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LESIONS LINKED TO ATHLETIC ACTIVITIES IN THE ANCIENT ROMAN POPULATION FROM HERCULANEUM (ITALY, FIRST CENTURY AD)

ABSTRACT: Through archaeological and written sources we know that the Romans devoted great attention to many athletic activities. However, the examination of skeletal materials carried out until now had not provided biological evidence for this love of sport. For this reason, the authors examined the frequencies and types of traumatic lesions (skeletal fractures, enthesopathies, and syndesmoses) observable on the perfectly preserved skeletons of the inhabitants of the Roman town of Herculaneum who died during the volcanic eruption of Mount Vesuvius on August 25, 79 AD. The authors show that in this population the epidemiology, topographic distribution, and typology of the skeletal fractures, as well as the syndesmoses and enthesopathies, were largely linked to daily activities and to stress risks typical of the time (including slavery) and place (including the major economic activities, such as fishing). However, the authors also discovered a possible boxer (with typical nasal and hand bone fractures) and a possible javelin-thrower (with typical humeral epicondylus exostoses); stress fractures of the foot linked to long marches and fractures of the talus due to foot hyperextension are also well documented. The authors show that some of these lesions can be linked to the sporting equipment typical of the Romans, and also match lesions observed in modern athletes. The authors conclude that among the victims of the eruption of Vesuvius there were athletes that worked in Herculaneum's gymnasia and circus.

KEY WORDS: Paleopathology – Sports lesions – Herculaneum

INTRODUCTION

Through written sources and archaeological evidence we know that the Ancient Romans were quite familiar with athletics, devoting special attention to muscular and physical activity in public hot baths, gymnasia, circuses, etc.; we also know that there were professional athletes among the Ancient Romans, including gladiators, boxers, fight-men, etc. In addition, we have much evidence of special buildings devoted to athletic activities in ancient Roman towns throughout the Empire.

In contrast with this detailed information from both written sources and archaeological evidence, no biological data on athletic activities had emerged from the osseous remains of the Romans, despite the examination of thousands of skeletons of Ancient Romans from many Italian regions.

With an eye on discovering osseous lesions possibly related to athletic activities, we examined the skeletal remains of the victims of the volcanic eruption of the Vesuvius who died during the night of August 25, 79 AD. These skeletal materials are of particular paleobiological interest in our investigation because they represent a homogeneous series of subjects whose bones were perfectly preserved through sudden death and immediate burial under an impressive thickness (about 20 meters) of volcanic mud that completely encased them for millennia (Capasso 2000a).

In addition, we know that in the ancient town of Herculaneum there were two gymnasia and a circus at the

time of the volcanic eruption; the people who worked in these public sporting complexes lived in the town and were present at the moment of the final tragedy.

Using paleopathological methods we examined the skeletal remains of the victims of the Herculaneum eruption to identify athletes through bone lesions indicative of athletic activities.

MATERIALS AND METHODS

In carrying out this study, we examined the skeletal series of the victims of the eruption of Mount Vesuvius who were recovered on the ancient beach of Herculaneum (Capasso 2000a). These materials comprise the skeletons of 143 subjects whose sex and age distribution at the moment of death are given in *Table 1* (Capasso 2000a); we note that there are only 100 adult subjects, while 43 subjects were between 0 and 14.9 years of age. All the skeletons are essentially complete, and very well preserved (Capasso 2000a).

The sample reveals a slight prevalence of males, with a Male : Female ratio of 1.38 : 1 (Capasso *et al*. 2000).

To identify skeletal lesions possibly attributable to stresses linked to athletic activities, we examined all the bones macroscopically, and analysed the skeletal modifications observed with standard roentgens and stereomicroscopy.

The lesions observed were compared with both similar alterations observed in modern orthopaedic cases, and with archaeological evidence, including written sources and archaeological manufactures.

RESULTS

We devoted our attention to two possible pathological changes of the skeletal materials: (i) fractures, and (ii) traumatic lesions of ligaments and tendons.

TABLE 1. Number and breakdown of the subjects included in the sample population (the victims of the volcanic eruption of Vesuvius at Herculaneum, 79 AD).

Age (years)	Male	Female	?	Total	%
0–5	9	7	1	17	11.9
5–10	7	5	0	12	8.4
10–15	7	5	2	14	9.8
15–20	2	5	0	7	4.9
20–25	9	7	1	17	11.9
25–30	11	6	0	17	11.9
30–35	8	6	0	14	9.8
35–40	7	5	0	12	8.4
40–45	7	4	0	11	7.7
45–50	6	4	0	10	6.9
50–55	6	3	0	9	6.3
55–60	2	1	0	3	2.1

TABLE 2. Subjects with skeletal fractures in the studied sample population.

Subject No.	Sex	Age	Bone segments fractured
E2	M	30–35	Frontal bone
E8	M	7–8	Right radius, right ulna
E14	M	35–40	Right nasal bone, rib, right fifth metacarpal
E15	M	25–30	Right humerus
E17	M	50–55	Three right ribs
E31	M	45–50	First right metacarpal bone
E38	M	25–30	Frontal bone
E49	M	50–55	Frontal bone, right radium, second, third and fourth right metatarsal bones
E51	M	40–45	Eighth left rib
E54	F	4550	Fifth left metacarpal bone
E62	M	45–50	Right radius, right ulna, left scaphoid bone
E65	F	45–50	Right temporal bone (xiphoid apophysis)
E70	M	25–30	Frontal bone
E72	M	55–60	Fourth left metatarsal bone
E109	F	30–35	Mandibular condylum, right fourth metatarsal
E112	M	45–50	Right astragalus (processus posterior)
E120	M	35–40	Right ulna

Fractures

In 17 subjects we observed 31 skeletal segments that present traces of fractures in all stages of healing. Of the 17 subjects with fracture(s), 14 are males and only 3 are females, with a M : F ratio of 4.7 : 1 (*Table 2*).

The most frequently broken bones are the ribs (5 cases) and the metatarsals (also 5 cases), followed by the frontal bone and the ulna (both 4 cases) (*Table 3*).

The majority of these fractures involve the long bones of the limbs (19 cases, or about 29%), though an unexpected number of cases involve the cranial bones and the bones of axial skeleton (12 cases, or about 39%). The fractures of the long bones are absolutely prevalent in the right side (*Table 4*).

The majority of the subjects show a single fracture (10 subjects, or about 59%), but we have also some subjects with two fractured bones (in particular the classic localization of the forearm), and some examples of subjects with 3, 4 and 5 fractured bones (*Table 5*).

With the aim of linking fractures to possible athletic activities, we first examined subject No. E49, who had suffered fractures of the distal part of the bodies of the II, III and IV right metatarsal bones, with deviation of the bone axes and with an exuberant bone callus (*Figure 1*). The macroscopic aspect of these lesions, their topographic distribution on the forefoot skeleton, and the radiographic aspects of the bones involved show that this is a case of

TABLE 3. Frequencies of the skeletal fractures observed in the studied sample population (N=31).

Bone involved	Number of cases
Fontal bone	4
Nasal bone	1
Temporal bone	1
Jaw	1
Ribs	5
Humerus	1
Radius	1
Ulna	1
Carpal bones	1
Metacarpals	3
Femur	1
Talus	1
Metatarsal	5

TABLE 4. Laterality of the fractures of long bones (N = 19).

	Right	Left
Superior limb	9	3
Inferior limb	6	1
Total	15	4

TABLE 5. Number of fractured bones in each subject.

Number of fractured bones	Number of subjects (N=17)
1	10
2	3
3	2
4	1
5	1

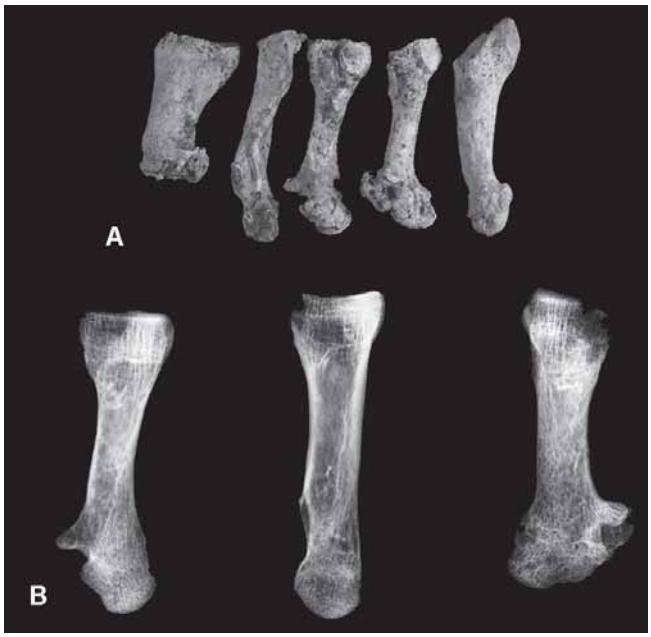

FIGURE 1. Second, third and fourth metatarsal bones of subject No. E49, showing macroscopic aspects of bone callus and axial deviation due to Deutschländer's fractures (A); the radiographic image of these bones shows that the fracture was well healed (B).

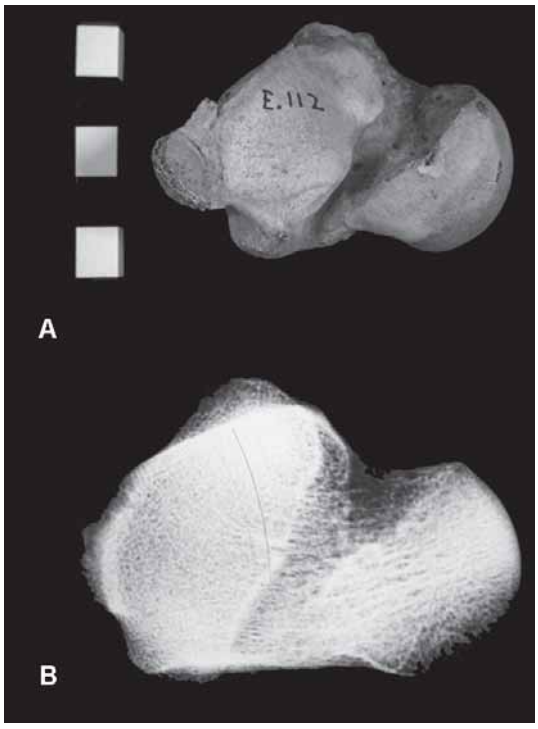

FIGURE 2. Superior view of the right talus of subject No. E112, showing a completely fused processus posterior. The macroscopic image shows a fracture line at the base of the anomalous processus (A); the radiographic image confirms the presence of a well healed fracture (B).

FIGURE 3. The facial region of subject No. E14 shows the fracture of the free margin of the right nasal bone, with introflexion of the fractured fragment (A, B). This type of nasal fracture is also typical of modern boxers, as is shown by the radiograph of a young modern boxer (C).

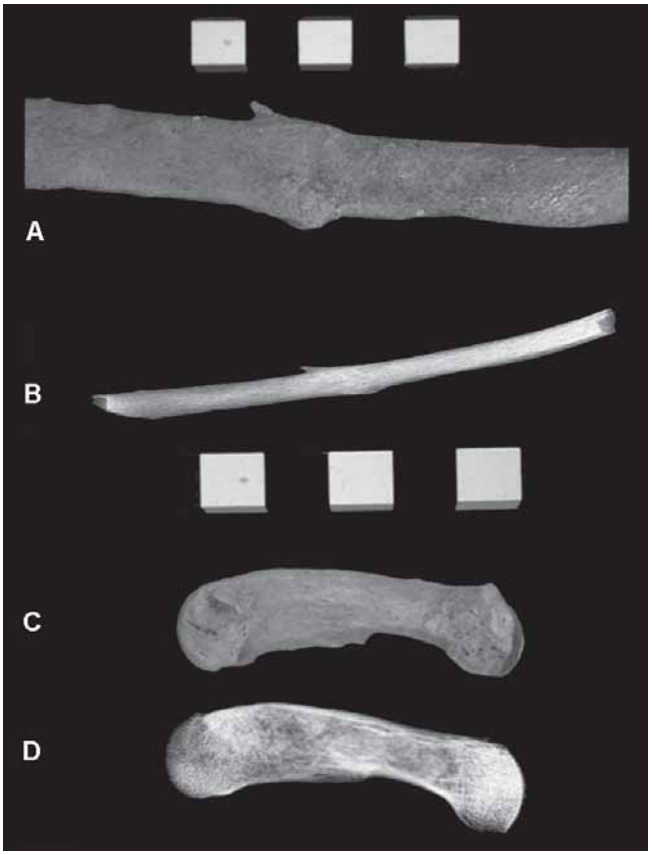

FIGURE 4. The post-cranial bones of subject No. E14 also show other healed fractures: on the middle part of a rib (A, B) and at the level of the first left metacarpal bone (C, D).

Deutschländer's fractures linked to very long marches on the part of a 50 to 55 year-old man.

The second case of possible interest regards subject No. E112, a man 45–50 years old, whose right talus

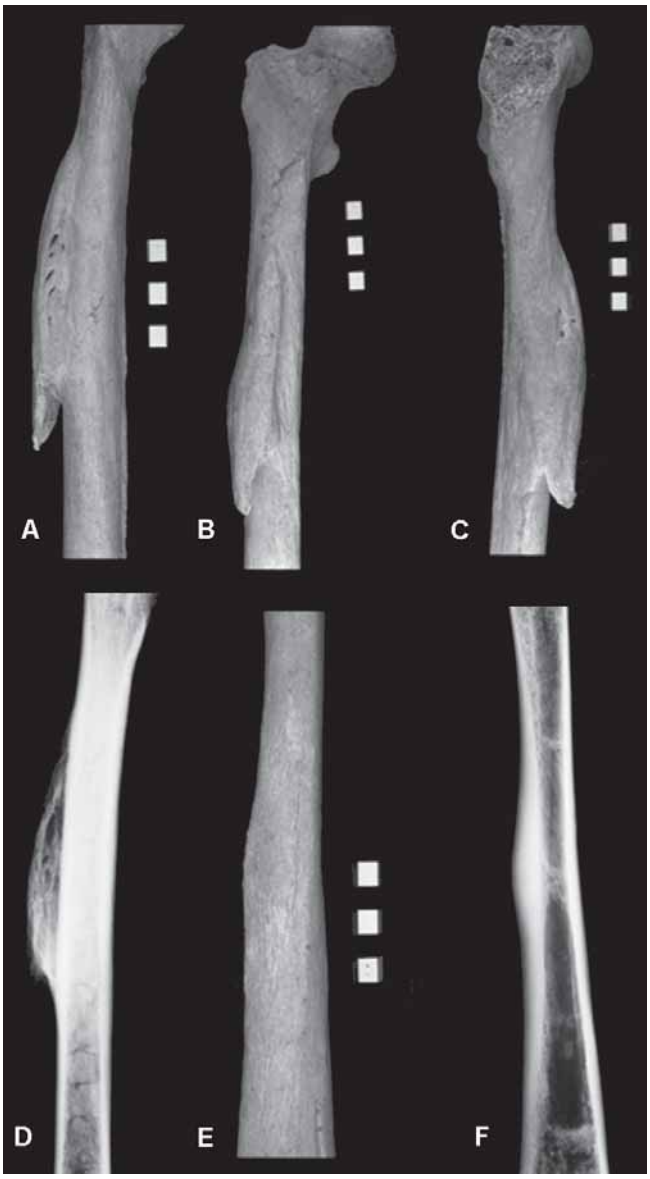

FIGURE 5. In subject No. E14 the soft tissues were also involved in post-traumatic lesions. Here we can see the sub-periosteal ossified haematoma at the level of the anterior surface of the right femur (A, B, C, D) and the anterior part of the right tibia (E, F); both macroscopic and radiographic images show that the origin of the new bone formation is sub-periosteal, and that the lesions occurred many years before the death of the subject.

presents a well developed accessory processus posterior. The macroscopic structure and the radiographic image of this region show the presence of well-healed fractures that completely cross the bases of the processus posterior (*Figure 2*).

The third case concerns subject No. E14, a 35–40-year-old man, who had suffered a fracture of the right nasal bone, with introflection of the inferior free margin of the bone; the fracture is completely healed, as showed both by the radiographic picture and stereomicroscopic analysis (*Figure 3*). It is also interesting to note that the same subject presents other fractures: a right middle thoracic rib and first V metacarpal bone (*Figure 4*), and that there are also

additional traces of traumatic lesions other than fractures on his skeleton. There are very large post-traumatic exostoses of the anterior face of both the right femoral diaphysis and the right tibial diaphysis (*Figure 5*). In addition, there is hypertrophy of the proximal and middle phalanx of the hands, with hypertrophy of the lateral crests (*Figure 6*). Small subperiosteal new bone buttons are present on the dorsal surface of the majority of the metacarpal body, and its radiographic and stereomicroscopic observations show that the new bone apposition was linked to local periosteal mechanical irritation (*Figure 7*).

FIGURE 6. Hypertrophy of the lateral crest of some hand phalanxes in subject No. E14; this type of hypertrophy is due to continuous use of the flexor muscles of the fingers.

Enthesis and syndesmoses

The bone insertions of tendons and ligaments can be affected by stressful activities, and in this case we can observe bone metaplastic changes of tendon and ligament, or bone resorption of their insertions (Iscan, Kennedy 1989).

In our sample we have observed cases of both bone resorption of tendon/ligament insertions and of osseous metaplasia of tendon/ligament terminations. In particular, the most frequent form is the so-called "rhomboid fossa", bone resorption of the inferior face of the middle end of the clavicle around the insertion of the costo-clavicular ligament (Anderson 1998). Resorption is due to the osteoclastic activity around the Sharpey's fibres under the stress of prolonged, intense use of the arms (Capasso *et al*. 1999). Rhomboid fossa was observed in 41.3% of males and 6.5% of females, both subadults and adults; in addition there is rhomboid fossa in 24% of all subadults (including subjects under 20 years of age).

With regard to the stressful activities that can produce osseous metaplastic changes in the tendon/ligament terminations, we observe that the most frequent localization of these changes in our sample is the ossification of the distal part of the tendon of the triceps muscle, which develops an ossification at the olecranum surface called the olecranon spur (Anderson 1998); in our sample this form of spur was present in 20.3% of all the subjects. The subcalcanear spur, Hasebe's spur (on the occipital), and other topographic localizations of these types of tendon/ligament ossifications were also observed in our sample (Capasso 2000b). A case of brachio-radial spur observed in subject No. E31, a male 45–50 years old, is of particular importance because it clearly demonstrates a link with an athletic activity. The lesion consists of a very large exostosis situated on the epicondylus of the right humerus (*Figure 8*); macroscopic, topographic and radiographic images show that this exostosis is the result of an ossification of the tendons of the medial epicondylar muscles, which include

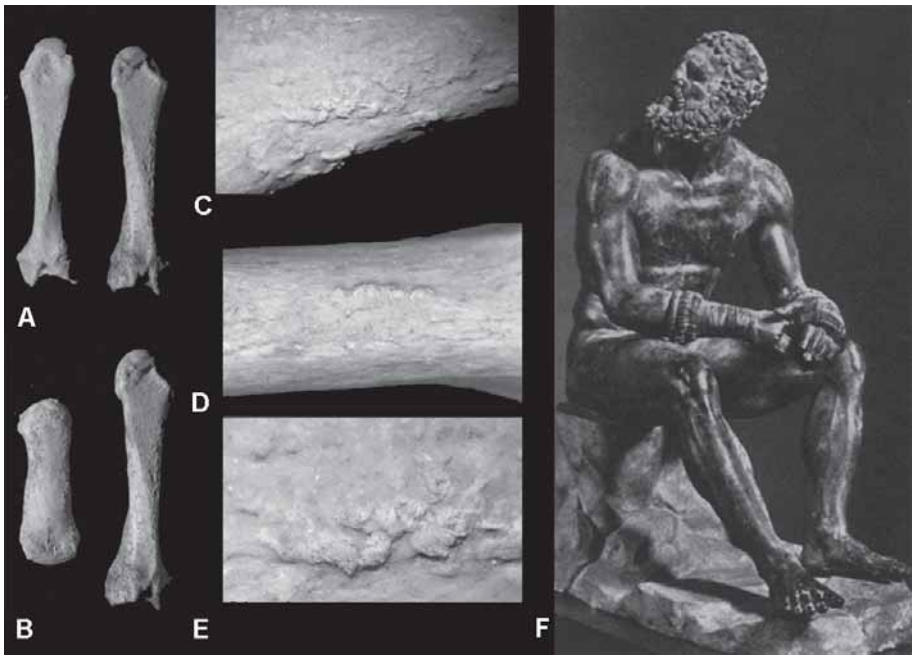

FIGURE 7. At the level of the dorsal surfaces of all the metacarpal bones of subject No. E14 we have observed a series of little new bone formations (A, B); the stereomicroscopic examination of these bone-buttons reveals their sub-periosteal origin, as a consequence of periosteal lesions (C, D, E). These periosteal lesions can be attributed to the continuous micro-traumatic action of the so-called caestus, the typical boxing gloves used by the ancient Romans, which were very hard bindings following the dorsal surfaces of the metacarpal regions precisely, as is clearly shown by contemporary sculptures (F: "The Boxer", sculpture at the Museo Nazionale Romano).

FIGURE 8. Distal epiphysis of the right humerus of subject No. E31, showing the so-called epicondylar spur (A) due to the ossification of the proximal ends of the muscles that were inserted in this region without destruction of the original cortical bone surface, as is shown by the radiographic picture (B).

the flexors of the wrist and digits (*flexor carpi radialis, palmaris longus, flexor digitorum superficialis*, and *flexor of carpi ulnaris*, as well as the *pronator teres*).

Hypertrophy of the bone crests of flexor muscles on the phalanxes of the hands was observed in many individuals; in particular this type of entesopathy is also shown by subject No. E14 (*Figure 6*), in association with the nasal bone fracture, metacarpal fracture, and post-traumatic underperiosteal new bone formations on the femur, tibia, and dorsal surfaces of the metacarpals (see the previous paragraph).

DISCUSSION

From an epidemiological standpoint, the very high value of the M : F ratio of the distribution of skeletal fractures (4.7 : 1), shows that the population of Herculaneum was differently exposed to the risk of traumatisms, and this was surely linked to sex-related differences in the distribution of labour in Herculaneum's society.

From a topographic standpoint, the fractures of the upper limbs occur prevalently on the right side, and this is congruent with normal daily activities. The high frequency of fractures involving the cranial and axial bones suggests a special pattern for these fractures, in particular, possible violent habits that can produce cranial trauma. Also, the presence of polytraumatisms, with 4 or 5 fractured bones, suggests that a percentage of our sample was involved in violent habits, or in violent activities.

In many cases we can reconstruct the mechanism and dynamics of trauma. We observe cases of accidental trauma, such as the impact of the soil against the hands in falls (i.e. No. E8) (Ottini *et al*. 2002). But at the same time we also observe very peculiar mechanisms, such as case No. E49, who presents Deutschländer's fractures (so called "stress fractures of the metatarsals" or "Murch's fractures" – *Figure 1*), which are clearly due to the continuous mobility due to hard walking, and can also be linked to military activities (Deutschländer 1921).

In particular, we directed our attention to two fractures that may be closely related to athletic activities. The first involves subject No. E112, in which we observe a completely healed fracture of the processus posterior of the right talus. We know that, when the processus posterior is fused with the talus, this accessory processus is exposed to possible fractures in the event of a violent, rapid hyper-extension of the foot; indeed, we now often encounter this type of fracture in football players who have given the ball a violent kick (Iscan, Kennedy 1989).

The lesions displayed by subject No. E14 are clearly indicative of a boxer. Indeed, the fracture of the right nasal bone is identical to those that often affect the nasal bones of modern boxers, as is shown in *Figure 3*. In addition, the presence of post-traumatic subperiosteal ossifications of the anterior surfaces of the femoral and tibial diaphyses (*Figure 5*) clearly indicate that the subject's lifestyle was violent, and easily in keeping with the daily life of a boxer. Further confirmation of the subject's lifestyle comes from the post-traumatic lesions of his hands, which present both a metacarpal fracture (*Figure 4*) and sub-periosteal new bone formation of the dorsal surfaces of some metacarpals (*Figure 7*); precisely these dorsal metacarpal surfaces were in contact with the very hard, strong, heavy boxing gloves that were called *caestus*. As is shown by many Roman sculptures (*Figure 7*), the *caestus* was a sort of leather hand binding that was stuffed with lead fragments. The continuous micro-traumatisms caused by the *caestus* were probably behind the post-traumatic lesions of the metacacarpal bones observed in this subject. In addition, extreme, continuous hyperflexion of the fingers can also produce the hypertrophy of the bone crests of the insertions of the flexors of the fingers on the phalanxes of the hands (Lai, Lovell 1992).

The very high frequency of enthesopathies and syndesmoses was largely due to the hard labour required to perform most of the daily work in Herculaneum, where the majority of the inhabitants were fishermen. For example, we can show that the very high frequency of asymmetric rhomboid fossa, which is prevalent in the males, was linked to the rowing of the small fishing boats that frequently appear in Pompeian and Herculaneum frescoes (Capasso, Di Domenicantonio 1998). Some types of syndesmoses were also frequent among children, and this unexpected datum reveals an ancient society in which children, even of the youngest age, engaged in heavy manual labour (Capasso, Di Domenicantonio 1998).

Though most of the cases of syndesmoses observed were work-related, that affected subject No. E31 seems to be

linked clearly to a very particular athletic activity. In fact, epicondylar exostosis is due to the metaplastic ossification of the proximal ends of the tendons of the flexor muscles of the wrists and digits; today this enthesopathy is associated with throwing and swinging of firmly grasped objects (Lai, Lovell 1992). In the present day, epicondylar exostoses are especially common among golfers and javelin-throwers (Biener 1975). Since we know that Roman athletic activities included throwing the javelin, it seems possible that the person in question practiced this activity in one of Herculaneum's gymnasia.

CONCLUSIONS

Among the population living in Herculaneum during the 1st century AD, immediately before the final volcanic eruption, traumatic lesions involving the bones (skeletal fractures, entesopathies and syndesmoses) were relatively frequent, affecting about 11.9% of all the subjects examined. Skeletal fractures were much more frequent in males than in females, as a result of sexually differentiated traumatic risk. Hard work linked to the local economy, which was based on fishing, presumably exposed a large fraction of the male individuals to traumatic events that are clearly visible on their skeletal remains.

Among these traces of traumatic events we focused on some cases that may be linked to athletic activities, and found at last two in which the skeletal lesions can be convincingly attributed to a particular sport. The first is subject No. E14, a possible boxer, who had undergone the fracture of the right nasal bone, the fractures of a rib and of a metacarpal, and large sub-periosteal ossifications of both femur and tibia; the small sub-periosteal, button-like, new bone formations on the dorsal surface of some of his metacarpals are especially significant because they can be convincingly linked to possible micro-traumatisms and continuous irritation of the local periostium due to the action of the *caestus*, the Roman version of boxing gloves.

The second case affects subject No. E31 and consists of the post-traumatic osseous metaplasia of the proximal ends of the flexor muscles of the wrist and the digits on the right humerus epicondylus; this lesion appears to be clearly linked to the activity of a possible javelin-thrower.

Some additional cases can be related to physical activities and stress possibly due to athletic or quasi-athletic activities. Among them, we note subject No. E112, in which the fracture of the accessory processus posterior of the right talus was probably due to a rapid hyperextension of foot; and subject No. E49, whose multiple fractures of the fore-foot bones, with exuberant callus, were more probably due to the stresses produced by very long, very hard marches, as is clearly shown by similar modern cases.

In conclusion, though traumatic lesions were relatively frequent among the inhabitants of Herculaneum, as a result of the customs typical of the time (e.g. slavery, which also affected children), and daily activities (e.g. fishing), we have identified some traumatic lesions indicative of the presence of athletes or sportsmen in Herculaneum at the time of the final tragedy.

The most intriguing aspects of our report relate to the comparison between the biological changes observed and the archaeological evidence, and the case of the *caestus* and the complex lesions of the hand bones in the Roman boxer.

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