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A New Forensic Collection housed at the University of Coimbra Portugal: the 21st Century Identified Skeletal Collection

ABSTRACT

The purpose of this study is to characterize and contextualize the new collection of identified skeletons housed in the Department of Life Sciences at the University of Coimbra, Portugal. The 21st Century Identified Skeletal Collection, which is still being enlarged, is currently composed of 159 complete adult skeletons (age at death range: 29 to 99 years) of both sexes. The skeletons consist almost exclusively of Portuguese nationals who died between 1995 and 2008. The state of preservation is good and more detailed antemortem information is presently being collected.

This collection constitutes a fundamental tool for forensic anthropology research, including development and validation studies of skeletal aging and sexing methods that target elderly adults. Moreover, this collection can also be used in conjunction with the other reference collections housed in the University of Coimbra to investigate secular trends in skeletal development and aging, among others.

INTRODUCTION

The first human skeletal collections were amassed in Europe and in the United States of America, prompted by influential individuals, such as the surgeon John Hunter, the anthropologist and physician Pierre Paul Broca or the professor William Turner [1–4]. The methodical assemblage and study of human skeletal remains have a longstanding scientific tradition in physical anthropology. Reference collections represent the primary foundation for the development of basic techniques in both forensic anthropology and bioarchaeology, which among others, include sex, age and stature estimation (e.g., [5–12]).

Reference skeletal collections are therefore recognized as an exceptionally valuable research asset but those with a significant number of human skeletons of recent origin are scarce. Also, it must be taken into account that the age range of a forensic case is considerably different from country to country, therefore many older collections are not entirely useful for the development of methods that can be reliably applied to more recent populations. To start with, documented skeletons are limited to a few assemblages (Table 1) [13–27], thus further decreasing the amount of forensically adequate collections.

Although reference skeletal collections are major resources for the physical anthropologist, there is a growing awareness about the empirical constraints in the application of universal standards to the identification of individuals in forensic settings and the construction of paleodemographic and paleoepidemiological profiles in bioarchaeology [28, 17, 24]. Physiological age indicators, growth patterns or sexually dimorphic traits vary across populations, demanding population-specific methodologies for the assessment of basic biological profiles of skeletonized individuals [29]. Most of the cited documented skeletal assemblages comprise individuals that died before 1950 and are biased samples of the populations from which they derive [25]. Also, the reliability of individual documentation in

these collections is heterogeneous, occasionally conveying inaccurate information. For example, some collections, including the well-known Terry Collection, include some or all individuals with self-reported ages [29]. As such, the methodologies applied to forensic cases should be developed on the basis of recent reference series. Having this in mind, we strove to amass a forensic identified skeletal collection.

The new reference collection presented here results from the sampling of recent individuals from Portuguese nationality and south European ancestry. The «Colecção de Esqueletos Identificados do Século XXI (herein CEI/XXI)» (21st Century Identified Skeletal Collection – ISC/XXI) housed at the Laboratory of Forensic Anthropology of the Life Sciences Department at the University of Coimbra, Portugal, currently comprises 159 documented adult skeletons from both sexes. This paper aims to depict the fundamental anthropological and demographic features of the new collection, as well as its organization history.

BUILDING A REFERENCE SAMPLE

A protocol of collaboration between the former Department of Anthropology of the University of Coimbra (UC), now integrated in the Life Sciences Department and the City Council of Santarém (responsible for the *Capuchos* cemetery) was established in 2009 for the bestowal of non-claimed skeletal remains. Since then, identified skeletons from individuals who died after the year 2000 have thus been received and curated at the UC.

In Portugal, according to ordinance nº 411/98 of December the 30th, it is possible to perform non-judiciary exhumations three years after the inhumation (provided that the body is fully skeletonized) thus allowing the reuse of burial ground [30]. The skeletons that are not claimed by relatives stay under the tutelage of the cemetery. Therefore, the CEI/XXI

collection is composed of corpses that were unclaimed or abandoned beyond the legal period. The Santarém City Council provided copies of the inhumation and exhumation registrations as well as the death certificates of each individual. Information about the name, age at death, sex, nationality, date of death, date of inhumation, date of exhumation and the burial slot at the cemetery is therefore available for each individual.

Currently, the skeletons are submitted to a preliminary cleaning process at the cemetery and transported to the UC packed in black plastic bags. However, the first 70 skeletons were not subjected to that process and still presented body hair, adipocere, soft tissues and clothes when received at the UC. In these cases, complete cleaning and maceration took place at the laboratory. After the cleaning process, the skeletons were stored individually inside plastic containers tagged with the correspondent serial number. The information linking the serial number to the name of each individual is kept in an Excel database with access restricted to researchers, in order to preserve the confidentiality of personal data.

Currently, 70 skeletons are available for study while the remaining 89 are still undergoing the cleaning and tagging processes. In order to process and keep the skeletons in good conditions, the Laboratory of Forensic Anthropology was renewed. It is worthwhile to briefly describe it since it was partially planned in function of this new collection. The laboratory includes a reception room where new skeletons are kept while the cleaning and maceration takes place. These procedures are done in accordance with standard hygienic conditions. Once cleaned, the skeletons are moved into a separate room where they are placed in individualized plastic boxes in a specific closet - both specifically designed to house them. It is in this latter room, equipped with modern technology (e.g.: 3D scanner; digital X-ray), that all the exhaustive analyses of the skeletons are accomplished. The existence of two separate rooms is designed to avoid any kind of organic contamination between newly arrived and already cleaned and stored skeletons. With the renewed facilities, it is possible to enlarge

the collection at a planned rate of 20 skeletons per year, which was something impossible to do previously.

DESCRIPTION OF THE COLLECTION

Demographic Composition

At the moment, the collection is composed of 159 skeletons from Portuguese of both sexes with ages at death between 29 and 99 years (Table 2). All the individuals died between 1995 and 2008 and have been exhumed between 1999 and 2013. The female sample represents 53.5% (n=85) of the collection and the age at death ranges from 50 to 99 years old ($\bar{x}$ = 81.84; *s.d.* = 10.99; *median* = 85). The male sample has 74 individuals (46.5%) with a larger age at death distribution since the younger individual is 25 years old and the oldest is 95 years old ($\bar{x}$ = 71.11, *s.d.* = 18.23; *median* = 75).

The majority of the individuals is quite old thus leading to the correlated "inconvenience" of severe ante mortem tooth loss. This is a research handicap for testing dental methods. Moreover, until now the series does not include a single subadult skeleton. In other words, whereas this series is an excellent opportunity to test and develop aging methods in older adults, no testing can be accomplished for subadults.

State of Preservation and Completeness

The bone representation of the skeletons is, fairly reasonable with only a few absent bones and the majority of the bones fully preserved (Fig.1). At the moment, a comprehensive analysis of the state of preservation was carried out only for the first 70 skeletons that were added to the collection [31]. This sample presents an age range between 33 and 97 years old

(38 males and 32 females), with a mean burial time of 6 years (*s.d.*: 3.766; range: 4.5 – 9.5 years).

The preserved soft tissues mostly encompass desiccated remains of adipocere, ligaments and tendons – particularly preserved on the posterior region of the thoracic and lumbar vertebrae, the sacrum, the more muscular areas of the *os coxae* and of the trochanters and *linea aspera* of the femur. These were present in 73.0% (51/70) of the individuals. Dehydrated remains of brain were also frequently found (57/70; 81.4%).

In terms of completeness, few bones are missing and most bone types are comprised of a majority of complete elements (meaning that the bone is 100% complete). The ribs, the scapula, the iliac and the sacrum are the exceptions (Table 3). A very low percentage of missing bones was expected considering the fact that the bodies were fully dressed, buried in coffins and without record of any kind of disturbance previous to the exhumation. Furthermore, and taking into account the observation of exhumations in other cemeteries, the absence of some of the bones can be explained by their incomplete recovery during exhumation. The failure to detect and recover skeletal parts typically affected fragmented and/or smaller bones, particularly those from the hands.

Supplementary Gathering of Personal Details

Currently, the cause of death is known only for 12 individuals in the collection. Notwithstanding, the on-going clearance of hospital records and autopsy reports will warrant the knowledge of the cause of death for most of the individuals. Moreover, the various types of prosthetic devices found in ten skeletons act as valuable assets for individual identification.

Particular care is being addressed towards identification data. Besides death certificates, we are focusing on the gathering of more biographical data about each individual. One kind of information that it is possible to obtain pertains living stature, since this personal

detail is included in Portuguese Identity Cards. This is a very valuable feature since it is not known for the great majority of identified skeletal collections worldwide. As mentioned above, since the deaths of the individuals in question are fairly recent, it is possible to collect data on the diseases and/or cause of death from the hospitals where they were admitted. This was already accomplished for a few individuals. In addition, as four individuals show signs of having been autopsied, the autopsy reports will be surveyed in order to have a better understanding of the observed lesions, mainly traumatic injuries. This could be particularly informative for the knowledge of the lesions' chronology during each individual's lifetime.

RESEARCH POTENTIAL

Besides its forensic relevance, the 21st Century Skeletal Collection includes another major asset, namely the possibility of comparing it with other identified skeletal collections of a similar geographic origin, thus comprising a biological repository with almost two centuries of history. The CEI/XXI is composed of individuals that died in the late 20th – early 21st centuries, while most of the individuals from the other Coimbra reference collections died between 1910 and 1940 [13]. Notwithstanding, some overlap in the years of birth of the individuals from the different reference osteological collections housed at the University of Coimbra is present. As such, there is a chronological continuity that provides a unique opportunity to document secular trends regarding growth and aging, among others.

Despite the fact that the collection is not yet fully organized, which is expected in the short term with the development of a specific software to manage the collected data, it was already the focus of two Doctoral theses [31, 32] and eight Master's dissertations [33–40]. In addition, the collection was used as a test sample to develop software for ancestry estimation, AncesTrees [41], to test an age at death estimation technique based on densitometric

estimation of bone loss [42] and to evaluate secular trends of proximal femur geometry in Portugal during the 20th century [43].

The potential of the collection is being further explored in other projects currently taking place at the Laboratory of Forensic Anthropology. For example, the first collection of identified burned skeletons, which is critical for the investigation of forensic scenes involving burned victims, is already being assembled. Also, a project to develop guidelines for differentiating trauma from postmortem processes is now starting.

A major research project on skeletal aging is currently underway, profiting from the demographic profile of the collection. Currently, a standard set of methods based on pubic symphysis and auricular surface are being tested to verify their usefulness in the estimation of age-at-death among individuals older than 60 years old. Also, an exhaustive analysis of alterations affecting the teeth is envisaged. Taking into account that, in Portugal, most forensic anthropology cases concern old individuals, the development of more accurate aging methodologies is paramount.

All taken together, this demonstrates the scientific value and research potential of the CEI/XXI collection which is now made available for researchers with an interest in human skeletal remains.

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TABLES

Table 1. Some of the existing identified skeletal collections in Europe.

Collection	Country	Individuals (N)	Chronology	Reference
Coimbra Identified Skeletal Collection	Portugal (Coimbra)	505	1904 to 1938	[13]
Bocage Museum (NMNH) Identified Skeletal Collection	Portugal (Lisbon)	1692	1880 to 1975	[14]
UAB Identified Skeletal Collection	Spain (Barcelona)	35	1977 to 1991	[15]
UCM Identified Skeletal Collection	Spain (Madrid)	119	1975 to 1985	[16]
Granada Osteological Collection of Identified Infants and Young Children	Spain (Granada)	230	1870 to 2009	[19]
Sassari Collection	Italy (Bologna)	606	First half of the twentieth century	[18]
Athens Human Skeletal Reference Collection	Greece (Athens)	225	1960 to 1996	[17]
Crete Human Skeletal Reference Collection	Greece (Crete)	178	1968 to 1998	[27]
St. Bride's Church Documented Collection	UK (London)	244	18th to 19th century	[20]
Christ Church Spitafields Collection	UK (London)	968	1729 to 1859	[21]

Table 2. Distribution by age group and sex.

Sex	Age Group					Totals
	20 – 29	30 – 49	50 – 69	70 – 89	90 – 99	
Male	3	8	13	43	6	73
Female	0	1	12	53	19	85
Global	3	9	25	96	25	158

Table 3 State of completeness of the 70 skeletons available for study.

Bone / Anatomic region		Complete (n; %)	Fragmented (n; %)	Absent (n;%)
Calvaria		65 (92.9%)	5 (7.1%)	0
Face		51 (72.9%)	17 (24.3%)	2 (2.9%)
Mandible		60 (85.7%)	9 (12.9%)	1 (1.4%)
Vertebrae	Cervical	48 (68.6%)	19 (27.1%)	3 (4.3%)
	Thoracic	43 (61.4%)	27 (38.6%)	0
	Lumbar	44 (62.9%)	26 (37.1%)	0
Sacrum		34 (48.6%)	34 (48.6%)	2 (2.9%)
Ribs	Right	15 (21.4%)	55 (78.6%)	0
	Left	15 (21.4%)	55 (78.6%)	0
Scapula	Right	35 (50.0%)	34 (48.6%)	1 (1.4%)
	Left	34 (48.6%)	35 (50.0%)	1 (1.4%)
Clavicle	Right	60 (85.7%)	9 (12.9%)	1 (1.4%)
	Left	58 (82.9%)	12 (17.1%)	0
Humerus	Right	57 (81.4%)	12 (17.1%)	1 (1.4%)
	Left	62 (88.6%)	6 (8.6%)	2 (2.9%)
Radius	Right	59 (84.3%)	11 (15.7%)	0
	Left	60 (85.7%)	10 (14.3%)	0
Ulna	Right	58 (82.9%)	12 (17.1%)	0
	Left	61 (87.1%)	9 (12.9%)	0
Os coxae	Right	19 (27.1%)	50 (71.4%)	1 (1.4%)
	Left	16 (22.9%)	54 (77.1%)	0
Femur	Right	61 (87.1%)	9 (12.9%)	0
	Left	61 (87.1%)	9 (12.9%)	0
Tibia	Right	62 (88.6%)	7 (10.0%)	1 (1.4%)
	Left	64 (91.4%)	5 (7.1%)	1 (1.4%)
Fibula	Right	37 (52.9%)	32 (45.7%)	1 (1.4%)
	Left	44 (62.9%)	25 (35.7%)	1 (1.4%)
Calcaneus	Right	59 (84.3%)	9 (12.9%)	1 (1.4%)
	Left	61 (87.1%)	8 (11.4%)	2 (2.9%)