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Keywords:	Entheseal changes , fibrocartilaginous enthese, ageing, Coimbra identified collection,, Luis Lopes skeletal collection, socio-economic status, Portugal

The Categorization of Occupation in Identified Skeletal Collections: A Source of Bias?

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ABSTRACT

Identified skeletal collections, *i.e* .skeletons for which sex, age at death and occupation at death are known, have been used to test methods for recording entheseal changes (EC). By testing methods on identified collections the sensitivity of EC for recording activity levels can be ascertained prior to applying the methods to test hypotheses in archaeological contexts. However, the definition of occupational categories used for this research may, in itself, be a source of bias. The aim in this study was to test how categorizing occupation affected the interpretation of EC. Male skeletons (n=211) from two Portuguese identified skeletal collections were used. Three methods for categorizing occupations, all of which have been previously published, were used each dividing occupations into 5, 3 and 2 categories, respectively. Fibrocartilaginous entheses were recorded and EC scored as present/absent. Results showed that the method for categorizing occupation affected the frequencies of EC found in occupational categories for specific entheses. Frequencies which were significantly different between occupational categories for one method were not necessarily significant for others. This demonstrates that the sensitivity of the occupational categorization does affect the results. However, using logistic regression age was found to have a greater effect than occupation. These results demonstrate the need for standardized occupational categories, as well as the importance of considering age.

Key words: Entheseal changes (EC), fibrocartilaginous entheses, Coimbra identified collection, Luis Lopes skeletal collection, ageing, socio-economic status, Portugal

Introduction

The use of identified skeletal collections for osteological analyses has been considerable in the past few years. This increased interest is due to the quantity and quality of data available about the lives of the individuals, which includes sex, age at death and occupation (Cardoso, 2006; Cunha and Wasterlain, 2007; Rocha, 1995). As a result, these collections have been used to develop and test methods for age at death and sex assessment, as well as to test correlations between those variables and osteological changes observed in the skeleton which are attributed to disease or activity (Alves Cardoso, 2008; Matos and Santos, 2006; Santos and Roberts, 2006). For research into the latter, entheseal changes (EC) have been the most widely recorded (Alves Cardoso, 2008; Alves Cardoso and Henderson, 2010; Campanacho *et al.*, 2012; Cunha, 1995; Mariotti *et al., 2004,* 2007; Milella *et al.*, 2012; Niinimaki 2011; Villotte *et al.*, 2010). However, the assumption that EC are directly and exclusively linked to muscle use during activity has been questioned for over a decade (Jurmain, 1999; Jurmain *et al.*, 2012). Nevertheless, testing these recording methods on identified collections continues as it is seen as the best method for controlling for factors affecting EC, such as sex, age at death and occupation. However, while sex and age at death are reliable in these collections, occupation at death is not. Occupation at probate does not provide the full record of activities an individual performed during his or her life course. Activities, such as hobbies, cooking, cleaning, and changes of occupation through life are not described in these records (Caffell *et al.*, 2012; Cardoso, 2005). Furthermore, when using occupation at death, in studies that aim to assess EC and activity, occupations are normally classified and grouped based on how heavy and repetitive workload was during life, but again these descriptions are also a source of bias dependent on the research objective and research design (Perréard Lopreno *et al.*, in this issue).

Aims and objectives

The aim of this study was to test the hypothesis that EC frequency is dependent on the method for categorizing occupation. If this is supported, it has implications for studies which have previously tested EC recording methods using these categories, the development of others, and those using them to differentiate between labour patterns. The study will also test the effect of occupational grouping on age profiles, because EC frequency has been shown to increase with age. The working hypothesis is that those individuals described as non-manual workers, and frequently associated with higher socio-economic status, will have a higher mean age at death due to better access to dietary and medical resources. If this is upheld then non-manual workers should also have a higher frequency of EC (due to the increased age), when compared to the working groups associated with lower socio-economic status, *e.g.* manual workers.

Materials and Methods

Two Portuguese identified skeletal collections were used: the Luis Lopes skeletal collection and the Coimbra collection. The Luis Lopes skeletal collection, curated in the Museum of Natural History in Lisbon, represents a predominantly urban population. In 2006 this collection was composed of 1,692 documented skeletons, and 75 unidentified individuals (Cardoso, 2006). Since that date new individuals have been incorporated into the collection (Hugo Cardoso, pers. comm.). Based on the detailed information available for 699 individuals, it was concluded (Cardoso, 2006) that the collection consists mostly of individuals of Portuguese nationality who were born and had died between 1805 and 1975. Based on the occupational profile of the collection, it was described as composed of individuals of lower to middle socio-economic status. Male individuals were predominantly working in sales (*e.g.* shop assistants), in services (*e.g.* were civil servants), or as artisans and in other skilled trades (*e.g.* carpentry or tailoring). Females were mostly listed as *doméstica*s (housewives/housekeepers) and these represented 85% of the total number of females, with other individuals listed as maids, teachers or students (Alves Cardoso, 2008; Cardoso, 2006).

The collection from Coimbra is currently curated in the Museum of Anthropology in the Department of Life Sciences in Coimbra University. This collection is composed of individuals who were born and died between 1826 and 1938 (Alves Cardoso, 2008; Rocha, 1995). The profile of this collection represents a similar distribution to that of Luis Lopes collection *i.e.* the lower to middle social classes of society (Alves Cardoso, 2008; Cardoso, 2006). The majority of the male individuals were employed at the time of their death as waiters, farmers and unskilled workers, or as skilled workers, *e.g.* barbers, carpenters, tailors and shoemakers. Occupations relating to commerce and transport, and professions such as teachers and lawyers were also represented (Alves Cardoso, 2008).

The sample used in this study was composed of a total of 211 individuals, 104 male skeletons from the Coimbra collection, and 107 male skeletons from the Lisbon Luis Lopes collection. These individuals were selected based on their specific activity with the aim to have similar number of individuals in occupational groups. This was not entirely possible to achieve due to skeleton preservation. Only male skeletons (n=211) were used for this study, as females were most commonly referred to in the records as '*doméstica*', *i.e.* housekeeper/housewives. This categorization of occupation was considered extremely ambiguous in relation to the actual tasks women were performing which could range from child care to farming activities (Alves Cardoso, 2008). Therefore categorization of female occupations was not appropriate, and this is one of the serious limitations of using documentary evidence of occupations at death to categorize work.

Three methods where used to categorize occupations (Roque, 1988; Villotte *et al.*, 2010 and Alves Cardoso and Henderson, 2010), all of which have been previously employed in skeletal analyses. These methods were used to divide the sample to test the hypothesis that EC frequency is dependent on categorization method and test their impact on age distribution. The three categories divide the occupations into 5 (Roque, 1988), 3 (Villotte *et al.*, 2010) and 2 categories (Alves Cardoso and Henderson, 2010) respectively.

Table 1 presents the full list of occupations, their categorization by method and the sample distribution. The first method, referred to forthwith as the Roque method (Roque, 1988), divides the sample into five categories (government, administrative and service industry, commerce and transport, skilled workers and artisans, farmers and servants, and unskilled workers). This method is based on contemporary Portuguese socio-economic status and, unlike the other two methods, was not devised by anthropologists studying past populations and activity-related stress. Therefore, this method does not consider the physical activity involved in an occupation, only the social and economic arena in which it takes place. Roque (1988), with his description of the social and economic constitution of the Coimbra city developed a characterization of Coimbra´s population, thought to be comparable to that of Lisbon (Alves Cardoso, 2008).

The second method is based on that published by Villotte and colleagues (2010) which divided the occupations into the following four categories: non-manual workers, manual workers, manual workers carrying heavy loads, manual workers probably involved in forceful manual tasks (Villotte *et al.*,2010: 22). However, while presenting and discussing their results (*ibid.*) they refer predominantly to three categories: non-manual, light manual and heavy manual. It is these three categories which will be used for this study. As described by Villotte and colleagues, their grouping criteria considered the descriptions of the occupations in the collections alongside the interpretation of the performance of these occupations in the past. The authors also took into account a medical perspective of occupational injuries. EC where then analysed using presence and absence (which corresponds to the definition of presence and absence used in this paper). Villotte and colleagues (2010) did not find differences between the light manual and non-manual workers, but there was a difference between both of these groups and heavy manual workers (*ibid.*).

The final method divides occupations into manual and non-manual workers (Alves Cardoso and Henderson, 2010). This grouping took into consideration the historical evidence for the activities performed (Roque, 1982, 1988; Alves Cardoso, 2008): *i.e.* occupations historically deemed more strenuous or physically demanding were grouped as manual, while those listed as non-manual were associated with less physically demanding activities. Within this grouping parameter, it is hypothesized, given that Villotte and colleagues did not find any differences between light manual and non-manual workers, that pooling heavy manual and light manual workers will mean that no statistically significant differences will be found between manual and non-manual workers.

Fibrocartilaginous EC were recorded as present, or absent as described in Alves Cardoso and Henderson (2010) based on anatomical descriptions of normal and abnormal entheses (Benjamin *et al*., 2002). The absence of EC is defined as no deviation from the normal smooth, well-defined enthesis (Alves Cardoso and Henderson, 2010; Benjamin and Ralphs, 1998). Any deviation from this, *e.g.* the presence of lytic lesions or bone formation, was recorded as present (Fig. 1). This method is only applicable to fibrocartilaginous entheses and not to fibrous ones (Alves Cardoso and Henderson, 2010; Jurmain *et al*., 2012). There is currently no agreed definition for the normal appearance of fibrous entheses (Jurmain *et al.,* 2012), therefore only fibrocartilaginous entheses were used in this study. The entheses recorded represented both the upper and lower limb. Entheses of the upper limb were recorded, as it is the arm, forearm and hand which are most commonly utilised for occupation-related tasks. The lower limb was included to study mobility as well as to record changes that may be due to occupational use of the lower limb, *e.g.* bending to pick up heavy loads. The entheses (all insertions, unless otherwise specified) recorded were: *m. subscapularis*, *m. infra and supraspinatus* (recorded as one enthesis as the fibres merge close to the attachment (Minagawa *et al*. 1998), common flexor origin, common extensor origin, *m. biceps brachii*, *m. triceps brachii*, *m. brachialis*, hamstring group (recorded as one enthesis), gluteus group (recorded as one enthesis), *m. triceps surae*.

The data analysis considered the importance both of age and occupation on EC frequency. Therefore, age distribution for the total sample was tested for normal distribution using a Shapiro-Wilk test prior to further decisions on appropriate statistical tests. The age distribution was not normal ($W=0.972$; $p<0.005$), therefore non-parametric tests were used to test if there were statistically significant age differences between the occupational categories: Mann-Whitney U was used for the binary division (manual versus non-manual) and Kruskal-Wallis was used for the other categorizations.

The relationships between EC and occupational categorization methods were tested using Chi-square tests, with the Fisher exact significance, so that the statistical assumptions for Chi-square test were not violated. Finally, logistic regression was used to test the effect of both occupational categorization and age on EC. Statistical significance for all these tests was set at 95%.

Results

Table 2 presents the age distribution and tests of normality for age by occupational category. The analysis of age differences between occupational groups revealed no statistically significant differences in age in the 5-category occupational grouping (H=1.748, p=0.782). However, once the sample is compacted into three occupational groups, there are statistically significant differences in age between groups (H=7.896, p=0.020) with non-manual workers having a significantly higher median age at death (56 years) than the light manual workers (45 years). The heavy manual workers had a median age at death (52 years). The trend for statistically significant differences in age between the occupational groups continues as they become less detailed, with the 2-category grouping non-manual workers having a higher median age at death (56 versus 47 years) than manual workers (U=3765.0, p=0.017).

Table 3 presents the frequencies of EC by enthesis for each occupational categorization method. Overall the levels of EC presence are not high but, where present, statistically significant differences were found (Table 4). This can, for example be seen in the left *infra*- and *supraspinatus* and the right *triceps brachii*: all demonstrating statistically significant differences between the occupational groups for all categorization methods. No other consistent patterns were found. The *gluteus* muscles had statistically significant differences for the left side in the 5-category method and the right side in the 3-category method, but no statistical difference for the 2-category method. The *brachialis*, common extensor origin and *subscapularis* all demonstrated statistically significant differences between occupations in the 5-category method, but for no other method. No further statistically significant differences were found.

For those entheses with statistically significant associations with occupation, the effect of age was tested. The results of the logistic regression, in which both age and occupational category were considered, are presented in Table 5. For two of the tests the model did not fit the data, these were: the right *brachialis* in the 5-category method, and the right *triceps brachii* in the 2-category method; therefore, these will not be discussed further. For those entheses found to have consistently significant differences when only occupation was taken into account, *i.e*. the left *infra*- and *supraspinatus* and the right *triceps brachii*, it was found that age and not occupation were statistically significant.

This was also found to be the case for most of the other entheses found to have statistically significant associations with occupation in the previous test, excepting the left common flexor origin for the 5-category group for which neither occupation nor age were statistically significant. However, two entheses stand out: the left *biceps brachii* enthesis in the 5-category group and the right gluteus muscles in the 3-category group. For the left *biceps brachii* both age and occupation were found to effect EC frequency. In contrast, only occupation was found to be significant for the right *gluteus* insertion.

Discussion

Testing methods on identified skeletal collections has become increasingly popular. This is due to the idea that normally unknown variables (in archaeological samples), such as sex and age-at-death, can be controlled for; this makes them ideal for testing the effects of these parameters. The study of entheseal changes associated with activity and labour patterns are amongst the most repeated analyses conducted on identified skeletal collection (Alves Cardoso, 2008; Alves Cardoso and Henderson, 2010; Cunha and Umbelino, 1995; Mariotti *et al.*, 2004, 2007; Milella *et al.*, 2012; Niinimaki 2011; Villotte *et al.*, 2010). However, researchers are increasingly becoming aware of the fact that identified skeletal collections may not be as illustrative of real life as previously thoughts (Alves Cardoso, 2008; Henderson *et al.,* in this issue; Hunt and Albanese, 2005; Komar and Grivas, 2008). The concern is not only whether they are a representative sample of the population, but the fact that the information provided in the documentary evidence associated with those collections omits many details that are relevant in a person's life, and cannot be encapsulated in a death certificate. For instance the documentary evidence does not include information on any changes in occupation during life (Caffell *et al*., 2012; Cardoso, 2006; Henderson *et al.,* in this issue), age at which they began to work, any hobbies, their clinical history; and, from a social and cultural viewpoint it also fails to provide information on the historical and cultural settings in which these individuals were living. This archival and historical information (Cunha, 1995; Herring and Swedlund, 2003; Santos, 1999) is not readily associated with the skeletons, and therefore further historical contextualisation of these individuals' life courses is necessary. Also, there is a growing concern that the research designs and the manner in which data and variables are coded may cause bias and compromise comparisons between studies (Perréard Lopreno *et al.*, 2012).

Taking all these factors into consideration, the aim of this paper was to test the hypothesis that the frequency of entheseal changes (EC) is dependent on the method for categorizing occupation. The results support this hypothesis. The categorization criteria of the occupations into 5, 3 or 2 occupation categories have shown that the significance of EC varies accordingly, and consequently so does the interpretation of the results. This is sufficient to question the accuracy of past population reconstruction of behaviour and behavioural patterns, as well as sexual division of labour. However, the latter was not explored in this paper due to the limited data on female occupations, as previously discussed. This limitation is a problem for most European identified skeletal collections (Alves Cardoso, 2008; Caffell *et al.*, 2012; Cardoso, 2006; Mariotti *et al,* 2004; Milella *et al.*, 2012; Rocha, 1995). With regard to male individuals, the grouping criteria were either based on perceived activity-levels (2-category and 3-category) or social and economic hierarchies (5-category): all of which are inherently subjective. As seen in Table 1, when categories are collapsed from a 5 to a 2-category group, specific occupations move between groups. For instance, stonemason, weaver and photographer are in the same category in the 5-category (skilled workers / artisans), in the 3-category group stonemasons change from skilled workers / artisans to heavy manual workers; weaver to light manual; and photographer to non-manual. While in the 2-category group stonemason and weaver are considered manual, and photographer non-manual. This change reflects perspectives on the interpretation of what occupation means and it is based on the criteria used to categorize the occupations. In the end the question of how to code and interpret the concept of "physical effort" involved in occupation is dependent upon the social, economic and cultural settings within which it is interpreted. This same problem has also been found in gender studies (Alves Cardoso, 2008; Fernandes, 2001; Geller, 2005; Marques, 2009; Sofaer, 2006).

Within the current work, when EC is analysed by occupational category, without controlling for age, only *infra-* and *supraspinatus* (recorded as one enthesis), and *triceps brachii* remain significant throughout the 3 methods for grouping activity (see Table 4). In the remaining cases, the significance levels vary according to entheses and categories. However, when age is considered as a predictor for EC presence, alongside occupation, it is clear that this association between EC and occupation was a false positive. In almost all cases in which statistical significance was found, age became the sole significant factor (Table 5). This observation is valid regardless of the occupation categorization method, *i.e.* it is not dependant on whether activity-levels or socio-economic status are the underlying concepts used to create the categorizations. The working hypothesis that individuals described as non-manual workers would have a higher mean age at death was also supported (Table 2). The importance of age in EC studies is not a new finding, but its significant impact on EC has only recently has been taken into serious consideration (Alves Cardoso, 2008; Alves Cardoso and Henderson, 2010; Cunha, 1995; Mariotti *et al.*, 2004; Milella *et al.*, 2012; Villotte *et al.*, 2010). Unfortunately, age assessment is extremely problematic in archaeological samples (Bocquet-Appel and Masset, 1982; Buckberry and Chamberlain, 2002; Falys *et al.*, 2006; Milner and Boldsen, 2012). Therefore, and faced with results that increasingly show the importance of age in EC interpretation, it is necessary to question the use of EC to reconstruct activity in archaeological populations (Jurmain *et al.*, 2012). On the other hand, a simple association between EC and age fails to express the multifactorial aspect of EC formation (Jurmain *et al.*, 2012) and simplistic interpretations of the association between EC and age (for example, to develop a new ageing method) should be avoided (Tichnell, 2012).

The presumed straightforward interpretation of the differences between occupational categories and EC frequency as being due to socio-economic status is not possible. The clustering of specific occupations into larger occupational categories masks occupations that may be on the borderline or straddle socio-economic groups. For example, in the Portuguese context individuals described as farmers may be representative of different socio-economic backgrounds and have differing occupational duties. The word *lavrador*/*agricultor* (farmer) could be used to name a number of different categories: tenant farmers, sharecroppers, landless day labourers or dependent poor. On the other hand there are also farmers, called *agricultores* who are wealthy landowners, while, in some cases, these individuals might be referred to as *proprietário, i.e.* owner. (Alves Cardoso, 2008; Lopes, 2003; Roque, 1988; Vaquinhas, 1993). Additionally, it is possible that some of the higher status individuals worked their way up from manual to non-manual work, changing socio-economic status as they went. This could explain the lack of significance in EC frequency between the groups (Caffell *et al.*, 2012). Occupation at death does not reflect all activities undertaken during life (Caffell *et al.*, 2012; Cardoso, 2005) nor even the variability of occupations throughout life. Currently, only occupation at death is known for most identified skeletal collections and this study demonstrates that further historical research is required to flesh out the lives of these individuals to fully understand the relationship between occupation, age and EC.

Conclusion

In summary, no occupational grouping method used in this study demonstrated a significant link with EC; whereas the results do reinforce the finding that age is a major confounding variable when studying any degenerative skeletal process. Studies of entheseal changes need to consider not only the recording methods used to assess EC, but also the categories used to group the skeletons. It is necessary to choose an occupational grouping category appropriate to the research question prior to recording, analysis or interpretation of the data. Individuals described as non-manual workers, and frequently associated with higher socio-economic status have higher mean values for age at death, and this may positively skew the EC frequency in these groups. The major conclusion of this paper is that the categorization of occupation is a source of bias. Therefore research should not blindly rely on occupation at death to test the relationship between EC and occupation.

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Table 1. Occupations and categorization by method.

Occupation	N	5 - category	3-category (non-manual, light manual and heavy manual)	2-category (manual, non - manual)
Chauffeur	2	Commerce/Transport	light manual	manual
Coach driver	3	Commerce/Transport	light manual	manual
Hospital employee	1	Commerce/Transport	light manual	manual
Pharmacy assistant	1	Commerce/Transport	light manual	manual
Shop assistant	25	Commerce/Transport	light manual	manual
Stallman	1	Commerce/Transport	light manual	manual
Commercial agent	2	Commerce/Transport	non-manual	non-manual
Industrial	8	Commerce/Transport	non-manual	non-manual
Insurance worker	2	Commerce/Transport	non-manual	non-manual
Merchant	9	Commerce/Transport	non-manual	non-manual
Newspaper man	1	Commerce/Transport	non-manual	non-manual
Salesman	2	Commerce/Transport	non-manual	non-manual
Salesperson	1	Commerce/Transport	non-manual	non-manual
Farmer	3	Farmers/Servants	heavy manual	manual
Road mender	3	Farmers/Servants	heavy manual	manual
Servant	3	Farmers/Servants	light manual	manual
Building constructor	1	Government and Services	heavy manual	manual
Bank clerk	3	Government and Services	non-manual	non-manual
City ouncil employee	2	Government and Services	non-manual	non-manual
Civil servant	13	Government and Services	non-manual	non-manual
Clerk	6	Government and Services	non-manual	non-manual
Corporation employee	1	Government and Services	non-manual	non-manual
Court official	1	Government and Services	non-manual	non-manual
Owner/proprietor	5	Government and Services	non-manual	non-manual
Pharmacist	1	Government and Services	non-manual	non-manual
Scribe	1	Government and Services	non-manual	non-manual
Solicitor	1	Government and Services	non-manual	non-manual
Student	1	Government and Services	non-manual	non-manual
Teacher	3	Government and Services	non-manual	non-manual
Baker	6	Skilled workers / Artisans	heavy manual	manual
Blacksmith	1	Skilled workers / Artisans	heavy manual	manual
Bricklayer	8	Skilled workers / Artisans	heavy manual	manual
Carpenter	15	Skilled workers / Artisans	heavy manual	manual
Foundry worker	2	Skilled workers / Artisans	heavy manual	manual
Glass blower	1	Skilled workers / Artisans	heavy manual	manual
Mechanic	1	Skilled workers / Artisans	heavy manual	manual
Stoker	1	Skilled workers / Artisans	heavy manual	manual
Stonemason	1	Skilled workers / Artisans	heavy manual	manual
Sawyer	1	Skilled workers / Artisans	heavy manual	manual
Barber	5	Skilled workers / Artisans	light manual	manual
Basket weaver	1	Skilled workers / Artisans	light manual	manual
Electrician	5	Skilled workers / Artisans	light manual	manual
Fishmonger	1	Skilled workers / Artisans	light manual	manual
Gilder	1	Skilled workers / Artisans	light manual	manual
Locksmith	3	Skilled workers / Artisans	light manual	manual
Plumber	2	Skilled workers / Artisans	light manual	manual
Shoemaker	12	Skilled workers / Artisans	light manual	manual
Tailor	3	Skilled workers / Artisans	light manual	manual
Tanner	1	Skilled workers / Artisans	light manual	manual
Toothpick artisan	1	Skilled workers / Artisans	light manual	manual

Upholsterer	1	Skilled workers / Artisans	light manual	manual
Weaver	1	Skilled workers / Artisans	light manual	manual
Wireman	1	Skilled workers / Artisans	light manual	manual
Photographer	2	Skilled workers / Artisans	non-manual	non-manual
Carrier / worker	1	Unskilled workers	heavy manual	manual
Worker	24	Unskilled workers	heavy manual	manual
Caretaker	2	Unskilled workers	light manual	manual
Pantry keeper	1	Unskilled workers	light manual	manual
Total	**211**			

Grouping Categories	**n**	**Grouping Categories**	**n**	**Grouping Categories**	**n**
Government and Services	39	heavy manual	69	Manual	146
Commerce/Transport	58	light manual	77	Non-manual	65
Farmers/Servants	9	non-manual	65	**Total**	**211**
Skilled workers / Artisans	77	**Total**	**211**		
Unskilled workers	28				
Total	**211**				

Table 2. Age distribution and tests of normality (Shapiro-Wilk test) for age by occupational category. Bold indicates statistically significant values (95%).

5-category	N	Minimum	Mean	Median	Maximum	Std. Deviation	Shapiro-Wilk	p-value
Government administration/Services	39	23	52.77	56.00	82	17.164	0.960	0.18
Commerce/Transport	58	20	51.79	49.50	85	18.888	0.955	**0.03**
Skilled workers/Artisans	77	20	49.13	46.00	84	17.771	0.960	**0.02**
Farmers/Servants	9	34	49.33	50.00	66	10.805	0.966	0.86
Unskilled workers	28	26	48.79	52.00	70	13.318	0.937	0.09
3-category	N	Minimum	Mean	Median	Maximum	Std. Deviation	Shapiro-Wilk	p-value
heavy manual	69	23	50.61	52.00	84	15.906	0.974	0.16
light manual	77	20	46.71	45.00	83	16.737	0.965	**0.03**
non-manual	65	23	54.86	56.00	85	18.096	0.955	**0.02**
2-category	N	Minimum	Mean	Median	Maximum	Std. Deviation	Shapiro-Wilk	p-value
Manual	146	20	48.55	47.00	84	16.410	0.975	**0.01**
non-manual	65	23	54.86	56.00	85	18.096	0.955	**0.02**
Total	211	20	50.50	50.00	85	17.154	**0.972**	**p<0.005**

Table 3. Description of the fibrocartilaginous entheses used and EC frequency for each occupation categorization method. Note that the *infra* and *supraspinatus* insertions were recorded as one enthesis.

	Subscapularis				***Infra-* and *supraspinatus***				**Common flexor origin**				**Common extensor origin**				***Biceps brachii***			
	left		right		left		right		left		right		left		right		left		right	
5-category	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%
Government administration/Services	9/32	28.1	10/36	27.8	5/27	18.5	2/26	7.7	2/30	6.7	3/31	9.7	3/30	10	5/31	16.1	9/35	25.7	9/37	24.3
Commerce/Transport	11/54	20.4	14/51	27.5	5/45	11.1	8/46	17.4	0/45	0	2/43	4.7	8/44	18.2	9/45	20	18/55	32.7	19/54	35.2
Skilled workers/Artisans	17/72	23.6	19/74	25.7	6/72	8.3	7/67	10.4	1/68	1.5	3/63	4.8	7/69	10.1	10/63	15.9	24/75	32	18/73	24.7
Farmers/Servants	0/8	0	0/8	0	1/8	12.5	1/8	12.5	0/9	0	0/9	0	0/9	0	0/9	0	1/9	11.1	1/9	11.1
Unskilled workers	5/27	18.5	8/26	30.8	1/24	4.2	4/26	15.4	1/24	4.2	2/25	8	2/25	8	3/25	12	13/28	46.4	8/27	29.6
3-category																				
heavy manual	14/66	21.2	16/66	24.2	4/64	6.3	9/61	14.8	2/65	3.1	4/60	6.7	7/64	10.9	8/60	13.3	27/68	39.7	18/67	26.9
light manual	12/70	17.1	19/70	27.1	5/65	7.7	7/65	10.8	0/59	0	1/58	1.7	4/61	6.6	7/59	11.9	19/75	25.3	18/71	25.4
non-manual	16/57	28.1	16/59	27.1	9/47	19.1	6/47	12.8	2/52	3.8	5/53	9.4	9/52	17.3	12/54	22.2	19/59	32.2	19/62	30.6
2-category																				
manual	26/136	19.1	35/136	25.7	9/129	7	16/126	12.7	2/124	1.6	5/118	4.2	11/125	8.8	15/119	12.6	46/143	32.2	36/138	26.1
non-manual	16/57	28.1	16/59	27.1	9/47	19.1	6/47	12.8	2/52	3.8	5/53	9.4	9/52	17.3	12/54	22.2	19/59	32.2	19/62	30.6
Total	42/193	21.8	51/195	26.2	18/176	10.2	22/173	12.7	4/176	2.3	10/171	5.8	20/177	11.3	27/173	15.6	65/202	32.2	55/200	27.5

	Triceps brachii				***Brachialis***				**Hamstrings**				**Gluteus muscles**				***Triceps surae***			
	left		right		left		right		left		right		left		right		left		right	
5-category	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N	%
Government administration/Services	2/32	6.3	7/31	22.6	2/36	5.6	2/35	5.7	11/37	29.7	14/35	40	12/37	32.4	11/33	33.3	12/33	36.4	11/32	34.4
Commerce/Transport	2/47	4.3	6/49	12.2	5/54	9.3	8/53	15.1	17/54	31.5	19/55	34.5	22/53	41.5	18/56	32.1	18/50	36	19/53	35.8
Skilled workers/Artisans	8/73	11	9/67	13.4	4/76	5.3	7/73	9.6	27/71	38	30/74	40.5	20/76	26.3	28/75	37.3	23/68	3.3.8	29/69	42
Farmers/Servants	0/9	0	0/9	0	0/9	0	0/9	0	2/9	22.2	2/9	22.2	1/9	11.1	2/9	22.2	2/5	40	3/6	50
Unskilled workers	2/26	7.7	2/25	8	1/28	3.6	2/28	7.1	12/28	42.9	10/28	35.7	7/28	25	6/27	22.2	10/26	38.5	9/27	33.3
3-category																				
heavy manual	5/65	7.7	6/63	9.5	2/69	2.9	4/67	6	26/65	40	26/67	38.8	18/69	26.1	15/68	22.1	20/58	34.5	26/62	41.9
light manual	7/68	10.3	6/64	9.4	5/74	6.8	9/71	12.7	20/72	27.8	22/73	30.1	21/73	28.8	31/73	42.5	22/67	32.8	26/69	37.7

non-manual	2/54	3.7	12/54	22.2	5/60	8.3	6/60	10	23/62	37.1	27/61	44.3	23/61	37.7	19/59	32.2	23/57	40.4	19/56	33.9
2-category																				
manual	12/133	9	12/127	9.4	7/143	4.9	13/138	9.4	46/137	33.6	48/140	34.3	39/142	27.5	46/141	32.6	42/125	33.6	52/131	39.7
non-manual	2/54	3.7	12/54	22.2	5/60	8.3	6/60	10	23/62	37.1	27/61	44.3	23/61	37.7	19/59	32.2	23/57	40.4	19/56	33.9
Total	14/187	7.5	24/181	13.3	12/203	5.9	19/198	9.6	69/199	34.7	75/201	37.3	62/203	30.5	65/200	32.5	65/182	35.7	71/187	38

n/N = number of individuals with presence of EC/total number of individuals where EC observation was possible: % refers to positive cases of EC within that specific sub-group. Total refers to the total sample.

Table 4. Results of the statistical tests for the association between EC and occupational categories.

	5- category						3- category						2- category					
	left			right			left			right			left			right		
	n/N	$\chi2$	p-value	n/N	$\chi2$	p-value	n/N	$\chi2$	p-value	n/N	$\chi2$	p-value	n/N	$\chi2$	p-value	n/N	$\chi2$	p-value
Subscapularis	42/193	3.359	0.7	51/195	3.222	**0.030**	42/193	2.221	0.134	51/195	0.189	0.743	42/193	1.891	0.184	51/195	0.041	0.860
Infra- and *supraspinatus*	18/176	3.346	**0.038**	22/173	1.975	0.068	18/176	5.632	**0.013**	22/173	0.450	0.477	18/176	5.559	**0.025**	22/173	0.0	1.0
Common flexor origin	4/176	4.448	**0.032**	10/171	1.842	0.100	4/176	2.141	0.149	10/171	3.102	0.089	4/176	0.823	0.583	10/171	1.794	0.288
Common extensor origin	20/177	3.640	0.069	27/173	2.58	**0.036**	20/177	3.25	0.075	27/173	2.657	0.079	20/177	2.652	0.121	27/173	2.008	0.118
Biceps brachii	65/202	5.114	**0.033**	55/200	3.357	0.118	55/202	3.376	0.071	55/200	0.485	0.517	65/202	0.0	1.0	55/200	0.446	0.608
Triceps brachii	14/187	2.780	0.140	24/181	4.364	**0.020**	14/187	1.894	0.146	24/181	5.376	**0.019**	14/187	1.569	0.243	24/181	5.375	**0.030**
Brachialis	12/203	1.995	0.101	19/198	3.604	**0.046**	12/203	1.854	0.216	19/189	1.803	0.213	12/203	0.898	0.515	19/198	0.016	1.0
Hamstrings	69/199	2.439	0.067	75/201	1.525	0.158	69/199	2.486	0.113	75/201	2.930	0.085	69/199	0.234	0.633	75/201	1.808	0.206
Gluteus muscles	62/203	5.715	**0.025**	65/200	2.546	0.061	62/203	2.229	0.144	65/200	6.687	**0.014**	62/203	2.109	0.183	65/200	0.003	1.0
Triceps surae	65/182	0.239	0.658	71/187	1.375	0.203	65/182	0.814	0.331	71/187	0.805	0.425	65/182	0.777	0.407	71/187	0.554	0.513

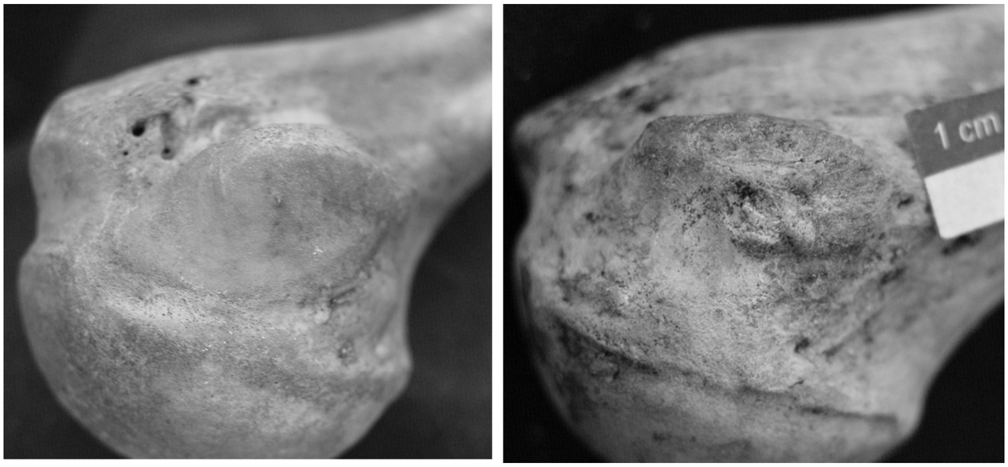
Statistical significance (at 95%) are highlighted in bold: n/N = number of individuals with presence of EC/total number of individuals where EC observation was possible.

Table 5. Results of logistic regression for those entheses and categories with statistically significant associations between EC and occupation. The Wald statistic tests the statistical significance of each coefficient (age and occupational category) in the model.

	Predictors	Wald statistic/ df	p	Wald statistic/ df	p
		left		right	
	Age			30.845/1	< 0.001
Subscapularis	5-Category			0.965/4	0.915
	Age	17.731/1	< 0.001		
Infra- and *supraspinatus*	5-Category	2.187/4	0.701		
Infra- and *supraspinatus*	Age	18.403/1	0.791		
	Age	7.207/1	0.007		
Infra- and *supraspinatus*	2-Category	0.004/1	0.947		
	Age	1.985/1	0.159		
Common flexor origin	5-Category	1.455/4	0.835		
	Age			23.771/1	< 0.001
Common extensor origin	5-Category			0.221/4	0.994
	Age	39.507/1	< 0.001		
Biceps brachii	5-Category	8.689/4	0.069		
	Age			12.122/1	< 0.001
Triceps brachii	5-Category			2.048/4	0.727
	Age			11.333/1	0.001
Triceps brachii	3-Category			2.404	0.301
	Age			14.860/1	< 0.001
Brachialis	5-Category			1.242/4	0.871
	Age	35.382/1	< 0.001		
Gluteus muscles	5-Category	3.627	0.459		
	Age			0.070/1	0.791
Gluteus muscles	3-Category			6.249/2	0.044

The Hosmer-Lemeshow goodness-of-fit test was not significant in the cases presented ($p>0.05$).

Figure 1. Insertion of the *m. subscapularis* in two left humeri (from the Luis Lopes Collection). A. normal appearance of the fibrocartilaginous insertion site. B. abnormal appearance with disruption to the normally smooth enthesis, *i.e.* entheseal changes which include new bone formation.



175x80mm (300 x 300 DPI)