Busy Bones: Osteoarthritis and musculoskeletal stress markers as evidence of physical activity and social differentiation in post-medieval The Netherlands

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1. Introduction

Palaeopathology is an active and diverse field of research. Beyond documentation and diagnosis, it is important to establish why pathological processes occurred. Some lesions can provide important information about the activities of the deceased. However, deriving knowledge about activity and occupation from human skeletal remains is a contentious area of osteoarchaeology. The many different activities a person undertook in their lifetime create a palimpsest of different signs on the bones, making it difficult for the osteoarchaeologist to determine the type of work in which the person might have engaged. Except for cases in which the exact activities the population engaged in are known, it is not yet possible to assign specific activities to a skeleton with a reasonable degree of certainty. This study examines osteological markers of activity in a historically documented skeletal collection from a rural area of The Netherlands. Hypotheses are limited to determining relative activity levels rather than single activities. Two osteological activity markers are selected: (1) the pathological changes associated with osteoarthritis (OA), and (2) the morphology of muscle attachment sites (also known as musculoskeletal stress markers or MSMs). Combining a pathological and a non-pathological activity marker provides insights into their validity, as well as a more detailed dataset.

2. Materials and methods

The sample is from the cemetery site of Middenbeemster (fig. 1) which was excavated in the summer of 2011 by Leiden University. Middenbeemster is located in the Beemster Polder, a UNESCO world heritage site. The cemetery contains inhabitants from the whole Beemster Polder, a rural area which focused on dairy farming. The Beemster was a relative latecomer to modernization and farming machinery. The interments date from the early seventeenth century to 1866. For this study, 48 male and female adult individuals between 26 and 49 years of age were examined (late young adults (LYA, 26-35) and middle adults (MA, 36-49)). The study was limited to the non-shoulder bearing upper limb.

a) Osteoarthritis

Osteoarthritis is a joint disease occurring in synovial joints which causes erosion of the cartilage. In skeletal remains, this is easily recognized as a change in the basic morphology of the joint. Bone can react to osteoarthritis in four ways: (1) it can form new bone, on the joint surface as well as at the edges of the joint; (2) the articular cartilage can become porous; (3) the whole joint contour can change; and, (4) areas on the joint surface can attain a polished appearance (fig. 2). The last, very characteristic, osteoarthritic change is called eburnation (Waldron 2006, 27-49).

b) Musculoskeletal stress markers

The morphology of the muscle attachment sites was scored using the standardized system created by Mariotti et al. (2004, 2007). The method incorporates osteophyte formation, osteolytic lesions and general robusticity of the MSMs. The selected muscle attachment sites on the upper limb include the same functional complexes as the joints chosen for OA. On the humerus, the greater, minor, major, and brachioradialis muscle attachment sites were examined. On the radius the biceps brachii was examined and on the ulna the triceps brachii (fig. 3).

3. Results and discussion

a) Handedness

The osteoarthritis data showed no statistically significant asymmetry. The MSM data, however, showed a clear development of the left side for the brachioradialis major (fig. 4) in the latissimus dorsi/teres major muscle attachment site, the left dominance was statistically significant. This suggests strenuous activity in which the right arm directs the motions while the left provides the brunt of the physical force. Possible activities include the use of a shovel, rake or scythe.

b) Sex

There was no evidence of sexual division of labor based on the OA. However, the efforts of estrogen on osteoarthritis in women (Spyker and MacGregor 2004), it can be argued that OA is not a good activity marker to establish whether one sex performed more strenuous or different activities then the other. The MSM data show sexual differentiation, with males developing more pronounced MSMs at all sites but the triceps brachi (fig. 5). Generally, men appeared to engage in more strenuous physical activity than females. The higher level of development in males was most prominent in the biceps brachi. High development of this muscle is consistent with the habitual carrying of heavy loads on the forearm. The only MSM which was most pronounced in women was the triceps brachi, suggesting that females performed more tasks which extend the lower arm, extend or adduct the arm, require the bracing of the elbow joint, and/or push/pull something down from a flexed position. This last movement could correspond to the milking of dairy cattle.

c) Age

The osteoarthritis prevalence was not correlated with age (13 LYA and 13 MA affected), yet the severity of OA did increase with age, suggesting a combination of genes and activity in the occurrence of the disease, and a degenerative process once the disease began. MSMs show a clear positive correlation with age, concuring with existing hypotheses on their accumulative nature (Wells 2007, 931).

d) OA and MSMs combined: Activity and social differentiation

The correlation between OA and MSMs was very low, considering that both are activity markers (fig. 6). This made combining the data to establish social differentiation difficult. If there was a clear system with laborers and elite, as was likely in this rural post-Medieval population, distinct groups should be visible. There individuals did however have low scores for both OA and MSMs, and they could have belonged to a higher class. The historical data derived from the bones helps clarify this rather musculoskeletal system. They provide information on the professions exercised in the Beemsterpolder. As these included among others farmers, ostlers, housekeepers, artisans, priests, and merchants, establishing a clear-cut connection between activity level and social status is difficult. Given the current relatively limited knowledge of activity markers, such historical data is of great value.

Comparisons between the MSM data and other studies indicated clear differences in the patterns of muscle use. In the Beemster population, the deltoid development ranked lowest in relation to the other muscles studied (fig. 4), which is surprising as this is an important multifunctional muscle. In the Afghan Burial Ground Population, for example, this muscle was most pronounced (Witvak 2004). In Natufian hunters, it ranked as the second most pronounced MSM (Eshed et al. 2004). Future research is needed to establish the meaning of the difference.

When the OA data are compared to contemporary Dutch settlements, it becomes clear that the agricultural Beemster community engaged in more strenuous physical labour. For example, in the urban context of Amsterdam in the 18th and early 19th century, elbow OA prevalence was 9% (Braasen 2004, 62-64). A similar trend is visible in Middenbeemster. This is supported by the lack of pronounced handedness for both OA and MSMs.

4. Conclusion

Analysis of osteoarthritis and musculoskeletal stress markers provides tantalizing glimpses into past lifeways. Osteoarthritis indicated generally high physical stress in the Beemster population. Its use thereby transcends the basic palaeopathological level. Musculoskeletal stress markers added data on sexual differentiation within the population, showing a clear sexual division of labor. Together, the activity markers provided information at an intra- and inter-population level. However, as the correlation between these activity markers is low, great care must be taken with the interpretation, and further research into their etiology is necessary.

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6. Bibliography

[Insert list of references related to the study]