University Press, Cambridge, MA.
SCIEULLI P. W., GIESEN M. J., 1993: Brief communication: An update on stature estimation in prehistoric Native Americans of Ohio. *Amer. J. of Phys. Anthrop.* 92: 395–399.
SJØVOLD T., 1990: Estimation of stature from long bones utilizing the line of organic correlation. *Hum. Evol.* 5: 431–447.
STROUHAL E., 1967: Das anthropologische Material des Gräberfeldes aus dem Übergang des Aeneolithikums und der Bronzezeit Ivánka/Donau in der Südwestslowakei. *Ac. Fac. Rer. Nat. Unive. Com. Anthrop.* 12: 7–54.
TABACZYŃSKI S., 1970: *Neolit środkowoeuropejski. Podstawy gospodarcze*. Wrocław – Warzawa – Kraków.
VAMPOLOVÁ J., VANČATA V., in press: Morphometry of the upper limb bones – Comparison of recent and upper Paleolithic man. In: I. Pap, T. Toth (Eds.): *Proceedings of the 3rd symposium on Upper Paleolithic, Mesolithic and Neolithic Populations.* Hungarian National Museum, Budapest.
VAMPOLOVÁ J., 1992: *Evoluční morfologie pletence a dlouhých kostí horní končetiny vyšších primátů a člověka ve vztahu k evoluci proporcí horní končetiny.* Thesis. Laboratory of Evolutionary Biology, Czechoslovak Academy of Science, Prague.
VANČATA V., 1981: *Evolution of hominoid locomotor apparatus and locomotion: Origin and evolution of bipedality (in Czech).* Ph.D. (CSc.) Thesis. Department of Evolutionary Biology, IM, Czechoslovak Academy of Science, Prague.
VANČATA V., 1988: Ecological aspects of skeletal sexual dimorphism in microevolution of *Homo sapiens*. *Anthropologie (Brno)* 26: 83–92.
VANČATA V., 1991: Evolution of higher primate femur and tibia: Adaptive morphological patterns and phylogenetic diversity. *Hum. Evol.* 6: 1–47.
VANČATA V., 1993: Evolution of hominid femur and tibia: A morphometric approach to the evolutionary research in anthropology. *Hum. Evol.* 8 (2): 65–79.
VANČATA V., 1996: Major patterns of early hominid evolution: Body size, proportions, encephalisation and sexual dimorphism. *Anthropologie (Brno)* 34(1–3): 313–328.
VANČATA V., 1997: *Body size and shape as an indicator of important evolutionary changes in hominoid phylogeny (in Czech).* Habilitation thesis. Charles University, Prague.
VANČATA V., 2000: Reconstruction of body height, body mass and body shape in fossil and historical human populations. In: J. Charzewski, J. Piontek (Eds.): *Nowe techniky i technologie badan materialow kostnych.* Pp. 11–34. Akademia wychowania fyzicznego Josefa Pilsudskiego, Warszawa.

Václav Vančata
Department of Biology
Division of Anthropology
Faculty of Education
Charles University in Prague
M. D. Rettigové 4
116 39 Praha 1
E-mail: Vaclav.Vancata@pedf.cuni.cz