Medical humanities in search of mobility and physical activity

-theoretical principles

Mobility and physical activity has been a major interest for fields of physical anthropology, history and clinical medicine for the past decades. Mobility, in broad context, includes not only locomotion and physical activity but also mobility and migration over the landscape with different means of transportation. In anthropology human mobility can be traced through population demographics, genetic trait frequencies, internal and external bone morphology and differences in diet (e.g. isotope analysis). Physical activity studies include daily activities, such as occupation and sports. Physical activity can be studied anthropometrically through modifications in the skeleton such as musculoskeletal stress markers, markers of occupational stress, overuse injuries and bone biomechanical properties.

Clinical medicine has formulated the theoretical principles behind bone remodeling and thus behind the interpretation of mechanical loading. Imaging methods and –equipment have been fast developing and now adopted for wider use to investigate alterations due to mechanical loading in bone morphology. Previously mainly plain radiography has been utilized in anthropological studies but recent development in noninvasive medical imaging has increased the possibilities of imaging both skeletal as well as clinical samples.

It is of interest to study human temporal and ecogeographical variation in addition to consequences of decreased demands in physical strength. Combining historical information from the skeletons and evidence from archives and artifacts will aid in forming a comprehensive picture of human mobility in the past. We invite papers from archaeology, history and clinical medicine related with studies of mobility and physical activity through studies of population demographics, bone morphology (e.g. bone biomechanical properties, musculoskeletal stress markers, markers of occupational stress, and genetic trait frequencies), food intake (e.g. isotopes), and transportation methods.

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The relationship between physical activity and vertebral strength

Reduced vertebral strength is a clear risk factor for vertebral fractures. Men and women with vertebral fractures have often reduced vertebral size and bone mineral density (BMD). Factors behind vertebral strength are controlled by both genetic and developmental factors. Malnutrition and low levels of physical activity are commonly considered to result in reduced bone size during growth. The relationship between BMD and physical activity is also clear as exercise increases the bone density.

In this study we wanted to explore the association between physical activity and bone strength parameters in the spine, especially in vertebral cross sectional size (CSA) and vertebral bone density. To conduct this study we measured dimensions of the 4th lumbar vertebra from MRI scans of the Northern Finland Birth Cohort 1986 and performed T2* relaxation time mapping, reflective of BMD. Vertebral strength was based on these two parameters.

The study population consisted of 6928 boys and girls who, at 15–16 years of age, responded to a mailed questionnaire inquiring about their physical activity. Our study population consists of a subsample of 380 individuals that volunteered to a lumbar spine MRI examination at the mean age of 21 yr. The analyses, using analysis of variance, indicated no association between vertebral strength and physical activity during childhood and adolescence.

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The reconstruction of skeletal robusticity and habitual physical activity level: Controlling for effects of body size and body proportions

Cross-sectional diaphyseal dimensions and thus cross-sectional properties (e.g., areas, second moments of area) response to mechanical loading resulting from physical activities. Body mass and body proportions must be taken into account when reconstructing relative skeletal robusticity and/or habitual physical activity level because they affect the mechanical loading of especially weight-bearing skeletal elements. Cortical area should be scaled with body mass (either observed or estimated) because a bone shaft's ability to resist compression is proportional to its cortical area. Second moments of area (bending rigidity) should be scaled with the product of body mass and moment arm length (e.g. biomechanical bone length) because altering biomechanical bone length in relation to body mass and second moments of area affects its ability to resist bending. As an example, these procedures are applied on different archaeological skeletal populations that had different subsistence practices and technology to demonstrate the relationship between skeletal robusticity and habitual physical activity level.

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Reconstructing mobility: new insights into musculoskeletal stress markers as activity indicators – what enthesis scoring method to use?

Past activity patterns are traditionally reconstructed using musculoskeletal stress markers (MSM) and bone biomechanical properties. Thanks to sports medicine, the relationship of the latter with physical activity is well established, but activity effects on the former are less well known. However, a recent study has shown that the same causal mechanisms are likely to affect also MSM, where bone models towards the primary axis of stress. This occurs under mechanostat theory: bone modeling increases bone mass if appropriate threshold values are reached. Several enthesis scoring methods have been developed, but only Villotte (2006) considers the type of muscle-bone attachment: fibrous (F) and fibrocartilaginous (FC). Villotte method applies well for FC but it performs less accurately for F entheses. Most popular of the old methods (Hawkey and Merbs, 1995) has produced well for F entheses where the relationship between bone biomechanical properties and MSM as well as the relationship between activity intensity and MSM has been established. Therefore, for scoring F enthesis Hawkey and Merbs performs quite well, whereas scoring for FC Villotte method is best. The current recommendations for entheses scoring as suggested in American Association for Physical Anthropologists meeting in Portland, Oregon in April 11–14, 2012 are also presented.

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Bone collagen isotopic ratios from Eastern Fennoscandian contexts – from fragments to practice

The temporal window into the past lives of our ancestors is usually determined by radiocarbon dating of archaeological finds. One way to unveil the window open is to examine the isotopic ratios. Information about diet, surrounding environment and metabolism of the human body has been coded into the isotopic ratios of both the inorganic and organic bone components. Indeed, isotopic ratios of bones have had a key role in the paleodietary studies already since 1980's (e.g. Schoeninger & DeNiro 1983).

Although the potential of these measurements has been realized, these studies have been scarce in Finland. Radiocarbon dating requires always a measurement of carbon-13 to carbon-12 ratio (δ13C) for a fractionation correction (Stuiver & Polach 1977). Therefore, radiocarbon dating laboratories usually possess the ability for such measurements. Together with the surrounding research environment, our laboratory has supported the idea to lift the measurement capabilities of bone collagen carbon and nitrogen isotopic ratios to the state-of-the-art level in Finland. This has included recruitment and supporting of capable personnel, preliminary measurements of several Finnish and Estonian contexts, launching of international collaborations for intercomparison measurements and fine-tuning the existing laboratory processes (e.g. Longin 1971).

This contribution presents the status of the bone collagen isotopic ratio measurements in Finland by discussing the obtained results with respect to the corresponding isotopic data within Baltic Sea. We will aim to proceed from fragmentary measurements to larger measurement programmes via research collaborations with interested partners. Via such a scheme the bone collagen isotopic measurements will most likely become a standard part of the researchers' toolbox also within the Eastern Fennoscandia.

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Study of the mummified remains of vicar Nikolaus Rungius

In Finland burials were made in churches until the 19th century. Due to this the deceased were placed in conditions favoring mummification. One of the mummified corpses belonged to the late vicar of Kemi parish, Nikolaus Rungius (1560–1629) of Keminmaa. The aim of this study was to examine the preservation, anthropometric qualities and pathological conditions of his remains using computed tomography. The skin was mainly intact. However, the mummy was hollow with only remains of soft tissue. The right forearm and six cervical vertebrae were missing. The living-stature was estimated to have been c. 177 cm and the weight 75 kg. The weight was likely underestimated as the mummy's appearance suggests overweightness, although, putrefaction may have caused the bloatedness. However, DISH which is related to old age and obesity manifested in the spine. Additionally, an assumed spondylodiscitis and various calcifications raised suspicions of tuberculosis. The dentition was healthy with the exception of moderate periodontitis, minor calculus formation and few caries lesions. The molars exhibited flat wear-pattern which and the dental health profile suggest a protein-rich diet. Among his contemporaries, vicar Rungius was a large man with age and obesity related conditions, and a typical Northern Finnish diet of the time.

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Modern imaging methods in mummies

Already in 1895, within a year of discovery, x-rays were used to study fossils. For the first time it was possible to study internal morphology of specimens with non-destructive method. From thereon radiologic methods have been utilised by paleoanthropologists. X-ray radiography is a projection imaging method, which is based on attenuation of x-ray beams in solid subjects. Attenuation is proportional to the product of object density and thickness. In 70s and 80s discoveries of computed tomography (CT) and magnetic resonance imaging (MRI), both techniques recognized by Nobel Prize, provided more sophisticated tools for scientists. CT employs a computer to reconstruct image "slices" from x-ray penetration data. Modern clinical CT-technology can yield sub-millimetre volumetric resolution from entire human body in a minute. High spatial resolution of images facilitates accurate measurements and 3D visualisation of the scanned subject. If even better resolution is needed, micro-CTs designed for laboratory animals can yield resolution of 50 microns or less. However, only small specimens can be scanned. Whole-body CT-scanners are usually stationary and therefore when imaging mummies, the specimens has to be transported to the scanning location. After positioning to scanner bed, a virtual three-dimensional electronic record of a mummy can be achieved in minutes. However, due to large datasets, a powerful 3D workstation is needed to study the obtained information efficiently. MRI, although more recent innovation, does not provide better resolution when compared to CT. It's power is in excellent soft tissue contrast. Drawback of MRI in imaging mummies is that conventional MRI contrast is based on imaging proton nuclei in water and therefore it is best suited for imaging hydrated specimens. However, with fast imaging techniques, MRI has been used successfully to image e.g. desiccated ancient Egyptian mummy brain. MR spectroscopy is a technique, which can be used to evaluate chemical composition of studied specimens. The aforementioned Egyptian mummy brain was also studied with this technique. Soft tissue discrimination of CT technology can be enhanced by scanning the subject with two x-ray energies. It however, needs special equipment and in clinical setting it is used to image e.g. gout tophi. We used clinical CT-scanner to image mummified body of Nikolaus Rungius, vicar of Kemi church who died in 1629.

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