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HARRIS LINES IN THE LATE MEDIEVAL TO EARLY MODERN SKELETAL MATERIAL FROM THE OULU CATHEDRAL AND IIN HAMINA CHURCHYARD SITES

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INTRODUCTION

Lines of arrested growth, better known as Harris lines (HL) are line formations of increased bone density visible in radiographs. They are found in metaphyseal regions of long bones and represent the position of growth plate during the cycle of osseus growth arrest and growth resumption. Traditionally these lines are understood as a result of malnutrition and pathological conditions during growth (e.g. Harris 1926; 1931; 1933). However, alternative explanation has suggested that they are results of growth spurts (Alfonso-Durruty 2011; Papageorgopoulou et al. 2011). HL are found in modern-day clinical materials as well as in archaeological human bones.

Traditionally paleopathologists have been interested in HL as they may correlate with childhood development stress and, as a result, describe living conditions or health status of individuals (McHenry 1968; Hughes et al. 1996; Berrocal-Zaragoza & Subirá 2008; Beom et al. 2014). They are often used as an indicator of poor nutritional status or other stress factors of small children and juveniles (Mays 1985; 1995; Gronkiewicz et al. 2001; Ameen et al. 2005; Geber 2014) as it is more difficult to identify them in adults (Mays 1995) due to bone remodelling (Garn & Schwager 1967; Hummert & Van Gerven 1985). For instance, Piontek et al. (2001) studied HL in skeletons from medieval cemetery in Cedynia, Poland, and found that their frequency was at the largest between the ages of 6 to 12, and then dropped significantly in older age categories. It is thus believed that the majority of HL in this population was developed during this age phase. In addition, females may have a slightly higher tendency to develop HL due to the differences in bone remodelling rates between the sexes (Arnay-de-la Rosa et al. 1994; Lewis & Roberts 1997; Papageorgopoulou et al. 2011; Beom et al. 2014).

Mays (1995) examined nearly 700 skeletal remains (10th to 19th centuries) excavated from church and churchyard in Wharram Percy, North Yorkshire, England, for the presence of HL. Of these skeletons 107 juveniles and 181 adults scored for HL. Nevertheless, also much higher prevalence has been obtained. Papageorgopoulou et al. (2011) studied the occurrence of HL by looking at 241 tibiae from medieval Swiss remains (11th to 15th centuries) using a standardised, semi-automated detection and analysis tool. HL were found in 185 of the examined individuals (76.8%).

Apparently even less than severe stress can lead to development of HL (Dreizen et al. 1964). Moreover, in order for them to be observable in

Fig. 1. Oulu Cathedral and Iin Hamina churchyard sites are located on the coast of Bothnian Bay in Northern Ostrobothnia, approximately 40 km apart. Illustration: T. Väre.

bones, the individual needs to recover from the causative factor of HL (Lewis & Roberts 1997). This in turn suggests a better state of health compared to ones who die before developing any possible indicators of stress in their skeleton. Essentially, HL should be used in association with other indicators of malnutrition, disease or stress (Hughes et al. 1996; McEwan et al. 2005; Alfonso-Durruty 2011).

MATERIALS

The studied material consisted of 86 disarticulated tibiae and 69 femora excavated from late medieval/early modern churchyard sites in Oulu and Iin Hamina (Fig. 1). The preservation state of bones varied, and only the bones with well-preserved distal metaphyses were chosen for the analysis.

The sites are situated c 40 km apart on the coast of Bothnian Bay in Northern Ostrobothnia, Finland. The material thus represents the late-14th-century to late-18th-century population of the coastal Northern Ostrobothnia. The Oulu Cathedral site is located centrally in the city of Oulu and its skeletal remains date to the 17th and 18th centuries. The site was excavated in 1996 and 2002. In addition to several tombs built of stone and wood and individual graves, pits of secondarily placed human bones were uncovered during the excavations (Sarkkinen & Kehusmaa 2002; Maijanen 2006; Lipkin & Kuokkanen 2014). The material used in this study consists of these disarticulated bones of individuals of different ages and sexes.

Only 9 tibiae and 19 femora are from Oulu, while the rest of the material originates from Iin Hamina. These bones were excavated in 2009 from Iin Hamina discontinued churchyard site. Similarly to the Oulu material, the bones used in this study derive from secondary location, ‘a bone pit’. Based on the crania found in the pit, the minimum number of individuals was 160 and the distribution of sexes rather even. Most of the bones where those of adults and the preservation of fragile children’s bones was poorer, a typical feature in osteoarchaeological materials. The bones from Iin Hamina are slightly older than those excavated from the Oulu Cathedral site, dating roughly from the late 14th century to the early 17th century (Heikkilä 2011; Korpi & Kallio-Seppä 2011).

Altogether 86 tibiae (L=40; R=46) and 69 femora (L=37; R=32) were selected for the radiological imaging. Because the material consists of disarticulated bones instead of complete skeletal individuals, the two sides needed to be considered separately in analyses to avoid over-representation, as the sides would likely have been bilaterally affected.

METHODS

Radiographs were obtained with a digital radiography system (Digital Diagnost, Philips Medical Systems, Hamburg, Germany) on a Bucky table with 115 cm source to detector distance and exposed at 58 kVp and 3 mAs. The pixel

	N	Aff.	%	L	Aff.	%	R	Aff.	%
Tibia dist.	86	58	67.44	40	27	67.50	46	31	67.39
Tibia prox.	66	37	56.06	29	17	58.62	37	20	54.05
Tibia	86	64	74.42	40	30	75.00	46	34	73.91
Femur dist.	69	25	36.23	37	15	40.54	32	10	31.25
All	157	91	57.96	77	45	58.44	78	44	56.41

Table 1. Harris lines in the lower extremity long bones from Iin Hamina and Oulu Cathedral churchyards.

size of the obtained images was 0.14 x 0.14 mm and detector records 12 bits in gray level. Images were evaluated using a radiology workstation with high resolution diagnostic displays by musculoskeletal radiologist. HL that exceeded half of the bone thickness were calculated at both metaphyses of tibia and distal metaphysis of femur.

RESULTS AND DISCUSSION

In analyses HL were observed in nearly 75% of the tibiae and c 36% of the femora in the material. The proportion of bones affected with HL is similar in both sides (Table 1). In several bones more than one line were radiologically observable (Fig. 2). The prevalence of HL in tibiae is similar to that obtained in the study of medieval Swiss population (Papageorgopoulou et al. 2011). However, the percentage of affected tibiae is a minimum number as several bones were missing their proximal ends (N=20, five of which had no distal HL). Thus, it remains uncertain whether the proximal metaphyses of these bones were also affected. Nevertheless, in comparison with the distal ends of tibiae, the HL were clearly less often present in the proximal ends, which was also observed in the Swiss sample (Papageorgopoulou et al. 2011). In our sample, it was uncommon for the proximal metaphysis to be solely affected (N=6). Overall, HL occurring in the proximal end of tibia was approximately as common as in

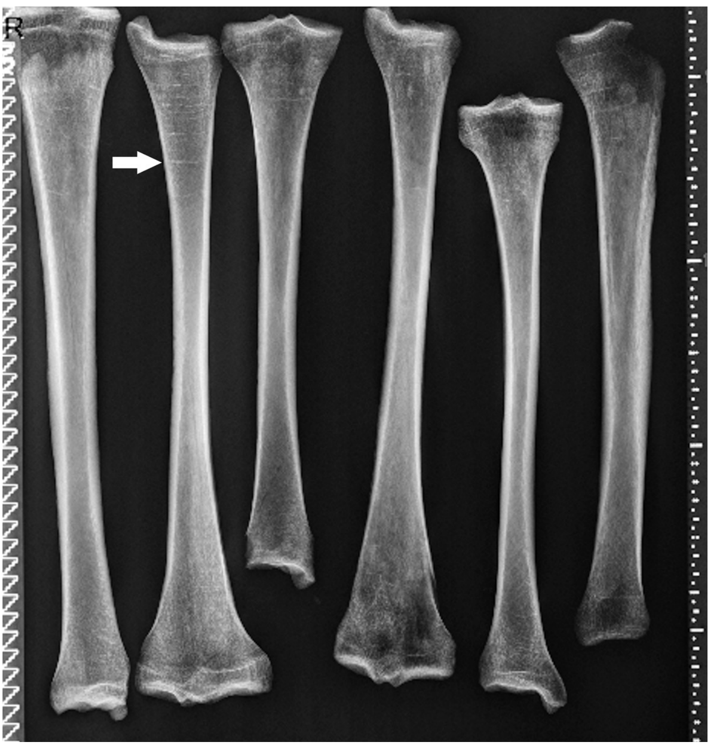

Fig. 2. Several Harris lines are seen in the radiographs of the tibiae from the Oulu Cathedral site. An example is indicated by an arrow. Photo: J. Niinimäki.

the distal shaft of femur. Unfortunately the material consisting of disarticulated bones does not allow examining whether they were typically simultaneously afflicted.

As our material consisted of secondary burials and mostly individual bones, reliable sex and age determination was impossible. This may be significant, although the above-mentioned difference in the tendency to develop HL between the sexes has not been observed in all the studied populations (e.g. Mays 1995). The population of Iin Hamina has been estimated to have died relatively young (Heikkilä 2011), which may partially explain the high prevalence of HL, as the lesions are more difficult to identify in adults (Mays 1995). However, Papageorgopoulou et al. (2011) did not report any differences between the age groups in the Swiss sample.

If the presence of HL is, indeed, interpreted indicating disturbances in nutrition or health during the growth period, the studied sample seem to have suffered from less than ideal childhood conditions. The mean statures in Iin Hamina were estimated as c 161.8 cm for men and c 153.9 cm for women, and in Oulu as c 166.9 cm for men and c 154.6 cm for women respectively (Maijanen 2006; Kortelainen et al. 2011). According to these estimates both populations were rather short. For instance, the current mean height for young Finnish men is 180.7 cm and for women 167.2 cm (Saari et al. 2011). The stature is influenced by childhood conditions: factors such as poor nutrition or malabsorption caused by disease often result in short adult stature (Eveleth & Tanner 1990: 222–3; Malina et al. 2004: 511–2). Short mean statures and high prevalence of HL in our sample may indicate disturbances in childhood conditions.

The present research was the first attempt to study Harris lines in osteoarchaeological materials of Northern Finland. In the future we hope to continue our study with other skeletal materials and also combine the information of HL with other adequate research methods, such as osteometry and stable isotope analyses. Ten right tibiae from Iin Hamina were already sampled for stable isotope analyses to assess their nutrition. To enable further comparisons, five of these bones were affected with HL, while five showed no signs of these defects.

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