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SHORT REPORT

Exploring poverty: skeletal biology and documentary evidence in 19th–20th century Portugal

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Abstract

Background: The inference of the state of wealth or poverty from human skeletal remains is a difficult task, as the limited number of skeletal changes are mediated by numerous other physiological, biomechanical and pathological events. In recent years, identified skeletal collections have become valuable resources in enabling aetiologies of these changes to be understood while controlling for some known causative factors, e.g. age, sex and occupation. This has favoured more rigorous data analysis and interpretation.
Aim: This study compares the presence of osteological makers of occupation—specifically degenerative joint changes (DJC)—between socio-economically framed occupational groups whilst controlling for age-at-death.
Materials and methods: A total of 603 individuals were distributed into seven occupational groups used as a proxy for their socio-economic status.
Results: The results demonstrated that age was a contributing factor for DJC. Differences between occupational groups were only found for the hips, right shoulder and ankle.
Conclusions: Differences found were not necessarily representative of low vs high socio-economic status. Furthermore, there are limitations associated with the use of occupation-at-death, based on documentary evidence, which does not necessarily reflect wealth-status.

Keywords

Degenerative joint changes, occupation, identified collections, skeletons, socio-economic status

History

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Introduction

The World Health Organisation (WHO, 2015) calculates that *circa* 1.2 billion people currently live on less than a dollar per day and nearly 800 million people in developing countries are under-nourished (OECD, 2003). This reality substantially affects the immune system, contributing to an increase in the incidence and severity of diseases, as well as to low life expectancies, to which living conditions and exposure to pollutants and lack of healthcare or social provision only contributes (OECD, 2003). Such contexts have severe implications for a person's development and life course. A life of famine and hardships may be seen in skeletons through changes mediated by physiological and biomechanical stress and ill-health. In fact, the relationship between certain physiological stress markers and the living conditions of past populations is an issue frequently addressed in the palaeopathological literature (see Grauer, 2012, for detailed bibliographic references). Numerous challenges remain when using skeletal changes to infer socio-economic status or wealth, nevertheless this remains common (for overall summary see Grauer, 2012). In recent years, the use of skeletal changes as proxies for wealth and health has been scrutinised (Alves Cardoso, 2008; Roberts et al., 2012). Recent palaeopathological approaches to human remains have made it clear that this is a complex discipline and that bone lesions should not be interpreted simplistically (Jurmain et al., 2012).

One of the primary limitations associated with the study of skeletal indicators of physiological and biomechanical stress is the inability to precisely control for sex and age: variables which have significant impact on human development and homeostasis (Roberts et al., 2012). Despite the number of sex and age-at-death assessment methods, these still lack accuracy (Falys et al., 2006). This growing awareness of the limitations of using skeletal changes as proxies for external stressors and the need for testing these methodologies and interpretations while controlling for some variables is becoming better understood (Alves Cardoso & Henderson, 2013). Q1

Recently, bioarchaeologists (those studying archaeologically derived biological material, in this case human remains) have turned more to human identified skeletal collections (HISC) to test such relationships (e.g. Alves Cardoso & Henderson, 2013; Henderson et al., 2013). HISC have made it possible to access accurate skeletal biographical data, e.g. sex and age-at-death. Such collections enable these variables to be controlled, which would otherwise negatively impact upon the accurate interpretation of the cause of skeletal changes

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(Alves Cardoso & Henderson, 2013). Furthermore, HISC enable the contextualisation within well-known historical and social contexts of these individuals facilitating rigorous data analysis and interpretation.

The combination of skeletal biological data with documentary evidence based on probate records and other historical documentation provides an optimal scenario for the exploration of the relationship between socio-economic status and skeletal changes. This study aims to explore biological skeletal indicators commonly used to assess activity, specifically degenerative joint changes (DJC), and to determine if these are a good biological indicator of socio-economic status. Occupation as listed at death will be used as a proxy for wealth status based on contemporaneous documentary evidence. The analysis will control for age-at-death and sex of the individuals. The hypothesis is that those with low socio-economic status will have physically harder occupations, poorer nourishment and worse living conditions, leading to higher DJC rates.

Materials and methods

Skeletons ($n = 603$: 300 males and 303 females) from two Portuguese identified collections covering the late 19th to early 20th centuries were selected for analysis: the Coimbra Identified Skeletal Collection (CISC) and the Luis Lopes Skeletal Collection (LLSC) (Cardoso, 2006; Rocha, 1995). For each collection, biographical data from death records provides each individual's name, age, cause of death, place of death, occupation and their address. The sample studied consists of individuals who lived and died between 1822–1965. The skeletons were selected based on the accessibility to biographical information, state of preservation and absence of pathological skeletal changes to avoid biasing the interpretation of DJC (for sample selection see Alves Cardoso, 2008). Seven major occupational groups were created (Alves Cardoso, 2008; Roque, 1988) aiming to contextualise the sample within the Portuguese social and economic framework. The socio-economic status (SES) of each occupational group was inferred based on the income values from the Annual Statistical Reports available, which were produced by the Instituto Nacional de Estatítica ~~(National Institute of Statistics: D.G.E. 1904–1906, 1919, 1929–1934; I.N.E. 1936)~~. The reports were selected according to the year of death of the individuals, ranging from 1904–1936, and their availability for online consultation. Based on these income values, two broad categories, low and high incomes, were created to classify each occupational group (see Table 1 for details on occupational groups). Eight joints, upper and lower limbs combined, were scored (from 0–4) for DJC based on marginal lipping (i.e. changes occurring around the joint rim), porosity, eburnation and osteophytes on the articular surface (Buikstra & Ubelaker, 1994). These scores were added together into a single number (SUM_DJC) to quantify changes at the shoulder, elbow, wrist, hip, knee and ankle; the higher the value the more changes exist at that joint (Alves Cardoso, 2008). Descriptive statistics were computed and differences in age between occupational groups were calculated using a Kruskal-Wallis test. Analysis of covariance (ANCOVA) was used to study the relationship of DJC for each occupation,

Table 1. Descriptive statistics of age-at-death and the sum of DJC scores (Sum_DJC) for each occupational group and joint.

		Age at death					SUM_DJC LEFT																	
							Shoulder			Elbow			Wrist			Hip			Knee			Ankle		
Occupational groups	SES	n (♀/♂)	Mean	SD	Min.	Max.	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Government administration/Services	High	52 (5/47)	55.6	17.73	23	88	51	4.14	4.41	50	2.08	3.04	51	1.04	2.07	52	3.5	2.93	52	3.17	3.31	52	0.56	0.75
Commerce/Transport	Low	85 (0/85)	51.26	17.5	20	85	84	4.32	4.34	83	1.89	2.88	83	0.69	1.33	84	4.14	3.49	85	2.73	3.77	85	0.61	0.91
Skilled workers/Artisans	Low	102 (4/98)	48.76	18.32	20	88	102	3.58	4.09	102	1.37	1.96	100	0.79	1.52	102	3.19	3.16	102	2.48	4.21	101	0.37	0.91
Farmers/Servants	Low	28 (18/10)	46.54	17.93	21	80	28	3.68	4.21	28	1.82	3.84	28	0.43	1.4	28	2.07	2.16	28	1.71	3.29	28	0.68	1.42
Unskilled workers	Low	37 (0/37)	49.22	13.32	26	70	37	3.97	4.04	37	2.11	3.08	36	1.06	2.34	37	3.7	2.91	37	1.95	2.66	37	0.3	0.57
Army/Navy	High	23 (0/23)	38.35	15.89	20	73	22	1.36	2.63	22	1.41	4.09	21	0.95	1.99	23	2.43	3.04	23	1.35	2.12	23	0.35	0.65
Domésticas (housewives)	Low	276 (276/0)	56.74	19.59	20	98	275	4.87	5.6	270	2.75	4.53	264	0.78	2	273	3.6	2.94	275	4.16	5.22	276	0.58	0.92
Total sample		603 (303/300)	52.88	18.89	20	98	599	4.27	4.9	592	2.2	3.75	583	0.8	1.84	599	3.49	3.05	602	3.23	4.5	602	0.52	0.91
							SUM_DJC RIGHT																	
Government administration/Services	High						51	4.59	4.85	51	2.37	3.65	52	1.33	2.51	51	4.06	3.45	52	3	3.64	52	0.81	1.12
Commerce/Transport	Low						83	5.08	5.09	84	2.27	3.43	81	0.77	1.3	85	4.13	3.15	85	3.13	4.03	85	0.8	1.17
Skilled workers/Artisans	Low						102	3.93	4.42	101	1.48	2.02	98	0.88	2.19	102	3.37	2.98	102	2.85	5.39	101	0.53	0.93
Farmers/Servants	Low						28	3.32	5.07	28	2.46	5.58	28	0.71	1.98	28	2.5	2.67	28	1.75	3	28	0.29	0.53
Unskilled workers	Low						37	5.7	6.08	37	2.41	3.54	37	1.27	2.59	37	4.16	4	37	1.7	2.53	37	0.54	0.93
Army/Navy	High						23	2.39	3.07	23	1.35	3.66	21	0.86	1.85	23	2.61	3.03	23	1.65	2.35	23	0.43	0.84
Domésticas (housewives)	Low						273	4.76	5.4	269	2.75	3.93	263	0.86	1.98	275	3.92	3.62	275	4.49	5.55	272	0.49	0.84
Total sample							597	4.55	5.13	593	2.35	3.66	580	0.91	2.03	601	3.77	3.42	602	3.48	4.93	598	0.56	0.94

SD, standard deviation; Min, minimum age-at-death; Max, maximum age-at-death; SES, socio-economic status.

while considering the effect of age and sex with post-hoc tests used to identify major differences in occupational groups. All data analyses were undertaken using SPSS software version 14.04 for Windows (SPSS Inc., Chicago, IL).

Results

Significant differences in age-at-death existed between occupational groups (H = 35.120, $p < 0.001$), with a significant emphasis on the differences between the army/navy (lowest mean value) and the government administrative/services and housewife categories (highest mean value) (Table 1). Therefore, a covariance analysis (ANCOVA) was used to explore the presence of DJC by joints, with occupational groups as a fixed factor and age as a covariant (Alves Cardoso, 2008: 105–109). The results showed that age-at-death had a significant impact on the development of DJC in all joints observed ($p < 0.001$). The role of occupation was generally non-significant, except for the right shoulder, hips and right ankle (Table 2). Post-hoc tests pinpointed which occupational groups exhibited major differences. The results showed that the highest DJC mean values were estimated in commerce and transport (hips, right ankle) and unskilled labourers (hips, right shoulder). Housewives (left hip, right ankle), farmers and servants (left hip) had the lowest values (Table 2).

Discussion

Occupation and socio-economic status are seen as closely interwoven, due to the close association with income. Therefore, studying the relationship of indicators of occupation (e.g. DJC) in HISC should demonstrate whether this is a feasible approach to identify socio-economic status in

Table 2. ANCOVA test and post-hoc test results for the sum of DJC scores (Sum_DJC) by joints, considering age-at-death and occupational groups.

Joints	df	*F*-value	*p* value	Post-hoc test results
SumDJC_Left				Groups with significant interactions
Shoulder				
Age	−1.591	376.705	<0.001	
Occupation	−6.591	0.495	0.812	
Elbow				
Age	−1.584	134.157	<0.001	
Occupation	−6.584	0.795	0.574	
Wrist				
Age	−1.575	84.982	<0.001	
Occupation	−6.575	1.349	0.233	
Hip*				
Age	−1.591	372.693	<0.001	
Occupation	−6.591	3.354	0.003	>M = Gov. administration/Services & Unskilled workers <M = Farmers/Servants & Housewives
Knee				
Age	−1.594	235.931	<0.001	
Occupation	−6.594	1.305	0.253	
Ankle				
Age	−1.594	95.664	<0.001	
Occupation	−6.594	1.179	0.316	
SumDJC_Right				
Shoulder*				
Age	−1.589	376.632	<0.001	
Occupation	−6.589	2.469	0.023	>M = Commerce/Transport & Unskilled workers <M = Gov. administration/Services & Skilled workers/Artisans & Housewives
Elbow				
Age	−1.585	193.541	<0.001	
Occupation	− 6.585	0.880	0.509	
Wrist				
Age	−1.572	97.023	<0.001	
Occupation	−6.572	1.550	0.16	
Hip*				
Age	−1.593	543.559	<0.001	
Occupation	−6.593	3.375	0.003	>M = Commerce/Transport & Unskilled workers <M = Gov. administration/Services & Farmers/Servants & Housewives
Knee				
Age	−1.594	214.061	<0.001	
Occupation	−6.594	1.782	0.1	
Ankle*				
Age	−1.590	70.560	<0.001	
Occupation	−6.590	2.957	0.007	>M = Gov. administration/Services & Commerce/Transport <M = Farmers/Servants & Housewives

*Statistically significant levels.
df, degrees of freedom; >M, higher value of estimated mean (M) based on the ANCOVA test; <M, lower value of estimated mean (M) based on the ANCOVA test.

non-identified skeletons. This study demonstrated that this is not a viable approach. Age-at-death was shown to be a stronger contributing factor with the mean values of DJC (Sum_DJC), reflecting the age-at-death of the individuals within the occupational groups and not occupation. This represents a serious limitation to applying the method to past populations because of the previously described problem of accurately determining age, thus biasing the interpretation of socio-economic inequalities. A further limitation is the presence of males and females in some occupation categories, however, 276 of the 303 were housewives and, of the remaining 27, there were 17 servants, one farmer, four seamstresses, one nurse, one proprietor, one post office employee, one student and one teacher (distribution according to occupational group is found in Table 1). These numbers do not affect the final results or interpretation (Cardoso, 2008). It is also necessary to consider the timing of events and how these physiological or biomechanical stressors may differentially impact upon the skeleton, i.e. the organism may react differently if individuals undergo events at an early compared to an older age (Karsenty, 2003; Roberts et al., 2012). The time of occurrence of the changes cannot be determined from the changes, although some, due to their expression, imply a cumulative response by the organism. This observation points to an added dimension when attempting to infer poverty using skeletal biology, i.e. that of an individual life course and its socio-economic context. What is observed in bones, at the time of death, is a freeze frame of a life lived and may not be representative of a lifetime of occupations or of biomechanical events (Henderson et al., 2013). This is valid both for the biological context of bone change, as well as the biographical data used to explore the aetiology of it, which in the present study relates to the use of occupation-at-death as an indicator of socio-economic status.

Q5

In the current study a significant association was found to exist between DJC and some of the joints analysed, when age was taken into account: namely the right shoulder, hips and right ankle (Table 2). The traditional assumption indicates that those with the highest values undertook the most physically demanding workload. Thus, it could be interpreted that those working in commerce or in unskilled labour were experiencing higher loading (whether repetitive or in absolute force) on these joints than housewives, farmers and servants. However, these differences are not necessarily representative of low vs high socio-economic status. In fact these interpretations are far from representative of the known historical socio-economic context of these occupational groups. According to data from the National Institute of Statistics, as well as other historical records (see Alves Cardoso, 2008, for details) farmers and servants represented some of the most economically challenged people within 19th and 20th century Portuguese society. Therefore, and in the current study, DJC are not necessarily representative of economic status and should not be blindly used in the interpretation of social inequalities.

Conclusions

The aim of this study was to utilise DJC, often interpreted as indicators of heavy workload (often attributed to the poorest in society), to study socio-economic stress in 19th and 20th century Portugal. The skeletons used were from two HISC which span the socio-economic spectrum and, most importantly, have documentary evidence enabling their sex, age and occupation to be known. In this study occupation was used as a proxy for socio-economic status. The results demonstrate that age has a significant impact on the presence of DJC and must be taken into account in all such studies. The expected results, that individuals in lower socio-economic groups would have higher levels of DJC due to their heavier workload, were not supported. However, HISC do not provide a complete picture of economic variables, such as poverty, either from the directly available biographical data or from the indirect skeletal evidence. Occupation, in this sample, is not a direct indicator of wealth status and neither are DJC.

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Declaration of interest

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