A12 Musculoskeletal Stress Markers as Evidence of Manual Labor: The Allumiere Cemetery Case

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After attending this presentation, attendees will better understand the importance of musculoskeletal stress markers on human bones.

This presentation will impact the forensic science community by providing an additional tool to enhance the biological profile and osteobiography of unknown human skeletal remains.

Entheses are muscle and tendon attachment sites on bones that can vary morphologically in relation to muscle activity. The analysis of these marks on skeletal remains can help to identify physical activity carried out by a subject during life. An enthesis is an interface between hard and soft tissues where high biomechanical stress is concentrated. The result of this stress could be represented by acute or overuse injuries that may develop into an enthesopathy.[1] Marks on skeletal tissue could be also influenced by different factors, such as intense muscle activity, postural habits, and medical or nutritional conditions.[2]

For this study, an Italian historical skeletal collection housed at the Department of Biology of the University of Rome Tor Vergata was examined. The skeletal remains belong to a cemetery in Allumiere (Rome, Italy), an area historically related to alum exploitation. A preliminary anthropological analysis was performed in order to assess sex, age at death, stature, and general osteobiographic traits. The sex ratio value (45M:7F) supports the theory that the cemetery area was mainly used by miners.

The analysis of entheses was performed according to the protocol proposed by Mariotti and colleagues; the 23 entheses proposed in that protocol have been integrated with those proposed by Borgognini Tarli and Reale.[3-5]

The analysis focuses on three parameters: robusticity, osteophytic formations and osteolytic enthesopathies. Robusticity represents the normal bone marks at a muscle, tendon or ligament attachment site, and it is nearly always recognizable, with the exception of extensive osteolytic processes affecting the entire osseous area.[3] The analysis of the degree of development is conducted following a scaling system: degree 1 (weak-moderate enthesal expression), degree 2 (strong development), and degree 3 (very strong development). Nevertheless, subcategories (1a, 1b, 1c) were provided for degree 1, corresponding to "very slight," "low," and "medium" development. Even for the other two parameters, a scaling system was used from 0 (absence) to 3 (marked) osteophytic or osteolytic process.

High-level biomechanical stress was detected analyzing single bone entheses. The results were then clustered into functional groups (shoulder, elbow, forearm, hand, hip, knee, foot) and all entheses of the entire upper and lower limb were considered in order to reconstruct the biomechanics and body movements.

The mechanical stress experienced by a surface is proportional to the force experienced in each unit area of that surface.[6] It is undeniable that the relationship between muscle activity and enthesal morphology is neither as simple nor as obvious, but morphological variation in the attachment site does exist and likely reflects some aspects of *in*

vivo stimuli. Skeletal entheses are thoroughly connected with the attaching muscles so, through them, it is possible to investigate the *in vivo* activity of those muscles.[7]

The availability of data regarding the different phases of alum production and the related labor categories opened the possibility of associating every individual to a specific work task correlated to alum extraction and exploitation making the presented case a "collector's item."[8] It was possible to assign different task groups. For instance, a young adult male showed a marked development of pectoralis major in addition to osteolytic lesions corresponding to costoclavicular ligament insertion on clavicle; this biomechanical stress that involved both the upper limb and the shoulder girdle could be related to the extraction in the cave through iron picks.

The goal of this pilot study is to demonstrate the relationship between musculoskeletal stress markers on human bones and activity patterns through a multidisciplinary approach that involves different points of view, such as anthropological, biomechanical and historical.

In addition, this research demonstrates the potential application in forensic contexts in which anthropologists have to investigate compromised unknown human remains (decomposed, mummified, mutilated, burned, and dismembered). The possibility of identifying musculoskeletal and occupation stress markers and moreover to reconstruct *in vivo* biomechanical stimuli related to daily tasks could become an important improvement to biological profiling opening the possibility of reconstructing muscle body movements and hypothesizing activity patterns, in order to increase the chance of sorting candidates for identification.

Presented here is a pilot study that, even if limited by the small sample size, demonstrates the potential of an empirical experiment and provides an important additional tool to forensic investigations.

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Entheses, Osteobiography, Activity Patterns