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# BIOSOCIAL DIFFERENTIATION IN LITHUANIAN IRON AGE POPULATION

*ABSTRACT: Biological differences within the population can be influenced by social processes. The variations in stature and osteometric indices are consequences of social stratification. As differential access to food resources is much related to social status, one can expect parallels between the physical development and dietary indicators. The aim of the paper is to discuss relations between individual social status, bone lengths, stature and trace element concentrations in the 5th–6th cc. A.D. population of Plinkaigalis, Lithuania. Data of 82 adult males and 64 females were analysed. Statistically significant trend of male osteometric indices was found: individuals inhumed in rich grave inventory graves were taller. As no such tendency was detected for females, social groups also differed in terms of sexual dimorphism (the highest dimorphism was found in the richest group). However, general mineralisation of the skeleton and trace element analysis (contents of Ca, Zn, Cu, Mn, Fe, Pb, Sr, Zn/Ca and Sr/Ca ratios) revealed only weak regularities: males of high social status were consuming more food rich in animal protein, while the diet of females and low status males was based mostly on plant products.*

*KEY WORDS: Osteometry – Stature reconstruction – Trace elements – Biosocial differentiation – Lithuania – Iron Age*

## INTRODUCTION

Historical sciences have lately been paying much more attention to the history of daily life, or the "history from below". History is considered not only as a chain of historical events or acts of personalities' will, but also as the history of so-called "nameless crowd". Thus principal topics of everyday life – modes of subsistence, nutrition, disease, epidemics and population dynamics – also became the objects of historical sciences (Wolfsperger 1993). Concerning anthropology, its principal object always were those anonymous individuals who left no written records (Cohen, Armelagos 1984).

Investigation of biological processes within the populations is one of the trends in contemporary historical anthropology (Goodman *et al.* 1988). Intra-population differentiation can be analysed from the geographic, diachronic and social points of view. Numerous investigations prove the presence of biological differences between social groups in recent (Bielicki, Welon 1982, Ekwo *et al.* 1992, Hulanicka 1992, Cieslik, Kosinska 1993) and archaeological populations (Boldsen 1988, Molleson 1992, Kozak 1993, Buzhilova 1995, Mednikova 1995). Sometimes distinct craniometric differentiation in archaeological populations is noted (Rösing, Schwidetzky 1987, Teschler-Nicola 1989). Better life conditions enable more complete phenotypical realisation of the individual genotype (Bergman 1987). However, this general rule can have exceptions, as phenotypic expression of particular traits in a particular population depends not only on the ecosensitivity of the trait, but also on the genetic polymorphism of the population (Henneberg, Lewicki 1978).

Variations of stature – the best analysed index of biological status – are one consequence of social differentiation. In many socially stratified archaeological populations individuals of higher social status were also of higher stature. Examples are known from the Bronze

Age (Teschler-Nicola 1989), Early Medieval Alemans and Slavs (Rösing, Schwidetzky 1987), Late Medieval samples (Kunter 1994). Later historical sources also confirm this phenomenon (Wurm 1983, Mascie-Taylor 1991). Stature decrease and gracilisation were noted during transition to a more sedentary mode of life, dietary shift to more vegetarian food (Pap 1986), also during early urbanisation (Fedosova 1993, Jankauskas 1995).

According to the opinion of some authors, lower stature is a consequence of higher stresses experienced by the total population or its part (Frisancho *et al.* 1970, Goodman 1993). Malnutrition, especially protein deficiency, diseases etc. are the causes of such stresses (Goodman *et al.* 1988, Mascie-Taylor 1991). Males are more sensitive to harmful factors of environment (Stini 1969, Frayer, Wolpoff 1985), as in males the genetic component of stature is lower (Mascie-Taylor 1991). Probably selection was acting in favour of higher female resistance, as females are confronted with higher stresses related to pregnancy and lactation. On the other hand, unfavourable conditions of the environment could have less impact on males, as in a majority of societies boys occupy a more privileged position (Stinson 1985). It means that if other factors are stable, male and female stature differences can vary due to the environment. Thus the expression of sexual dimorphism in different populations or social groups within the same population for a long time is the subject of interest of bioanthropologists (Bennet 1981, Hamilton 1982, Goodman *et al.* 1988). Fluctuations in sexual dimorphism can be explained as a consequence of long-term directional selection and mating systems (in case of polygamy, more robust and aggressive males can expect more numerous progeny), gender role differences and division of labour (Borgognini Tarli, Repetto 1986, Sciulli *et al.* 1993), but such explanations are difficult to prove in human communities (Frayer, Wolpoff 1985). For human biosocial differentiation, short-term ecological vectors are more important, when not adaptation on population level, but individual acclimatisation takes place. Nutritional factors play the crucial role. Malnutrition causes stature decrease, and to higher extent for males. Due to this, sexual dimorphism in population also decreases (Stini 1969, 1972, Gray, Wolfe 1980).

In this way nutrition could be the principal cause of stature variation within the stratified population. For individuals with different social status, differential access to alimentary resources takes place. Thus diet investigations could provide valuable data on human social organization (Klepinger 1984, Molleson 1992, Perez-Perez, Lalueza Fox 1992). The chemical composition of an inorganic fraction of compact bone to some extent reflects nutrition of an individual. Hydroxyapatite crystals due to exchange of ions can accumulate other elements that substitute calcium. Such processes can take place both intravitally (biogenic processes) and postmortally (diagenesis) (Lambert *et al.* 1985). Taking into account both processes, numerous studies have been performed in order to evaluate peculiarities of ancient diets (Sillen, Kavanagh 1982, Klepinger 1984, Gilbert, Mielke 1985, Arrhenius 1990, Wolfsperger 1993, Lidén 1996). Trace elements, composing less than 0.01% of body mass, are the most informative; in theory, according to their absolute contents and ratios it is possible to estimate animal/vegetable food components (Sandford 1992).

Strontium (Sr) is one of the most valued trace elements. Sr can substitute calcium (Ca) in plant and animal metabolism, but Sr is discriminated in favour of Ca by enterocytes during intestinal absorption; moreover, Sr is faster excreted through kidneys. As 99% of absorbed Sr is deposited in bones and its concentration is little affected by diagenesis, Sr contents indicate the rank of an animal in the food chain. Sr concentration and Sr/Ca ratio decrease from herbivores to carnivores, omnivores occupying an intermediate position (Sillen, Kavanagh 1982, Klepinger 1984, Sandford 1992). This phenomenon was extensively used in numerous paleodietary studies (Fornaciari, Mallegni 1987, Francalacci 1988, Grupe, Bach 1993, Smrčka *et al.* 1994). However, other peculiarities of nutrition and metabolism can bring confusion and make the interpretation of results difficult: high calcium intake with dairy products decreases Sr level (Wolfsperger 1993), marine food increases Sr (Yaşar Işcan, Marits 1992), and lactation increases Sr, too (Sandford 1992, Polet 1992).

Zinc (Zn) is another valuable diet indicator, as it is also less influenced by diagenesis. The principal source of Zn is animal food, hence high concentration of Zn reflects high animal protein contents in the diet (Francalacci 1988, Molleson 1990, Sandford 1992, Smrčka *et al.* 1994). Nevertheless, its absorption can be compromised by high concentration of phytate ingested with vegetable components (Kasavina, Torbenko 1975, Wolfsperger 1993).

Copper (Cu) and iron (Fe) are potentially good indicators of animal proteins, but their concentration is strongly influenced by diagenesis (Lambert *et al.* 1984, Francalacci 1988, Sandford 1992, Yaşar Işcan, Marits 1992). The same is true for manganese (Mn), mostly obtained from vegetable food – it can serve as an indicator of pollution (Wolfsperger *et al.* 1993). Lead (Pb), a toxic element, is considered to be a marker of pollution and intoxication (Sandford 1992).

Therefore, this paper has two goals:

1. To discuss relations between individual social status, bone length, stature as an integrative index of physical development, and sexual dimorphism.
2. To search for parallels between general skeletal mineralisation, trace element concentrations as dietary indicators, physical development and social status.

## MATERIALS AND METHODS

Material from Plinkaigalis 5th–6th cc. A.D. burial ground was used for analysis. The site is located in Central





TABLE 1. Male upper extremity bone length, in mm (measurements according to Martin, Saller 1957; H1 – *humerus*; R1 – *radius*, U1 – *ulna*).

| | Rich | | | Average | | | Poor | | | Total sample* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H1 | R1 | U1 | H1 | R1 | U1 | H1 | R1 | U1 | H1 | R1 | U1 |
| Sample size (N) | 14 | 17 | 12 | 29 | 33 | 30 | 6 | 10 | 7 | 53 | 64 | 51 |
| Average (M) | 346.6 | 265.6 | 287.5 | 339.1 | 261.8 | 285.5 | 328.3 | 251.4 | 275.1 | 340.6 | 261.8 | 285.8 |
| Standard deviation (S) | 15.5 | 10.0 | 8.1 | 14.4 | 11.9 | 11.1 | 10.6 | 12.8 | 7.1 | 15.7 | 12.7 | 11.4 |
| Minimum (Min.) | 320 | 244 | 275 | 306 | 238 | 261 | 316 | 232 | 266 | 306 | 232 | 261 |
| Maximum (Max.) | 370 | 282 | 305 | 363 | 290 | 309 | 344 | 280 | 285 | 370 | 290 | 316 |
| Significance of difference (p) | | | | | | | | | | **0.0463** | **0.0137** | **0.0359** |

*including not classified

TABLE 2. Male lower extremity bone length, in mm (measurements according to Martin, Saller 1957; F2 – *femur*; T1 – *tibia*, Fi1 – *fibula*).

| | Rich | | | Average | | | Poor | | | Total sample* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F2 | T1 | Fi1 | F2 | T1 | Fi1 | F2 | T1 | Fi1 | F2 | T1 | Fi1 |
| Sample size (N) | 19 | 17 | 3 | 36 | 30 | 7 | 10 | 10 | 4 | 69 | 62 | 15 |
| Average (M) | 481.9 | 399.9 | 382.3 | 474.9 | 392.7 | 378.6 | 460.8 | 376.6 | 359.5 | 479.9 | 393.4 | 373.1 |
| Standard deviation (S) | 19.8 | 11.0 | 20.0 | 20.5 | 19.8 | 22.8 | 22.6 | 23.8 | 9.1 | 21.8 | 21.6 | 20.9 |
| Minimum (Min.) | 437 | 385 | 354 | 434 | 355 | 338 | 428 | 336 | 352 | 428 | 366 | 338 |
| Maximum (Max.) | 517 | 424 | 397 | 513 | 435 | 412 | 501 | 425 | 375 | 517 | 461 | 412 |
| Significance of difference (p) | | | | | | | | | | **0.0445** | **0.0123** | **0.3197** |

*including not classified

TABLE 3. Female upper extremity bone length, in mm (measurements according to Martin, Saller 1957; H1 – *humerus*; R1 – *radius*, U1 – *ulna*).

| | Rich | | | Average | | | Poor | | | Total sample* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H1 | R1 | U1 | H1 | R1 | U1 | H1 | R1 | U1 | H1 | R1 | U1 |
| Sample size (N) | 2 | 3 | 1 | 16 | 20 | 17 | 14 | 14 | 12 | 39 | 46 | 35 |
| Average (M) | 313.0 | 230.7 | 249.0 | 309.7 | 238.3 | 261.2 | 312.4 | 241.1 | 264.1 | 311.6 | 238.6 | 262.9 |
| Standard deviation (S) | 5.0 | 1.2 | - | 12.7 | 12.0 | 9.2 | 14.8 | 14.8 | 17.5 | 15.8 | 14.3 | 14.9 |
| Minimum (Min.) | 308 | 229 | - | 277 | 210 | 236 | 290 | 224 | 245 | 277 | 210 | 235 |
| Maximum (Max.) | 318 | 232 | - | 331 | 257 | 271 | 350 | 278 | 305 | 361 | 278 | 305 |
| Significance of difference (p) | | | | | | | | | | **0.8505** | **0.4555** | **0.5474** |

*including not classified

TABLE 4. Female lower extremity bone length, in mm (measurements according to Martin, Saller 1957; F2 – *femur*; T1 – *tibia*, Fi1 – *fibula*).

| | Rich | | | Average | | | Poor | | | Total sample* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F2 | T1 | Fi1 | F2 | T1 | Fi1 | F2 | T1 | Fi1 | F2 | T1 | Fi1 |
| Sample size (N) | 3 | 1 | 0 | 27 | 20 | 1 | 17 | 14 | 0 | 55 | 39 | 1 |
| Average (M) | 449.0 | 361.0 | - | 438.7 | 359.6 | 374.0 | 433.3 | 357.3 | - | 437.8 | 359.9 | 374.0 |
| Standard deviation (S) | 9.0 | - | - | 21.0 | 15.5 | - | 23.4 | 25.1 | - | 23.1 | 21.0 | - |
| Minimum (Min.) | 438 | - | - | 391 | 320 | - | 384 | 313 | - | 384 | 313 | - |
| Maximum (Max.) | 460 | - | - | 472 | 384 | - | 496 | 414 | - | 499 | 414 | - |
| Significance of difference (p) | | | | | | | | | | **0.4763** | **0.9546** | **-** |

*including not classified

Lithuania, on a flat morenic hill. Investigations took place in the years 1977–1984, an area of 4,500 m² was excavated, and 364 inhumation graves containing 379 skeletons, 8 cremations, and 3 graves of horses were uncovered. The soil conditions (white sand and tawny gravel of the hill) favoured excellent preservation of skeletons and grave goods (more than 2,200 artefacts of metal, glass, amber, stone and clay) (Kazakevičius 1993).

The geographical environment of the area at that period was very favourable: the curved valley of a small river was convenient for dwelling. The soil was fertile, turf-carbonate, rich in potassium and nitrogen compounds. Therefore a dense network of archaeological sites of that period was established in the area. In the Lithuanian archaeological chronology, the period to which Plinkaigalis burial ground belongs is attributed to the Middle Iron Age. It coincides with the Great Migration period in Europe. Remarkable cultural changes took place at that time, including changes of settlement type. Communities were living in small hamlets (4–10 families). Daily subsistence

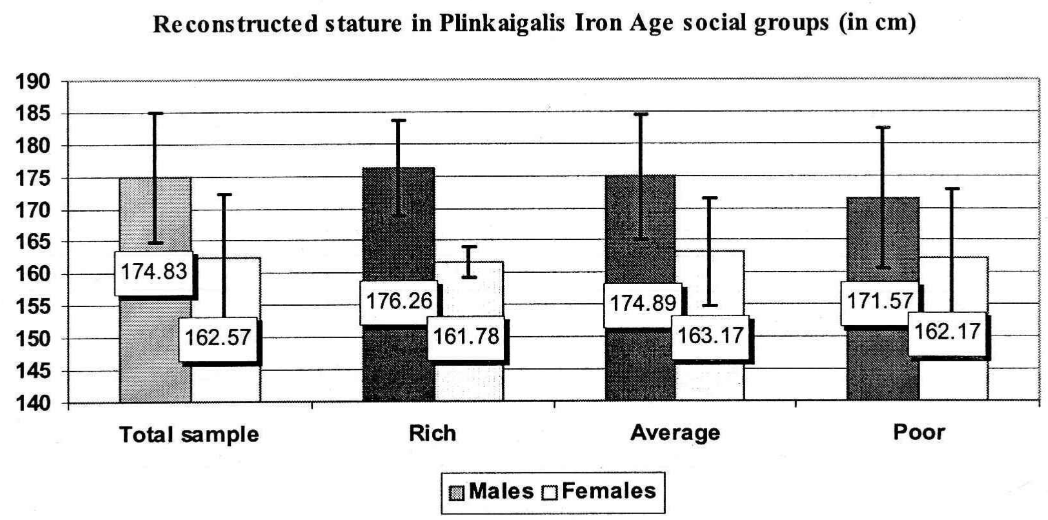


FIGURE 1. Average stature in Plinkaigalis sample social groups (bars – standard errors of means).

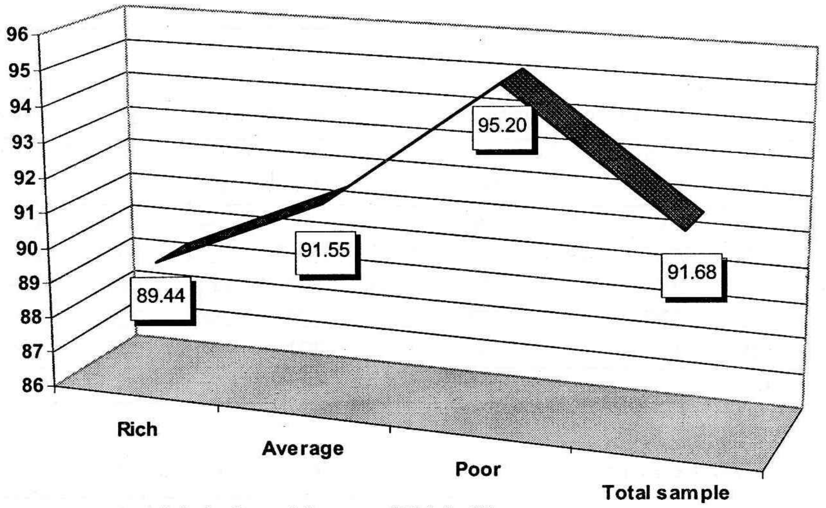


FIGURE 2. Sexual dimorphism of stature in Plinkaigalis social groups (F/M, in %).

was based on terrestrial food – agriculture products (mostly barley, wheat, peas and beans, some vegetables), husbandry (beef, pork, sheep and goat, horse meat; milk products, eggs constituted a lesser part of the diet and depended on the season). Big game (deer, elk) was also substantial. Fishing, products of foraging (honey, berries, mushrooms) were supplementary (Tautavičius 1996).

Data of adult individuals (82 males, 64 females) were taken for analysis. Sex and age was determined using conventional morphological features (Sjøvold 1988, Szilvássy 1988). According to the grave inventory, archaeologist A.Tautavičius classified the graves into 3 categories: rich, average, and poor. Each skeleton was osteometrically investigated according to the standard programme (Martin, Saller 1957). Stature reconstruction from all long bones was performed using Lithuanian regression equations (Garmus, Jankauskas 1993). Left side bones were given preference. For general mineralisation (GM) and trace element concentrations, samples of compact bone were taken with hollow drill from the proximal end of the tibia. GM was estimated as percent ratio of bone organic mass to bone sample mass. For trace element concentrations, Hitachi and Perkin Elmer atomic flame spectrophotometers were used (Kozlovskaya 1993). Regretfully, no soil samples for comparison were available; however, this methodological shortage could be also benefited for an evaluation of the usefulness of museum specimens for such an analysis.

## RESULTS AND DISCUSSION

### Bone length, stature and sexual dimorphism

The analysis of limb bone lengths revealed a statistically significant trend for males (results of ANOVA): males from graves rich in inventory (assumption was made that this





TABLE 5. General mineralisation (GM) (%) of the skeleton in Plinkaigalis social groups of males and females.

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 27 | 11 | 59 | 1 | 21 | 12 | 40 |
| Average (M) | 76.31 | 80.55 | 78.93 | 78.95 | 80.84 | 78.57 | 79.52 | 79.41 |
| Standard deviation (S) | 4.25 | 6.29 | 4.72 | 5.90 | - | 5.43 | 6.81 | 6.19 |
| Minimum (Min.) | 68.6 | 68.6 | 72.4 | 68.6 | - | 69.6 | 72.9 | 69.6 |
| Maximum (Max.) | 85.1 | 94.1 | 90.1 | 94.1 | - | 92.5 | 93.1 | 93.1 |
| Significance of difference between social groups (p) | | | | 0.0654 | | | | 0.8715 |

*including not classified

TABLE 6. Calcium (Ca) contents in Plinkaigalis social groups of males and females (mg/g).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 62 | 1 | 21 | 14 | 42 |
| Average (M) | 263.0 | 277.0 | 274.0 | 272.6 | 250.6 | 264.5 | 269.7 | 272.0 |
| Standard deviation (S) | 45.6 | 45.9 | 55.9 | 47.4 | - | 34.7 | 32.0 | 43.3 |
| Minimum (Min.) | 154.6 | 210.7 | 206.6 | 154.6 | - | 186.6 | 216.0 | 183.6 |
| Maximum (Max.) | 333.6 | 423.7 | 381.2 | 423.7 | - | 317.8 | 315.8 | 464.0 |
| Significance of difference between social groups (p) | | | | 0.6568 | | | | 0.8215 |

*including not classified

TABLE 7. Zinc (Zn) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 15 | 29 | 11 | 61 | 1 | 21 | 14 | 42 |
| Average (M) | 72.95 | 75.41 | 71.33 | 75.40 | 67.07 | 72.35 | 72.74 | 72.00 |
| Standard deviation (S) | 9.72 | 9.88 | 8.54 | 11.93 | - | 15.83 | 15.81 | 14.86 |
| Minimum (Min.) | 55.28 | 58.26 | 59.70 | 55.28 | - | 50.10 | 53.45 | 50.10 |
| Maximum (Max.) | 93.03 | 93.60 | 89.80 | 120.93 | - | 104.61 | 112.56 | 112.56 |
| Significance of difference between social groups (p) | | | | 0.4617 | | | | 0.9452 |

*including not classified

TABLE 8. Copper (Cu) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 62 | 1 | 21 | 14 | 42 |
| Average (M) | 70.58 | 3.67 | 2.02 | 20.57 | 3.76 | 4.30 | 2.69 | 3.47 |
| Standard deviation (S) | 197.07 | 5.29 | 0.83 | 104.43 | - | 8.20 | 0.96 | 5.89 |
| Minimum (Min.) | 1.24 | 1.00 | 1.11 | 0.87 | - | 1.14 | 0.80 | 0.80 |
| Maximum (Max.) | 809.16 | 26.43 | 4.36 | 809.16 | - | 40.48 | 4.75 | 40.48 |
| Significance of difference between social groups (p) | | | | 0.1197 | | | | 0.7772 |

*including not classified

TABLE 9. Manganese (Mn) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 61 | 1 | 21 | 14 | 42 |
| Average (M) | 30.82 | 46.55 | 40.70 | 39.23 | 13.10 | 63.42 | 100.52 | 69.60 |
| Standard deviation (S) | 26.09 | 38.22 | 32.77 | 33.64 | - | 72.65 | 185.45 | 121.61 |
| Minimum (Min.) | 7.15 | 6.23 | 9.18 | 6.23 | - | 8.77 | 3.48 | 3.48 |
| Maximum (Max.) | 96.05 | 149.13 | 128.14 | 149.13 | - | 247.36 | 696.16 | 696.16 |
| Significance of difference between social groups (p) | | | | 0.3607 | | | | 0.6496 |

*including not classified

TABLE 10. Iron (Fe) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 62 | 1 | 21 | 14 | 42 |
| Average (M) | 68.80 | 69.65 | 78.84 | 72.11 | 59.70 | 117.71 | 146.15 | 119.46 |
| Standard deviation (S) | 45.67 | 40.06 | 57.78 | 46.45 | - | 69.01 | 120.99 | 89.10 |
| Minimum (Min.) | 12.80 | 17.64 | 18.03 | 12.80 | - | 27.12 | 32.37 | 27.12 |
| Maximum (Max.) | 197.21 | 212.15 | 197.96 | 212.15 | - | 258.07 | 532.71 | 532.71 |
| Significance of difference between social groups (p) | | | | 0.8335 | | | | 0.5436 |

*including not classified

TABLE 11. Lead (Pb) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 2 | 4 | 1 | 8 | 0 | 3 | 2 | 6 |
| Average (M) | 7.52 | 1.16 | 0.50 | 2.82 | - | 2.57 | 1.36 | 1.76 |
| Standard deviation (S) | 5.69 | 0.53 | - | 3.98 | - | 2.32 | 0.33 | 1.89 |
| Minimum (Min.) | 1.83 | 0.39 | - | 0.39 | - | 0.88 | 1.03 | 0.10 |
| Maximum (Max.) | 13.20 | 1.72 | - | 13.20 | - | 5.86 | 1.69 | 5.86 |
| Significance of difference between social groups (p) | | | | 0.2712 | | | | 0.6135 |

*including not classified

TABLE 12. Strontium (Sr) contents in Plinkaigalis social groups of males and females (ppm).

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 62 | 1 | 21 | 14 | 42 |
| Average (M) | 84.72 | 112.32 | 103.84 | 92.82 | 85.92 | 102.05 | 108.77 | 103.26 |
| Standard deviation (S) | 24.48 | 31.36 | 18.48 | 29.60 | - | 21.04 | 34.08 | 29.51 |
| Minimum (Min.) | 23.28 | 73.44 | 79.04 | 23.28 | - | 62.96 | 58.72 | 19.84 |
| Maximum (Max.) | 117.52 | 133.28 | 150.96 | 213.28 | - | 150.64 | 191.60 | 191.60 |
| Significance of difference between social groups (p) | | | | 0.0104 | | | | 0.6310 |

*including not classified

TABLE 13. Zinc and Calcium ratios (Zn/Ca) in Plinkaigalis social groups of males and females.

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 15 | 29 | 11 | 61 | 1 | 21 | 14 | 42 |
| Average (M) | 0.289 | 0.279 | 0.269 | 0.284 | 0.268 | 0.278 | 0.278 | 0.271 |
| Standard deviation (S) | 0.080 | 0.057 | 0.053 | 0.064 | - | 0.068 | 0.088 | 0.072 |
| Minimum (Min.) | 0.166 | 0.154 | 0.180 | 0.154 | - | 0.170 | 0.184 | 0.170 |
| Maximum (Max.) | 0.445 | 0.394 | 0.340 | 0.445 | - | 0.397 | 0.519 | 0.519 |
| Significance of difference between social groups (p) | | | | 0.7488 | | | | 0.9914 |

*including not classified

TABLE 14. Strontium and Calcium ratios (Sr/Ca) in Plinkaigalis social groups of males and females.

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Rich | Average | Poor | Total* | Rich | Average | Poor | Total* |
| Sample size (N) | 16 | 29 | 11 | 62 | 1 | 21 | 14 | 42 |
| Average (M) | 0.338 | 0.408 | 0.396 | 0.388 | 0.343 | 0.393 | 0.403 | 0.384 |
| Standard deviation (S) | 0.144 | 0.104 | 0.122 | 0.119 | - | 0.096 | 0.104 | 0.106 |
| Minimum (Min.) | 0.096 | 0.280 | 0.240 | 0.098 | - | 0.216 | 0.208 | 0.076 |
| Maximum (Max.) | 0.728 | 0.792 | 0.624 | 0.791 | - | 0.576 | 0.608 | 0.607 |
| Significance of difference between social groups(p) | | | | 0.1820 | | | | 0.8420 |

*including not classified





equals to their higher status in society) had longer bones of extremities (*Tables 1* and *2*). Concerning females, no impact of grave inventory quantity or quality on limb bone length could be found (*Tables 3* and *4*). Data on reconstructed stature (more general, although less exact index) confirm this statement (*Figure 1*).

Data on sexual dimorphism are very instructive (*Figure 2*): if in the rich grave group average length of all bones of extremities for females composed only about 90% of male lengths (this corresponds to 10% sexual difference), in the poorest group this index was 96% (minimal, only 4% sexual difference). In this way the opinion of other investigators that social stratification can be reflected in indices of physical development, is confirmed. This phenomenon could have two explanations: either taller and physically stronger males had better possibilities to reach higher social status, either people of higher rank, especially males, had better conditions already in childhood, during growth, i.e. the status was achieved not only by one's individual life and efforts, but (at least in part) was also inherited. The last hypothesis suggests that Lithuanian Iron Age communities were on the advanced stage of chiefdoms, approaching the level of statehood.

### General mineralisation of the skeleton and trace element contents

As the factor of age at death had no significant impact neither on GM, nor on trace element concentrations, age group samples were pooled. The analysis of GM revealed no sexual differences; no significant tendencies in male and female social groups could be found (*Table 5*). It can be concluded that GM variation can be related to the different intensity of decay, not to lifetime peculiarities.

Calcium and Zinc contents also did not vary significantly among social groups (*Table 6, Table 7*). Although females tend to have lower Ca and Zn levels, differences did not reach significance level. Copper contents were enormously high in some rich male graves (*Table 8*), causing very high range of variation. We think that this is conditioned by diagenesis – pollution of bones from the bronze grave goods and other copper containing artefacts. Notwithstanding this phenomenon, social and sexual differences were insignificant. For Manganese and Iron, a reverse tendency could be traced: their concentrations tend to be slightly, although insignificantly, higher among females and lower status groups (*Table 9, Table 10*). Again, these trace elements demonstrate substantial variability, suggesting effects of diagenesis. Lead was found in higher concentrations among rich males (*Table 11*), but differences were insignificant, and range of variation broad. Only Strontium concentrations among males (*Table 12*) show clear statistically significant dependency on the social status: in rich graves its concentration is lower. Females also have slightly higher Sr contents. Zn/Ca and Sr/Ca ratios (*Table 13, Table 14*) point to weak and insignificant tendencies: the increase of Zn and the decrease of Sr in higher status groups, especially among males.

Finally, the testing of relations between trace element concentrations and bone lengths was performed. As correlation coefficients were low (0.2 and less) and insignificant, the conclusion was made that it is impossible to detect such relations in the Plinkaigalis sample.

Thus, indices of skeletal mineralisation and trace element concentrations have rather weak direct relations to biosocial differences. This could mean that generally speaking, all social groups in that agricultural society had similar diets. In our opinion, very complex interactions of biogenetic and diagenetic factors should also be taken into account. However, lower Sr and Mn, higher Zn concentrations indicate that individuals of high social rank, especially males, were consuming more "prestigious" food, rich in animal protein. The diet of females and low status community members was more based on plant food. As dairy products gained significance in Europe only in Late Medieval times (Wolfsperger 1993), we could assume that the impact of milk consumption on Sr/Ca ratios was minimal. The effect of marine food can also be rejected (Tautavičius 1996).

## CONCLUSION

Middle Iron Age communities in Lithuania were not uniform in both social and biological aspects. Social stratification had also influence on biological differences. Physical development of adults could be a good illustration of such stratification. The cause of such biological differences could also be unequal access to animal protein products, optimally amino-acid balanced, easily absorbed, rich in calories, i.e. of higher biological value. Although studies of trace elements as diet indicators meet methodological problems difficult to solve, parallels between Sr, Sr/Ca, Zn indices and social status indicators allow us to confirm this assumption.

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