

Enthesopathies – Proposal of a Standardized Scoring Method and Applications

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ABSTRACT

Enthesopathies are alterations that could be present at entheses. Two types of enthesopathies have been defined: osteophytic (OF) and osteolytic (OL). In the present paper, we propose a standardized method to score the degree of development of each form of enthesopathy. With this method, the intra- and interobserver errors are less than 5%. The standard was used to study a sample (113 individuals) deriving from osteological collections from the late XIX-early XX century. Information about the age, sex and occupation of the individuals is available. This study demonstrated an effect of age on the form and the degree of development of enthesopathies. The influence of factors related to sex and occupation cannot be excluded. Therefore, functional interpretations of data on enthesopathies in osteoarchaeological series must take account of the estimated age and sex of the specimens and the distribution of the lesions within a single skeleton.

Key words: enthesopathies, scoring method, occupation

Introduction

The aim of bioarchaeological studies of human remains is to investigate ancient human societies from a biocultural point of view. Various skeletal markers are used to provide information for reconstruction of the paleodemography and the style and quality of life. The first problem, common to the study of many of these markers, is the scarcity of standardized scoring methods, which negatively affects the repro-

ducibility and comparability of the observations. Another problem arises when the results must be interpreted, since osseous traits generally have a multifactorial etiology in which the effects of age, sex, individual factors, pathologies, physical activity, etc., can overlap. For these reasons, our research group from the University of Bologna is conducting a broad methodological investigation of aspects

concerning the standardization of scoring methods and the problems of interpretation of osseous and dental indicators of age, sex, health state, physical activity, etc.^{1–6}.

The scoring of so-called »musculoskeletal stress markers« (MSM⁷), i.e. the degree of development of entheses and the presence of enthesopathies, presents difficulties due to the qualitative nature of these traits. These markers have been used as indicators of occupational stress in many studies^{7–19}. However, »... a significant obstacle stands in our path and needs to be addressed. This is the absence of standards for making accurate identifications of MOS [markers of occupational stress] and determining their etiologies.«²⁰. Standardized scoring methods have been proposed by some authors^{21–26} but they are not currently used, with the previously mentioned effect on the reproducibility of observations and the comparability of results. Moreover, assessment of the etiology of MSM is difficult because there are only two types of bone responses to any kind of stress: a proliferative or erosive response²⁷. Thus, »... an understanding of the role and rate of bone remodeling, the effect of hormonal differences and pathological agents on bone growth, and how biomechanical variables (including the role of individual variation in muscle attachment, muscle fiber arrangement, and origin/insertion type) may affect musculoskeletal stress markers.«²⁸ is very important for reliable interpretations of the results obtained. The study of MSM can lead to the identification of gross workload patterns and the division of labor on a sexual or social basis, while in the presence of ethnographic or archaeological evidence, it can also indicate particular tasks^{25,28,29}. MSM can also be used to investigate locomotor stresses not related to work but due to skeletal affections like fractures, alterations of the vertebral column, etc.^{30–32}.

The aim of this paper was to define the features to be recorded (entheses vs. enthesopathies, types of enthesopathies) and to provide a standardized scoring method for enthesopathies. The method was then used to study modern skeletal collections (Sperino and Sardinian collections, late XIX-early XX c.) to evaluate the relationship between the observed features and the age, sex and occupation of the individuals.

Methodological Aspects: Definition of the Traits and Illustration of the Scoring Method

The term »enthesis« refers to the osseous attachment site for muscles, ligaments and capsules^{11,33,34}. Some authors^{23,27,35,36} make a distinction between »enthesis« (site of muscular attachment) and »syndesmosis« (site of ligament attachment); however, Dutour³⁷ points out that the anatomical distinction between entheses and syndesmosis has no functional justification. In this paper, the term »enthesis« will be used to indicate both muscle and ligament attachment sites.

Muscle and ligament markings are always identifiable on bones as irregular or rough surfaces, sometimes elevated or depressed, or as remodeled surfaces. Since entheses are involved in the transmission of forces to generate movement, they are subjected to mechanical stress, which inevitably induces a response by the bone. The type and magnitude of the response can vary, probably depending on several factors (e. g. type and magnitude of the stress, age and sex of the individual, etc.), giving rise to different degrees of development and also to different morphologies. The term »enthesopathy« indicates an aspecific pathological status of the enthesis, which can be of mechanical, metabolic, inflammatory, etc., origin^{33,38}. In the anthropological literature, it is normally used to indicate an enthesis with signs of

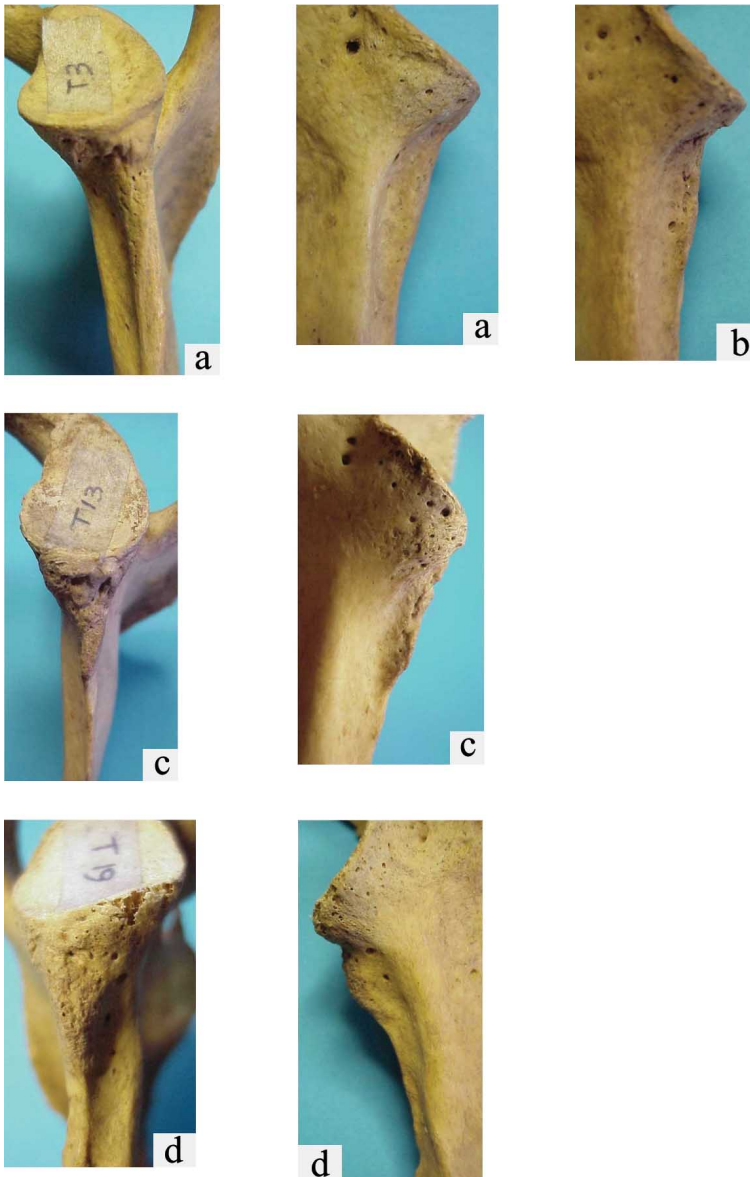


Fig. 1. Standard for scoring the degree of development of robusticity of the scapular origin of the long head of m. triceps brachii. Degree 1: a – the profile of the infraglenoid tubercle does not interrupt the profile of the axillary border of the scapula. b – the infraglenoid tubercle interrupts the profile of the axillary border, assuming an oblong crest-like or roughly triangular shape in frontal view. In both cases (a and b), the surface is smooth or moderately rugose. Degree 2: c – the infraglenoid tubercle emerges as a distinct formation of the axillary border, assuming the form of a real tubercle or crest. The surface is irregular or rugose. Degree 3: d – the infraglenoid tubercle, in the form of a tubercle or crest, is very prominent and rugose.

this pathological condition. However, as far as we know, »enthesopathy« has never been unequivocally defined in relation to the type of bone feature observed (rugosity, enthesophytes, osteolytic lesions, all of them?). We propose that the term »enthesopathy« be reserved for an enthesis with areas of exostosis or erosion, even though an *a priori* attribution of a pathological nature to these formations seems implicit. Instead, they may be a simple expression of idiopathic factors in the bone's response to various stimuli or even be part of normal age-related changes. It should also be underlined that even when a pathological origin of a given osseous trait can be recognized, there is always continuous variability between the two extreme forms (normal and pathological) and it is very difficult (and arbitrary) to assign a border between them.

Nevertheless, it seems acceptable and practical to consider two aspects of entheses separately:

- »robusticity« (cf. Hawkey and Merbs⁷), representing the »normal« osseous marking at the site of attachment of a muscle or ligament; it is always observable, although with a variable degree of expression;
- enthesopathies, which can be absent or present in different degrees of development.

Enthesopathies have been divided into:

- a proliferative, »osteophytic« form (OF), characterized by the presence of »enthesophytes«, defined by Paolaggi³⁴ as »équivalent[s] tendineux de l'ostéophytose articulaire«, and by Fournié and Fournié³³ as »ossifications juxta-osseuses, sessiles ou libres, qui se produisent dans les enthèses pathologiques«;
- an erosive, osteolytic form (OL), characterized by pitting or eroded areas.

A standardized scoring method was proposed by Mariotti³ for 23 entheses of

the postcranial skeleton. For each enthesis, a standard for the degree of *robusticity* was provided, consisting of 3 possible levels: *degree 1* includes weak to moderate expression; *degree 2* corresponds to strong development of the enthesis and *degree 3* is reserved for very strong expression of the trait but without the presence of an enthesopathy. As suggested by Robb^{25,39}, these levels were defined by setting up a series of bones (circa 30) in increasing order of degree of development of the enthesis considered and dividing the observed variability into classes. The bones came from ossuaries of several Sardinian cemeteries (XX century) and are housed in the Museum of Anthropology, University of Bologna. The standardized scoring method consists in the description of the possible classes of development of each enthesis and their photographic documentation, as shown in Figure 1. The standard for robusticity of the above-mentioned entheses will be published shortly. Here instead we present the proposed methods for the scoring of enthesopathies. In this case, the scales are applicable to any enthesis; they include *degree 0*, corresponding to absence of the trait, and three degrees of development:

»Osteophytic« formation (OF)
(modified from Crubézy²¹)

- 0. absence of exostotic formations;
- 1. minimal exostosis (<1 mm) (Figure 2);
- 2. clear exostosis (1–4 mm) (Figure 3);
- 3. substantial exostosis (>4 mm) (Figures 4 and 5);
- nr. trait not recordable: when the enthesis is missing or in a poor state of preservation (more than 50% of the area is illegible) or when the alterations are so weak their effective presence is in doubt.

Note: exostoses of the enthesis can have different morphologies: small ele-



Fig. 2. OF degree 1: enthesophyte about 1 mm in height at the medial border of the bicapital tuberosity on a right radius.



Fig. 3. OF degree 2: digitiform enthesophytes at the insertion of the Achilles tendon on a left calcaneus.



Fig. 4. OF degree 3: digitiform enthesophytes at the attachment site of the m. quadriceps femoris tendon on a patella.



Fig. 5. OF degree 3: »sail«-shaped exostosis at the insertion of m. brachialis on a right ulna.



Fig. 6. Varying degrees of OF in the form of circumscribed protuberances and crests at the common flexor origin and ulnar collateral ligament attachment on a right humerus (medial epicondyle).



Fig. 7. OL degree 1: diffuse fine porosity at the attachment site of the costo-clavicular ligament (right clavicle).

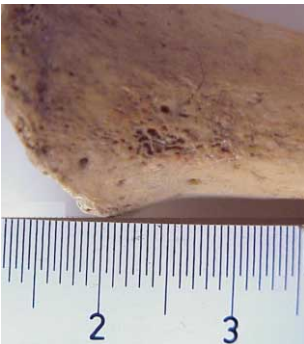


Fig. 8. OL degree 1: porosity (<1 mm in diameter) at the attachment site of the costo-clavicular ligament (right clavicle).



Fig. 9a, b. OL degree 2: two examples (left clavicles) of diffuse porosity with holes around 1 mm in diameter at the attachment site of the costo-clavicular ligament.



Fig. 10. OL degree 2: a small area of erosion (around 4 mm in length or diameter) at the attachment site of the costo-clavicular ligament (left clavicle).

vated areas or crests (Figure 6), digitiform enthesophytes (Figures 3 and 4), or »sail-shaped« enthesophytes (Figure 5).

Osteolytic formation (OL)

0. absence;

1. presence of fine porosity (holes <1 mm in diameter) (Figures 7 and 8);
2. diffuse porosity, with holes ca. 1 mm in diameter (Figures 9a, b), or presence of a small area of erosion (ca. 4 mm in length or diameter) (Figure 10);
- 3a. presence of several small areas of erosion (ca. 4 mm in length or diameter);
b. at least one extensive and deep osteolytic area (>4 mm in length or diameter) (Figure 11);
- nr. trait not recordable: when the enthesis is missing or in a poor state of preservation (more than 50% of the area is illegible) or when the alterations are so weak their effective presence is in doubt or in cases of doubtful interpretation (e.g. Figure 12).

To test the validity of this method of scoring enthesopathies, we calculated the intraobserver error: the percentage of errors committed by the same observer in attributing the various traits to the defined categories in two independent scor-

ing sessions a few months apart. A sample of 60 complete skeletons (43 males and 17 females) from the Sardinian collection (early XX c.) of the Museum of Anthropology, University of Bologna, was used for this test.

The error was calculated with a program in Visual Basic For Applications (1998). It compares the contents of cells of two Excel spreadsheets containing the data of the first and second scoring sessions. The program computes the total number of cells, the number of different cells and the percentage error (no. different cells \times 100/total no. cells), both as a total, i.e. indiscriminately for all the observed traits, and for each trait. The total intraobserver error was 3.5% for the osteophytic formations and 3.9% for the osteolytic ones. Likewise we calculated the interobserver error, which was less than 5%. It must be noted that the procedure to define the classes of development presents an objective limit: the necessity to divide continuous variability into discrete categories. Thus, these values were considered acceptable and the standard was judged to be suitable for use.



Fig. 11. OL degree 3 at the attachment site of the costo-clavicular ligament in three right clavicles (OL 3a in the first specimen on the left, OL 3b in the other two specimens).



Fig. 12. Hole of doubtful interpretation at the right bicipital tuberosity (T.13A, Casalecchio di Reno, Bologna, Roman Imperial age).

Applications: Relationship of Enthesopathies to Age, Sex and Occupation

Materials and methods

We used the proposed standard to study a sample of 113 individuals deriving partly from the Sperino Collection (52 males, late XIX century) housed in the Institute of Anatomy of the Modena Hospital and partly from the Sardinian collection (44 males and 17 females, early XX century) of the Museum of Anthropology, University of Bologna. Information about the age, sex and occupation of the individuals is available for both skeletal collections. The males worked at various jobs, although most were farmers (Table 1), while the females were all housewives.

To investigate age-related differences, we considered only the 96 males (Table 1)

divided into three classes: 54 »young« adults (YA, 20–29 years), 27 »mature« adults (MA, 30–39 years) and 15 »old« adults (OA, >40 years). For sampling reasons (few individuals over 40 years), we did not use the classic subdivision of Buikstra and Ubelaker⁴⁰ (YA: 20–35 years; MA: 36–50; OA: >50). To test for possible sex differences, we selected individuals between 30 and 39 years to avoid any effects of a too young or too advanced age. The sample consisted of 17 females and 20 males.

For each grouping based on age or sex, we calculated the absolute frequencies and percentages of presence/absence and, in the case of presence, of each degree of development for each enthesis, also taking account of the side. For sampling reasons, it was decided to combine the degrees 2+3. The significance of the diffe-

TABLE 1
COMPOSITION OF THE MALE SAMPLE BY AGE AND OCCUPATION IN SARDINIAN AND SPERINO COLLECTION

	20–29		30–39		>40		Total		Total
	Sardini-ans	Spe-rino	Sardini-ans	Spe-rino	Sardini-ans	Spe-rino	Sardini-ans	Spe-rino	
Farmer	10	8	8	3		1	18	12	30
Mason	5	4	1	1		1	6	6	12
Carpenter	2	1					2	1	3
Smith						2	0	2	2
Butcher		1				2	0	3	3
Baker		2		1			0	3	3
Shoemaker		5		1		1	0	7	7
Miner	2	1	1			1	3	2	5
Porter		1		2			0	3	3
Shepherd	1			1			1	1	2
Artist	1		1				2	0	2
Shop-keeper	3		2	1			5	1	6
Salesman		1				2	0	3	3
Hawker	1			1		1	1	2	3
Employee	1		1			1	2	1	3
Other	3	1	1	1		3	4	5	9
Total	29	25	15	12	0	15	44	52	96

TABLE 2
 FREQUENCY DISTRIBUTION (%) BY AGE OF THE PRESENCE OF ENTHESTOPATHIES IN THE
 OSTEOPHYTIC (OF) AND OSTEOLYTIC (OL) FORMS IN THE MALE SAMPLE (SARDINIAN AND
 SPERINO COLLECTIONS TOGETHER) (p VALUE REPORTED ONLY WHEN <0.05)

	Left						Right							
	N	20–29	N	30–39	N	>40	p	N	20–29	N	30–39	N	>40	p
OF														
<i>m. biceps brachii</i> (radius)	51	3.9	26	3.8	15	20.0		52	5.8	27	11.1	15	13.3	
<i>m. triceps brachii</i> (ulna)	49	0.0	27	3.7	15	33.3	0.000	48	4.2	24	8.3	15	33.3	0.005
greater trochanter (femur)	54	3.7	26	11.5	15	26.7	0.025	50	6.0	26	7.7	14	21.4	
<i>m. iliopsoas</i> (femur)	52	19.2	27	11.1	13	46.2	0.035	49	14.3	27	7.4	13	46.2	0.007
patellar lig. (tibia)	47	4.3	26	30.8	14	35.7	0.002	47	6.4	26	38.5	14	21.4	0.003
patellar lig. (patella)	49	14.3	24	25.0	12	50.0	0.027	45	20.0	24	25.0	13	46.2	
Achilles tendon (calc.)	46	26.1	24	45.8	13	69.2	0.013	48	27.1	25	44.0	13	69.2	0.017
OL														
costoclavicular lig. (clavicle)	54	74.1	26	46.2	13	69.2	0.046	52	86.5	26	69.2	14	71.4	
<i>m. deltoideus</i> (clavicle)	53	18.9	26	11.5	13	7.7		53	26.4	26	15.4	14	7.1	
<i>m. pectoralis major</i> (hum.)	53	34.0	27	3.7	15	6.7	0.002	51	31.4	27	3.7	15	6.7	0.005
<i>m. lat.dorsii/teres m.</i> (hum.)	53	26.4	27	3.7	15	13.3	0.038	51	39.2	26	3.8	15	13.3	0.002
<i>m. biceps brachii</i> (radius)	51	7.9	26	3.8	15	20.0		52	5.8	27	7.4	14	14.3	

rences among age classes or between the sexes was evaluated by chi-squared test and when possible (2 × 2 table) by Fisher's exact test^{41–43}.

Even though similar occupations were pooled, the resulting groups were not sufficiently large. Therefore, we did not calculate the frequencies nor were we able to use statistical tests to assess possible differences related to occupation.

Results

OF formations

Digitiform enthesophytes are more frequent in some entheses (ulnar insertion of *m. triceps brachii*, attachment of the patellar ligament on the patella and tibial tuberosity, insertion of the Achilles tendon on the calcaneus). »Sail-shaped« enthesophytes were only found at the ulnar insertion of *m. brachialis* in two females (SS137, 32 years, degree 3 on the left; SS157, 34 years, degree 3 on the right, Figure 5) and at the scapular origin of the long head of *m. triceps brachii* in a

cobbler (SP141, 39 years, degree 3 on the right).

In general, the presence of OF increases significantly with age (Table 2). This trend has been observed by different authors^{16,18,25,44,45}. In effect, the time during which microtraumatic factors due to muscle use can act on the enthesis increases with the passing years, thus leaving more evident markings. Indeed, we noted that OF are usually more developed in old adults (Table 3). Moreover, in young and mature adults, the frequency of OF is generally higher on one side, while in old adults the frequency is often the same on the two sides (Table 2). This pattern could be related to the greater workload of the younger individuals.

Regarding sex differences (Tables 4 and 5), the development of enthesophytes is generally greater in males, except for the insertion of *m. brachialis* (flexor of the forearm), perhaps in relation to occupational differences.

Regarding occupation, there is no particular job-related distribution, a result

TABLE 3
 FREQUENCY DISTRIBUTION (%) BY AGE OF DEGREE 1 AND 2+3 OF ENTHESTOPATHIES IN THE
 OSTEOPHYTIC (OF) AND OSTEOLYTIC (OL) FORMS IN THE MALE SAMPLE (SARDINIAN AND
 SPERINO COLLECTIONS TOGETHER)

	Left									Right								
	20–29			30–39			>40			20–29			30–39			>40		
	N	1	2+3	N	1	2+3	N	1	2+3	N	1	2+3	N	1	2+3	N	1	2+3
OF																		
<i>m. biceps brachii</i> (radius)	51	2.0	2.0	26	3.8	0.0	15	13.3	6.7	52	5.8	0.0	27	7.4	3.7	15	6.7	6.7
<i>m. triceps brachii</i> (ulna)	49	0.0	0.0	27	0.0	3.7	15	20.0	13.3	48	2.1	2.1	24	8.3	0.0	15	13.3	20.0
greater trochanter (femur)	54	1.9	1.9	26	11.5	0.0	15	6.7	20.0	50	4.0	2.0	26	7.7	0.0	14	0.0	21.4
<i>m. iliopsoas</i> (femur)	52	7.7	11.5	27	3.7	7.4	13	23.1	23.1	49	2.0	12.2	27	7.4	0.0	13	38.5	7.7
patellar lig. (tibia)	47	2.1	2.1	26	23.1	7.7	14	14.3	21.4	47	2.1	4.3	26	23.1	15.4	14	7.1	14.3
patellar lig. (patella)	49	4.1	10.2	24	4.2	20.8	12	41.7	8.3	45	4.4	15.6	24	4.2	20.8	13	23.1	23.1
Achilles tendon (calcaneus)	46	13.0	13.0	24	16.7	29.2	13	38.5	30.8	48	12.5	14.6	25	12.0	32.0	13	30.8	38.5
OL																		
costoclav. lig. (clavicle)	54	37.0	37.0	26	26.9	19.2	13	46.2	23.1	52	32.7	53.8	26	30.8	38.5	14	35.7	35.7
<i>m. deltoideus</i> (clavicle)	53	11.3	7.5	26	7.7	3.8	13	7.7	0.0	53	18.9	7.5	26	11.5	3.8	14	7.1	0.0
<i>m. pectoralis major</i> (hum.)	53	20.8	13.2	27	3.7	0.0	15	6.7	0.0	51	17.6	13.7	27	0.0	3.7	15	6.7	0.0
<i>m. lat. dorsii/teres</i> <i>m.</i> (hum.)	53	17.0	9.4	27	0.0	3.7	15	13.3	0.0	51	27.5	11.8	26	3.8	0.0	15	13.3	0.0
<i>m. biceps brachii</i> (radius)	51	3.9	3.9	26	0.0	3.8	15	6.7	13.3	52	3.8	1.9	27	3.7	3.7	14	7.1	7.1

perhaps influenced by the fact that many occupations are represented by only a few individuals (Table 1). Nevertheless, the presence of OF at some insertion sites can be attributed, albeit not unequivocally, to particular work activities. For example, the »sail-shaped« enthesophyte of degree 3 at the right scapular origin of the long head of *m. triceps brachii* of the cobbler SP141 (39 years) could be related to forced extension of the elbow when stitching leather by hand. The functional etiology of this characteristic is supported by its unilateral presence. It should be noted that a similar enthesophyte was

observed in the right scapula of an ancient Roman who walked with the use of crutches, thus with the arms forcibly extended³¹ (Figure 13). For these »sail-shaped« enthesophytes we cannot exclude a macrotraumatic origin, as hypothesized by Hawkey and Merbs⁷ for the features they define as »ossification exostosis«.

OL formations

The presence of osteolytic formations generally follows a particular trend, with a higher frequency in young adults, a decrease in mature adults and a slight increase in old adults, but often with lower

TABLE 4
 FREQUENCY DISTRIBUTION (%) BY SEX OF THE PRESENCE OF ENTHESTOPATHIES IN THE OSTEOPHYTIC (OF) AND OSTEOLYTIC (OL) FORMS IN MALES AND FEMALES (30–39 YEARS) OF THE SARDINIAN COLLECTION. (p VALUE, CALCULATED USING FISHER'S EXACT TEST, REPORTED ONLY WHEN <0.05)

	Left					Right				
	M		F			M		F		
	N	%	N	%	p	N	%	N	%	p
OF										
<i>m. brachialis</i> (ulna)	20	0.0	17	5.9		20	0.0	17	5.9	
greater trochanter (femur)	19	15.8	15	0.0		19	10.5	15	13.3	
patellar lig. (tibia)	19	31.6	17	0.0	0.020	19	42.1	17	5.9	0.020
patellar lig. (patella)	18	33.3	17	23.5		20	30.0	16	25.0	
Achilles tendon (calcaneus)	17	58.8	16	56.3		18	61.1	15	46.7	
OL										
costoclavicular lig. (clavicle)	20	45.0	17	23.5		20	60.0	17	23.5	0.045
<i>m. lat.dorsii/teres m.</i> (hum.)	20	5.0	17	35.3	0.034	20	5.0	17	17.6	

TABLE 5
 FREQUENCY DISTRIBUTION (%) BY SEX OF DEGREE 1 AND 2+3 OF ENTHESTOPATHIES IN THE OSTEOPHYTIC (OF) AND OSTEOLYTIC (OL) FORMS IN MALES AND FEMALES (30–39 YEARS) OF THE SARDINIAN COLLECTION

	Left						Right					
	M			F			M			F		
	N	1	2+3	N	1	2+3	N	1	2+3	N	1	2+3
OF												
<i>m. brachialis</i> (ulna)	20	0.0	0.0	17	0.0	5.9	20	0.0	0.0	17	0.0	5.9
patellar lig. (tibia)	19	21.1	10.5	17	0.0	0.0	19	21.1	21.1	17	5.9	0.0
patellar lig. (patella)	18	5.6	27.8	17	0.0	23.5	20	5.0	25.0	16	6.3	18.8
Achilles tendon (calcaneus)	17	17.6	41.2	16	43.8	12.5	18	16.7	44.4	15	40.0	6.7
OL												
costoclavicular lig. (clavicle)	20	30.0	15.0	17	11.8	11.8	20	25.0	35.0	17	11.8	11.8
<i>m. lat.dorsii/teres m.</i> (hum.)	20	0.0	5.0	17	35.3	0.0	20	5.0	0.0	17	17.7	0.0

frequencies than in young adults (Table 2). The highest degree of development (degree 3) seems typical of young adults, although an effect of activity cannot be excluded, while the increase in OL fre-

quency in old adults is due to pitting (degree 1) (Table 3). An insertion »sous forme de fosse«⁴⁶ has been observed by numerous authors in juvenile subjects, especially adolescents, at the attachment sites of the



Fig. 13. »Sail«-shaped enthesophyte (OF degree 3) at the right scapular origin of the long head of *m. triceps brachii* of an ancient Roman (T. 130B of Casalecchio di Reno, Bologna; Roman Imperial age) who probably walked with the aid of crutches.

costo-clavicular ligament (clavicle), *m. pectoralis major* and *m. latissimus dorsi/teres major* (humerus), *m. gluteus maximus* (femur), *m. soleus* (tibia) and, more rarely, in other entheses^{25,46–48}. Castex⁴⁶ noted that fossa-shaped insertions are generally present in the skeleton of subadults. Therefore, this particular enthesis morphology seems to be due to the strong remodeling processes accompanying growth, during which there is a continuous »migration« of the enthesis in the growing bone^{39,49}. The presence of this trait in young adults has also been observed by other authors^{46,48}. In these cases, the »fossa form« is often found only in some entheses and could represent a remnant of juvenile characters that are dis-

appearing (Figure 14). We can also hypothesize an interaction between biomechanical factors and the patterns of bone remodeling related to age in the formation of these traits. Therefore, the term 'stress lesions' given to these features by Hawkey and Merbs⁷ seems inappropriate, since age appears to play a very important role in their formation.



Fig. 14. »Fossa«-shaped enthesopathy (OL degree 3) at the insertions of *m. pectoralis major* (left of the photo) and *m. latissimus dorsi/teres major* (right of the photo) on a right humerus from a Sardinian ossuary (age and sex unknown).

Regarding sex differences, there were only two attachment sites with OL in the considered age class (mature adults). Females present a higher frequency of this trait at the insertion of *m. latissimus dorsi/teres major*, males at the attachment of the costo-clavicular ligament (Table 4–5). The sex differences could reflect a male-female division of labor. In fact, in the early medieval necropolis of Vicenne-Campochiaro (studied with the same

method) both these entheses presented more frequent OL in males⁴⁴. The small sample size used to evaluate sex differences does not permit a more in-depth discussion, but we are currently studying the complete sample of Sardinians (around 300 males and 300 females) and our evaluation of sex differences in other age classes will yield new information in this regard.

Conclusions

The study of enthesopathies in osteoarchaeological series can provide interesting information for reconstruction of the style and quality of life of past populations. They can be used to investigate the possible physical activity of individuals, the postural and locomotor anomalies resulting from pathologies or the consequences of traumas that alter the »normal« functioning of the musculoskeletal apparatus. They can also be helpful in diagnosing several diseases, such as DISH or spondylarthropathies, which can cause the appearance of enthesophytes at various sites^{37,50–54}.

Because of the breadth of possible applications, it would be desirable to employ standardized scoring methods, which instead are not widely used by anthropologists and paleopathologists. For this reason, first of all, we defined an unequivocal terminology for the considered traits that allows one to distinguish between the absence and presence of a trait. Then we provided indications for the evaluation of the degree of development, even though a certain amount of subjectivity in its attribution is inevitable due to the partly qualitative nature of the considered traits.

In this regard, it is particularly important to furnish photographic documentation that also took account of the variability of the different degrees of development. The use of a digital camera has allowed

us to create a rich and easily accessible computer archive of photographs.

On the basis of our study, an effect of age on the type and the degree of development of enthesopathies seems very probable, and a sex-related influence also cannot be excluded. For these reasons, the results of studies of enthesopathies must be interpreted in a critical manner, taking into account their multifactorial etiology. This is especially true for osteoarchaeological specimens in whom the state of preservation often prevents a clear attribution of age and sex.

With regard to the use of enthesopathies for the reconstruction of occupational activities in past populations, the most reliable hypotheses could be made in the following cases:

1. presence of OF in young or mature adults;
2. presence of OL in mature adults;
3. exclusion of diseases that may be responsible for the onset of enthesopathies;
4. non-generalized distribution of enthesopathies in the same skeleton;
5. evident lateralization of the presence or degree of development of OF and OL.

The application of our standard to various osteoarchaeological series has allowed us to formulate interesting functional hypotheses that have been confirmed by archaeological and historical evidence^{44,55,56}. In the case of prehistoric collections, where it is more difficult to obtain information about possible activities, we have been able to make significant inferences about the level of physical stress and the division of labor on a sexual or social basis^{57,58}.

Our research group has also worked on the standardization of scoring of several cranial entheses (masticatory muscles and ligaments of the temporo-man-

dibular joint)^{59,60}. The standardized scoring methods for robusticity of cranial and postcranial entheses will be published shortly.

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ENTEZOPATIJE – PRIJEDLOG STANDARDIZIRANE METODE PROCJENE I NJEGOVA PRIMJENA

SAŽETAK

Entezopatije su promjene koje se pojavljuju na entezama. Postoje dva tipa entezopatija: osteofitičke (OF) i osteolitičke (OL). U radu predlažemo standardiziranu metodu ocjenjivanja stupnja razvoja za svaki oblik entezopatije. Primjenom ove metode intra- i inter-promatrački postotak pogreške iznosi manje od 5%. Metoda je primijenjena na uzorku (113 osoba) iz osteoloških zbirki kasnog 19. i ranog 20. stoljeća, gdje su podaci o dobi, spolu i zanimanju individue bili dostupni. Studija je pokazala utjecaj dobi na oblik i stupanj razvoja entezopatije, te da se utjecaj čimbenika vezanih uz spol i zanimanje ne može isključiti. U osteoarheološkim serijama potrebna je funkcionalna interpretacija podataka o entezopatijama, te je ujedno potrebno voditi računa o procijenjenoj dobi i spolu uzorka, te distribuciji promjena na svakom kosturu.