Abstract

Universities of the Third Age (U3As) empower older adults through tailored, lifelong learning programs, which have significantly grown both in Europe and worldwide since the 1970s. In Spain, these programs foster active aging through cultural and scientific engagement. This study examines a workshop within the Programa Interuniversitario de la Experiencia in Burgos, focusing on age estimation and paleopathology in bioarchaeological contexts.

The workshop addressed the challenge of accurately determining the age of individuals from skeletal remains, particularly amongst older adults whose representation in archaeological records is often limited. This underrepresentation affects our understanding of past reproductive patterns and life histories. To tackle this, a theoretical-practical workshop was conducted with 49 students, employing original skeletal elements from the San José Cemetery in Burgos.

The workshop's aims included distinguishing age categories via dental and skeletal analysis, identifying age-related pathologies, and understanding the scarcity of older adults in archaeological records. The workshop consisted of an introduction to age estimation methods and pathologies, hands-on analysis of original materials, and a concluding survey. Our results suggest that this workshop represents a successful educational strategy for lifelong learning programs targeting older adults. Through the integration of theoretical content, practical engagement, and critical reflection on biological aging and archaeological interpretation, the initiative responds effectively to the learning styles and needs commonly associated with this age group.

Introduction

A forgotten audience: University classes for older adults

Although public engagement in archaeology and bioarchaeology has grown significantly in recent decades, it often tends to focus on children and younger adults (Moshenska 2017; Richardson and Almansa-Sánchez 2015). While the younger generation is essential to the future of the discipline, older people bring a deeper, temporal perspective and rich life experiences that can meaningfully inform and enrich public engagement efforts. Moreover, older adults are undergoing the very processes of biological and social aging that bioarchaeology seeks to interpret in past populations. Because the body is shaped by both biological processes and cultural contexts (Lorentz 2008; Sofaer 2006a,b), it is essential to develop interpretations of age and embodiment that move beyond purely skeletal analysis (Schutkowski 2008). This creates a unique intersection between scientific content and personal relevance, where older learners

may engage not only out of curiosity, but also out of a desire to understand their own bodies and trajectories through the lens of the past (Swain 2007).

Moreover, older adults represent a growing yet often overlooked audience in science education and outreach. To the best of our knowledge, only one previous study in educational bioarchaeology has focused on this population group, exploring online learning during the pandemic (Ward et al. 2023). The present article presents and evaluates a hands-on educational workshop designed to introduce older learners to age estimation and paleopathology techniques commonly used in bioarchaeology. Through the integration of theoretical instruction, direct interaction with original skeletal material, and guided reflection, the workshop aims to foster active learning and critical engagement with both the biological and social dimensions of aging. We argue that this approach is particularly effective for older learners, as it builds on their lived experiences and offers a meaningful context for engaging with scientific knowledge. The workshop not only promotes a deeper understanding of skeletal aging but also creates a space for challenging age-related stereotypes through the lens of archaeological science. In doing so, it contributes to a broader conversation about the role of lifelong learning by empowering older adults as active participants in academic and scientific environments.

This workshop was carried out within the framework of Spain's expanding University Programs for Older Adults, a movement rooted in the tradition of the Universities of the Third Age. Since the 1970s, these programs have offered older learners opportunities to pursue academic, cultural, and personal development (Casanova et al. 2024; Velázquez and Fernández 1999). In Spain, the number of such initiatives has increased significantly since the late 1990s, and today, many universities—such as those of Barcelona, Zaragoza, and the Basque Country—offer structured educational pathways under names like "Universities of Experience". In Castilla y León, where this study was conducted, the Programa Interuniversitario de la Experiencia exemplifies this trend. Coordinated by the regional government in partnership with public university (Servicios Sociales de Castilla y León 2024), the program promotes active aging and lifelong learning across the region. It provides a unique platform for interdisciplinary initiatives such as the workshop described in this article, allowing older adults to engage with complex academic content in a socially meaningful context.

Original human materials as teaching tools

Original human materials housed in educational institutions have been used as teaching tools since the 3rd century BC (Standring 2016). Academic institutions maintain collections of human remains as valuable resources for advancing our understanding of human biology and evolution. However, it is crucial to note that the use of human remains in academic settings must adhere to strict ethical guidelines, legal regulations, and respectful handling practices (National Committee for Research Ethics on Human

Remains 2022). Proper consent, documentation, and storage protocols must be in place to ensure the ethical use of these valuable resources (BABAO 2019a, 2019b; Caffel and Jakob 2019; Cassman et al. 2006; Giesen 2013; Márquez-Grant et al. 2011; Passalacqua et al. 2014; Passalacqua and Pilloud 2018; Roberts 2013; Squires et al. 2019, 2022; Squires and García-Mancuso 2021).

Engaging directly with authentic human skeletal remains offers learners a unique opportunity to explore the natural variability of human anatomy, including individual differences, pathological conditions, and taphonomic changes that are often absent in replicas (Goodison and Aris 2023). This hands-on experience fosters a deeper understanding of human biology and evolutionary processes. For participants in the Programa Interuniversitario de la Experiencia, who often come from diverse educational backgrounds and may include individuals with disabilities, interacting with real human remains provides a tangible connection to the subject matter. This multisensory engagement supports inclusive education by accommodating various learning styles and needs. Moreover, the ethical use of human remains in educational settings encourages critical discussions about cultural sensitivity, legal considerations, and the respectful treatment of human materials. These conversations are integral to developing a comprehensive understanding of the field and preparing students for real-world applications of their knowledge.

The problem with recognizing senescence in the archaeological skeletal record

Estimating age from adult skeletal remains in archaeological contexts presents significant challenges, particularly when identifying individuals over 50 years old. While age estimation in children is relatively accurate due to predictable growth patterns, adult age estimation is complicated by individual variability in skeletal aging processes. This disparity is well documented in the literature, with various studies highlighting the limitations of current methods (Bocquet-Appel and Masset 1982, 1985; Hoppa and Vaupel 2002; Konigsberg and Frankenberg 1992). For adults, age estimation relies on various skeletal changes, including bone degeneration, dental wear, cementum and secondary dentin deposition, and bone remodeling. These processes are heavily influenced by multiple factors, such as genetics, environment, sex, and population-specific traits (Işcan et al. 1987; Oettlé and Steyn 2000; Djurić et al. 2007; Hoppa 2000; Kimmerle et al. 2008; Schmitt and Murail 2004; Rissech and Steadman 2011; Buk et al. 2012; Hens and Belcastro 2012; Harper and Crews 2000; Schmeling et al. 2000; Bedford et al. 1993; Falys and Prangle 2015; Bullock et al. 2013; Merritt 2013; Nikita 2013). Additionally, variables like body mass index (BMI) and height can affect age estimation in adults (Merritt 2013; Wescott and Drew 2015). Moreover, with advancing age, skeletal changes are no longer strictly biological or chronologically linear, but are shaped by an array of extrinsic factors—such as nutrition, health status, physical activity, and occupational stress—that vary widely between individuals and

populations. As a result, the same chronological age can correspond to very different biological profiles. This is especially evident in markers like dental wear and vertebral degeneration, which are commonly used markers for age estimation but are highly sensitive to diet, oral hygiene, workload, posture, and other lifestyle factors.

A key concept in adult age estimation is the "Trajectory Effect", where skeletal indicators become increasingly variable with age. This phenomenon results in a wider margin of error for adult age estimates compared to those for non-adults (Nawrocki 2010). Similar difficulties are observed in clinical and forensic contexts, where age estimation in living adults also becomes less reliable with advancing age due to the same complex interplay of biological and environmental influences. This characteristic explains why the margin of error in age estimation is smaller for non-adult individuals than for adults. Despite ongoing efforts to refine age estimation methods, biological anthropologists must remain aware of these limitations when interpreting population dynamics of past societies. In age estimation methods for adult individuals, precision and repeatability tend to fail, as the proposed age range is sometimes too narrow, too broad, or an open-ended category (e.g., 50+). Additionally, the reference samples used to develop these methods are almost entirely from the United States (San Millán et al. 2013).

This underrepresentation of older adults has implications for understanding past populations, particularly concerning aspects like reproductive lifespan and senescence (Muñoz-Guarinos 2024). For instance, the scarcity of individuals identified as over 50 years old hinders our ability to study menopause and fertility patterns in ancient societies.

To address these challenges, researchers are exploring new methods, including the use of Bayesian statistics and a broader range of skeletal indicators to improve age estimation accuracy for adults (Boldsen et al. 2022). These advancements aim to provide a more comprehensive understanding of age structures in past populations, which is essential for studies in educational gerontology and related fields.

Aims and objectives

The primary aim of this study is to explore how older adult learners can acquire a better understanding of age estimation methods in bioarchaeology and apply this knowledge to interpret the composition and life courses of past populations. Rather than framing the activity around the representation of old individuals in the archaeological record, we focus on how educational interventions can foster student engagement with key concepts such as skeletal aging, degenerative processes, and the challenges inherent to adult age estimation.

To this end, we designed a theoretical-practical workshop for students enrolled in the Programa Interuniversitario de la Experiencia, specifically those students following the Geography, History, and Art tracks, using original osteological material to provide

a more effective, hands-on learning experience. Skeletal material was preferred over digital or casted replicas due to their superior capacity to convey age-related morphological changes (Goodison and Aris 2023). We hypothesize that this direct engagement enhances conceptual understanding of the biological markers of aging, the limitations of existing estimation techniques, and the implications these challenges have for interpreting archaeological populations. Furthermore, we aim to evaluate how older adults perceive and respond to the experience of interacting with human remains that are of a similar age to themselves and exhibit pathologies that they might personally encounter.

The workshop had three educational objectives:

a. Develop practical skills in identifying older adults through comparative visual analysis of dental wear and age-related changes in the hip bone, with particular emphasis on the auricular surface of the ilium and the pubic symphysis.
b. Foster critical reflection on the limitations of current age estimation methods for older adults and the resulting impact on interpreting demographic profiles of past populations.
c. Promote understanding of how practical and participatory educational approaches can enhance knowledge acquisition in bioarchaeology, especially in adult learning contexts.

Materials and methods

The skeletal material

The use of real human skeletal remains in this educational workshop was carefully considered. While we acknowledge the value of using plastic models and 3D-printed replicas for certain educational contexts, the pedagogical objectives of this workshop—namely, to engage older adult learners in the complexity of biological ageing, individual variation, and diagnostic uncertainty—required direct interaction with original skeletal material. Authentic remains allowed participants to appreciate natural anatomical variation, postmortem alterations, and the morphological subtleties that are often missing from replicas or idealized casts. This hands-on exposure was essential to illustrate why age estimation in adults is inherently imprecise and must be approached critically. The study followed the internal ethics policy of the University of Burgos and adhered to international recommendations regarding the respectful and educational use of human remains in academic settings (BABAO 2019a).

To conduct the workshop, we selected skeletal materials from the San José Cemetery, curated at the Laboratory of Human Evolution at the University of Burgos. This collection of human remains is commonly used for teaching and research purposes and is composed of an ossuary from the early 20th century from the city of Burgos. Participants were fully informed in advance that human skeletal remains would be

shown during the workshop, both in physical form and in digital presentation slides. Informed consent was obtained prior to participation.

For the age-at-death estimation section of the workshop, we selected 30 coxal bones (15 right and 15 left) and 20 mandibles belonging to different individuals. Both males and female skeletal remains were selected. For the paleopathology identification section, we selected 20 vertebrae without signs of pathology (10) and with different pathologies associated with age, such as osteoarthrosis (4), spondylitis (3) and Schmorl's nodes (3). In addition, some of the mandibles we selected had caries, periapical lesions, antemortem tooth loss, and alveolar bone resorption. The pathological conditions observed in the mandibles were not severe enough to hinder the students' ability to apply the dental wear aging methods.

The workshop

The workshop was taught by three biological anthropologists, lasted two hours, and was divided into three parts. The first part (40 minutes) consisted of an introduction to age-estimation methods in adults and non-adults using dental and skeletal features (AlQahtani et al. 2010; Brooks and Suchey 1990; Buckberry and Chamberlain 2002; Demirjian et al. 1973; Lovejoy et al. 1985; Lovejoy 1985; Miles 1963; Moorrees et al. 1963; Scheuer and Black 2000; Todd 1920), as well as an introduction to pathologies affecting vertebrae and teeth. During the introductory session, we facilitated an open discussion about the ethical and legal aspects of working with human remains, emphasizing respectful handling, cultural sensitivity, and the responsibilities of researchers and educators. In this context, we also introduced the complexity of age estimation in adults and the scarcity of individuals over the age of 50 in archaeological samples. This issue was presented as particularly relevant for interpreting age groups such as their own and for understanding major biological milestones, such as menopause.

Two regions of the pelvis that are relatively good indicators of skeletal age were emphasized: the auricular surface of the ilium and the pubic symphysis (Buckberry and Chamberlain 2002; Brooks and Suchey 1990). In the case of the mandibles, we highlighted alveolar bone loss and dental wear. Regarding the vertebrae, our focus was on distinguishing between specimens with and without signs of pathology. When pathologies were present, we aimed to differentiate between at least three conditions: Schmorl's nodes, spondylitis, and osteoarthrosis. Schmorl’s nodes are vertical herniations of the intervertebral disc into the vertebral body, typically through the endplate (Mann and Hunt 2005). They often appear as small, round depressions on the superior or inferior surfaces of vertebral bodies. Spondylitis refers to inflammation of the vertebrae, which can result from infectious, autoimmune, or degenerative processes (Waldron 2019). In bioarchaeological contexts, it is often used to describe vertebral lesions suggestive of conditions like tuberculous spondylitis (Pott’s disease),

which leads to vertebral body collapse and kyphosis. Osteoarthrosis is a joint disease characterized by cartilage breakdown, subchondral bone remodeling, and the formation of osteophytes (bone spurs) (Waldron 2019). In the spine, it typically affects the vertebral facet joints and can lead to reduced joint space, eburnation, and hyperostosis. Although the frequency of these bony alterations increases with age, they are not necessarily age markers, but rather must be interpreted in light of individual lifestyle and activity patterns.

In the second part (1 hour), students were able to hold the original material and compare young and old individuals, as well as bones with and without signs of pathology. Students were divided into three groups to facilitate class management, ensuring that each group received the same number of bones from the original material. Each biological anthropologist was assigned to one group. During this portion of the workshop, students were encouraged to consider and discuss the potential life circumstances and environmental factors that could have contributed to the observed conditions in the skeletal remains. This approach aimed to foster critical thinking about the relationship between bone pathology and an individual's lived experiences, including aspects such as diet, occupation, lifestyle, and overall health status.

The third part of the workshop (20 minutes) involved having each student complete an anonymous and voluntary survey, which was approved by the Ethics Committee of the University of Burgos. The survey administered at the end of the workshop was structured in three distinct parts, each designed to capture specific information from the participants. The initial section focused on gathering demographic data about the class composition (Table 1). This included basic information such as sex, age, and level of education, as well as any visual or hearing difficulties the participants might have. Additionally, it assessed their prior knowledge of human anatomy. Participants with no prior knowledge had never studied or interacted with anatomical or osteological material before the workshop. Those with basic knowledge were generally familiar with the human skeleton, able to identify major bones, and had a general sense of bodily structure, often acquired through introductory lectures, museum visits, or personal interest, but without formal instruction. Intermediate knowledge referred to a more developed understanding of osteology, including the ability to identify specific skeletal elements and features and distinguish between adult and non-adult bones. Finally, participants with advanced knowledge had received formal education in disciplines such as medicine, biology, archaeology, or forensic anthropology and were able to apply age estimation methods and identify pathological changes with a high level of confidence and accuracy.

Table 1. Part 1 of the survey (demographic data).

Basic data	Possible answers
Sex	Female
	Male
	I prefer not to answer
Educational level	Primary school
	High School
	Professional training
	University
	PhD
Age	60-70 years
	70-80 years
	80-90 years
Previous knowledge about human anatomy	None
	Basic
	Intermediate
	Advanced
Can we use this data for educational research?	Yes
	No

The second section of the survey consisted of a brief test (Table 2). This was designed to evaluate the overall effectiveness of the workshop, providing a quantitative measure of the knowledge gained and the impact of the teaching methods employed. To more accurately assess the educational efficacy of the workshop, the same test was also administered two days before the workshop. This strategy allowed us to compare participants' prior knowledge with their post-workshop understanding.

Table 2. Part 2 of the survey (final test). The right answer is indicated in bold.

		Pre-test		Post-test	
Question	**Possible answers**	**Correct answers**	**Incorrect answers**	**Correct answers**	**Incorrect answers**
Which individual is younger? (According to dental remains)	Individual 1	73.46% (36/49)	26.53% (13/49)	81.63% (40/49)	18.36% (9/49)
	Individual 2				
	Individual 3				
Which individual is older? (According to the coxal bone)	Individual 1	44.89% (22/49)	55.10% (27/49)	75.51% (37/49)	24.48% (12/49)
	Individual 2				
	Individual 3				
Which pathology is present in this vertebra?	Osteoarthrosis	42.86% (21/49)	57.14% (28/49)	68.57% (34/49)	30.61% (15/49)
	Schmörl nodules				
	Spondylitis				
	None				

		Pre-test		Post-test	
Question	**Possible answers**	**Correct answers**	**Incorrect answers**	**Correct answers**	**Incorrect answers**
Why would you say this individual is young?	They don't have much caries	65.31% (32/49)	34.69% (17/49)	81.63% (40/49)	18.36% (9/49)
	They have all the teeth				
	Their teeth are not very worn down				
	They have deciduous and permanent dentition				

The third part of the survey delved into the participants' opinions on various aspects of the workshop (Table 3). Specifically, it asked about the usefulness of the original skeletal material in understanding age estimation techniques for adults using dental or skeletal remains. It also sought feedback on how well the workshop explained the vertebral and dental pathologies present in themselves. Finally, we asked whether the workshop helped participants see themselves represented in the archaeological record. The survey was entirely voluntary with the consent of the participants and the Programa Interuniversitario de la Experiencia.

Table 3. Part 3 of the survey (opinions on usefulness of the workshop).

Question	Possible answers
Have you had difficulties understanding the explanations provided in class?	Yes
	No
If you answered yes to the previous question, what do you consider to be the main causes of your difficulty?	Complexity of the subject
	Speed of the explanation
	Lack of clear examples
	Other
Do you have any type of visual or auditory difficulty?	Yes
	No
How do you assess the use of archaeological material in teaching?	Unnecessary
	Useful
	Vital
Do you think you have learned a bit more about anatomy?	Yes
	No
Has this workshop helped you see yourself represented in human history?	Yes
	No
Has this workshop helped you to understand the scarcity of old adults in archaeological contexts?	Yes
	No
Have you observed any pathologies that you yourself suffer from?	Yes
	No
If you answered yes to the previous question, has this workshop helped you better understand your condition?	Yes
	No

Statistical analyses

To tests our hypothesis, we analysed the data from the surveys using two different approaches. To evaluate the educational effectiveness of the workshop, we compared the participants' answers to the same test administered two days before and immediately after the workshop using McNemar's test. This statistical test is appropriate for paired nominal data and assesses whether the marginal frequencies of two related samples are equal. To evaluate participants' self-perceived learning and satisfaction we used $\chi 2$ test. All statistical analyses were carried out in Rstudio version R 4.1.2 (R Core Team 2021). Differences were considered significant at a p-value < 0.05.

Results

Demographic data

The survey collected data from 49 participants, providing insights into their demographic characteristics and knowledge base. Importantly, all 49 participants (100%) consented to their data being used for educational research purposes and completed the survey. Most participants were female, accounting for 59.18% (29 out of 49), while males represented 38.77% (19 out of 49). One participant (2.04%) preferred not to disclose their sex. Regarding educational background, the largest group consisted of those with professional training at 42.85% (21 participants), followed closely by those with a high school education at 36.73% (18 participants). University graduates made up 16.32% (8 participants), and a small fraction (4.08% or 2 participants) completed primary school. Notably, there were no PhD holders among the respondents. The age distribution of the participants was primarily concentrated in the 60-70 years range, comprising 59.18% (29 participants). The 70-80 years age group followed with 38.77% (19 participants), while only one participant (2.04%) fell into the 80-90 years category. When asked about their prior knowledge of human anatomy, the majority (59.18% or 29 participants) reported having no previous knowledge. 32.65% (16 participants) claimed basic knowledge, and 8.16% (4 participants) reported intermediate knowledge. None of the participants considered themselves to have advanced knowledge in this area.

Workshop's educational impact

The second part of the survey included a final test with four questions related to age estimation and pathological identification based on skeletal remains. For the first question, which asked to identify the youngest individual based on dental remains, the results of the test carried out two days prior to the workshop showed that 73.46% (36 participants) correctly identified Individual 3 as the youngest (Figure 1). Following the workshop, this number increased to 81.63% (40 participants). The McNemar's test revealed no statistically significant improvement in performance after the workshop ($p > 0.05$).

Figure 1. Mandibles used on the first question of part two of the survey for identifying the youngest individual based on dental remains.

The second question required participants to identify the oldest individual based on the coxal bone. After the workshop, a 31% increase in correct responses was observed compared to two days before. Initially, 44.89% of participants correctly identified Individual 3 as the oldest, which increased to 75.51% (37 participants) after the workshop (Figure 2). In this case, the McNemar's test revealed a statistically significant difference between the results obtained two days prior to the workshop and those collected immediately after ($p < 0.05$).

Figure 2. Coxal bones used on the second question of part two of the survey for identifying the oldest individual based on pubic and auricular surface degenerative changes.

In the third question, participants were asked to identify a specific pathology present in a vertebra (Figure 3). In this case, the responses were more varied. Two days before the workshop, 42.86% (21 participants) correctly identified osteoarthrosis, while 32.65% (16 participants) chose Schmorl's nodules, 20.41% (10 participants) selected Spondylitis, and 4.08% (2 participants) believed there was no pathology present. Following the workshop, the percentage of participants correctly identifying osteoarthrosis increased significantly to 68.57% (34 participants). The proportion of participants who chose Schmorl's nodules, Spondylitis, and no pathology decreased to 18.37% (9 participants), 8.16% (4 participants), and 4.08% (2 participants), respectively. The McNemar test was applied to paired responses before and after the workshop, revealing a significant improvement in correct identifications ($p < 0.05$), indicating that the workshop had a statistically significant positive effect on participants' ability to recognize osteoarthrosis.

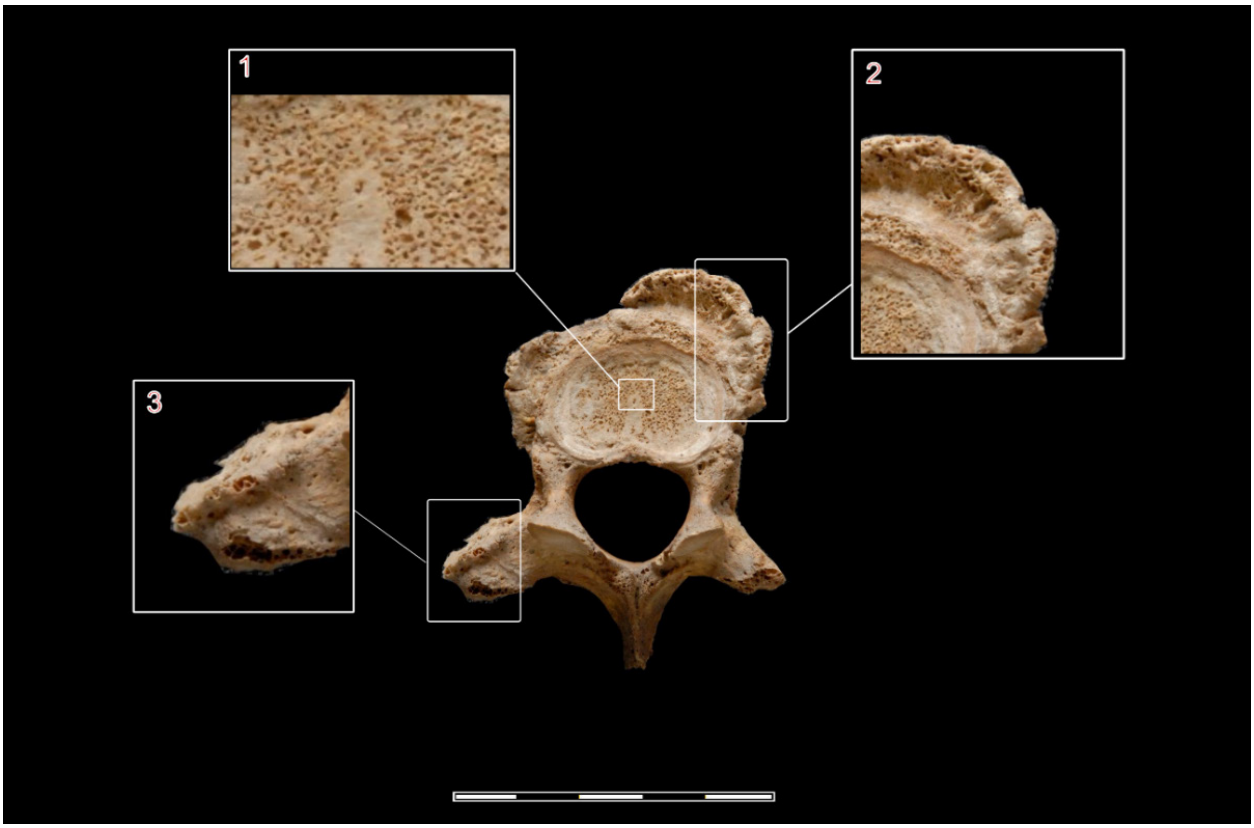

Figure 3. Vertebra with osteoarthrosis used on the third question of the second part of the survey. 1 – porosity; 2 – osteophytes; 3 – eburnation.

The final question asked why a particular individual would be considered young. Two days before the workshop, 65.31% (32 participants) correctly answered that the individual was considered young because their teeth were not very worn down (Figure 4). Meanwhile, 12.24% (6 participants) thought it was due to a lack of caries, 10.20% (5 participants) believed it was because of the presence of both deciduous and permanent

dentition, and 12.24% (6 participants) chose the option that the individual had all their teeth. Following the workshop, the percentage of correct responses increased significantly to 81.63% (40 participants), with decreases in the other options: 8.16% (4 participants) for lack of caries, 6.12% (3 participants) for presence of both dentitions, and 4.08% (2 participants) for having all their teeth. The McNemar's test applied to paired responses revealed a significant improvement in correct identifications ($p < 0.05$).

Figure 4. Mandible used on the final question of the second part of the survey.

Participants' self-perceived learning and satisfaction

The third part of the survey gathered participants' opinions on the usefulness of the workshop, focusing on their understanding, personal experiences, and learning outcomes. When asked if they had difficulty understanding the explanations provided in class, 77.55% (38 participants) reported no difficulties, while 22.44% (11 participants) said they did encounter challenges. Among those who experienced difficulties, the majority (81.81%, or 9 out of 11) attributed it to the complexity of the subject. A smaller percentage (18.18%, or 2 out of 11) cited the speed of the explanation as a factor, while no participants identified a lack of clear examples or other reasons as causes for their difficulties. Regarding visual or auditory difficulties, 46.93% (23 participants) stated they had such challenges, while 53.06% (26 participants) reported no issues. Participants were also asked to assess the use of original skeletal materials in teaching. Nearly half

(46.93%, or 23 participants) considered it vital, while 42.85% (21 participants) found it useful. A minority (10.20%, or 5 participants) deemed it unnecessary. The vast majority of participants (93.87%, or 46 out of 49) believed they had learned more about anatomy through the workshop, while only 6.12% (3 participants) disagreed. When asked if the workshop helped them see themselves represented in human history, an overwhelming 95.91% (47 participants) responded affirmatively, with only 4.08% (2 participants) answering negatively. A large proportion of participants (91.83%, or 45 out of 49) agreed that the workshop helped them understand the scarcity of old adults in archaeological contexts, while 8.16% (4 participants) did not feel this way. More than half of the respondents (53.06%, or 26 participants) observed pathologies during the workshop that they themselves suffered from, while 46.93% (23 participants) did not make such observations. Among those who identified with certain pathologies, 92.30% (24 out of 26) said that the workshop helped them better understand their condition, whereas 7.69% (2 out of 26) felt it did not.

When the variables of usefulness of the original skeletal material and the usefulness of the workshop to understand the scarcity of old adults in archaeological contexts were compared, a statistically significant difference was obtained ($p < 0.05$). While participants who found the workshop useful also appreciated the original material, those who did not found both resources to be of limited use. However, one person considered the workshop to be useful but not the original material. When comparing the variables of usefulness of the original material and the workshop's effectiveness in helping the audience understand their pathologies, we also found a significant relationship ($p < 0.05$). All individuals who reported that the workshop helped them better understand their pathologies also found the original material vital for teaching.

Discussion and conclusions

The demographic profile of participants in this study—predominantly women in their 60s and 70s with professional backgrounds but limited prior anatomical knowledge—reflects broader European trends in lifelong learning and educational attainment. The overrepresentation of women in Universities of the Third Age aligns with well-documented patterns across Europe (Cybulski et al. 2020; Gierszewski and Kluzowicz 2021). As of 2023, tertiary educational attainment among Spanish women aged 25–34 (48.8%) surpasses that of men (37.6%), mirroring trends throughout the EU (Eurostat, 2024). Many of these women, previously restricted by societal or economic barriers, are now actively engaging in adult education (Claeys-Kulik et al. 2019). This demographic context underscores the importance of designing educational experiences that consider gender dynamics and lifelong learning trajectories. However, it is crucial to acknowledge that not all older adults are equally represented in such programs; factors like self-confidence, health, motivation, and awareness continue to influence participation (Villar et al. 2010).

From an instructional design perspective, the results demonstrate the considerable pedagogical benefits of incorporating hands-on, original skeletal material into bioarchaeology and age-estimation learning experiences. The workshop, tailored to the Programa Interuniversitario de la Experiencia participants, highlights the efficacy of experiential learning strategies for older adults, particularly those with limited prior subject knowledge. This aligns with adult learning theories emphasizing active engagement, multisensory input, and practical relevance as central to meaningful knowledge acquisition (Knowles 1980; Merriam and Bierema 2013).

The statistically significant improvement in post-workshop assessments—especially in identifying the oldest individual from skeletal remains and recognizing vertebral pathology—illustrates how interactive, applied learning formats can deepen comprehension beyond traditional lecture-based methods. The increase in correct responses regarding youthfulness based on anatomical markers further suggests the capacity of older learners to integrate complex biological and archaeological concepts when engaged in participatory, context-rich environments. Interestingly, the only area without significant improvement was the question related to identifying the youngest individual through dental analysis. This may be attributed to participants' prior intuitive knowledge or experience distinguishing dental characteristics, possibly stemming from their own familial roles. Many older adults are familiar with differentiating deciduous from permanent teeth due to their experiences with children or grandchildren, providing a baseline competence in this domain. This suggests that leveraging learners' existing life experiences and tacit knowledge can be an effective strategy to scaffold new learning.

More broadly, this workshop aligns with a growing body of research that highlights the pedagogical value of practical, object-based learning in archaeology, anthropology, and paleontology. Previous studies have demonstrated the effectiveness of conducting workshops using original skeletal materials, 3D replicas, and virtual models to foster engagement and accessibility among diverse audiences, including school students, visually impaired learners, and adult participants in outreach programs (Anđić et al. 2024; Díaz-Navarro and Sánchez de la Parra-Pérez 2023; Evelyn-Wright et al. 2020; Brumpt et al. 2023). These approaches not only promote conceptual understanding, but also improve retention, motivation, and inclusivity. In this sense, our findings contribute to the broader, interdisciplinary discourse on experiential learning and support calls for the integration of tactile, visual, and applied strategies in teaching bioarchaeological concepts to non-specialist audiences (Ward et al. 2023; Fernández-Laso et al. 2023; DeSilva 2004).

The principles of andragogy, the theory and practice of adult learning, further supports these findings. Andragogy emphasizes self-directed learning, the value of drawing on learners' prior experiences, and the importance of content relevance to adult learners' personal and professional lives (Knowles 1980). Our workshop's success in linking bioarchaeological content to participants' own histories and lived experiences

exemplifies these core principles, facilitating motivation and deeper learning. This adult-centered approach helps bridge the gap between new knowledge and existing cognitive frameworks, fostering more meaningful and sustained educational outcomes.

Furthermore, the overwhelmingly positive self-reported outcomes and high satisfaction levels point to the critical role of motivation and personal relevance in adult education. The workshop's success in helping participants see themselves reflected in human history, and in recognizing similarities between observed pathologies and their own conditions, emphasizes the importance of connecting content to learners' lived experiences. Such contextualization fosters engagement and supports transformative learning processes (Mezirow 1991). Nonetheless, 22.44% of the participants noted some difficulties, mainly related to the complexity of the subject. To address this, we recognize the need to adapt certain aspects of the workshop to better support diverse learning needs, particularly those of older adult learners. Given the two-hour duration of the session, the amount and density of information may have been challenging for some participants. Future iterations may benefit from a more scaffolded structure, where foundational concepts are introduced gradually before progressing to more advanced material. In line with principles of adult education, strategies such as relating content to personal experience, encouraging active participation, and allowing time for reflection can support deeper understanding. Offering optional pre-session reading materials or short preparatory videos may also help participants engage with the content at their own pace. These approaches aim to enhance accessibility and inclusivity without compromising the academic rigor of the program.

The use of original human remains was integral to the success of the workshop, as tangible, authentic materials provide concrete, multisensory learning stimuli that make abstract or complex concepts more accessible. For older adult learners, who benefit from practical applications and real-world connections, this approach enhances inclusivity by accommodating diverse learning styles and cognitive needs (Brookfield 1986). This reinforces the pedagogical value of authentic artifacts in adult education programs. We also believe that this component was crucial in enhancing students' understanding of the very pathologies they experience themselves, particularly spinal conditions, which were the primary focus of the workshop. This is especially significant as it provides students with direct exposure to their own ailments—an opportunity they might not otherwise have. In summary, incorporating original human skeletal materials into the curriculum of the Programa Interuniversitario de la Experiencia significantly enriched the learning experience, providing students with authentic insights into biological anthropology.

Nonetheless, this study has some limitations that should be acknowledged. First, the relatively small sample size limits the generalizability of the findings and may not capture the full range of perspectives among older adult learners. Future iterations of the workshop would benefit from a larger and more diverse participant pool, both

in terms of demographic background and prior exposure to anatomy or archaeology. Second, while the structure of the workshop was designed to balance individual and group activities, the potential influence of peer discussion or group dynamics on individual responses cannot be ruled out. Finally, the short duration of the intervention provides only a snapshot of its impact, and longitudinal studies are needed to assess long-term retention and engagement.

Following the positive reception of this pilot workshop, we intend to continue developing engagement activities that connect bioarchaeological research with older adult learners. Future iterations will explore new skeletal topics, such as mobility or dietary reconstruction, and may include longer or multi-session formats to deepen learning and foster continued participation. We also aim to evaluate the long-term educational impact of these interventions and to collaborate with other institutions interested in integrating archaeological science into lifelong learning programs.

In conclusion, this workshop exemplifies a highly effective instructional approach for lifelong learning initiatives aimed at older adults. By combining theoretical foundations with hands-on interaction and critical reflection on biological aging and archaeological interpretation, the program addresses the unique preferences and capacities of older learners. Such strategies promote active aging, personal growth, and social inclusion through meaningful, participatory educational experiences. Future programs should continue to prioritize original skeletal materials and experiential methods to maximize engagement and learning outcomes within this demographic.

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Contribution statement

Julia Muñoz-Guarinos: Conceptualization (lead); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal).

Alba Navarro-Pérez: Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal).

José Miguel Carretero: Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal); funding acquisition (equal).

Rebeca García-González: Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal); funding acquisition (equal).

Ethics committee approval

This work has been granted ethical approval by the University of Burgos.

Participant consent

Written and informed consent was obtained from all focus group participants for publication of anonymous reports on their data.

Data availability assessment

The raw data that support the findings of this study are available upon request to the authors.

References Cited

AlQahtani, S. J., M.P. Hector, and H.M. Liversidge
2010 Brief Communication: The London Atlas of Human Tooth Development and Eruption. *American Journal of Physical Anthropology* 142(3):481-490.

Anđić, B., Z. Lavicza, E. Ulbrich, S. Cvjetićanin, F. Petrović, F., and M. Maričić
2024 Contribution of 3D modelling and printing to learning in primary schools: a case study with visually impaired students from an inclusive Biology classroom. *Journal of Biological Education* 58(4):795-811.

Bedford, M. E., K.F. Russell, C.O. Lovejoy, R.S. Meindl, S.W. Simpson, and P.L. Stuart-Macadam
1993 Test of the multifactorial aging method using skeletons with known ages-at-death from the grant collection. *American Journal of Physical Anthropology* 91(3):287-297.

Bocquet-Appel, J. P., and C. Masset
1982 Farewell to Paleodemography. *Journal of Human Evolution* 11(4):321-333.

Bocquet-Appel, J. P., and C. Masset
1985 Matters of Moment. *Journal of Human Evolution* 14(2):107-111.

Boldsen, J. L., G.R. Milner, and S.D. Ousley
2022 Paleodemography: From Archaeology and Skeletal Age Estimation to Life in the Past. *American Journal of Biological Anthropology* 178:115-150.

British Association of Biological Anthropology and Osteoarchaeology (BABAO)
2019a Codes of Ethics and Practice. Retrieved from https://babao.org.uk/wp-content/uploads/2024/01/BABAO-Code-of-Ethics.pdf

British Association of Biological Anthropology and Osteoarchaeology (BABAO)
2019b BABAO Recommendations on the Ethical Issues Surrounding 2D and 3D Digital Imaging of Human Remains. Retrieved from https://babao.org.uk/wp-content/uploads/2023/08/BABAO-Digital-imaging-code-2019.pdf

Brookfield, S. D.
1986 *Understanding and Facilitating Adult Learning*. Open University Press, Glasgow.

Brooks, S., and J. M. Suchey
1990 Skeletal age determination based on the os pubis: a comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. *Human Evolution* 5:227-238.

Brumpt, E., E. Bertin, L. Tatu, and A. Louvrier
2023 3D printing as a pedagogical tool for teaching normal human anatomy: a systematic review. *BMC Medical Education* 23(1):783.

Buckberry, J. L., and A. T. Chamberlain
2002 Age estimation from the auricular surface of the ilium: a revised method. *American Journal of Physical Anthropology* 119(3):231-239.

Buk, Z., P. Kordik, J. Bruzek, A. Schmitt, and M. Snorek
2012 The age at death assessment in a multi-ethnic sample of pelvic bones using nature-inspired data mining methods. *Forensic Science International* 220(1-3):294.e1-9.

Bullock, M., L. Márquez, P. Hernández, and F. Ruíz
2013 Paleodemographic age-at-death distributions of two Mexican skeletal collections: A comparison of transition analysis and traditional aging methods. *American Journal of Physical Anthropology* 152(1):67-78.

Casanova, G., J. Weil, and M. Cerqueira
2024 The Evolution of Universities of the Third Age around the World: A Historical Review. *Gerontology & Geriatrics Education* 45(3):483-498.

Cassman, V., N. Odegaard, J. Powell (eds.)
2006 *Human Remains: Guide for Museums and Academic Institutions*. AltaMira Press.

Claeys-Kulik, A., T.E. Jørgensen, and H. Stöber
2019 Diversity, Equity and Inclusion in European Higher Education Institutions Results from the INVITED Project. European University Association, Brussels. Retrieved from https://www.eua.eu/publications/reports/diversity-equity-and-inclusion-in-european-higher-education-institutions-results-from-the-invited-project.html

Cybulski, Mateusz, Łukasz Cybulski, Urszula Cwalina, Krystyna Kowalczuk, and Elżbieta Krajewska-Kułak
2020 Mental Health of the Participants of the Third Age University Program: A Cross-Sectional Study. *Frontiers in Psychiatry* 11(656):1-13. https://doi.org/10.3389/fpsyt.2020.00656.

Demirjian, A., H. Goldstein, and J.M. Tanner
1973 A New System of Dental Age Assessment. *Human Biology* 45(2):211-227.

DeSilva, J.
2004 Interpreting Evidence: An Approach to Teaching Human Evolution in the Classroom. *The American Biology Teacher* 66(4):257-267.

Diaz-Navarro, S., and S. Sanchez De La Parra-Perez
2023 Human Evolution in Your Hands. Inclusive Education with 3D-printed Typhlological Replicas. *Journal of Biological Education* 57(2):295-307.

Djurić, M., Djonić, D., Nikolić, S., Popović, D., & Marinković, J.
2007 Evaluation of the Suchey–Brooks method for aging skeletons in the Balkans. Journal of Forensic Sciences, 52(1), 21-23.

Eurostat
2024 Adult Education Survey. European Commission. Retrieved from https://ec.europa.eu/eurostat/web/microdata/adult-education-survey

Evelyn-Wright, S., A. Dickinson, and S. Zakrzewski
2020 Getting to grips with 3D printed bones: Using 3D models as ‘diagrams’ to improve accessibility of palaeopathological data. *Papers from the Institute of Archaeology* 29(1):1-10.

Falys, C. G., & Prangle, D. (
2015 Estimating age of mature adults from the degeneration of the sternal end of the clavicle. American Journal of Physical Anthropology, 156(2), 203-214.

Fernández-Laso, M. C., A. Amores, and J. Viciano
2023 Problems-based Learning for Teaching Forensic Anthropology in High School. *Alteridad* 18(2):191-202.

Gierszewski, D., and J. Kluzowicz
2021 The role of the University of the Third Age in meeting the needs of older adult learners in Poland. *Gerontology & Geriatrics Education* 42(3):437–451. https://doi.org/10.1080/02701960.2021.1871904

Giesen, M.
2013 *Curating Human Remains: Caring for the Dead in the UK*. Boydell Press, Woodbridge.

Goodison, G. A., and C. Aris
2023 Analysis of the use of human remains as teaching materials in higher education: examining differing opinions between population subgroups. *European Journal of Anatomy* 27(4):503-516.

Harper, G. J., and D.E. Crews
2000 Aging, Senescence, and Human Variation, in *Textbook of Human Biology: An Evolutionary and Biocultural Perspective*, edited by S. Stinson, B. Bogin, and D. O’Rourke, pp. 465–505. Wiley–Liss, New York.

Hens, S. M., and M.G. Belcastro
2012 Auricular surface aging: a blind test of the revised method on historic Italians from Sardinia. *Forensic Science International* 214(1-3), 209.e1-5.

Hoppa, R. D.
2000 Population variation in osteological aging criteria: an example from the pubic symphysis. *American Journal of Physical Anthropology* 111(2):185-191.

Hoppa, R. D., and J. Vaupel
2002 Paleodemography: Looking Back and Thinking Ahead, in *Paleodemography: Age Distributions from Skeletal Samples*, edited by R.D. Hoppa and J.W. Vaupel, pp. 9-28. Cambridge University Press.

Işcan, M. Y., S.R. Loth, and R.K. Wright
1987 Racial variation in the sternal extremity of the rib and its effect on age determination. *Journal of Forensic Sciences* 32(2):452-466.

Kimmerle, E. H., L.W. Konigsberg, R.L. Jantz, and J.P. Baraybar
2008 Analysis of age-at-death estimation through the use of pubic symphyseal data. *Journal of Forensic Sciences* 53(3):558-568.

Knowles, M. S.
1980 From pedagogy to andragogy. *Religious Education* 75(4):202-211.

Konigsberg, L. W., and S.R. Frankenberg
1992 Estimation of age structure in anthropological demography. *American Journal of Physical Anthropology* 89(2):235-256.

Lorentz, K.
2008 From Bodies to Bones, and Back: Theory, and Human Bioarchaeology, in *Between Biology and Culture*, edited by H. Schutkowski, pp. 273-303. Cambridge University Press.

Lovejoy, C. O.
1985 Dental wear in the Libben population: its functional pattern and role in the determination of adult skeletal age at death. *American Journal of Physical Anthropology* 68(1):47-56.

Lovejoy, C. O., R.S. Meindl, T.R. Pryzbeck, and R.P. Mensforth
1985 Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of adult skeletal age at death. *American Journal of Physical Anthropology* 68(1):15-28.

Mann, R. W., and D.R. Hunt
2005 *Photographic Regional Atlas of Bone Disease: A Guide to Pathologic and Normal Variation in the Human Skeleton*. Charles C. Thomas, Springfield, IL.

Márquez-Grant, N., and L. Fibiger (eds.)
2011 *The Routledge Handbook of Archaeological Human Remains and Legislation: An International Guide to Laws and Practice in the Excavation and Treatment of Archaeological Human Remains*. Routledge.

Merriam, S. B., and L.L. Bierema
2013 *Adult Learning: Linking Theory and Practice*. John Wiley & Sons.

Merritt, C. E.
2013 Testing the accuracy of adult skeletal age estimation methods: original methods versus revised and newer methods. *vis-à-vis: Explorations in Anthropology* 12(1):102-119.

Mezirow, J.
1991 *Transformative Dimensions of Adult Learning*. Jossey-Bass, San Francisco.

Miles, A. E. W.
1963 Dentition in the estimation of age. *Journal of Dental Research* 42(1):255-263.

Moorrees, C. F., E.A. Fanning, and E.E. Hunt Jr.
1963 Age variation of formation stages for ten permanent teeth. *Journal of Dental Research* 42(6):1490-1502.

Moshenska, G.
2017 *Key Concepts in Public Archaeology*. UCL Press.

Muñoz-Guarinos, J.
2024 Estudio comparativo del periodo de vida fértil a través del análisis de los restos esqueléticos y dentales en poblaciones actuales y su aplicación a los fósiles pleistocenos de la Sima de los Huesos (Sierra de Atapuerca, Burgos). Unpublished PhD Dissertation. Universidad de Burgos. https://riubu.ubu.es/handle/10259/10811

National Committee for Research Ethics on Human Remains (Human Remains Committee)
2022 Guidelines for Ethical Research on Human Remains, Norway. https://www.forskningsetikk.no/en/guidelines/human-remains/guidelines-for-research-ethics-on-human-remains/

Nawrocki, S. P.
2010 The nature and sources of error in the estimation of age at death from the skeleton, in *Age Estimation of the Human Skeleton*, edited by K.E. Latham and M. Finnegan, pp. 79-101. Charles C. Thomas, Springfield, IL.

Nikita, E.
2013 Quantitative assessment of the sternal rib end morphology and implications for its application in aging human remains. *Journal of Forensic Sciences* 58(2):324-329.

Oettlé, A. C., and M. Steyn
2000 Age estimation from sternal ends of ribs by phase analysis in South African Blacks. *Journal of Forensic Sciences* 45(5):1071-1079.

Passalacqua, N. V., and M.A. Pilloud
2018 *Ethics and Professionalism in Forensic Anthropology*. Academic Press.

Passalacqua, N. V., M.A. Pilloud, and G.A. Gruters
2014 Professionalism: Ethics and scholarship in forensic science. *Journal of Forensic Sciences* 59:573-575. https://doi.org/10.1111/1556-4029.12433

R Core Team
2021 R: A language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org/

Richardson, L. J., and J. Almansa-Sánchez
2015 Do You Even Know What Public Archaeology Is? Trends, Theory, Practice, Ethics. *World Archaeology* 47(2):194-211.

Rissech, C., & Steadman, D. W.
2011 The demographic, socio-economic and temporal contextualisation of the Universitat Autònoma de Barcelona collection of identified human skeletons (UAB collection). *International Journal of Osteoarchaeology*, *21*(3), 313-322

Roberts, C. A.
2013 Archaeological human remains and laboratories: Attaining acceptable standards for curating skeletal remains for teaching and research, in *Curating Human Remains Caring for the Dead in the UK*, edited by M. Giesen, pp. 123–134. Boydell Press, Woodbridge.

San Millán, M., C. Rissech, C., and D. Turbón
2013 A test of Suchey-Brooks (pubic symphysis) and Buckberry-Chamberlain (auricular surface) methods on an identified Spanish sample: paleodemographic implications. *Journal of Archaeological Science* 40(4):1743-1751.

Scheuer, L., and S. Black
2000 *Developmental Juvenile Osteology*. Academic Press, San Diego.

Schmeling, A., W. Reisinger, D. Loreck, K. Vendura, W. Markus, and G. Geserick
2000 Effects of ethnicity on skeletal maturation: consequences for forensic age estimations. *International Journal of Legal Medicine* 113(5):253-258.

Schmitt, A., and P. Murail
2004 Is the first rib a reliable indicator of age at death assessment? Test of the method developed by Kunos et al (1999). *Homo* 54(3):207-214.

Schutkowski, H. (ed.)
2008 *Between Biology and Culture*. Cambridge University Press.

Servicios Sociales de Castilla y León
2024 Programa Interuniversitario de la Experiencia de Castilla y León. Retrieved from https://serviciossociales.jcyl.es/web/es/personas-mayores/programa-interuniversitario-experiencia.html

Sofaer, J.
2006a *The Body as Material Culture. A Theoretical Osteoarcheology*. Cambridge University Press.
2006b Gender, Bioarchaeology, and Human Ontogeny, in *Social Bioarchaeology of Funerary Remains*, edited by R. Gowland, and C. Knüsel, pp. 155 – 167. Oxford: Oxbow.

Squires, K., and R. García-Mancuso
2021 Desafíos Éticos Asociados al Estudio y Tratamiento de Restos Humanos en las Ciencias Antropológicas en el Siglo XXI. *Revista Argentina de Antropología Biológica* 23:1-22. https://doi.org/10.24215/18536387e034

Squires, K., Errickson, D., and N. Márquez-Grant (eds.)
2019 *Ethical Approaches to Human Remains: A Global Challenge in Bioarcheology and Forensic Anthropology*. Springer. https://doi.org/10.1007/978-3-030-32926-6

Squires, K., C.A. Roberts, and N. Márquez-Grant
2022 Ethical considerations and publishing in human bioarcheology. *American Journal of Biological Anthropology* 177(4):615-619.

Standring, S.
2016 A Brief History of Topographical Anatomy. *Journal of Anatomy* 229(1):32-62.

Swain, H.
2007 *An Introduction to Museum Archaeology*. Cambridge University Press.

Todd, T. W.
1920 Age changes in the pubic bone. I. The male white pubis. *American Journal of Physical Anthropology* 3(3):285-334.

Velázquez, M., and C. Fernández
1999 "Autoconcepto y envejecimiento." *International Journal of Third Age Learning International Studies* 9:27-30.

Villar, F., C. Triadó, S. Pinazo, M. Celdran, and C. Solé
2010 Reasons for older adult participation in university programs in Spain. *Educational Gerontology* 36(3):244-259.

Waldron, T.
2019 Joint Disease, in *Ortner's Identification of Pathological Conditions in Human Skeletal Remains*, 3rd ed., edited by J. E. Buikstra, pp. 719–748. Academic Press.

Ward, S. M., A. C. L. Barker, R. Shoocongdej, N. Wangthongchaicharoen, J.J. Miszkiewicz, C.L. King, and S.E. Halcrow
2023 Investigating the Effectiveness of Online Bioarchaeology Education through Participant Survey of a Cohort of International Adult Learners. *Advances in Archaeological Practice* 11(4):421-433.

Wescott, D. J., and J.L. Drew
2015 Effect of obesity on the reliability of age-at-death indicators of the pelvis. *American Journal of Physical Anthropology* 156(4):595-605.