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SOME MACRO—AND MICROSTRUCTURAL ASPECTS OF THE LOWER EXTREMITY BONES IN THE POPULATION OF LATVIA ACCORDING TO PALAEOANTHROPOLOGICAL DATA

ABSTRACT. — The samples of thighbones and shinbones coming from different parts of Latvian prehistory and from historical times were studied.

It was found that heavier physical loads and hard living conditions contributed to both macro and microstructural changes in long bones. A lower cellular element number in compact substance of medieval long bones can be explained by hard living conditions (e.g. forced labour, undernourishment, insufficient rest).

The slightly lower cellular element number in long bones compact substance of the twentieth century population is due to urbanization, lower physical load, higher motorisation and less walking.

INTRODUCTION

The transformation of higher ape species to primitive man took many hundred thousand years (M. F. Nesturkh, 1970, J. Jelínek, 1977).

Subsequent alterations in primitive man's skeleton were functions of physical loads and living conditions.

Higher physical loads were found to cause changes not only in the bone relief, but also in the bone microstructure (L. Vyhnánek, M. Stloukal, 1968, V. J. Derums, 1973, V. J. Derums, G. I. Demidov, 1976).

As shown by expertiments on animals exposed to intensified physical loads tubular bones had their inner microstructure rearranged, with additional osteon occurences (E. A. Klebanova, 1954).

The first microstructure was studied in Egyptian mummies by J. Czermak (1879) (quoted from E. Strouhal, L. Vyhnánek, 1979). This study was continued by M. A. Ruffer (1911) (quoted from E. Strouhal, L. Vyhnánek, 1979) but in 1949 W. Graf (quoted from E. Strouhal, L. Vyhnánek, 1979) perfected this method and proposed the term "Paleohistology".

Extensive investigations of Egyptian mummies have been made in 1979 (E. Strouhal, L. Vyhnánek). There are reports from Byelorussia (L. N. Kazei, 1973) that cellular elements have been found in the bones of the people, living in the 11—13th centuries.

When studying the microstructure of pathological processes in fossil bones, besides investigating the surface lately microroentgenography has been applied, too (C. A. Baud, 1980).

Our efforts to find any published information dealing with age-long alterations of the extremity bone microstructure due to improving social/economic conditions, better tools and lower physical loads, have failed.

Our recent studies of palaeoanthropological ossesous matter (1978, 1980) were designed to reveal any dynamics in alterations occuring in the lower extremity bone microstructure and its biomechanical properties.

With the recent decade seeing human body development acceleration established, this problem seems to have become even more acute importance.

TABLE 1. *Indices of Tibiae Bones Measurements of the Population in Latvia from Neolithic to the 20th Century of Our Era*

Numbers of 11 measurements	1	2	3	4	5	6	7	8	9	10	11
Men											
1. Neolith. Cemetery Zvejnieki. Excavations — F. Zagorskis.	36.88 ± 1.33*	7.40 ± 0.46	5.23 ± 0.39	2.38 ± 0.31	2.09 ± 0.20	4.87 ± 0.43	3.34 ± 0.42	3.92 ± 0.42	0.80 ± 0.17	0.80 ± 0.18	12.80 ± 3.04
2. Bronze ages. Cemetery Kivutkalns. — Excavat. J. Graudonis.	38.96 ± 0.45	7.26 ± 0.16	5.37 ± 0.51	2.52 ± 0.19	2.22 ± 0.16	4.95 ± 0.40	3.56 ± 0.36	3.75 ± 0.33	0.81 ± 0.14	0.86 ± 0.26	12.70 ± 1.57
3. Middle ages (14—16th c.) Cemet. Mārtinsala — Exc. E. Mugurevič.	37.97 ± 0.74*	7.59 ± 0.40*	5.28 ± 0.28	2.52 ± 0.17	2.20 ± 0.12	5.02 ± 0.35	3.13 ± 0.22*	3.81 ± 0.33	0.75 ± 0.13	0.76 ± 0.14	11.00 ± 0.82*
4. Middle ages (15—16th c.). Cemet. Valmiera — Excav. M. Atgāzis.	37.99 ± 2.16	7.50 ± 0.41	5.27 ± 0.24	2.47 ± 0.28	2.03 ± 0.18*	4.81 ± 0.43	3.16 ± 0.45*	3.57 ± 0.35	0.67 ± 0.11*	0.70 ± 0.15	12.71 ± 1.60
5. XX century. Muzeum of normal Anatomy — Medic. Instit. Riga.	37.50 ± 0.62*	7.03 ± 0.18*	5.21 ± 0.36	2.37 ± 0.27	2.13 ± 0.20	4.72 ± 0.42	3.26 ± 0.25*	3.56 ± 0.25	0.70 ± 0.12*	0.35 ± 0.12*	10.50 ± 0.71*
Women											
1. Neolith. Cemetery Zvejnieki. Excavations — F. Zagorskis.	34.63 ± 1.25	6.78 ± 0.86	4.86 ± 0.28	2.21 ± 0.20	1.89 ± 0.14	4.73 ± 0.24*	3.60 ± 0.50*	3.42 ± 0.37	0.77 ± 0.12	0.62 ± 0.16	11.50 ± 1.43
2. Bronze ageg. Cemetery Kivutkalns. — Excavations. J. J. Graudonis.	35.91 ± 1.95	6.82 ± 0.78	4.58 ± 0.65	2.26 ± 0.23	1.97 ± 0.18	4.28 ± 0.46	2.82 ± 0.26	3.34 ± 0.33	0.72 ± 0.10	0.73 ± 0.16	11.80 ± 1.14
3. Middle ages (14—16th c.). Cemet. Mārtinsala — Excav. E. Mugurevič	34.91 ± 2.31	6.67 ± 0.31	4.71 ± 0.35	2.18 ± 0.13	1.87 ± 0.08	4.60 ± 0.15*	2.73 ± 0.12	3.10 ± 0.21*	0.70 ± 0.08	0.66 ± 0.10	9.71 ± 0.49*
4. Middle ages (15—16th c.). Cemet. Valmiera. — Excav. M. Atgāzis.	35.80 ± 1.34	6.82 ± 0.65	4.40 ± 0.26	2.90 ± 0.82*	2.06 ± 0.43	4.32 ± 0.43	2.62 ± 0.08	2.94 ± 0.23*	0.62 ± 0.08	0.48 ± 0.08*	12.80 ± 0.84*
5. 20th century. Muzeum of normal Anatomy. Medic. Instit. Riga.	32.69 ± 1.35*	6.26 ± 0.32*	4.44 ± 0.34	2.22 ± 0.34	1.90 ± 0.17	4.15 ± 0.32	2.49 ± 0.26*	2.82 ± 0.33*	0.75 ± 0.09	0.62 ± 0.11	10.60 ± 0.97*

Places of measurements of tibiae bones (see Illustration). 1. Length (in centimeter), 2. the breadth of the upper epiphysis, 3. the breadth of the lower epiphysis, 4. the breadth of diaphysis on the level of foramen nutritium, 5. the biggest breadth in the upper third, 6. the biggest sagittal diameter on the level of tuberositas tibiae, 7. the biggest sagittal diameter on the level of diaphysis middle, 8. sagittal diameter on the level of foramen nutritium, 9. Roentgen: the thickness of pars corticalis media, 10. the thickness of pars corticalis lateralis, 11. the number of trabeculae in the upper epiphysis.

** A significant difference exist from the numbers of the Bronze age.*

MATERIAL AND METHODS

We have studied 26 male thighbones found in archeological excavations within the territory of the Latvian SSR with 7 bones from F. Zagorskis excavations in Zveinieki referring to the Neolithic Age, 6 bones from J. Graudonis' excavations in Kivutkalns referring to the Bronze Age, 9 bones from E. Mugurevič' excavations in Martinsala referring to the 14—16 centuries. 4 bones referring to the 20th century were obtained from the Normal Anatomy Museum of the Medical Institute in Riga.

Anthropometric measurements *(Ill.)* were made on 10 shinbones referring to the period from the Neolithic to the 20th century of our era (see *Table I*). Here, microstructure was investigated in 20 male shinbones, with 4 shinbones for each historic age. (Anthropometric data processed using the variation statistics technique.) Transversal and longitudinal sections taken from the upper middle third

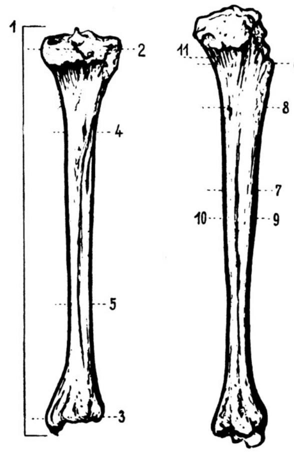

ILLUSTRATION *Tibia bone with 11 reported measurements.*

of the anterior part of bone diaphyses were used to determine the number of osteons and their circular lamellae, the number of osteocyte side branches was counted in 50 microscope reticle squares of 0.5 mm^2 area each (objective lens 10). Osteon and Haversian canal diameters (in μm) were determined using MBO-15X Model Screw Eyepiece Micrometer.

RESULTS

Higher anthropometric values were found not only in thighbones from Latvia's Bronze Age population (V. J. Derums, 1973), but also, to a certain degree, in shinbones (see *Table I*).

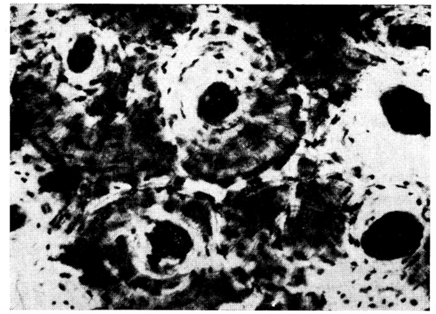

FIGURE 1. *Transversal grind of a femoral bone Bronze Age. Cemetery Kivutkalns. Grave 38, 41, 224. Excavation by Ja. Graudonis 1967, obj. 9, ocul. 7.*

It seems also of interest to note the age-long microstructure alterations in lower extremity bones. The highest osteon number was found to be present in the Bronze Age human extremity bones (see *Table 2*). It was also noted that thighbones were characterized by higher values: $\bar{x} = 9.6 \pm 1.26$ *(Fig. 1)*, while in the Middle Ages (14 to 15th centuries) $\bar{x} = 5.9 \pm 0.29$. Approximately the same osteon may be observed in human bones referring to the 20th century of our era *(Fig. 2)*.

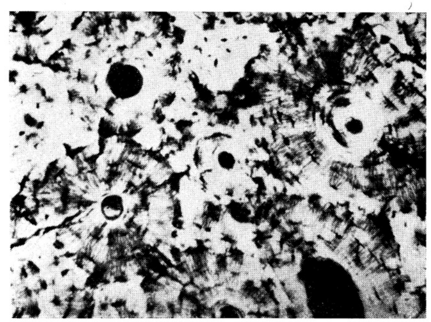

FIGURE 2. *Transversal grind of a femoral bone from the Middle Ages. Cemetery Valmiera. Grave 16. Excavation by M. Atgazis 1972; Cemetery Martinsala. Grave 1416, 1583. Excavation by E. Mugurevič, 1976, obj. 9. ocul. 7.*

TABLE 2. *The Microstructure of the compact subtsance of thigh- and skin- bones of men, inhabiting the territory of Latvia from Neolithic to the 20th century of our era*

Distribution of cell elements	Neolithic cemetery Zvejnieki, Grave N. 252, 251** (228, 222).	Bronze ages cemetery Kivutkalns. Grave N. 38, 41, 224 (47, 168).	Medieval cemetery Martinsala. Grave N. 1416, 1583 (1482, 1614)	20th century A. D. Museum of norm. Anatomy Riga Medic. Institut
	Arithmetical mean			
1. The number of osteons Femoral bones, tibiae	6.64 ± 0.19* 7.22 ± 0.9	9.60 ± 0.2 7.70 ± 0.23	5.90 ± 0.29* 5.31 ± 0.57*	5.30 ± 0.92* 5.23 ± 0.25*
2. The number of osteons laminae Femoral bones, tibiae	— 8.80 ± 0.2	10.82 ± 0.40 9.34 ± 1.0	10.20 ± 0.31 8.94 ± 29	9.44 ± 0.25* 7.64 ± 0.35*
3. The number of osteocyte branches Femoral bones, tibiae	— 30.47 ± 1.44*	40.65 ± 8.72 41.08 ± 4.54	25.80 ± 1.44* 25.34 ± 0.47*	34.97 ± 0.23* 21.19 ± 0.64
4. The diameter of osteons (micron) Femoral bones, tibiae	189.20 ± 7.7* 196.99 ± 7.6*	278.60 ± 12.5 248.20 ± 8.68	228 ± 12.22* 281 ± 9.26	268.14 ± 8 258.26 ± 7.08
5. The diameter of Haversian canals (mcr) Femoral bones, tibiae	69.30 ± 4.56* 88.64 ± 4.9	84.50 ± 5.6 91.05 ± 6.48	79 ± 6.95* 73.20 ± 5.77*	108 ± 26 93.26 ± 7.08
6. The length of osteocytes (micr). Femoral bones, tibiae	— 28.27 ± 1.9*	27.90 ± 1.3 20.44 ± 1.8	24.25 ± 1.01 28.48 ± 0.82*	29.16 ± 9.9 21.60 ± 1.6

* *A significant difference exist from the numbers of Bronze age*
** *Numbers without brackets—graves with femoral bones, numbers with brackets—graves with tibia bones*

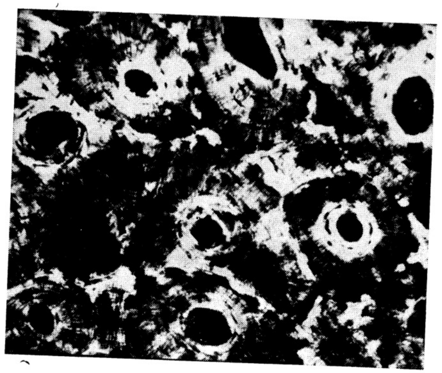

FIGURE 3. *Transversal grind of a tibia bone from the Bronze Age. Cemetery Kivutkalns. Grave 47, 168. Excavation by Ja. Graudonis 1967, obj. 9, ocul 7.*

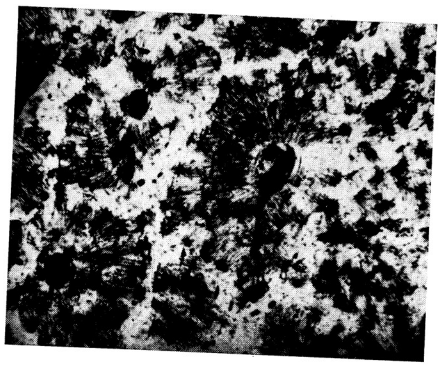

FIGURE 4. *Transversal grind of a tibia bone from the Middle Ages. Cemetery Martinsala. Grave 1482, 1614. Excavation by E. Mugurevič, 1967, obj. 9, ocul. 7.*

In the compact substance of the Bronze Age human shin-bones, $\bar{x}$=7.70 ± 0.23 *(Fig. 3)*, whereas in the Middle Ages and in the present time the osteon number but slightly exceeds 5 *(Fig. 4)*. The number of circular lamellae in human thighbones of the Bronze Age is $\bar{x}$=10.82 ± 0.40, while that in the 20th century is but a little higher than 9.

The number of osteon lamellae in the Bronze Age human shin-bones is $\bar{x}$=9.34 ± 1.0, whereas in the 20th century it is $\bar{x}$=7.64 ± 0.35. The Bronze Age human bones are also noted for the highest number of osteocyte side branches, the said number being $\bar{x}$=40.65 ± 8.72 for thighbones and $\bar{x}$= 41.08 ± 4.54 for shin-bones *(Fig. 5)*, whereas at present the osteocyte side branch number is almost twice as low *(Fig. 6)*.

FIGURE 5. *Longitudinal grind of a femoral bone from the Bronze Age Cemetery Kivutkalns, Grave 38, 41. Excavation by Ja. Graudonis 1967, obj. 10, ocul. 16.*

FIGURE 6. *Longitudinal grind of a femoral bone from the 20th century. Museum of Normal anatomy. Riga Medical Institute.*

As for the osteon diameter, no sufficient difference between data for the Bronze Age and those for the 20th century has been revealed (see *Table 2*).

The largest Haversian canal diameter in thighbones was found for the 20th century: $\bar{x}$ = 108.14 ± 26 μm. Osteocyte length is much more difficult to determine because of corrosion due to long stay in the soil (detrimental effects of the soil and climatic conditions).

For tighbones, it varies from $\bar{x}$ = 27.9 μm in the Bronze Age to 29.16 ± 9.9 μm in the 20th century. For the Medieval human shin-bones, $\bar{x}$ = 28.5 ± 0.82 μm.

In another paper by the present author (1978), it was indicated that Latvia's Neolithic and Bronze Age inhabitants had better developed inner microstructure of male humerus, as compared with that of the Medieval population (The 14th to 16th centuries).

CONCLUSION

Heavier physical loads and severe living conditions as well as natural selection may be presumed to have contributed to both macro and microstructural enhancement in extremity bones. A lower cellular element number in extremity bone compact substance of the Medieval population may be explained by more severe living conditions (e.g. forced labour, undernourishment, insufficient rest).

The somewhat lower cellular element number in bone compact substance of the 20th century people is due to urbanization, lower physical loads, higher motorization and less walking.

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