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RICKETS IN PAST AND MODERN TIMES – CASES FROM SOME ARCHAEOLOGICAL SITES IN POLAND

ABSTRACT: The cause, characteristic features and short history of rickets are presented, and 25 cases from seven archaeological sites in Poland are described (Table 1).

KEY WORDS: Rickets – Past and Modern Times – Poland

Rickets is a disease difficult to recognize in the excavation material and, consequently, reports on it are scarcely found in palaeopathological literature (Ortner, Mays 1998). Yet, a survey of that literature does reveal quite a few publications on the disease, and one may only deliberate whether a particular description, documentation, and diagnosis have always been reliable.

Rickets is commonly taken to manifest mainly in children in the first months and years of their life (2–4 years). The disease strongly affects the bone system, yet does not end in fatalities. It leaves some traces that in a growing child can disappear altogether once its causes have been eliminated. Consequently, it is occasionally difficult to determine in adult skeletons, for example, whether the bending of long bones, mainly in lower extremities, was caused by rickets.

Rickets is a metabolic disease attributed to various factors and has no homogeneous etiology, the primary cause being some imbalance of calcium, phosphates, and vitamines. It is a disturbance in the formation of bone in the growing skeleton caused by a failure in depositing calcium and phosphorus within the organic matrix of cartilage and osteoid (Steinbock 1976).

The contemporary classification of the disease is as follows: 1. Rickets due to vitamin D deficiency, which most commonly affects infants; 2. Forms of metabolic rickets that appear as a result of primary disturbance in metabolism of calcium and phosphorus, first manifesting in infancy, after the first year of life, or in children at pre-school age. The most commonly encountered is hypophosphophatemic rickets and hypophosphatasia, which are diagnosed according to the level of calcium, phosphorus, and alkaline phosphatase; 3. Forms of renal rickets that are a consequence of chronic, severe, inborn renal diseases accompanied by acidosis and excessive calcium and phosphate excretion. These forms of the disease generally manifest in children at pre-school and school age. The radiological picture of rickets is dependent on age. Prior to the full growth of bone, there are always changes in metaphyses that become flared, and in the growth plates that become jagged. Osteoporosis is present in metabolic and renal forms of rickets, causing, in extreme cases, bending of bones and growth disturbances, including dwarfism. Osteoporosis is not always observed in deficiency-based rickets (Kokot 1978, Galus, Jaworski 1982).

The most common cause of rickets is vitamin D deficiency that causes inadequate absorption of calcium and phosphorus from the intestine. Other causes are chronic intestinal diseases, insufficient amount of calcium and phosphorus in the diet, and chronic renal tubular malfunction (Steinbock 1976). Social customs can also be a factor in producing rickets. As Steinbock (1976) notes, Wilson had discovered skeletal rachitis lesions in 40% of 1982 Moslem girls aged 5–17 years in India (girls keep their faces and bodies heavily covered and rarely venture outside). Another cause of rickets, as in other diseases, can be attributed to stress (Bush 1991).

A natural source of vitamin D is nutrition. Vitamin D occurs naturally only in the fat of certain food products of animal origin. In 90% it is also synthetized in the body when ultraviolet rays from sunlight rays convert ergosterol in the skin into vitamin D.

Ortner and Mays (1998) have produced a list of characteristic rickets features that includes: "1. cranial vault porosity; 2. orbital roof porosity; 3. deformation of the mandibular ramus; 4. deformation of arm bones; 5. deformation of leg bones; 6. flared costo-chondrial ends of ribs; 7. irregular and porous cortex of the costo-chondral ends of ribs; 8. abnormality of the growth plates of long bones; 9. irregular and porous surfaces of the metaphyseal cortex; and 10. thickening of the long bones, particularly in the metaphyseal areas."

There are more rickets features commonly known, as for example: 1. thinning of the vault (craniotabes); 2. thickening – in advanced rickets – "squared heads"; 3. thinning of the cortex, sparse and slender spongy trabeculae (atrophy); 4. thickening of the cortex and narrowing of the marrow cavity; 5. rachitic rosary; 6. forward bending of sternum (pigeon breast); 7. hypoplastic defects in the enamel, particularly of the upper incisors; 8. scoliosis and kyphosis due to demineralization of the vertebral bodies; 9. changes in pelvis, e.g. narrowing of the canal; 10. subperiosteal bone deposition; 11. delayed closure of fontanels; 12. slowed growth lines of arrested growth (Harris lines); (Steinbock 1976, Kokot 1978, Bach 1978, Ortner, Putschar 1981, Capasso 1985).

Determination of rickets etiology is very difficult, especially when based on excavated material. Vyhnánek (1969) states, for example, "das rachiticher Zwergwuchs vom renalen hyperphosphatamischen Zwergwushs nach Verändrungen am den Knochen nich zu unterscheiden sei". Undoubtedly, very useful here are histological investigations that reveal reduced mineralization depending on the duration of the disease (Capasso *et al.* 1995).

Differentiation is not easy either, since rickets often coexists with other diseases such as scurvy, syphilis, or anaemia (Carli-Thiele 1995, Ortner *et al.* 1999).

RICKETS HISTORY

Rickets is a worldwide disease that happens with various intensity, and attacks not only human beings, but animals as well. Accordingly, rickets was diagnosed in a pleistocene bear whose remains were found in, for example, Belgium (Moodie 1930) and Poland (Nowakowski 1999). Giant pleistocene dire wolves also suffered from the disease, as noted by Moodie (1930), a femoral bone with possible rickets-like features and markedly bent along its length was found in Rancho de Brea. Dokládal (1972) is one of several authors that have mentioned possibly rachitic changes in the Neanderthals. Truswell (1983) describes three children from a Bushmen series dating back to the Early Palaeolithic Period as "very mild rickets manifested as craniotabes" (after Grimm 1984).

Other possible cases of rickets come also from the Mesolithic Period, one from Ukraine (Konduktorowa 1974), and two cases from the Baltic Region (Derums 1967). Traces of rickets in Neolithic bones from Denmark and Norway were described by Fürst in 1920 (Siegerist 1955), by Grimm (1983) in Mecklenburg, and from the Eneolithic Period by Ullrich (1972).

Maximilian (1962) described a male skeleton coming from Sarata-Monteora (Romania) comprising a bent tibial bone. He dated it back to 1800–1400 BC and labelled as of rachital character. Bouvielle *et al.* (1983) also gave a picture of a femoral bone with a strong lateral curvature (SP 74) that came from Abri Cornille and dated back to a period between 6180 and 8320 BC. Yet no diagnosis was produced.

Müller (1961) presented bent long bones of the lower limb out of grave No. 9 from the Early Bronze Age and claimed they carried signs of rickets. From the Bronze – Iron Age there was a skeleton from Transcaucasia characterized by sabre-like bones (Rösler 1901) that may represent traces of rickets. Passarello and Diotaallers (1980) showed an adult skeleton from a graveyard in Alfedena that revealed Harris lines and was described as 'to be due to rickets'. From the Iron Age there are also remains carrying signs of rickets according to descriptions by Kühl (1967), Farkas and Marcsik (1976), and Mallegni *et al.* (1979). Literature references to rickets may be found in China dating back to 300 BC (Lee 1967). Cases of rickets from the Roman times were presented by Delsaux (1973), Ery (1968), and from the 4th century AD by Blondiaux (1998) and Matiegka (1891).

Cases of rickets from the Middle Ages presented in the literature are much more numerous. It was Watermann in 1972/73 who, among the skeletons recovered from St. Albana Church in Cologne, came across several cases of femoral bones strongly bent, which might have been a sign of rickets.

Thurzo (1969) described sabre-like bent tibial bones from a graveyard in Lupka in Nitra, and Simon (1982) presented three cases from Schirmenitz (Oschatz region), Moller-Christensen (1958) found 8 cases of rickets among 800 skeletons from Aebelhold Monastery in Denmark, Janssen and Maat (1999) described a case of rickets in a 60-year-old man buried at St. Servaas Basilica in Maastricht (1070–1521 AD), Teichmann *et al.* (1999), who have identified in several cases some changes caused by deficiency in vitamin C or D among skeletons from three graveyards, and finally Ulrich-Bochler (1982) who found some bent and slightly shortened femoral bones in a series from 11th–15th centuries at a church in Ansuldingen, Switzerland. They might have been caused by vitamin D deficiency. In the Historical Museum in Chur, Switzerland, there is a male skeleton of 50 years of age from the medieval site of Bonaduz in the Canton of Grissons. The only evidence of deformity is seen in the tibiae. Both of them show a bowing with an increased antero-posterior diameter of the midshaft and a very prominent anterior edge (Ortner, Putschar 1981). Two possible cases of rachitis from a graveyard in Sweden have been reported by Gejvall (1960). Rickets cases from medieval England have been presented, among others, by Ortner and Putschar (1981): "In the Winchester Saxon collection is a case of healed rickets in a child about six years of age: right femur, tibia and fibula. Anterior bowing is most pronounced on the femur and tibia. Another case of healed rickets is from the royal College of Surgeons of England pathology collection at the British Museum; the case is from the Ludgate Hill site in England – the right femur of an adult. There is marked antero-lateral bowing with antero-posterior flattening and a build-up of bone along the *linea aspera*." Additionally, Daves and Magilton (1980) described rickets in a seven-year-old child from the cemetery in St. Helen-on-the-Walls, Aldwark.

Reports on rickets cases in America are also found in the study by Ortner and Putschar (1981), where on page 283 one reads: "Snow (1948: 508) describes a possible case of rickets in an 8-month-old infant (Burial 633, Indian Knoll site, Kentucky, USA) ...", and also in a paper by Steinbock (1976), who states on pages 264–265: "Two possible cases have been reported in Archaic Indians from Kentucky around 3300 BC (Foote 1927, Snow 1948). One of those individuals is a twelve-to-fifteen-month old infant with beading of the ribs at the costrochondral junctions. The distal and proximal portions of the tibiae and distal portion of the femora and ulnae appear swollen and spongy. This is particularly evident in the tibiae. The hypertrophy evident in these limb bones is characteristic of advanced rickets in infancy." The text contains no description of the second case. Foote (1927) quoted here by Steinbock says in his study 'Evidence of Rickets prior to 1650' only the following: "US Army Medical Museum in Washington contains a skull of a pre-Columbian boy from Peru who was about 5 years of age. This skull, which is typically rachitic, is labelled 'rickets and probably syphilis' and there is also a deformed radius of a youth aged about 19, which is labelled 'deformity of radius, probably due to rickets' (pre-Columbian burial place, No. 9, Calhoun, Ky – *Figure 2*)."

Ubelaker (1994) analysed skeletons from the St. Francisco Convent in Quito, Ecuador, that dated back to the years 1492–1570 and described, among others, two cases (a 25-40-year-old female No. 767 and a 25-30- year-old female No. 618) that carried clear signs of rickets in the form of well pronounced bone bendings. Commenting on the cases, he states: "A likely cause is rickets due to vitamin D deficiency." In four children analysed, he detected "fine porosity on the parietals. The orbits were not involved" and he commented as follows: "rickets seems to be a likely diagnosis, since there is no evidence of infection or the cortical expansion expected of the anemias."

Rickets had not been described until the 17th century. The disease started truly to spread in the 15th century. From the year 1475 Cologne had been an industrial centre, and particularly in the second half of the 15th century there appeared favourable conditions for rickets to develop: big towns, poverty, climate, the lack of hygiene (Foote 1927). The author claims rickets had been known for ages, and frequently as a disease of industrial centres of, for example, Germany and Holland, where it had been present for almost 200 years before being described in the 17th century. It was only in the 17th century that some attention had been paid to the disease frequently affecting children, mainly in northern Europe and North America, and some link had been detected between the disease and industrialization and the appearance of big towns (Ortner, Putschar 1981). The authors report that Escherich in 1899 recognized rickets in 97% of children in Vienna, while Schmorl in 1909 found it in 89% of children aged 2 months to 4 years in the town of Dresden, and Hess in 1921 in 75% of children in New York. Europe, particularly its northern part, was a typical area stricken by rickets at the time of industrial revolution (Wells 1964, Steinbock 1976, Foote 1927), though the other countries of Europe were not rickets-free at all (Capasso 1985, Capasso *et al.* 1993). According to Fildes (1986) as quoted by Roberts and Manchester (1999), rickets in the 17th and 18th centuries was so common in England as to be called "the English disease". Even the sacred art of the period pictured the Holy Infant with some rachitic features and, for example in 1485, Bernhard Striegel from Nürenburg painted the Holy Family with the Holy Infant having a square head and the Harris grooves seen against the Infant's chest (Foote 1927).

Rickets was first described by Whisler in 1645, while Glisson (1650) called it a totally new disease (Foote 1927). Deformities to the extremities in children had been long known and, as a matter of precaution, children were kept wrapped up in cloth. A written record on that dates back to the 2nd century AD, and Soranus of Ephesus stated that wrapping up children prevented deformities that developed when the toddler was only too eager to walk (Foote 1927).

Descriptions of rickets in modern times have been rather rare. In 1968 Andersch and Schott presented some material dating back to the 16th–18th centuries from the St. Nicholas Church in Berlin and there, out of 126 skeletons, they recognized those affected by rickets. Holliman (1970) in Virginia, USA, found cases of rickets among 100 skeletons from a 16th century graveyard. In 1973, Grimm and Wustman came across rickets cases in a material from a Laas site, Oschhatz area, dating back to 1745–1806. Benedek-Jaszman (1980) presented a description produced by a physician of the Danish Royal Family whose member had suffered from rickets. Post-rachitic changes were found also in the skeletons of the "Mary Rose" sailors as well as in those of the Swedish "Vasa" crew – the ships had sunk in 1545 and 1628, respectively (M. Beaconsfield, T. Beaconsfield 1983). Power and Sullivan (1992) reported on post-rachitic changes in the 19th century that came across in Waterford, Ireland, while Mollison and Cox (1993) pictured them in a series from the 18th–19th centuries. Working on a material from Spitalfield – London, they recognized rickets in 20 children and 15 adults.

MATERIAL AND METHODS

The material comes from several archaeological sites from the Neolithic Period, Middle Ages, and Modern Time. The data from two burial grounds come from a work by Gleń-Haduch *et al.* (1993) and a paper by Szukiewicz and Marynowski (1961).

Age at death was estimated using dental development and from long bone length. Measurements were done, and the indices of pilaster, curvature, and the angle of rotation were calculated after Martin–Saller (1957). Pathological changes were recorded microscopically and radiologically, and in one case by CT.

DESCRIPTION OF THE MATERIAL

Neolithic Period

The series comes from the village of Złota, Sandomierz region, and amounts to 218 skeletons, very many of them either incomplete or of mixed bones. In the bones labelled Z.M. 18, the skull and mandible were preserved along with humeral bones, bones of both forearms and the femoral and tibial bones. The skeleton belonged to a 25–30-year-old female. The left femoral bone is well preserved and markedly different from the other bones. It is S-shaped and markedly twisted. The angle of rotation is about 40 degrees. The proximal end is abnormally flattened and has a lateral bowing, while the distal metaphysis has an anterior bowing (*Figure 1a*). On radiological examination, osteoporosis was revealed in metaphyses, and Harris lines were demonstrated (*Figure 1a–b*). Radiologically, these changes may be attributed to inadequate diet, probably to rickets the female had suffered from in her childhood, or they might have been caused by poliomyelitis.

FIGURE 1. Femoral bone: a) rotation, anterior bowing of distal part and strongly flattened proximal part; b) X-ray – atrophic changes and Harris line. Female, adult, Neolithic No. 18 (Photo A. Klejna).

Middle Ages

There are two known cases from the Middle Ages that were probably caused by rickets, one coming from Będzin, southern Poland, and the other from Czarna Wielka, north-eastern Poland.

A series from the 12th–13th centuries Będzin, Katowice area, was recovered during some rescue operation and comprises 62 skeletons (Krężołek 1998). Burial No. 53 contains fragments of the skull and mandible as well as femoral bones of a child of 1.2–2.5 years of age. The frontal bone squama on either side thereof and both the parietal bones as well as the orbital vaults show porous surfaces. The femoral bones are partly damaged and have markedly enlarged distal metaphyses (flaring and cupping) and irregular, rough surfaces of the growth plate. The bone structure of metaphyses is rarefied with some areas of belated growth (Harris lines). The changes to the vault and femoral bones were caused by rickets.

The series from the village of Czarna Wielka, Białystok area, that dates back to 12th–14th centuries comprises 250 skeletons, most of them being in a good state of preservation. Skeleton No. 34/I/51 was of a young female, 25–30 years of age. About 3/4 of the skeletal bones were preserved, yet in a very severely damaged condition. Of particular interest is the left humeral bone with the slightly damaged distal metaphysis. The bone has a marked anterior bowing at the level of deltoid tuberosity. The angle of the upper end deflection from the long axis of the bone is about 30–35 degrees. Radiological examination revealed porosity of the upper end of the bone without any damage to its structure, which indicates it had not been a fracture, but rather rickets the female had suffered from in her childhood.

Modern Times

The material comes from four sites: a graveyard by the Warsaw cathedral, a burial ground in the village of Maniowy, Podhale, graves discovered in a Gdańsk church, and in the Royal Chapel.

The series from the graveyard of St. John's Cathedral in Warsaw dates back to 13th–16th centuries and was uncovered during some rescue operation. The series comprises about 138 skeletons, a part of them being assembled from haphazardly mixed up bones at the site,

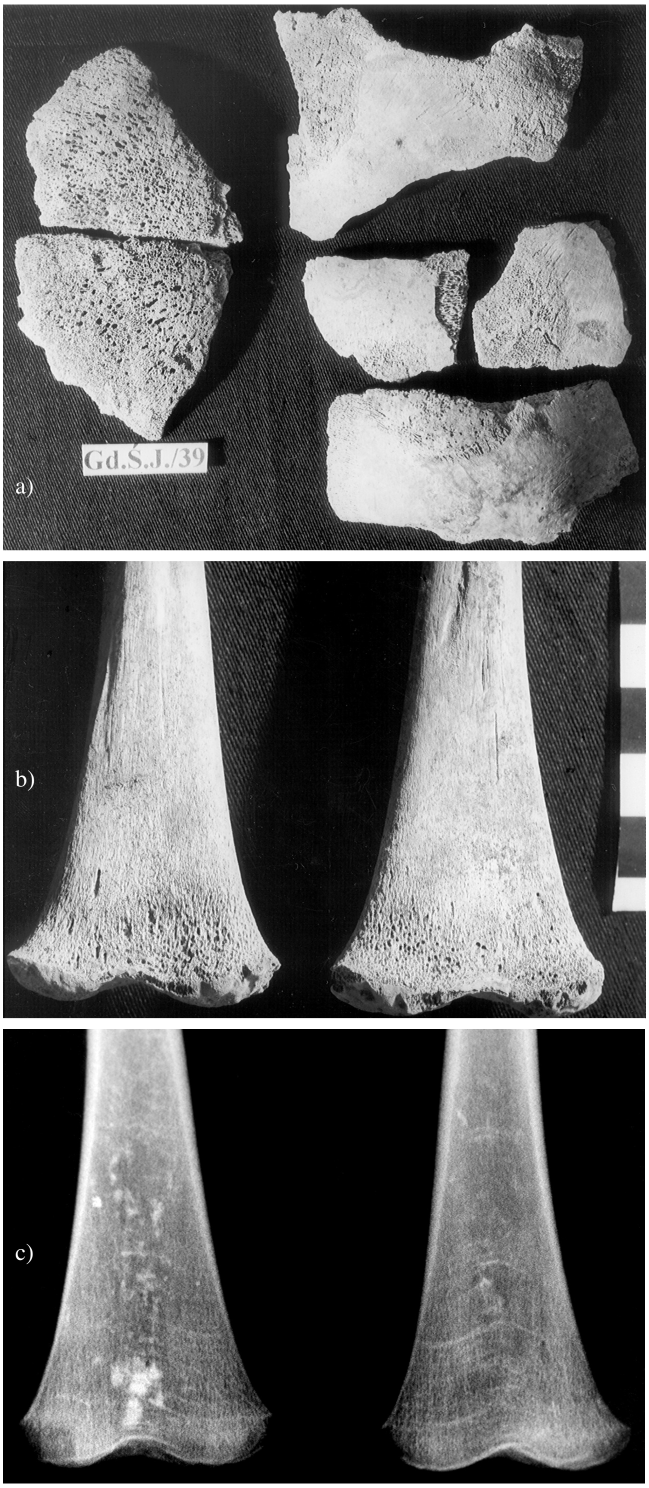


FIGURE 2. Fragments of cranial vault: a) porosity; b) femoral bones: porous and enlarged distal metaphyses with abnormal growth plate; c) X-ray, bone atrophy, cupping metaphyses, Harris line. Infans, aged 5–6, No. 39. XVIth–XVIIth cent., Gdańsk – St. John's church (Photo A. Klejna).

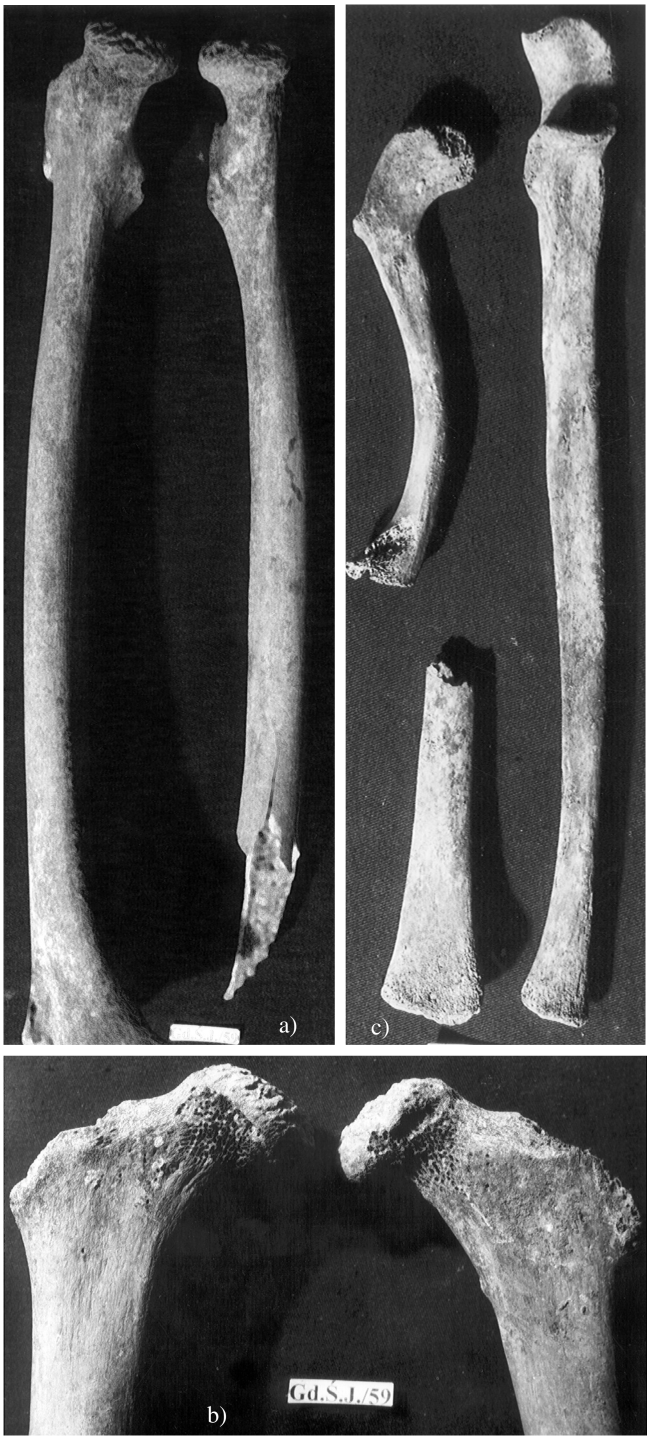
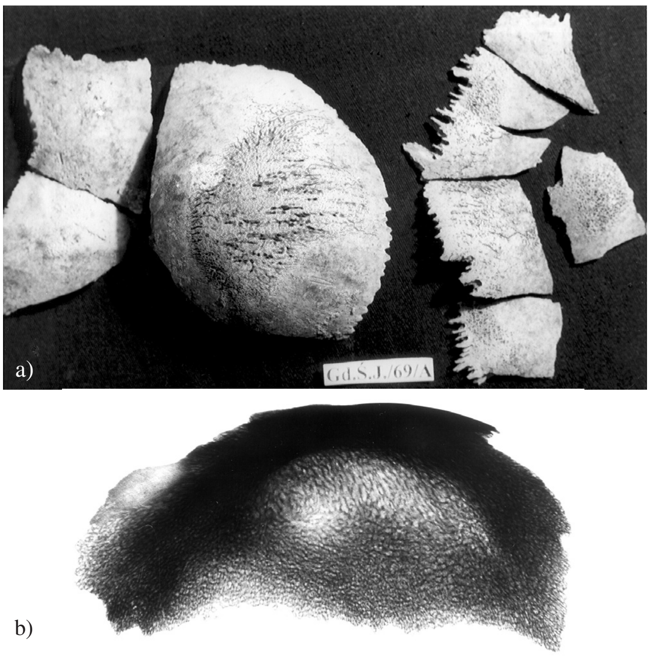


FIGURE 3. Long bones: a) porous distal metaphyses and bowing distal part of the ulnar bone; b) lateral bowing enlargement of the distal metaphysis of femoral bones; c) porosity and growth plate abnormality. Infans-iuvenis, No. 59, XVIth–XVIIth cent., Gdańsk – St. John's church (Photo A. Klejna).

and thus leaving many others incomplete (Szukiewicz, Marynowski 1961). The authors differentiated between the bones with pathological changes and the bones of a particular structure. Their report suggests that at least in 5 cases (two children and three adults) there are visible signs that had been possibly caused by rickets. These signs are as follows: skeleton No. III/50 that was of a small child (infans I). The preserved femoral bone has in its lower part

FIGURE 4. Femoral bones: a) bowing shafts, enlarged distal metaphyses and irregular surface of growth plate; b) X-ray, thickened cortex of the opposite side of anterior bowing. Female, iuvenis, No. 61, XVIIth cent., Gdańsk – St. John's church (Photo A. Klejna).



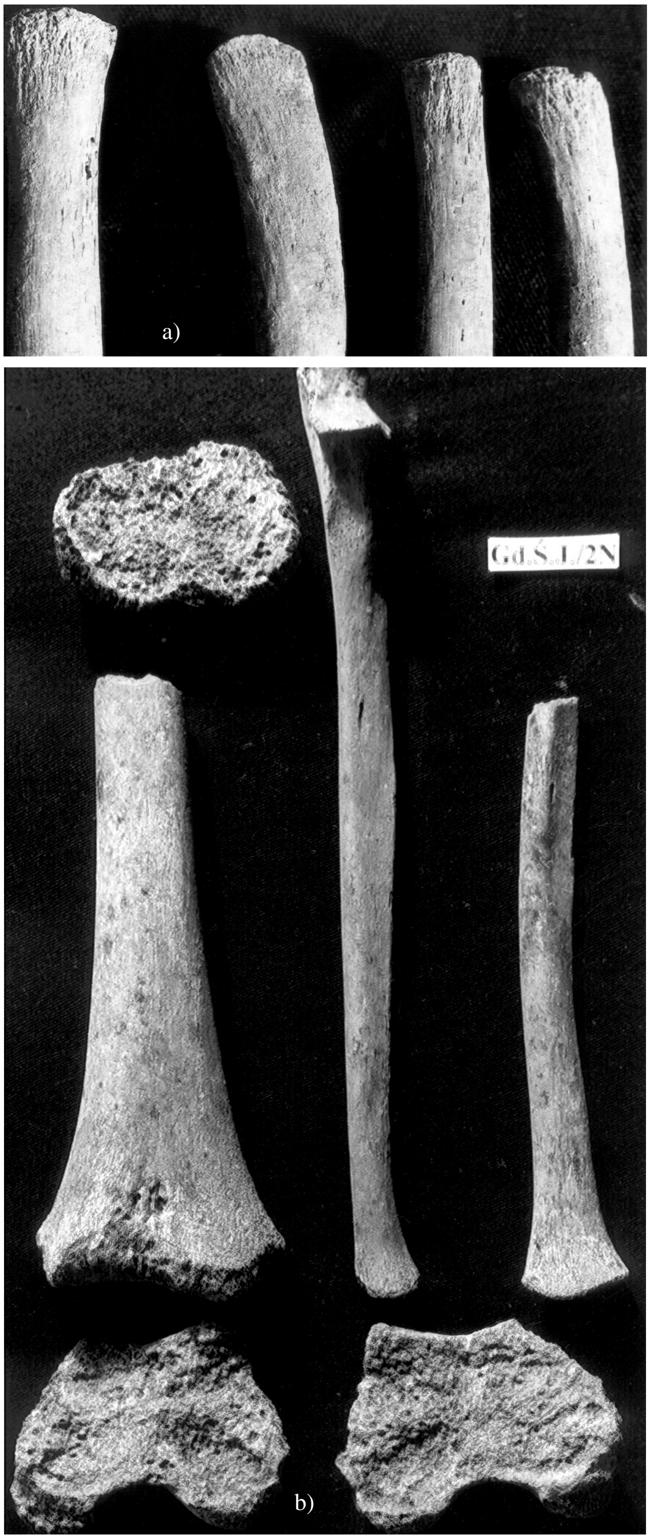


FIGURE 6. a) Ribs – flared, porous costo-chondral ends; b) abnormal curvature of antebrachial bones, growth plate abnormality, femoral bones with porous metaphyses, enlarged, distal metaphyses and abnormal surface of growth plate. Infans, aged 11–14, No. 2N, XVth–XVIIth cent. Gdańsk – St. John's church (Photo A. Klejna).

← FIGURE 5. Fragments of vault: a) porotic bone deposition of parietal bones. b) CT – thickening and porous diploe. Infans, aged 2–3, No. 69A, XVIth–XVIIth cent., Gdańsk – St. John's church (Photo A. Klejna).

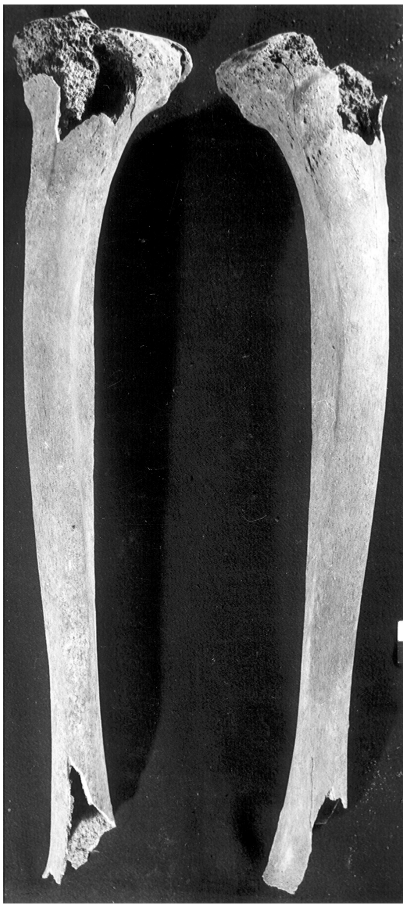


FIGURE 7. Tibial bones, anterior bowing. Male maturus-senilis, No. $2V_1$, XVIth–XVIIth cent., Gdańsk – St. John's church (Photo A. Klejna).

FIGURE 8. Ribs, flared, porous costo-chondral ends and partly ossified costal cartilage (rachitic rosary). Male, senilis, No. 2, XVIIth cent., Gdańsk – King's Chapel (Photo D. Jeżyk).

a marked anterior bowing, and in its upper par is abnormally flattened antero-posteriorly. Another femoral bone of an older child No. 13 (infans II) has a well-pronounced anterior bowing, but this time at the whole length of the bone shaft. In yet another example, the ulnar bones of the senile female No. 9a (senilis) have a strong bending at the distal end, and the tibial bones in an old female No. 51 (maturus-senilis) are strongly bent laterally in a sabre-like manner. The third skeleton No. 57 was of an aged man (maturus-senilis) whose humeral and forearm bones have a marked anterior bowing (Szukiewicz, Marynowski 1961).

The series from Podhale comes from a graveyard discovered at Maniowy, Czorsztyn area, where burial ceremonies were conducted from 14th to 18th centuries. The series comprises about 2263 skeletons (Gleń-Haduch *et al.* 1993). Out of 144 skeletons two were selected of children of about 2 years of age that carried traces of rickets. Skull No. 46/47 consists of thin bones, it is of bulbous shape (*caput quadratus*), and has a non-fused anterior fontanel and a porous orbital vault (*cribra orbitalia*). Skull No. 70 is strongly flattened antero-posteriorly, mainly in the vicinity of parietal tubercles. The anterior fontanel is fused, and the case also presents *cribra orbitalia* (Gleń-Haduch *et al.* 1993).

The third series, also obtained in the course of some rescue operation, comes from graves discovered in St. John's Church in Gdańsk. These burials date back to 14th–19th centuries. They produced bone remains of about 165 skeletons, 73 of which were recovered from graves. The others were assembled from the particular layers that contained rather mixed up bones.

There are 14 skeletons from that site that carry visible signs possibly attributable to rickets. Most of them –11 – were of children, of which six were small (infans I), and five were of older children (infans II). Two skeletons were of teenagers (juvenis) and one was of an older man (senilis).

Skeleton No. 35 was of a 6–8-year-old child. In it, about 1/3 of the bones were preserved. Both humeral bones (without a lower one third in them) and both femoral bones (the lower metaphyses are partially damaged) show porous patches on the metaphyses, and subperiosteal deposits on the shafts. The lower metaphysis of the right femoral bone is markedly enlarged (flaring and cupping), and the surface of the growth plate is irregular.

Skeleton No. 39 was of a child of 5–6 years of age. About three quarters of the bones are present. The preserved parietal bones show deposits of porous bone (*Figure 2a*). On the metaphyses there are porous patches, and the surfaces of the growth plate are abnormal (*Figure 2b*). The lower metaphyses show flaring and cupping with lines of arrested growth (Harris lines – *Figure 2c*).

Skeleton No. 57a was of a 5–7-year-old child. Only the right femoral bone was present with porous patches on its metaphyses, the lower one being enlarged and with irregular surface of the growth plate.

Skeleton No. 59 was of a female teenager (15–18 years) and was relatively well-preserved. Only the skull, mandible, and the bones of hands and feet are missing. All the metaphyses are porous, and the distal ones show flaring and cupping. The surfaces of growth plate are irregular (*Figure 3a, b*).The distal metaphysis of the ulnar bone has an excessive bowing antero-laterally (*Figure 3c*), and the shafts of the femoral bones have an excessive anterior bowing (*Figure 3a*). The pilaster index is 110.5, the curvature index is 13.4 (campholomorphic type – Janssens *et al.* 1992), and the rotation angle is about 25–35 degrees.

Skeleton No. 61 was of a young female (15–20 years) and presents only the femoral and crural bones. The metaphyses show porous patches, and the surfaces of the growth plates are porous and irregular. The distal metaphyses are flared and cupped (*Figure 4a*). An X-ray picture shows thickened cortex of the concave side (*Figure 4b*). The pilaster index is 122.7, the curvature index is 15.6, and the rotation angle is about 40 degrees.

Skeleton No. 69A was of a small child (infans I) and presents only fragments of the skull. There are deposits of parietal bones (*Figure 5a*). A CT picture shows a considerable thickening of the diploe with bone rarefaction (*Figure 5b*). Additionally, the regions of superciliary arches and orbital vaults are porous.

Skeleton No. 75 was of a child of 2–5 years of age and presents only the crural bones (the fibulas are damaged) and a couple of bones of the feet. The metaphyses present porous patches, and distal metaphyses are flared. The surfaces of the growth plate are abnormal, and the bone shafts have an excessive anterior bowing.

Skeleton No. 2A was of an older child of 11–14 years of age, and presents only tiny skull fragments, the damaged mandible and the right humeral bone whose growth plate shows some irregularity.

Skeleton No. 2F was of an older child of 6–9 years of age. About one third of the bones are present. The distal metaphysis of the present right femoral bone is enlarged. On both metaphyses there are porous patches, and the surface of the growth plate is irregular.

Skeleton 2N belonged to an older child of 11–14 years of age. About three quarters of the skeleton are present. The costo-chondral ends of ribs are slightly flared, and the cortex has strands, irregular slits, pits and patchy deposits of bone (*Figure 6a*). The metaphyses of the preserved bones show porous patches (*Figure 6b*). The lower femoral bone metaphyses, these of the radial and ulnar bones present flaring and cupping, while the surfaces of growth plates of metaphyses and epiphyses are rough and irregular (*Figure 6b*). The shafts, particularly these of the preserved radial and ulnar bones, have an excessive bowing (*Figure 6b*).

Skeleton No. $2P_1$ belonged to a child of about 2.5–5 years of age. There were only the left parietal bone and the left femoral bone preserved of the skeleton. The metaphyses show porous patches. The distal metaphysis is considerably enlarged (flared and cupped), and the shaft cortex surface is irregular with patchy bone deposits. The growth plate surfaces are porous and irregular.

Skeleton No. $2V_1$ belonged to an older man (senilis). One third of the skeleton is preserved. Both the tibial bones (damaged) have a considerable sabre-like anterior bowing (*Figure 7*). The cortex on the concave side is thicker. The changes are probably attributable to rickets in childhood.

Skeleton No. 3B was of a child of about 4–6 years of age. It presents only the frontal bone, the lumbar vertebra, left femoral bone, and both right crural bones. The orbits and the region of glabella show some porosity, and the metaphyses of long bones present porous patches, while the distal epiphysis of femoral bone (the tibia is damaged) is enlarged (flaring and cupping). The growth plate surfaces are abnormal.

Skeleton No. 3"0" was of a small child (infans I). Only the left femoral bone and a proximal phalanx of the finger are present. The metaphysis of the femoral bone shows porous patches, the surface of the growth plate is irregular, and the shaft cortex has patchy bone deposits.

Three skeletons were discovered in the Royal Chapel in Gdańsk (17th century). Skeleton No. 2 belonged to an older man (senilis). The case requires some attention for the ribs that are mostly present and have enlarged, thickened, and tuberous sternal edges (*Figure 8*). These are changes probably sustained in childhood (rachitic rosary – Gładykowska-Rzeczycka, Iwanek, 2001).

RESULTS AND DISCUSSION

As seen in the description of the cases, the material is highly differentiated in both its completion that translates into the number of features allowing for making a diagnosis, and in the age of analysed cases. Skeletons of children are dominant in the material. There are 10 cases of children aged from 1.2 to six years, five cases of older children of up to 14 years of age, and two cases of children of unspecified age. Cases of young people comprised two females, while adults were represented by four females and two males (*Table 1*).

Observations of many authors (Foote 1927, Sigerist 1955, Gejvall 1960, Wells 1964, Grimm 1972, 1973, 1984, 1985, Živanowicz 1975, Steinbock 1976, Ortner, Putschar 1981, Capasso 1985, Stuard-Macadam 1988, Ivanhoe 1995, Roberts, Manchester 1999) have indicated that skeletons with traces of rickets are more often encountered in Modern Times.

The material from Gdańsk included in the current paper presented rachitic changes mostly in children over three years of age, yet signs of rickets seem to be very distinct.

TABLE 1. Cases probably due to rachitis from some Polish archaeological sites.

Period	Site/district	No. of skeletons	Skeleton No.	Sex	Age	Bone (s)	Characteristics of changes	Photo	X-ray	Author
Neolithic	Złota/ Sandomierz	218	18	F	ad.	femoral	bowing, flattening, rotation	+	+	Gładykowska-Rzeczycka 1989
Middle-Ages 12th–13th cent.	Będzin/Kielce	62	53	?	1.5–2.5	skull (fragm.), femoral	porous vault, *cribra orbitalia*, flaring metaphysis, atrophy	+[1]	+[1]	Krężołek 1998
12th–14th cent.	Czarna Wielka/ Białystok	250	34/1/I	F	ad.	humeral	lateral bowing of the superior end	+[1]	+[1]	Gładykowska-Rzeczycka 1989
Modern Time	Maniowy/	144	46/47	?	±2	skull	"squared head", craniotabes, *cribra orbitalia*,	–	–	Gleń-Haduch
16th–18th cent.	Czorsztyn		70	?	±2	skull	flattened (antero-posterior), *cribra orbitalia*	–		*et al.* 1993
13th–16th cent.	Warsaw – St.	138	III/50	?	inf. I	femoral	bowing and flattened diaphysis	–	–	Szuszkiewicz
	John's		13	?	inf. II	femoral	anterior bending of diaphysis	–	–	*et al.* 1961
	Cathedral		9 a	F	sen.	ulnar (s)	bending of distal metaphysis	–	–	*ibid.*
			51	F	mat.	tibial (s)	well marked lateral bowing	–	–	*ibid.*
			57A	M	sen.	sup. extremity (s)	well marked anterior bowing	–	–	*ibid.*
16th–17th cent.	Gdańsk – St.	207	35	?	6–8	fem., hum.(s)	porous metaphyses, growth plate abnormality	+[1]	+[1]	Gładykowska-Rzeczycka
	John's Church		39	?	5–6	skull, femoral (s)	vault and metaphyses porosity, Harris line	+	+	*et al.* 2000
			57a	?	5–7	femoral	flaring, porous metaphyses, growth plate abnormality	+[1]	–	*ibid.*
			59	F	15–18	extr. sup. a. inf.	porous metaphyses, bending, growth plate abnormality	+	+	*ibid.*
			61	F	15–20	leg	porous metaphyses, growth plate abnormality	+	+	*ibid.*
			69A		2–3	skull (fragm.)	vault thickened, porosity, *cribra orbitalia*	+	CT	*ibid.*
			75	?	2–5	tibial (s)	porous metaphyses, growth plate abnormality, bowing, Harris l.	+[1]	+[1]	*ibid.*
			2A	?	11–14	humeral	porous methaphyses, growth plate abnormality	–	–	*ibid.*
			2F	?	6–9	femoral	porous metaphyses, growth plate abnormality	+[1]	+[1]	*ibid.*
			2N	?	11–14	fem., ribs, antebr.	porous, flaring metaphyses, growth plate abnormality, bowing, flared-ribs	+	+[1]	*ibid.*
			$2P_1$	?	2.5–4	femoral	porous, flaring metaphyses, growth plate abnormality	+[1]	+[1]	*ibid.*
			$2V_1$	M	m/s	tibial	anterior bowing, bone atrophy	+	+[1]	*ibid.*
			3B	?	4–5	skull, femoral,	porous, flaring, cupping metaphyses, growth	+[1]	+[1]	*ibid.*
						tibial (s)	plate abnormality, *cribra orbitalia*			*ibid.*
			3"0"	?	inf. I	femoral	porous methaphyses, growth plate abnormality	+[1]	+[1]	*ibid.*
17th cent.	Gdańsk – King's Chapel	3	2	M	sen.	ribs	rachitic rosary	+	–	Gładykowska-Rzeczycka, Iwanek, 2001

Tiny porous patches are characteristically seen on all the metaphyses and, in the case of femoral bones, they are associated with Allen's area. They are bigger, though, and not so clearly bounded. Many analysed bones also had abnormal bowings that were seen in bones of extremities in older children, female teenagers, and adults. They are known to have appeared in the period of active rickets when the child began to take the vertical posture, toddle, and walk. All of the most commonly encountered signs of rickets are known to be an effect of mineralization disorders that predominantly result from inadequate diet. That mechanism has been presented by the authors from the list quoted above which included Steinbock (1976), Ortner and Putschar (1981), Capasso (1985), Ortner and Mays (1998), Roberts and Manchester (1999), and also Friedlung and Sandberg (1994), the latter analysing in detail the influence of grain product diet on rickets development.

The problem of rickets and metabolic diseases is certainly one of the more difficult ones in palaeopathology as it is not easy to pinpoint the cause of some overgrowth or atrophic changes in, say, the region of the skull. Such changes may coexist in many diseases such as syphilis, scurvy, or anemias of different origin. The condition of the material to be analysed, very often fragmentary, constitutes yet another problem in establishing a diagnosis.

There is no doubt that the small number of reports on rickets in excavated material is – as indicated by Ortner and Mays (1998) – a result of very often too general and rather imprecise analyses of investigated cases. Every article on rickets is then contributory towards completing the history of the disease in time and space.

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