University of Warsaw
Faculty of Archaeology

Wenchi Yan
Record book number: 416482

Analysis of Commingled Skeletal Remains of the Third Silesian Uprising Participants from Ligota Dolna

Master's thesis
in the field of archaeology

The thesis was written under the supervision of
dr hab. Wiesław Więckowski
Faculty of Archeology

Warsaw, June, 2023

Summary

This dissertation is dedicated to the bioarchaeological analysis of skeletal remains from participants of the Third Silesian Uprising, excavated from a construction site in Ligota Dolna. The study of the commingled and fragmented human remains involved in this research will help to enrich the literature on physical anthropology researches in Poland and on the study of commingled assemblages of bones. To achieve the objectives of the study, we first collected relevant background information, such as historical accounts of the Third Silesian Uprising, geographical and demographical data, and historical-bioarchaeological analysis of Polish population. We also obtained from the literature an appropriate bioarchaeological methodology applicable to the analysis of the present problem. Based on the standard procedures in the field, we developed our own protocol to handle our research material and executed this process. Finally, we collected biological data from the skeletal remains, inferred osteobiographies of the possible individuals contained in the remains, and established a straightforward protocol for similar problems.

Keywords

Third Silesian Uprising, human remains, commingling, fragmentation, osteobiography, protocol

Title of the thesis in Polish language

Analiza pomieszanych szczątków szkieletowych uczestników III powstania śląskiego z Ligoty Dolnej

General scheme

This thesis consists of four parts. The first part is the introductory chapters, namely *Chapter 1 Introduction* and *Chapter 2 Material*. The second part (*Chapter 3 Methods*) introduces the methodology, methods and references used in this thesis in detail. The third part (namely *Chapter 4 Results and interpretation* and *Chapter 5 Discussion*) presents the analysis results and discusses them. The fourth part is *Chapter 6 Conclusion*, which gives the conclusion of this paper. Following the main topics of this thesis is the bibliography. Attached as a separate file is a .csv file containing all the original data for this thesis.

Chapter 1 Introduction

1.1 History review

The Third Silesian Uprising

In 1918, when Poland regained its long-desired independence after World War I, in the land of Silesia, formerly a German province before the war, the local population was divided over whether their homeland should belong to Germany or to the newborn Poland. Most of the residents who recognized themselves as Germans were the more socially established Protestants, while the Poles were mostly working class and Catholic. To the latter, some of them regarded German rule as discriminatory, and returning to *motherland* seemed to bring them new hope for equity, while some others deemed that staying in German would lead to a more promising future.

Despite the fact that the Treaty of Versailles already mandated a plebiscite in 1921 to settle the dispute, the Polish patriots, with the Polish Military Organisation (Polish: 'Polska Organizacja Wojskowa', POW) at its core, spontaneously launched two less-than-successful uprisings before the plebiscite. The Germans counteracted in the form of *Freikorps*[1]. The First Silesian Uprising was extinguished by the Germans, while the Second Silesian Uprising slowly ended after many mediations. Finally, the plebiscite carried out on 20 March 1921 gave a result not much different than centuries before. In the end, 59.6% of the voters chose Germany and 40.4%, for whatever reason, chose the nascent Poland (Tooley, 1988). Although it is true that a simple majority chose Germany, the difference between the two sides was not overwhelming. Moreover, the Poles and Germans lived in separate gatherings and absolute majorities for either side were achieved in most towns(e.g. Quo vadis Silesia, 2021). Geographically, a simple line that perfectly divides German and Polish settlements did not exist. For the Poles who made up about 40 percent of the voting population, it was unacceptable to merge their native place, not to mention the industrialized parts, to Germany. For Germans, the industrial triangle east of the Oder River, consisting of Beuthen (Bytom), Gleiwitz

[1] The German term *Freikorps* ("Free Corps") refers to any of private paramilitary groups that first emerged in December 1918, following Germany's defeat in World War I. They are composed of e x-soldiers, unemployed youth, and other discontents, and led by ex-officers and other former military personnel. The majority were nationalists and radical conservatives who were employed clandestinely but effectively to quell left-wing revolts and uprisings.

(Gliwice) and Kattowitz (Katowice), was predominantly German in composition and rightfully belongs to Germany. Separatists on the Polish side believed that the result of the plebiscite had been manipulated by the Germans and launched a general strike in almost all industrial plants after the plebiscite. On the night of May 2, 1921, the Third Silesian Uprising began.

Compared to the two previous uprisings, the Third Silesian Uprising was larger in both scale and impact (Image 1.1). Supported by the Polish state, Wojciech Korfanty became the dictator of the Uprising and planned the actions to be taken by the insurgents. The insurgent troops, totalling more than 40,000 people, were divided into operational groups, tactical groups, and rear and specialized units, each consisting of several battalions. These groups were made up of civilians from almost every corner of Upper Silesia, including Beuthen (Bytom), Gleiwitz (Gliwice), Katowice, Königshütte (Królewska Huta), Pleß (Pszczyna), Hindenburg (Zabrze), Rybnik, Ratibor (Racibórz), Loslau (Wodzisław), Sohrau (Żory), Cosel (Koźle), Lublinitz (Lubliniec), Rosenberg (Olesno), Groß Strehlitz (Strzelce Opolskie) and Tarnowitz (Tarnowskie Góry). Later on, volunteers from other parts of Poland also joined the insurrection. The majority of the insurgents were not veterans of the recently concluded world war. Prior to joining the insurgency forces, many lacked any military training. The age of insurgents was roughly 23 on average. The majority of them were single males with industrial employment (Institute of National Remembrance, 2022). They quickly had to contend with seasoned German volunteer soldiers.

The foregoing provides a historical overview of the Third Silesian Uprising. However, it is imperative to recognize that the narrative, often simplified as a conflict between Polish civilians and German veterans, does not encapsulate the complexity of the event. Silesia, with its intricate history of sovereignty, having been under the dominion of Poland, Bohemia, Austria, Prussia, and the German Empire over the past six centuries, is inherently multi-ethnic and multicultural. Consequently, the biological ancestry of the individuals involved in the uprising is likely to be highly diverse. Moreover, the uprising drew participants from a wide array of sources. While a significant number hailed from Silesia and other regions of Poland, the ranks were also bolstered by the inclusion of Cossack cavalry and prisoners of war from Ukraine,

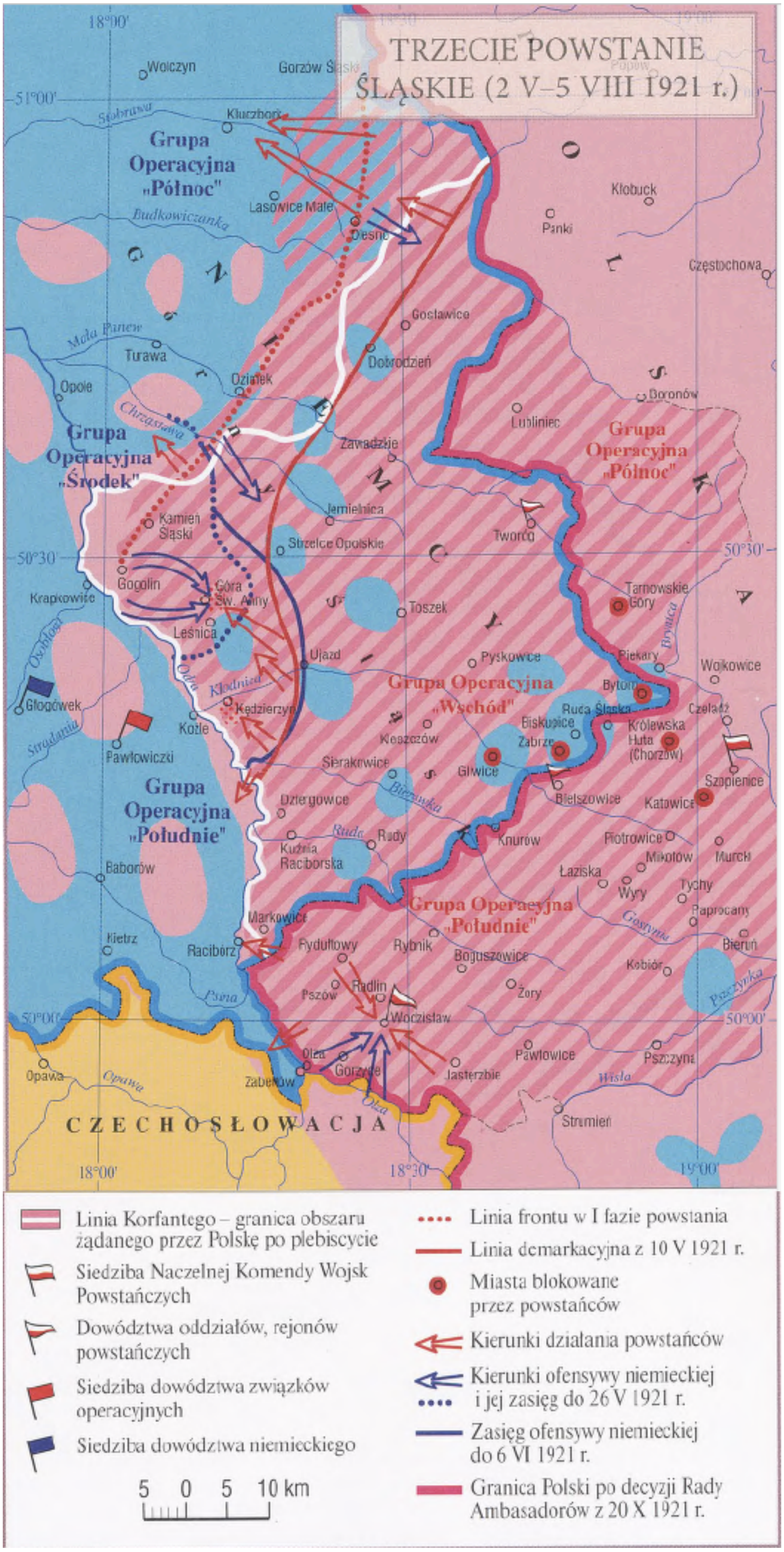

Image 1.1 Map of the extent of the Third Silesian Uprising (Demart, 2019)

Belarus, and Russia (Pałys, 2019). It is plausible to surmise that the skeletal remains of the civilians and veterans involved in the uprising would exhibit disparities in health conditions, attributable to their varied backgrounds and histories of engagement in armed conflicts.

The Battle of Annaberg

The biggest combat during the Third Silesian Uprising, known as the Battle of Annaberg (Polish: Bitwa o Górę Św. Anny), was fought on a strategic hill named Annaberg (Polish: Góra Św. Anny) close to Opole. More than a thousand fighters from the Polish side initially took possession of Annaberg on May 4, 1921. In addition to slicing through the German front line, the insurgent positions around it created a Polish defense arc that protected the Upper Silesian Industrial District. The German side spent two weeks to gather troops, recruit volunteers from Germany, and accept several paramilitary organizations such as *Freikorps Oberland* and the Self-Defense of Upper Silesia (German: *Selbstschutz Oberschlesien*), paramilitary battalions partly composed of veterans. On May 21, 1921, two groups of German of about 900 men launched a fierce attack, with the main force from Gogolin, and the other from the north through Strzelce Opolskie. Eventually, the Germans were able to breach the defenses despite the ferocious resistance of the insurgents, and capture the hill Chełm. On May 23, the Polish "Bogdan" Subgroup's units from the north assisted the Insurgent Army's 1st Division as it launched a counteroffensive. The bloodiest battle, which was also hand-to-hand, was near Leśnica, south of Chełm Hill. However, the counterattack by the insurgents was unsuccessful despite initial gains. On May 25, the Germans proposed peace negotiations, which put an end to the Annaberg fight. The Polish firing stopped on May 26. 120 persons are estimated to have perished in this conflict overall. (Citino, 2005). Less intense fighting in this area also took place in the following days. Prior to the Uprising's official end, however, violent combat raged on until early June.

After the Third Silesian Uprising, the decision about the division of Upper Silesia between Germany and Poland was finally left in the hands of the Commission of Experts of the League of Nations Council, with the assistance of the League of Nations. Germany gained the western third of the area, while Poland received the eastern two-thirds. Overall, more than two thirds of the hard coal mines, metalworks, plants, ore mines and other facilities were left on the Polish side. The taking of control of the plebiscite territory by Germany and Poland, which took place from June 17 to July 10, 1922, marked the final completion of the mandate of the Treaty of Versailles. The partition, however, saw the transfer of several of the insurgents' home regions, including Opole, Strzelce Opolskie, and Raciborz, as well as Annaberg itself, to Germany. This also means that the remains of the uprising participants are also under German jurisdiction. The land weren't transferred back from Germany to Poland once more until the end of World War II. And it took a long time—not until the German-Polish Border Treaty of 1990—for the border between Poland and Germany in the Upper Silesian region to be officially established. (The Federal Republic of Germany and the Republic of Poland, 1990). Yet in terms of national identity, there are still some different voices about it even now. For example, in the 21st century, organizations such as the Silesian Autonomy Movement (Polish: Ruch Autonomii Śląska) are still campaigning for the autonomous status of Upper Silesia. (Kastelik, 2022). Moreover, according to surveys, more than 100,000 people in the Upper Silesian region currently identify themselves as belonging to the German nation (Sojka, 2021).

The Silesian Uprisings had a positive impact on Polish modern history, despite the fact that Poland did not achieve a military triumph in them. First, it had a direct influence on Poland's development by providing it with resources and land. In this region, 90% of Poland's industrial output was concentrated. Second, the Uprisings stoked Poles' patriotic sentiment. For instance, there were existing movies about this topic already at the time, such as *Nie damy ziemi, skąd nasz ród* in 1920, *Nie zachował się do dnia dzisiejszego* in 1922, and *Taśmy Jana Skarbka-Malczewskiego: Przyłączenie Śląska do Polski* in 1922. Thirdly, the largest of the series of Polish uprisings for independence, the Third Silesian Uprising, continues to fuel the nation's nationalistic spirit and is remembered as one of the most significant of them all. Numerous memorial activities were held in honor of the Third Silesian Uprising's 100th anniversary (see e.g. Kancelaria Prezydenta, 2021). In this context, the reconstruction and reburial of the excavated remains of participants in the Silesian uprising has positive social significance.

The Battle of Annaberg itself, as the largest battle of the Silesian Uprisings, was also commemorated both by the Germans and the Poles. On top of the Annaberg hill, the Poles built a monument to the Silesian Uprisings (Polish: Pomnik Czynu Powstańczego), which honors the region's historical struggles for Polonization. An annual celebration honoring the Third Silesian Uprising takes place there in May (Policja Opolska, 2022). The study of Polish history between the Wars and the creation of the Polish nation both benefit from an understanding of the Silesian Uprisings. And when researching the Silesian Uprisings, it is impossible to overlook the Battle of Annaberg. Today, partly as a result of the autonomy movement in the Upper Silesian region, the study of these historical events has become even more interesting than ever. The biological profile of those involved in the uprising, as well as the reconstruction of the fighting, are questions that people now eager to know the answers to.

1.2 Excavation overview

On November 13 and 22, 2019, on behalf of the Institute of National Remembrance (Polish: Instytut Pamięci Narodowej, IPN), the company *Zabytki, Badania, Projekty, Realizacje Michał Grabowski* carried out an excavation in Ligota Dolna, municipality of Strzelce Opolskie. The legal basis for this work was Decision No. 231/2019 of the President of the Institute of National Remembrance, contained in letter No. BUWII-9200-90(9)19 of August 28, 2019. The work was aimed at exhuming the remains of the Silesian insurgents who died in May 1921 during the fighting in the area of Annaberg, and then burying them in the indicated cemetery.

IPN's investigation, based on historical records of the German offensive, indicates that during the German invasion on May 21, 1921, insurgents were shot and killed on part of the front line between the villages of Dąbrówka and Ligota Dolna. The location of their deaths and burials may also indicate that their attempts to escape from the woodlands near or adjacent to the German-occupied settlement of Dąbrówka failed.

The initial excavation attempt was to investigate a grave site (Image 1.2) featuring a memorial tablet on its surface. Local accounts suggested that this burial site was associated with the interment of two insurgents of the Third Silesian Uprising.

However, upon meticulous examination and analysis, the excavation ultimately proved unsuccessful. It became evident that this grave served a purely symbolic purpose, devoid of any actual human remains or relics beneath its surface.

On the memorial stone tablet accompanying the symbolic grave, the following words are inscribed (in Polish),

WIECZNA CHWAŁA BOHATEROM
POLEGŁYM W POWSTANIU ŚLĄSKIM
POD GÓRĄ ŚW. ANNY W ROKU
1921

which would be translated as

ETERNAL GLORY TO THE HEROES
FALLEN IN THE SILESIAN UPRISING
NEAR ST. ANNE MOUNTAIN
IN 1921.

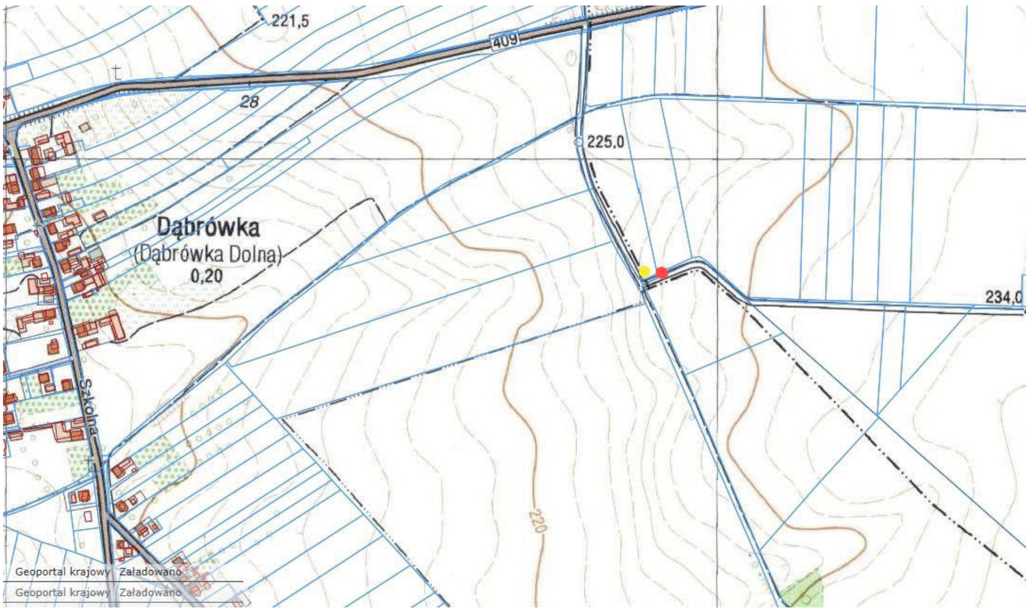

Image 1.2 Ligota Dolna, municipality Strzelce Opolskie. Location of the graves of (supposedly to be two) Silesian insurgents from 1921 (the place of the symbolic grave - the yellow point; actual burial - the red point). Scale 1: 5,000. Source: www.geoprtal.pl. Prepared by D. Sikorski.

Further investigation into local records revealed that the symbolic grave was

Image 1.3 Ligota Dolna - insurgent grave disturbed (Photo M. Rudnicki).

established in 1945, following the war, as a social commemorative act. It became apparent that the actual burial site was likely located elsewhere, possibly in close proximity. A subsequent attempt to locate the true burial site was conducted on November 22, 2019. Approximately 150 meters away from the symbolic grave, the excavation team discovered a grave pit beneath the roadbed (Image 1.2 for the location). The pit measured approximately 180×160 cm and contained the remains of approximately five individuals (Image 1.3). The cause of death could not be determined due to severe skeletal fragmentation, prompting the transfer of the remains to the Department of Bioarchaeology at the Institute of Archaeology, University of Warsaw, for detailed anthropological analysis.

The orientation of the burial debris aligned along the W-E axis. The destruction of the burial site was likely a result of the construction and subsequent use of the road, which had been built in the 1930s to connect to a German military airfield. Excavations of the grave yielded various artifacts, including buttons (including a military button, although its specific condition could not be further ascertained), a toolbox, and a fragment of a round glass (possibly from a compass). These findings suggest a connection between the remains discovered and the sought-after graves of the Silesian insurgents. However, the number of individuals found exceeded initial expectations. It is probable that this disparity arises from imprecise historical accounts regarding the exact number of individuals interred.

1.3 Geography of the site and demography

Ligota Dolna [liˈɡɔta ˈdɔlna] (German: Nieder Ellguth), the place where we obtained our research material, is located at 50° 28' 59.99" North and 18° 06' 60.00" East. It is a village in Gmina Strzelce Opolskie administrative district, in Strzelce County, Opole Voivodeship, in southwest Poland. It is around 12 kilometers west of Strzelce Opolskie and 25 kilometers south-east of Opole, the regional seat.

In the village there is a Triassic limestone quarry (Middle Triassic), closed in the 1990s, and a historic lime kiln from the 19th century (Niedźwiedzki, 2012). The predominant soil type in the area is Loess (Państwowy Instytut Geologiczny, 2004). In light of the potential impact of heavy metal elements on children's development, we examined the mineral distribution in the area. Surveys confirmed the absence of metal deposits in the entire Strzelce Opolskie region (mindat.org & Hudson Institute of Mineralogy, 2019), allowing us to exclude the issue of heavy metals from our future paleopathological research.

Approximately 100 people live in Ligota Dolna today (GUS, 2011). Interestingly, at the time of the 1921 plebiscite, a simple majority of voters in this region favoured Germany (Landsmannschaft der Oberschlesier, 2017).

1.4 Purpose and perspective of research

The excavation of the remains of participants in the Third Silesian Uprising presents a valuable opportunity to learn about the battlefield archeology of the uprising, as well as life in Poland at the turn of the 19th and 20th centuries. For such civilians who lack historical documents, it is most suitable to establish individual osteobiographies with the methods of bioarchaeology (which is "the study of bones and other biological materials found in archaeological remains in order to provide information about human life or the environment in the past”, entry: *Bioarchaeology* in Oxford Languages).

Osteobiography involves assembling all information available from the skeleton to create a life narrative for a single individual (Saul, 1972). The creation of an osteobiography necessitates the extraction of biological data from exhumed skeletal remains. This includes the identification of fragments, determination of the minimum number of individuals, estimation of sex and age at death, stature, ancestry, identity, and possible cause of death. However, unlike obtaining the characteristics of an entire group through statistical methods, establishing an individual's osteobiography focuses on the life journey of each individual, and when feasible, the individual may also be juxtaposed with others of a similar social/cultural background. It embodies a more humane concern and is able to explore deeper relationships among the data, helping us understand the lives of unnamed individuals (Hosek & Robb, 2019). Moreover, considering that we only exhumed a small number of individuals from the excavation, it is more scientific to be content with letting them represent only a portion of the Silesian insurgents, rather than directly determining the biological characteristics of the 'Silesians' through these individuals.

Due to the commingled and fragmented nature of the skeletal remains involved in this study, the purpose includes also to assemble and articulate the skeletal fragments and distinguish individuals, thus making it possible to provide a set of identifying biological data. Additionally, the study employs a laboratory protocol that, while grounded in established methods featuring highly specialized techniques, has been adapted for small-scale, commingled, and fragmented skeletal remains for efficiency in time and labor. Consequently, an ancillary aim is to evaluate the efficacy of this modified protocol.

Furthermore, given that the bones of the participants in the Silesian Uprising are slated for ceremonial reburial, the study also encompasses non-scientific undertakings, including the reconstruction of skeletons.

Undoubtedly, a comprehensive investigation of mass graves requires a large-scale, multidisciplinary, long-term project, drawing on expertise in human anatomy, stratigraphy, physiology, demography, and molecular biology. However, practical constraints, such as funding, time, and researcher capacity, asked for a focused approach. In this context, a foundational understanding of human osteology is deemed sufficient for our study for three reasons. Firstly, our primary objective is to establish the individuals' osteobiography, which does not mean complex methods. Secondly, the fragmented and commingled nature of the remains precludes the use of many quantitative methods such as skull measurements. Lastly, the well-documented and recent historical context of the graves obviates the need for speculative deductions from the bones. Given these factors, the likelihood of achieving our primary goal is high.

Beyond the aforementioned purposes, the analysis of commingled and fragmented skeletons holds potential for reconstructing burial patterns (e.g., Boz & Hager, 2013), elucidating group identity concepts (e.g., Osterholtz, 2015), examining trauma and violence (e.g., Bower, 2010), and investigating migration, marriage patterns (e.g., Baustian & Anderson, 2015; Gregoricka, 2021), as well as health and associated diseases (e.g., Baustian, 2010). Through the analysis of these remains, the study also aspires to glean insights into the social relations of the insurgents, such as the extent of community reverence.

We also aim to contextualize the osteobiographies derived from this study within the broader framework of early 20th-century Polish physical anthropology, potentially facilitating comparative analyses across graves of analogous categories. Polish physical anthropology is replete with seminal studies, with notable contributions from Nowak (2011), Liczbińska et al. (2016), and Piontek & Śmiszkiewicz-Skwarska (1994). Incorporating data from the Silesian region, which is presently underrepresented, will contribute to the diversification of the field.

In summary, this study holds significance from three vantage points: 1. Constructing osteobiographies for individuals to address queries pertaining to the life conditions of the uprising participants; 2. Evaluating a modified protocol for commingled and fragmented skeletal remains; and 3. Utilizing the findings of this study to augment historical data on the Silesian Uprising, thereby contributing to the fortification of cultural cohesion within the region.

Chapter 2 Material

2.1 Material to be examined

In late November 2019, four containers housing human skeletal remains excavated from the Ligota Dolna burial site were received for bioarchaeological analysis at the Institute of Archaeology, University of Warsaw. The focus of this thesis is the analysis of the human remains within these containers. The containers, designated as No. 1 through 4, were constructed from varied materials. The skeletal remains within were observed to be partially damp, encased in clay, and fragmented to differing extents. The fragments were densely packed and unnumbered. Preliminary visual inspection indicated that the bones were commingled (Image 2.1). For instance, container No. 3 contained five pairs of humeri, while skull fragments from two separate individuals were identified in container No. 2

In addition to human skeletal remains, other excavated material not specified in

Image 2.1 Condition of the material upon arrival in the laboratory

Chapter 1, Section 1.2 was found within the containers. A large leather-like object the size of a shoe, for instance, was stored in container No. 1. A cross-shaped metal hook measuring approximately 2 centimeters was found in container No. 3. Multiple ivory white and brown button-like objects and an unidentified metal fragment were found in container No. 4.

2.2 General condition of the skeletal remains

An examination was conducted on the human remains contained within the four containers. A substantial number of these bones were found to be fragmented and commingled, with fragments dispersed across different containers. However, the fragmentation and commingling were not excessively detrimental to analysis. The bone fragments were generally larger than 5 cm and often retained identifiable morphological features, which facilitated their reassembly with corresponding fragments. The distribution pattern of cranial fragments and vertebrae within the containers suggests that the excavators made conscientious efforts to preserve the original spatial arrangement of the bones during excavation. Nonetheless, there is evidence of mixing of individuals from the original burial, as indicated by the commingling of various elements such as limb bones and shoulder bones within the containers. On a positive note, the surfaces of the bones were largely smooth and well-preserved, despite some taphonomic changes. This preservation allowed for the clear observation of the original morphology and characteristics of the bones, including teeth, as well as any pathological alterations.

Chapter 3 Methods

3.1 Basic concepts and principles

In alignment with the research objectives outlined in Chapter 1, Section 1.4, the research methodology was selected to: 1. Assemble and connect skeletal fragments and distinguish between individuals; 2. Construct bone biographies of the individuals interred; 3. Assess alternative approaches for handling mixed and fragmented bones; 4. Prepare individuals for reburial ceremonies. To accomplish these goals, it is essential to adhere to the appropriate frameworks of the relevant research fields, which include the exploration of methods in paleopathology, commingled and fragmented skeletons, and battlefield/conflict archaeology.

Specifically, constructing osteobiographies is closely intertwined with traditional bioarchaeology: to build an osteobiography, there is a continuous interplay between the general characteristics of the entire sample and the individual differences in specific individuals. The process starts with proxy evidence (e.g., isotope data serving as an indicator for nutritional status); it demands extensive examination and synthesis to integrate the proxy data into a life narrative; and it involves a constant oscillation between specific instances and general trends, utilizing general trends to draw conclusions, but with the caveat of data homogenization and loss of individual uniqueness (Robb et al., 2019). We must also integrate and layer multiple sets of data, encompassing anthropology as well as other domains like stratigraphy and history.

The imperfect human body

In the process of differentiating and reassembling individuals, we are confronted with a critical question: on what grounds do we assert that these fragments belong to the same individual? To make headway, we must first scrutinize the assumptions we are operating under. The initial assumption we employ is that the human body exhibits near symmetry, which forms the foundation for our capacity to pair sets of bones. Nonetheless, for precise reconstruction using bone fragments, the directional and fluctuating asymmetry of the human body must be acknowledged.

Another supposition is that alterations in the bones are continuous. For instance, if a lesion is present in the femoral head, it is likely to also be evident in the acetabulum. Concurrently, changes in bone density, shape, and taphonomic alterations were also continuous. This kind of uninterrupted change in bones or between joints serves as the foundation for us to conjoin bone fragments.

As inferred from these assumptions, despite the human body not being perfectly symmetrical, our reconstruction adopts a more ideal pairing than what is found in reality. In essence, the skeletons we reassemble from fragments and commingled human remains may not always depict the "actual" person, but rather the most compatible match to the bone among the existing bone fragments, thus potentially erasing the original individual body's imperfections. Naturally, during identification, we take into consideration as many variables as possible while minimizing errors.

Macroscopic and microscopic methods

In the field of bioarchaeology, qualitative, quantitative, macroscopic and microscopic methods are widely used. In general, we can only obtain satisfactory results if we employ all strategies at the same time. Regarding our research goals, we had to integrate as many methods as possible. This is because our data is inherently very diverse. In fact, one of the distinguishing qualities of bioarchaeology is the application of quantitative tools created by physical anthropologists and forensic scientists.

The first category of methods is macroscopic and visual, sometimes termed as "eye and pen." This is a traditional practice in bioarchaeology and remains relevant. Many bioarchaeological analyses today still rely on visual inspection (see Table 3.1). In this method, human remains are examined visually (sometimes with the aid of optical lenses), properties of the bones are sought, compared to established human skeletal models or patterns in literature, and then described using words or symbols. The properties observed and described include an overall assessment (complete or fragmented, well or poorly preserved, articulated or commingled), general shape (square, oval, round, elongated), peculiarities (uncommon features on bones), color (black, brownish, grey), texture (rough, smooth, pitted), and connections of bones

Table 3.1 Methods used to obtain biological information

Attributes	Bioarchaeological data
Ancestry	Visual inspection of the skull, osteometric measurements
Sex	Visual inspection of pelvic and cranial morphology, osteometric techniques
Age	Visual inspection
Stature	Osteometric measurements and formulae for estimating height
Population affinity	Comparison with existing osteometric population data, epigenetic features, cultural modifications
Physical appearance	Analysis of specific features, facial superimposition, facial reconstruction
Occupation	Muscular stress markers, osteodegenerative changes
Diseases	Markers of specific and nonspecific (infectious) diseases
Trauma/Cause of death	Antemortem and perimortem skeletal trauma, distribution, lethality, injury mechanism
Social status	Orbital cribra, dental enamel hypoplasia, dental caries, nonspecific periostitis, Schmorl's nodes, osteodegenerative changes, trauma

(linked, fused or unfused). All standard osteological evaluations must include such visual methods, as identifying bones, initially performed qualitatively through visual inspection, forms the foundation for all subsequent steps. It's worth noting that advancements in computer science and technology have made it possible to perform CT scans or 3D reconstructions of bones and identify them quantitatively using artificial intelligence (Anastopoulou et al., 2021). However, these advanced techniques are not universally accessible and may not be necessary for all studies. Currently, visual identification of bones is the most widely used technique in the field due to its efficiency and practicality. For the same reasons, a semi-qualitative estimation of the preservation percentage is performed to save resources and avoid unnecessary work. Based on sexual dimorphism and principles of bone growth, traditional methods have been able to evaluate sex, age, and pathology using primarily qualitative approaches. There are also numerous quantitative or measurement techniques available, especially for sex determination or specific pathological diagnoses. These are considered reliable and precise, though their reliability is often limited to specific populations.

Quantitative attributes such as height estimation require measurements. Moreover, modern techniques including DNA analysis, isotope analysis, and bone mineral density assessment through dual-energy X-ray absorptiometry (DXA) are commonly used. These microscopic methods would enrich our research; DNA analysis sheds light on ancestry, isotope analysis on migration and diet, and bone mineral density on bone development, age, sex, and diseases. Scanning Electron Microscopy (SEM) is another tool, providing qualitative and quantitative data for studying diagenesis and pathologies (Brothwell, 1969). However, due to the COVID-19 pandemic in 2020, we could not employ these microscopic methods. The implications of these limitations will be discussed in *Chapter 5.*

In conclusion, both qualitative and quantitative methods are crucial for collecting osteological data. An analytical approach, integrating inductive and deductive reasoning, is essential for evidence analysis and addressing research questions. Methodological considerations will be discussed in *Chapter 5, Section 5.2*.

Accuracy, precision, and estimate of error

To be accurate is to be correct. For example, estimating the age of a 28-year-old as between 20 and 30 years old is accurate but not precise. On the other hand, the term "precise" refers to having a tiny margin of error. Estimating the age of the same individual in the preceding example as between 32 and 33 years old is precise, but not accurate. Numerous eminent authors have highlighted the aspects that influence accuracy and precision. Specifically, according to White et al (2011), the accuracy and precision of determinations of sex, age, and ancestry depend on 1. the broader age category to which the individual belongs, 2. available skeletal elements (different elements have different developmental stages), 3. sample composition, 4. the analytical methods used, 5. the suitability of the analytical methods to the unknown individual or sample, and 6. research context. Gifford-Gonzalez's (2018) discussion of the same issue in zooarchaeology can also be well applied to our problem, and according to her, these factors are: 1. the abilities of the analyst, 2. the extent of specimen fragmentation by human action or other processes, 3. the screen size or other recovery methods used in obtaining the sample, 4. the likelihood of encountering two or more species of similar size and morphology in the region sampled, 5. whether identification of minimally identifiable specimens to grosser taxonomic levels is deemed to be a useful part of one’s overall analytical strategy, 6. whether identifications of minimally identifiable specimens to body region is deemed to be a useful part of one’s overall analytical strategy, 7. the amount of time and other essential resources one has for analyzing the assemblage.

In our analysis, these four factors were the most influential: 1. condition of the remains, 2. character of the remains[2], 3. model data that are used to be compared with and the methods used, 4. ability of the researcher. The final impact of these four factors will be shown in *Chapter 5*.

3.2 Definition of terms

Unless otherwise indicated, the terminology and concepts employed in this thesis conform to the conventions of medical science. Additionally, several terms that are frequently utilized throughout this thesis are elucidated below.

Bone preservation

A term to describe presence, partial presence, or non-presence of a bone fragment or a bone. It is expressed in a 6 point scale where 0 stands for non-presence and 5 stands for perfect preservation. The overall survivorship is calculated and converted from

[2] E.g. more difficult if they are all similar. One interesting example: when the author was a student in China earning her bachelor's degree, she was required to take part in mandatory military training. At the camp, all of the young women were organized into a number of different legions according to their height. Imagine if, in the event of a natural disaster or a bomb assault on the legion of the author, and she and one hundred other young females were buried *in situ*, it would be very challenging for future archaeologists to differentiate the author from the others.

this data. The original spreadsheet file for preservation assessment of the bones will be attached in the appendix.

Minimum number of individuals (MNI)

The smallest number of individuals to produce the observed bones.

Overall survivorship (%)

The percentage of the survived bone parts in contrast to the total bone parts that are supposed to be in the ideal condition. For example, 4 times 80% preserved and a 60% preserved left humeri make the overall survivorship of left humeri 76%.

Sex ratio

A ratio derived from the outcomes of sex assessment, represented as the proportion of males to females. When there is uncertainty in sex assessment, the sex ratio for a given sample set is not represented by a singular value, but rather as a range of plausible values.

Age seriation

To put skeletons in order by assessing the individual's age-at-death.

3.3 Methods for obtaining bioarchaeological information

Bioarchaeology is a relatively new field of study; the term "bioarchaeology" was not coined until 1972 (Clark, 1972). In spite of this, the vast findings of physical anthropology and forensic studies from the past have accelerated the development of bioarchaeology. Numerous classical methods were evaluated and incorporated into widely used textbooks within the field. *Human osteology: A laboratory and field manual* (Bass, 1995), *Guidelines to the standards for recording human remains* (often abbreviated as BABAO guidelines; Brickley& McKinley, 2004), *Juvenile osteology: A laboratory and field manual* (Schaefer et al., 2009), *Standards for data collection from human skeletal remains* (Buikstra & Ubelaker, 1994), Human osteology (White et al., 2011), and numerous others are well-established examples. Typically, these traditional techniques are applied to complete or articulated skeletons. Researchers have developed a number of methods for documenting skeletal remains, frequently adhering to the *Standards for data collection from human skeletal remains* (Buikstra & Ubelaker, 1994).

3.3.1 Minimum number of individuals (MNI)

The minimum number of individuals(MNI) was established according to the classic method as introduced by White (1953). Numbers of repeating bone element pairs are counted.

3.3.2. Reconstruction of skeletons and identification

In traditional textbooks, extensive knowledge is provided on how to recognize each bone and reestablish their anatomical relationships (as, for example, described in White et al., 2011). However, identifying or matching remains to distinct, named individuals is exceedingly difficult. To accurately identify an individual among their contemporaries, forensic information such as DNA analysis results, dental identification (matching teeth with a dental database), skeletal radiographs, and overlays and reconstructions of skulls and faces are needed. Additionally, recording personal information through identification documents or other written records is essential. In archaeology, identification involves elements like tombstones, seals, symbols, and badges.

In our case, and in similar cases, the challenge arises from the limited information available - only the fragmented and commingled remains, and the knowledge that they belonged to participants in the Third Silesian Uprising. Nonetheless, adhering to the methodologies and principles outlined at the beginning of Section 3.1 of this chapter, we attempted to **piece together** the individuals like a jigsaw puzzle based on the condition of the skeletal fragments themselves. Starting from these reassembled individuals, we conducted further measurements and analyses to address the question of "who are they". Different stages and elements of the investigation will utilize various methods.

3.3.3 Age estimation

Age categories

In bioarchaeology, age estimation is predicated on biological age indicators present in human remains. It is imperative to distinguish between biological age, which reflects physiological status, and chronological age, which denotes the time elapsed since birth. In addition, it should also be noted that skeletal development depends on the individual's overall health, rendering age estimation based on such factor less accurate for children. Biological age is also influenced by environmental, behavioral, genetic, and other factors, and as a specimen ages, its age markers may become less distinct (Cunha et al., 2009).

For the purposes of this research, the sociological implications of age categories are of primary interest. Questions regarding social roles associated with age, such as when an individual is considered a socially responsible adult, when adolescents transition to adulthood, and when children begin socialization, are central. Additional considerations include age thresholds for marriage, military service, workforce participation, and household responsibilities. The archaeology of childhood has been extensively explored (Grove et al., 2018; Baxter, 2005; Halcrow & Tayles, 2008), and responses to these questions have led to the delineation of distinct age groups. Notably, the demarcation of age groups has evolved over time, with the educational system playing a pivotal role. In contemporary society, education has established approximate age thresholds of 12 and 20 for the transition from childhood to adolescence and from adolescence to adulthood, respectively.

In the context of the Third Silesian Uprising, precise age estimates for adolescents and young adults are essential for inferring individuals' roles within the insurgent forces. Age estimation methods typically have an associated margin of error ranging from six months to two years, which can have significant implications for social roles. Consequently, employing a combination of techniques is necessary for more accurate age group determination.

It is worth noting that bioarchaeological literature reflects variations in age classifications. Buikstra and Ubelaker (1994), for instance, proposed seven age categories: fetus, infant (0-3 years), child (3-12 years), adolescent (12-20 years), young adult (20-35 years), middle adult (35-50 years), and old adult (50+ years), along with alternative terminology. This classification aligns with modern age demarcations and is thus applicable to this study.

Epiphyseal fusion

Since a common rate of bone development exists, it is possible to estimate the bone age of subadults or even young adults based on the status of epiphyseal fusion. As early as in 1924, Stevenson (1924) has noted that epiphyseal activities are the most obvious between 15 to 23 years old. This method is unreliable for individuals older than 28 years old because, in general, bone development ceases at around age 28 and there is no further epiphyseal development after that point.

The method of age estimation based on epiphyseal fusion is to compare the observed fusion stage of each individual's epiphyses with a recognized and trustworthy data pool. Such information can be found, for instance, in the book by Schaefer et al (2009). Some epiphyses are more informative than others, it should be noted. Basilar or spheno-occipital synchondrosis of the skull, for instance, is a good indicator of adulthood. Krogman and İşcan (1986) hold that if it is fused, the individual is older than 23 years old, and if it is not fused, the individual should be younger than that.

A variant of this method is to estimate age by the morphology of the sternal ends of ribs. This method is not in itself detecting the fusion of the epiphysis, but is closely related to it. İşcan et al. (1984) observed the fourth rib. Their method reaches an accuracy of about 2 years in the second decade of life and about 7 years in the fifth and sixth decade of life. The younger the age, the more accurate the estimation. To apply this method, one must determine the individual's race and gender beforehand. Obviously, one must also be able to confirm that he is evaluating the fourth rib. Kunos et al. (1999) and DiGangi et al. (2009) employed a similar technique, but they focused on the first rib. The latter two's method achieved approximately the same accuracy as the former. On the other hand, however, the first rib is always easier to identify, so this method is slightly simpler.

Fusion of cranial sutures is another variation of this type of method used to determine age. According to Stevenson (1924) and Krogman & İşcan (1986), cranial suture fusion begins after the age of 30, so this method is inapplicable to individuals under 30. (in their method all people under 30 years old scored 0). Additionally, there is no assurance that this method will be effective for individuals over the age of 30, as cranial development is highly variable (Brooks, 1955).

Dental status

Dental eruption stages are viable age indicators in adolescents. Ubelaker (1999) offers a method by assessing the extent of tooth eruption. It is pertinent to acknowledge that the precision and reliability of such methods wane with age of the individual, especially around the time of third molar's eruption as it is variable in human populations. Consequently, Ubelaker furnishes a set of reference tables for this method. An alternative approach, widely employed, involves considering the formation of individual teeth in contrast to the development of multiple teeth. This technique has been effectively utilized by various authors including Smith (1991), Moorrees et al. (1963), Liversidge & Molleson (2004), among others.

Age estimation can also be based on dental wear, as after formation of permanent teeth, individuals utilize the same set throughout life, leading to accumulated wear over time. Various studies, including those by Smith (1984) and Lovejoy (1985), have employed this approach. However, dental wear is influenced by diet, habits, dental diseases, among other factors. Consequently, the accuracy of this method is contingent upon the availability of contextual information and may not always be precise.

When neither skull nor pelvis were preserved, age will be estimated by dental conditions as follows. Dental attritions have been described according to Smith(1984) for each tooth separately and then assessed for age estimation by the method of Lovejoy(1985). Ageing by dental development stages follows the methods of Moorrees et al.(1963), Smith(1991) and Ubelaker(1979).

Length of long bones

In juvenile osteology, it is possible to estimate age by the length of long bones. Such is based on the fact that within a given group, the growth rate and average lengths of bones are consistent. This method only works for the individuals who are known to belong to a group with a low standard deviation. The estimated results will not be definitive or precise and should always be considered alongside the fusion stages. Detailed comparison and discussion can be found in the work by Ubelaker (1987) or Scheuer et al. (2010).

Age markers on the pelvis

Analogous to the long-bone-length method being exclusive to non-adults, the pelvic area approach is solely applicable to adults. In the initial stages of both the auricular surface ageing method and pubic symphysis methods, the development of the joint surface is scored, whereas post approximately 40 years of age, age estimation is based on surface degeneration, which is in a sense pathological. Therefore, observations should not be made until fusion is complete.

Three age indicators are present in the pelvic area: the pubic symphysis, the auricular surface, and the acetabulum. The method of deducing age from pelvic characteristics has historical roots, with physicians conducting autopsies as early as the Renaissance. Currently, the most prevalent age estimation methods in forensic anthropology are linked to this area. Over time, a wealth of information has been accumulated. The advent of modern approaches to this field occurred early in the 20th century. The longest-standing method, proposed by Todd (1920), was pioneering in its quantitative assessment, correlating aging with the appearance of the pubic symphysis. Despite its tendency to yield younger estimates, Todd's method retains some relevance. On the basis of Todd's (1920) work, Brooks and Suchey (1990) developed a similar but enhanced method. This Suchey-Brooks method is currently one of the most widely used. Klepinger et al. (1992) developed another technique utilizing the same marker. It was evaluated to be useful and quite accurate, and the results of this method should be accompanied by a 2-year margin of error. Other characteristics, such as parturition, dorsal edge pitting, and pubic tubercle extension, can be incorporated into the method. However, the Suchey-Brooks method is not always applicable. Bednarek et al. (2002), for instance, examined a sample of Polish males using the Suchey-Brooks method. When applied to the Polish population, their findings revealed that the method can only be used to determine the age of young males.

The auricular surface is also of interest. It is believed that evaluations based on this area are accurate and trustworthy, albeit with less precision, as represented by large error bars. According to numerous authors, it is only possible to determine which of the three age groups the assessed individual belongs to, namely, whether he is young, middle-aged, or elderly (see e.g. Falys et al., 2006). McKern and Stewart (1957) proposed a method for estimating age groups based on the scores of various auricular surface component features. Another commonly used method is provided by Lovejoy et al. (1985a), and Buckberry and Chamberlain offered a widely accepted improved method based on the original work of Lovejoy et al. (1985b). According to Mulhern and Jones (2004), the original method of Lovejoy et al. (1985a) is preferable for ages 20 to 49, whereas Buckberry and Chamberlain's revised version is preferred for ages 50 to 69. In the case of fragmented and disarticulated bones, auricular surface techniques may be too crude and ineffective for age classification (Lovejoy et al., 1985a, b). However, they can still offer some information for de-mingling.

The method of determining age based on acetabulum characteristics is much newer and less popular than those of the other two markers. The method proposed by Rissech et al. (2006) for determining age based on seven variables of the acetabulum is representative of this category of techniques. This method was assessed to be the most accurate and to have the least inaccuracy and bias compared to the other methods (Miranker, 2016). It is possible that this technique type will be developed in the future.

Microscopic and quantitative methods in ageing

Radiological analysis of bones is one of the most common microscopic techniques for determining bone age. In adults, bone loss associated with aging can serve as an accurate indicator of age. According to Castillo and López Ruiz (2011), X-ray images can be used to determine age and sex. From this perspective, it is not surprising that this analysis technique would not work well in a group of adolescents. Thankfully, however, such a method displays the microstructure of the bones more clearly, allowing for a better understanding of the developmental stages of young bones. Additionally, with the aid of suitable procedures, it is possible to conduct automated age evaluation (Mansourvar et al., 2013). The greatest disadvantage of this method is that the margin of error can be as high as 10 years, making it unsuitable for precise age assessment of individuals in the same age group. Two additional obstacles hinder its application: this analysis is typically expensive and it is difficult to find suitable institutions, laboratories, or facilities to collaborate, while sample extraction requires special care and expertise.

Multifactorial age estimation

In some sense, no researcher who estimates a person's age considers only one factor. Age estimation is always multifactorial, and so will be our investigation. In this context, the term roughly refers to a system of assigning different weights to each applied method. If the skeleton is complete, "multifactorial assessment" is feasible and recommended. Since the time of Todd (1920), this strategy has been followed. Examples of multifactorial assessment can also be found in Lovejoy et al. (1985b) or Baccino et al (1999). In a word, every method has both advantages and disadvantages (see Martrille et al., 2007 or Falys & Lewis, 2010 for a brief comparison).

The division of adults and subadults were made by the stage of union. For the adults, age is first of all described using the pubic symphysis with the noting of the stage according to Suchey-Brooks method (Brooks & Suchey, 1990) and individual components according to McKern-Gilbert(McKern & Stewart, 1957; Gilbert & McKern, 1973). Estimation methods using assessment of auricular surface both according to original method (Lovejoy et al. 1985a) and redesigned method using individual scoring system (Buckberry & Chamberlain, 2002) were also used. For subadults, age is firstly estimated through the stage of union, according to Schaefer et al.(2009) For subadults whose metrics were taken, tables of metrics in the same book were consulted. Measurements of bones, when available, were also used in age estimation for subadults.

Age seriation

Age seriation is done by utilising all above-mentioned methods, on each bone element, and as much as possible. In such a way, the difference between all individuals will be highlighted, and we may distribute the bones to their original owners as much as possible.

3.3.4. Sex estimation

Sex determination based on macroscopic skeletal features is feasible, though it inherently carries a degree of uncertainty, which persists even with DNA analysis (X-Y chromosome testing). It is important to note that DNA analysis yields biological sex, not the archaeologically more significant 'gender', and is still subject to errors. In the human skeleton, sexual dimorphism is most pronounced in the pelvic region and skull, with sporadic manifestations in other skeletal features. The outcomes of sex estimation are thus inherently probabilistic due to the diversity in the expression of sexual characteristics. As such, the terminology in sex estimation, as defined by various authors, encompasses descriptions of probabilities.

Before proceeding with sex estimation, particularly with methods based on the pelvic area, we must acknowledge that sex estimation techniques are usually only applied to adults. The explanation is straightforward: the secondary growth centers of juvenile skeletons have not yet fused. In instances of commingling, it is essential to conduct a thorough examination of morphological features on skeletal fragments, encompassing both sex-related and age-related characteristics. Additionally, it is critical to recognize that when inferring sex through comparison with a sample database, meaningful insights can only be derived from comparisons with closely related control data. However, even in such cases, the substantial variance in statistical data renders these 'sex estimations' as merely indicative or, in some instances, devoid of significance.

General robustness

According to a number of authors, including Stevenson et al. (2009), female bodies are typically smaller, leaner, and display fewer signs of muscle attachment than male bodies. Obviously, sexual dimorphism is much more pronounced in chimpanzees and gorillas, and size differences are also quite marked. Even though it is less prominent in *Homo sapiens*, the two sexes are statistically distinct. When an entire row of molars has erupted, for instance, it is possible to compare the size and shape of the mandibles. It is possible to make statistical estimates of the sexes when highly precise measurements of the teeth, such as differences in the width of the teeth that differ by

0.5 mm, can be taken. The reason for this is that hormonal influences cause men to have wider jaws, more prominent protrusions, etc., and in general more robust. Some established cranial-based sex estimation methods, such as those developed by Stevenson et al. (2009), make perfect sense in this context.

Post-cranial bones: Traits of the pelvis

The pelvic region is not only invaluable for age assessment but also serves as the primary reference for sex determination. The distinct reproductive roles of males and females result in significant variations in pelvic morphology as secondary sexual characteristics develop. As such, numerous markers in this area can be utilized, including the size and shape of the pelvic inlet, the width of the pubis, the sturdiness of the pelvis, and the presence of childbirth-related bone alterations. Typically, a female skeleton exhibits a smaller sacrum and os coxae, a larger pelvic inlet, a wider greater sciatic notch, an elongated pubis and pubic ramus, a more pronounced subpubic angle, and a smaller acetabulum. However, applying these general observations to individual cases can be challenging. Moreover, the reliability of sex determination diminishes in younger individuals where sexual dimorphism is not yet pronounced. Additionally, post-menopausal women may exhibit 'masculinization' due to hormonal changes, which can lead to misinterpretation of sex when relying on features such as the greater sciatic notch (Walker, 2005). The reliability of various methods has been extensively debated. In practical applications, most of the widely-used methods are adaptations of the technique developed by Phenice (1969). A modified version of Phenice's method, which incorporates additional traits such as the ventral arc, subpubic concavity, and ischial ramus, is also frequently employed (see, for example, Lovell, 1989; Ubelaker & Volk, 2002). It is important to note that these methods are only applicable when the pelvic region is well-preserved and the individual is an adult.

Post-cranial bones: measurement of bones

Length, width, and other measurements of metacarpal bones, ulnae, calcaneus, etc. are also employed in sex estimation. The femur is the most typical bone used. Since the femur is the largest bone in the human skeleton and therefore the one most likely to be preserved, special attention has been paid to it. Numerous studies have thus been conducted to determine sex based on femur measurements. (See e.g. Mall et al., 2001; Safont et al., 2000; Asala, 2001; Vora et al., 2019)

Multi-factorial assessment

Parallel to the estimation of age, the estimation of sex is similarly multi-factorial, although for sex determination, much fewer aspects will be considered. For data sets having a great deal of comprehensive information, a decision tree that interrogates and assigns weights to numerous parts of the data might be employed. One of these is the CHAID decision tree, which incorporates the X-test. In the study by Stevenson et al. (2009), pertinent procedures for this type of evaluation are outlined.

In the absence of DNA, it is difficult to accurately determine the sex of young skeletal remains because the majority of sexually dimorphic traits of the human skeleton evolve as secondary sex characteristics throughout adolescence. Due to the transitory character of the skeleton throughout puberty and the diversity of the adolescent growth spurt, it is not feasible to assess adolescent skeletons using the same assessment techniques for adults. Nonetheless, when employing a multi-factorial approach, determining the age of juveniles is also a worthwhile endeavor. The premise is that whereas sex dimorphism is absent in children (less than 12 years old), it is present in adolescents, though not completely. Boys and girls already exhibit different body build tendencies during the developmental stage. Works on sex determination of juvenile bones are extensive, but primarily on dentition (see e.g. Viciano et al., 2011), with additional attempts on mandible and ilium (Schutkowski, 1993) and distal humerus (Rogers, 2009). Ultimately, such results will only serve as supplementary references. Buikstra and Mielke (1985) evaluated the accuracy of many skeleton sexing procedures in useful tables, while Cox and Mays (2000) provide an overview of ways for determining the sex of mature and immature skeletal remains.

In general, the sex of each individual was assessed based on the morphology of the skull and pelvis using standard methods (Phenice, 1969; Buikstra and Mielke, 1985; Walker, 2005) documented in the manual by Buikstra & Ubelaker (1994), along with other relevant methods.

In addition to the widely used methods mentioned above, it is advisable to refer to alternative methods in instances where information is lacking or insufficient. Specifically, when neither the skull nor the pelvis is preserved, sex determination will rely solely on metric analysis, as introduced by White et al. (2011).

3.3.5. Stature estimate

As the skeleton constitutes the structural framework of the human body, an individual's height at the time of death is inherently associated with the dimensions of the skeletal remains. A conventional method for estimating height is the Fully method, introduced by G. Fully in 1956, which calculates height by summing the measurements of the bone segments that contribute to stature. The modified Fully method, as refined by Raxter et al. in 2006, is widely employed in contemporary practice. It is essential to recognize that this method requires single well-preserved, complete individuals, as the absence of any key component (including cranial height, maximum heights of the 2nd–7th cervical vertebrae, thoracic vertebrae, lumbar vertebrae, first sacral vertebra, femoral physiological length, tibial length, and talus-calcaneus height) renders the method inapplicable. Consequently, the Fully method is not suitable for individuals reconstructed from fragmented and commingled skeletal remains.

A second group of methods employs regression analysis, premised on the existence of consistent ratios between specific bones and overall stature. These methods tend to exhibit higher errors for individuals aged 60 and above due to the natural decrease in height with age, but are effective for young adults over the age of 20. Classic studies such as those by Trotter & Gleser (1958), Bass (1995), and Bennett (1993) provide reference tables for this approach. Presently, there are formulas tailored to various ethnic groups globally. These equations have distinct applicability constraints and levels of error. It is important to recognize that height is a multifaceted attribute, and individual variations can result in disparate estimated statures derived from different bones within the same individual. Consequently, the outcomes from this category of methods typically encompass a broader range of estimates.

In the current study, various formulae, including those developed by Trotter & Gleser (1952), are employed to estimate body height. As there is no formula in the literature specifically tailored for the exact time period (1921 ± 25 years) and geographical location (Upper Silesia) of this study, we utilize the general formula for modern European males and females. Ultimately, this allows for the creation of a seriation of body heights, albeit with an acknowledgment of the potential imprecision in stature estimation.

3.3.6. Ancestry and identity

The objective of examining biological ancestry is to supplement the biological profile for an individual. Additionally, it serves a practical purpose in ascertaining whether specific skeletal remains share biological ties with the groups to which they are intended for repatriation. Historically, there was a misguided belief in the existence of pure, biological "races" that could be categorized through morphological methods. Contemporary understanding, however, refutes this notion (Norton et al., 2019), and clarifies that: 1. Ethnic group is a sociocultural construct, and 2. The outcome of ancestry estimation through genetic testing is represented by varying frequencies of single nucleotide polymorphisms (SNPs), not a label of a specific ethnic group (for more information on the ADMIXTURE algorithm, see Alexander et al., 2009).

In this study, bone samples were collected for future DNA analysis, though no results were ultimately obtained. In cases where microscopic methods are not accessible, ancestry estimation often hinges on the examination of cranial features (e.g., Klales & Kenyhercz, 2014). In the absence of molecular-level testing and given the understanding that genetic ancestry manifests as a statistical abstraction of a trait complex, the metric-visual method, as described by Gill and Rhine (1990), serves as an alternative quantitative approach. Another avenue is to infer ancestry through biological traits, but this was not viable in our case due to the high ethnic variability and relatively small biological distances between ethnic groups in the region under study.

In our research, the determination of identity and ancestry was contingent upon the accurate reconstruction of the skull. Additionally, non-metric skeletal features can be instrumental in identifying individuals when isolated. Given the small sample size and the fragmented condition of the remains, the accuracy of skull reconstruction cannot be assured. Nonetheless, non-metric features of the skull and post-cranial skeleton were documented in accordance with the BABAO guidelines.

3.3.7. Health and trauma

First and foremost, teeth serve as a crucial indicator for evaluating overall health. Dental microwear, macrowear, calculus, and caries provide insights into diet (Hillson, 2001), while alveolar bone resorption and enamel defects shed light on oral hygiene and developmental issues, respectively (Ogden, 2008). Specifically, enamel hypoplasia is a significant marker when examining childhood development and stress.

In a similar vein, skeletal alterations convey information about metabolism, habitual activities, violence, diseases, and epidemics (Buikstra & Ubelaker, 1994; Waldron, 2009). It is important to recognize that while osteological stress markers (OSM) can be used to infer general health status, caution is required in interpreting these markers, as they may indicate low stress rather than high stress due to selection effects (this is referred to as the osteological paradox; see Wood et al., 1992).

Furthermore, bone mineral density (BMD) can be assessed using dual-energy X-ray absorptiometry (DXA) following radiographic imaging. BMD is a vital indicator of bone strength and serves as a key metric for evaluating the extent of osteoporosis and predicting fracture risk. Additionally, the presence of various chemical elements in the skeleton can reflect dietary composition at the microscopic level, which can be examined through stable isotope analysis (Schoeninger & Moore, 1992).

Regarding trauma and joint diseases, in the context of conflict or battlefield archaeological research, the type of trauma can offer insights into the kind of weapon employed and the intensity of the conflict. Additionally, the healing of *ante mortem* trauma and joint diseases can provide information about the nutrition and living conditions of the soldiers (Scott & McFeaters, 2010).

The health and childhood development of the subjects in our study can be deduced from various aspects. For subadults, morphological features and developmental stages are compared with standard reference tables. For all individuals, pathological changes observed on the bones will serve as indicators of potential disease history. Dental health and dental development characteristics are employed as markers for hygiene and growth. Ogden (2008) offers guidelines for describing the resorption of the alveolar process. For linear enamel hypoplasia (LEH) and dental calculus, we adhered to the BABAO Guidelines (Brickley & McKinley, 2004).

Regarding potential epidemiological traits within the sample, we adopted the general approach outlined by Buikstra and Ubelaker (1994). For instance, we recorded any common alterations in specific skeletal elements and their frequency.

In the course of examining the skeletal fragments, we also analyzed the origins of trauma and, if ample information is available, postulated their connection to the probable cause of death. Essentially, details of *peri mortem* trauma associated with death will provide supportive evidence but are not definitive. It would also be advantageous to detect lethal elements in bones. In cases where none of these conditions are present, our approach is to eliminate improbable causes of death.

3.3.8 Taphonomy

In general, from taphonomical features, it is also possible to extract information about fauna, flora and pedology of the site. Mortuary practice related to the site in the study could also be partially described according to the layout of the graves, the grave goods, and condition of skeletons. Such analysis will be done on the basis of the work by White et al. (2011).

3.3.9 Data recording

Deciding what needs to be observed and documented, as well as how to do so, is the initial task that must be tackled. In devising the recording procedure for this study, we followed a process similar to the practices of Nikita et al. (2019) in Cyprus and Osterholz et al. (2014), though with some differences. The recording form used here was developed by the Institute of Archaeology, University of Warsaw, and is accompanied by a coding manual provided by Fetner (2019). The number of specimens in our collection is significantly smaller compared to the hundreds of individuals in the mass graves that Osterholtz et al. (2014) and Nikita et al. (2019) had to work with. Additionally, the levels of fragmentation are much less severe. Also, since the Minimum Number of Individuals (MNI) is easily identified, it is more efficient to take notes in a traditional format with the ability to make minor adjustments as needed. However, it is crucial that the note-taking system aligns with the core idea of this research, which is that in cases of severe fragmentation and commingling, the recording method should focus more on skeletal elements rather than individuals. The approach should be based on skeletal features, and the documentation of the skeleton should be thorough.

To ensure accuracy, the records should encompass the following elements, as outlined by Fetner (2019), unless stated otherwise:

Inventory: basic information about identification of each bone fragments, teeth, their numeration, and percentage of preservation

Measurements: lengths, widths, circumferences of long bones, available measurements of clavicles, innominates, and scapulae, measurement of epiphyses

Non-metric traits: qualitative description of bone features that are peculiar to a small number of individuals and their numeration

Sex and age specific morphology: description and scores of marker traits according to physical anthropology conventions, showing differences between sex groups or age groups. For sex determination, characteristic areas of the skull include glabella, supraorbital margin, external occipial eminence, mental eminence, mastodoid process, gonial angle, mandibular angle, while morphologies of subpubic concavity, subpubic angle, ventral arc, sulcus preauricularis, greater sciatic notch, ischio-pubic ramus ridge within the pelvic area are recorded. For age estimation, morphologies of the pubic symphysis and the auricular surface are observed.

Dental records: presence or absence of each tooth (and its socket), eruption of each single deciduous or permanent tooth, dental development stage of the crown, root, and apex, dental attrition with respect to extent of dentin exposure, carries at each site-at-risk with records of discoloration, cavity, and lesion, severity of dental calculus, resorption of the alveolar processes with measurements of the space between the edge of the socket and the CEJ (cemento-enamel junction), enamel hypoplasia change type and measurements fo space between the CEJ and the hypoplastic line

Epiphyseal fusion (for subadults): stage of union is recorded according to the fusion percentage

Pathology and epidemiology: for pathological changes, qualitative and quantitative description of the bone, side, location, tissue activity and size of the change that can be indicative to diseases on every bone fragment are recorded. The occurrence of degenerative joint disease (DJD), cribra orbitalia, and porotic hyperostosis are tallied and documented to deduce potential epidemics.

Trauma: verbal description and measurements of *ante mortem* trauma and stage of healing, of *peri mortem* trauma, and the size and position of traumas

Taphonomy: qualitative verbal description of discoloration, attrition, weathering, corrosion, deformation, commingling, fragmentation

3.4 Research on commingled assemblages

With the 'commingled' or 'admixed' and fragmented state of human remains involved in the current study, we must also take into account specialized methods for examining such fragments. Commingling is a complex aspect of many anthropological analyses when it occurs (Adams, 2014). In reality, 'commingling' is a common phenomenon in archaeological contexts. Osterholtz et al. (2014) classified commingling into three major categories based on the various causes: long-term usage, episodic usage, and laboratory commingling. Factors contributing to commingling include mortuary customs, natural processes, geological and meteorological factors, as well as museum or laboratory handling. In the case of our research materials, commingling resulted from the mixing of individual remains

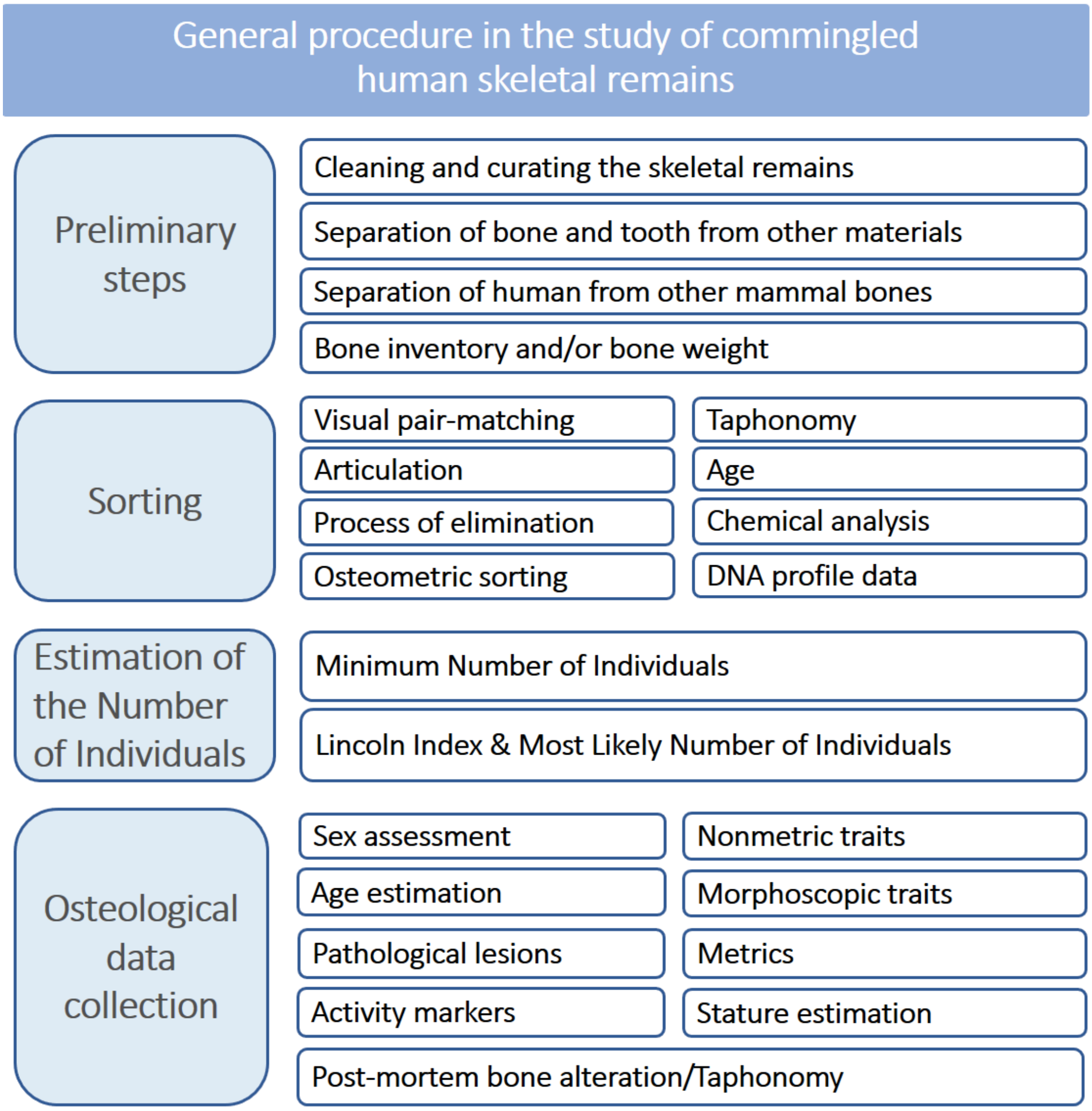

Image 2.1 General procedure in the study of commingled assemblages (Figure 1 from Nikita et al., 2019, pp. 8)

during the collection of the deceased from the battlefield for burial, around the time after the battle, and further mixing after excavation during transportation.

As regards bone fragmentation, there are numerous potential causes, including *pre-mortem* trauma, soil conditions, transport, and laboratory damage, among others. Fragmentation of the bones in our case was most likely caused by soil (due to the poor state of the grave), the act of exhumation, and transportation.

Many authors, such as Osterholtz et al. (2014), Adams and Byrd (2014), and Nikita et al. (2014), have conducted outstanding studies on the commingling and fragmentation of bones (2019). There have been numerous recording tools, such as Osteoware (Osterholtz, 2019) and Fox & Marklin's (2014) recording forms, for recording data of commingled skeletons. Adams and Konigsberg (2008) suggested a new method that had not been previously used based on zooarchaeological techniques for calculating the number of individuals in commingled burials. They modified the Lincoln Index (LI), a quantitative measure used to determine the initial population size of zooarchaeological specimens (Adams & Konigsberg, 2008). The modified LI, known as the most probable number of individuals (MLNI), required the matching of left and right components from the same individual. This nomenclature has demonstrated its utility for big commingled assemblages (Palmiotto et al., 2019). Several well-established approaches for the study of commingled and fragmented human remains are already in use, including bone articulating (Adams & Konigsberg, 2008), GIS-based methods (Herrmann & Devlin, 2004), and photo-matching (Zejdlik, 2014). Also recommended is the use of total stations (Sládek et al., 2012). Osterholtz's (2019) recording system, which has been utilized in five mass graves, is a good example of all these techniques. Their practice has yielded fruitful outcomes. Nikita et al. (2019) provided a general procedure for examining commingled skeletons (shown in Figure 2.1), which is also extremely informative.

Lab protocol used in the current study

0. In the following steps, make adequate photographic records.
1. **Initial observation**: make first observation of the human remains transported to the lab and briefly describe their general condition. Consult any preliminary assessments or basic information provided by the excavators, such as the number of skeletons and their general state. If available, review excavation notes/reports and any other pertinent documentation.
2. **Cleaning process**: ensure proper ventilation, desiccate, and meticulously remove any adhering mud, clay, or dirt using brushes.
3. **Identification and inventory**: decide the classification, laterality, and detailed preservation status of each bone fragment in a given container. If the bones are pre-labeled, it is advisable to input all relevant information into an electronic spreadsheet to create an inventory. If the packaging reflects the original spatial relationships among the bones, labeling of unlabeled bones should be performed at

this stage, followed by data entry into a computerized system (refer to appendix tables).

4. **Sorting**: within each container, group bone fragments of the same type.
5. **Conjoining**: across containers, match and join bone elements, commencing with long bones. Consider that bones originating from the same container may have a slightly higher likelihood of belonging to the same individual. Employ the criteria outlined in Section 3.1.
6. **Arranging by age**: arrange the matched sets of long bones in a sequence based on bone fusion stages.
7. **Numbering**: assign unique numbers to each newly matched set of long bones.
8. **Long bone measurements**: perform osteological measurements on the matched sets.
9. **Estimation and adjustment**: scrutinize the matched bones, and make necessary adjustments according to the bone measurements to the matching (retain original numbering).
10. **Data recording**: fill up the spreadsheet with information pertaining to long bones, including measurements and descriptive observations of additional features.
11. **Combination and arrangement by age** (step 11 to 14 is a procedure similar to step 6 to 10): match and combine other bone elements on an individual basis across containers in the following order:
    - A. scapulae and clavicles
    - B. innominates
    - C. skulls
    - D. carpals and tarsals
    - E. vertebrae
    - F. ribs

    and seriate them also according to age assessment
12. **Final adjustments and distribution**: make adjustments to the matched bones based on morphology, taphonomy, etc. Distribute each separated group of bones belonging to the same individual to the numbered sets of long bones, ensuring that the Minimum Number of Individuals (MNI) assessed from different bone elements aligns. Bones that cannot be allocated to any set should be counted and placed in separate bags.

13. **Measurements of additional bones**: Conduct measurements on the remaining bones.
14. **Final estimation and adjustment**: examine each set, estimate age, sex, and stature, and make necessary adjustments to the matching.
15. **Final data recording**: complete the spreadsheet with information pertaining to the remaining bones, including measurements and descriptive observations of additional features.
16.(**Sampling for DNA analysis**: extract bone samples for DNA analysis to be conducted by an external party.)
17. **Data analysis and comparison**: process the data, compile the final inventory of individuals with their age, sex, and other information. Compare the results with historical data (demography, etc.) and information provided by the archaeologists who conducted the excavation. If available, DNA analysis results can serve as definitive validation of the findings.

3.5 Research tools and research team

Traditional tools such as the osteometric board, sliding callipers, and tapes were used for taking measurement. Once the assembly of individuals was finalized, the measured data were documented on paper forms devised by the Department of Bioarchaeology, Faculty of Archaeology, University of Warsaw, in accordance with Fetner (2019)'s recording system.

Cameras and a computer equipped with spreadsheet software were utilized for data recording and digitization. The spreadsheet software used was *Numbers*, in which each worksheet corresponds to a section of content outlined in the *Data Recording* section, namely inventory, age, sex, non-metric traits, teeth (subdivided into inventory and alterations), measurements, stage of union (for subadults), pathological alterations, and taphonomical changes.

The analysis for this study was conducted by a single researcher.

3.6 Data collection and human remain treatment ethics

Archaeologists must evaluate the ethical consequences of disturbing human remains on purpose or by accident. Consideration must be given to the perspectives of current culture, family of the deceased, and the excavators themselves. Remains of the deceased must be handled with respect and care. This criterion should also apply to decisions regarding the publication, preservation, and online distribution of human remains-related material.

Another issue is about data protection. According to the *General Data Protection Regulation* (GDPR, Polish: RODO), personal data are defined as information about a natural person. Consequently, the law does not apply to archives containing medical records of deceased individuals. Nonetheless, excavation of human remains is susceptible to legal and ethical issues. Relevant articles on the UK measures can be found on the webpage of *Archaeology Data Service* (The University of York , 2010).

In any case, no photographic records have been disclosed to anyone. The photographs in the thesis were taken only for internal research purposes. In addition, the National Memorial Institute organized a grand reburial ceremony on July 6, 2021 (Leśniewski, 2021).

Chapter 4 Results and interpretation

4.1 Element-by-element presentation of the condition of the bones

Identification of skeletal elements

n this section, we present skeletal elements identified from skeletal fragments and calculated the overall % survivorship of skeletal elements according to the definition. (The raw data used to calculate the survivorship can be found in the electronic appendix of this thesis.) The different states of preservation among the different elements helped to reveal the burial process and also to reconstruct the individual. The analysis of each bone element (shown by the tables in the next section) naturally derives important information about the overall number, sex, age, health, and others of the individuals. In conducting the examination, the protocol was established and the sources of error were clarified.

Table 4.1 Condition of Frontal Bones

	Left	Right
No. of fragments	12	
MNI	5	
Survival	1 zygomatic process	1 zygomatic process
Fracturing	Mostly cracked on the sides except for those from one complete skull	
Marks/Pathology		

Cranial Bones

The assemblage includes one intact skull that is self-explanatory and four sets of fragments that can be conjoined. However, the majority of the skulls are fragmented, resulting in the loss of discernible features. An analysis of the fracture patterns reveals that the preservation of facial bones is inferior compared to that of the neurocranium. Furthermore, the right side exhibits marginally superior preservation compared to the left, as evidenced by the survival percentages (refer to Table 4.1-4.7). Generally, bones with greater robustness are better preserved, though they are susceptible to discoloration and cracking due to soil pressure and moisture exposure.

It is noteworthy that post-excavation analysis revealed fresh cut marks, indicating that the majority of the damage to the bones occurred during and subsequent to the excavation process. It is plausible to infer that the skeletons were relatively intact prior to excavation, notwithstanding the disturbance caused by the road in proximity to the excavation site.

One occipital bone exhibits a sharp-edged bullet hole with a beveled appearance on the opposite side (for reference, see Dix, 2000), as detailed in Table 4.6 and Image 4.1. While this is an isolated case, it provides insight into the cause of death for one individual and may suggest circumstances surrounding the demise of the group represented in the assemblage.

It is also worth mentioning that, barring approximately one hundred calottes measuring less than 1 cm in diameter, the skull fragments within the assemblage are all identifiable. However, post-restoration analysis revealed that the facial bones of three individuals were largely absent.

Table 4.2 Condition of Zygomatics

	Left	Right
No. of fragments	5	5
MNI	4	4
Survival	Except for a complete pair, only fragments of less than 1cm survived	
Fracturing		
Marks/Pathology		

Table 4.3 Condition of Maxillae

	Left	Right
No. of fragments	5	6
MNI	3	4
Survival	1 complete and 2 fragments with dentition and 1 small socket fragment with one molar; overall survivorship of 24%	1 complete, 1 large fragment with most dentitions, 2 smaller fragment with teeth; overall survivorship of 40%
Fracturing	Loss of zygomatic and frontal processes was common. Fracture along the sutures	
Marks/Pathology	Discoloration due to contact with copper with greenish stain on the small fragment with one molar	

Table 4.4 Condition of Mandibles

	Left	Right
No. of fragments	6	7
MNI	4	5
Survival	Present with dentitions. Clearly five mandibles in the assemblage.	
Fracturing	Anterior crushing and vertical zig-zag crack likely due to soil pressure, excavation or a combination of the two	
Marks/Pathology		Small concavity of about 8mm at the edge under canine and a groove of about 25mm*8mm anterior to mental foramen on one mandible and *ante mortem* loss of first molar, likely a healed trauma

Table 4.5 Condition of Parietals

	Left	Right
No. of fragments	8	10
MNI	5	5
Survival	Fragmented except for those from the one complete skull; overall survivorship of 64%	3 well-preserved and 2 sets of conjoin-able fragments; overall survivorship of 80%
Fracturing	Breakage at the time of burial and after excavation, fragments from 1-6cm large, usually conjoinable	
Marks/Pathology		The parietal articulated to the occipital that has a bullet hole has a porous look on inner surface, about one quarter large, adjacent to occipital and temporal

Table 4.6 Condition of Occipitals

No. of fragments	13
MNI	5
Survival	2 well-preserved and recognizable fragments from 3 individuals
Fracturing	Fragments show breakage due to taphonomic factors such as trampling and water soaking
Marks/Pathology	On one occipital, a sharp edged hole (*peri mortem*) about 8 mm in diameter on superior left - central of the left side, possibly a bullet hole

Image 4.1. Left: exterior view of an occipital bone Right: interior view of an occipital bone

Table 4.7 Condition of Temporals

	Left	Right
No. of fragments	12	10
MNI	4	4
Survival	Mostly fragmented except for those on the one complete skull, the preserved pieces usually are conjoined to neighbouring elements; 3 right mastoid processes preserved; overall survivorship of 42%	
Fracturing	Mostly post mortem taphonomical breakage at thinner parts such as squamas.	
Marks/Pathology		

The Shoulder

The shoulder, being an anatomically cohesive unit, was analyzed in conjunction with its constituent elements (refer to Table 4.8 and 4.9). Notably, both elements exhibited analogous taphonomic alterations, a phenomenon also observed in certain cranial bones. These alterations encompass discoloration, corrosion, and post-mortem breakage attributable to exposure to moistures and the compressive forces exerted by the soil during burial. The right side manifested marginally superior preservation compared to the left side.

Table 4.8 Condition of Clavicles

	Left	Right
No. of fragments		
MNI	4	5
Survival	Ends are mostly corroded and lost while the denser shafts are preserved	
Fracturing	Breakage usually at the thinnest point(middle) and fragments are usually large and conjoinable	
Marks/Pathology	Sign of deep muscular attachment about 20mm*6mm near the sternal end of one clavicle	1 depression with porosity about 20mm*6mm at impressio ligamenti costoclavicularis, possibly due to inflammation

Table 4.9 Condition of Scapulae

	Left	Right
No. of fragments	13	9
MNI	5	5
Survival	Bodies are mostly water-soaked, fragmented and lost, 5 remaining spines	3 punctured but survived bodies, 4 preserved glenoid fossae
Fracturing	Taphonomical breakage and corrosion of the fragile parts and edges, broken processes; small area of metal discoloration on one subscapular fossa	
Marks/Pathology		

The Upper Limb

The humerus, the ulna, the radius and the hand comprise the upper limb. In the assemblage, this group of bones is usually preserved (Table 4.10-4.13). The fragments are large and recognisable. As a whole, the middle of the upper limbs are better preserved than the joints to the shoulders or to the hands. Such a result appears to be more likely due to the man-selection effect during excavation than the factors related to burial.

Table 4.10 Condition of Humeri

	Left	Right
No. of fragments	7	9
MNI	5	5
Survival	3 humerus heads, lower parts are well-preserved except for some scraping	4 humerus heads, lower parts are well-preserved except for some scraping
Fracturing	Cut mark; post mortem breakage in the middle of shaft	
Marks/Pathology	Slight deformation about 50mm*17mm at the anterior medium part of one humerus, possibly a healed fracture	

Table 4.11 Condition of Radii

	Left	Right
No. of fragments	7	8
MNI	5	5
Survival	The shafts and proximal ends are well-preserved, 2 distal ends/epiphyses	4 proximal ends and 2 distal ends well-preserved
Fracturing	Cracks from corrosion; cut marks	cut marks
Marks/Pathology	The proximal epiphysis of one radius is abnormally small, about 1/2 size of the right ones.	

Table 4.12 Condition of Ulnae

	Left	Right
No. of fragments	7	7
MNI	5	5
Survival	The shafts and proximal ends are well-preserved, 3 distal ends/epiphyses	4 proximal ends and 2 distal ends well-preserved
Fracturing	In similar pattern to radii	
Marks/Pathology	One ulna is bent laterally from proximal 1/3 upwards(about 5cm long), no separate incisura rad.	

The good preservation also allow us to observe the abnormal size of one epiphysis. It may origin from trauma in the lifespan of the individual. We further found related anomalies and use this feature to conjoin three left elements.

Table 4.13 Condition of Hand Bones

		Left	Right
Carpals	**No. of fragments**	15	13
	MNI	2	2
	Survival	Mostly not present; the surviving ones are well-preserved; overall survivorship 13%	
	Fracturing	Abrasion and pitting on lighter parts	
	Marks/ Pathology		
Metacarpals	**No. of fragments**	17	13
	MNI	5	4
	MNE	30	
	Survival	Good preservation of the survived; some separated shafts and ends; overall survivorship 43.2%	Similar to the left-side ones; overall survivorship 36%
	Fracturing	the ends were cut off and crushed	
	Marks/ Pathology		
Hand phalanges	**No. of fragments**	57	
	MNI		
	Survival	25 proximal phalanges, 13 middle phalages, 1 distal phalange; loss of epiphyses (juvenile) and heads	
	Fracturing	Separation of heads and bases	
	Marks/ Pathology		

The survivorship of carpal bones is low, which is not beyond imagination. In fact, carpal bones (in particular juvenile carpal bones) are often underrepresented in assemblages, due to their fragility or similarity to pebbles.

The Vertebral Column

The vertebrae exhibited partial fragmentation. Generally, elements with reduced thickness, such as cervical vertebrae, were more susceptible to damage, resulting in a lower preservation status (refer to Table 4.14). Similarly, subadult vertebrae demonstrated inferior preservation compared to adult counterparts. Interestingly, the preservation of the sacra was only akin to that of the thoracic vertebrae (Table 4.15). This observation may be attributed to two factors: the differential bone mineral composition between lumbar vertebrae and sacra, and the sacra's inherently intricate structure rendering it vulnerable during excavation.

In relation to other skeletal elements, the vertebral columns underwent taphonomic changes analogous to those previously described, both antecedent to and subsequent to excavation. The preservation status of the vertebrae was suboptimal compared to the limbs, but the alterations were consistent with adjacent anatomical structures such as the shoulder and thorax.

Under typical circumstances, one might anticipate the presence of joint diseases in the vertebrae of individuals engaged in strenuous labor (presuming that the participants of the Third Silesian Uprising were labor-intensive workers exerting significant strain on their vertebrae). However, such pathology was not observed in our investigation.

Table 4.14 Condition of Vertebral elements

	Cervical	**Thoracic**	**Lumbar**
No. of fragments	15	31	17
MNI	5	5	5
Survival	2 better-preserved sets; fragmentation of vulnerable points; loss of thin parts and archs; overall survivorship 31.4%	3 better-preserved sets, rest are extensively fragmented; loss of epiphyses; overall survivorship 47%	5 distinct sets; well-preserved bodies and fragmented but conjoinable transverse processes; loss of epiphyses; overall survivorship 68.8%
Fracturing	post mortem taphonomical breakage; cracks from corrosion	post mortem taphonomical breakage; detachment of processes and bodies; cracks from corrosion	Some processes and bodies were cut apart
Marks/Pathology	Shows varying stage of fusion; mostly young-looking and slightest degree of joint disease		

Table 4.15 Condition of Sacra

No. of fragments	9

MNI	5
Survival	1 intact, 1 preserved with damage on upper left part, 3 distinct sets of fragments; overall survivorship 48%
Fracturing	Breakage along epiphyseal lines, separation of the sacral crest; cracks due to increased humidity
Marks/Pathology	

Thorax

The ribs and the sternum form the thorax. By nature, this part is prone to fragmentation (Table 4.16, 4.17). However, despite being fragmented and commingled, the number of survived ribs shows that the majority of ribs of the buried individuals were present in the assemblage, with the right side slightly better preserved than the left side. On the contrary, the sterna, being flat bones, did not survive so much as one may expect. The taphonomic changes of the thorax agree with other units such as the shoulder or the vertebral column.

Table 4.16 Condition of Ribs

	Left	**Right**
No. of fragments	65	81
MNI	5	5
Survival	Extensive fragmentation and loss of ends; 1 total preserved whole adult rib, 10 sternal ends, 20 vertebral ends, 34 recognizable fragments	Extensive fragmentation and loss of ends; 2 total preserved whole adult rib, 15 sternal ends, 31 vertebral ends, 33 recognizable fragments; 116 unsided unknown fragments
Fracturing	Crack after contact with liquid, fracture at the fragile points, abrasion of edges	
Marks/Pathology		

Table 4.18 Condition of Sterna

No. of fragments	5
MNI	3
Survival	Separated and partially lost
Fracturing	Separation of the manubrium and the body or separation along the epiphyseal lines
Marks/Pathology	

Pelvis

The pelvic girdles in the assemblage show an interesting preservation pattern (Table 4.18). The large, fan-shaped iliac crests are mostly preserved, while the thin pubes had a completely different fate. It could also be noted that the left side experienced more corrosion during inhumation. Overall, the more robust, the better survival, and the young age of the individuals might have a negative impact on the survivorship of their pelves.

Table 4.18 Condition of Pelvic girdles

	Left	Right
No. of fragments	9	13
MNI	5	5
Survival	Overall survivorship of ilium, ischium and pubis is 72%, 38%, 20%, respectively; loss of epiphyses	
Fracturing	corrosion marks; post mortem breakage in the middle of illiac fossa, ischial ramus, pubic symphysis; loss of edges and exposure of trabecular bones	post mortem reakage at the fragile points and loss of edges and exposure of trabecular bones
Marks/Pathology	Noticeable muscular attachments on iliac crests	Porosity of about 30mm*10mm close to the anterior superior crest on one ilium, possibly inflammation

The Lower Limb

The lower limb consists of the femur, the patella, the tibia, the fibula, and the foot. It is the best-preserved unit in the assemblage, and the tibia is the element in the best condition (Table 4.18-4.21). Similar to the upper limbs, fresh cut marks were present on the shafts. The middle and lower parts of the lower limbs were better preserved than the hip joint, although some patellae were unfound. The lower limb bones in the assemblage have overall young and dry look. The robustness and less corrosion may explain the higher survivorship of the lower limbs.

The foot bones within the assemblage predominantly exhibited a relatively desiccated state, akin to the central portions of the bodies (refer to Table 4.23). Notably, the more substantial and distinct tarsal bones, particularly the calcaneus and talus, were well-represented, in contrast to the carpal bones. Collectively, the preservation status of the foot bones surpassed that of the hand bones, which is congruent with the superior preservation observed in the lower limb bones compared to the upper limb bones.

Table 4.19 Condition of Femora

	Left	Right
No. of fragments	9	7
MNI	5	5
Survival	1 intact, 1 recognizable fragment, 3 fragmented; 4 femoral heads; epicondyles well-preserved	2 intact, 2 fragmented but conjoinable, 1 recognizable fragment; 2 femoral heads; epicondyles well-preserved
Fracturing	Fracture along the femoral neck or at the upper 1/4 of the shaft; scraping, vertical cut marks	
Marks/Pathology		

Table 4.20 Condition of Patellae

	Left	Right
No. of fragments	3	5
MNI	3	5
Survival	The survived 7 and half (unfused juvenile bone) are very well preserved	
Fracturing	No sign of any joint disease	
Marks/Pathology		

Table 4.21 Condition of Tibiae

	Left	Right
No. of fragments	14	13
MNI	5	5
Survival	The most well-preserved element in the assemblage; overall survivorship more than 84.4%	
Fracturing	Abrasion on distal epiphyses	Separation of the shaft and the condyle and distal epiphysis
Marks/Pathology		

Table 4.22 Condition of Fibulae

	Left	Right
No. of fragments	9	7
MNI	5	5
Survival	2 proximal ends and 3 distal ends, shafts well preserved	1 proximal end and 4 distal ends; shafts well preserved

	Left	Right
Fracturing	Separation of the shaft and the ends, fracture at the lower 1/4 of the shaft	
Marks/Pathology		One fibula thinner than its left counterpart

Table 4.23 Condition of Foot Bones

		Left	Right
Tarsals	**No. of fragments**	18	15
	MNI	5	5
	Survival	Half lost, yet remaining ones are well-preserved and conjoinable; 5 tali and 5 calcanei; overall survivorship 58.3%	Half lost; 5 tali and 5 calcanei; damage of trabecular parts; overall survivorship 43.4%
	Fracturing	Crushing on less dense parts and breakage of trabecular bones; abrasion and pitting	
	Marks/ Pathology		
Metatarsals	**No. of fragments**	18	21
	MNI	39	
	MNE	4 conjoinable and pair-able sets (incomplete) and fragments from one juvenile; survived adult bones are mostly well-preserved; overall survivorship 52.4%	
	Survival	the ends were cut off; post mortem breakage at midshaft	
	Fracturing		
	Marks/ Pathology		
Foot phalanges	**No. of fragments**	33	
	MNI		
	Survival	13 proximal phalanges, 5 middle phalanges, 6 distal phalanges; loss of heads (juvenile)	
	Fracturing	Separation of heads	
	Marks/ Pathology		

Tooth

The state of preservation of the facial bones had a bearing on the survivorship of teeth. There are 76 sockets and 67 teeth preserved, which constitute approximately half of the total teeth (refer to Table 4.24). Caries, dental calculus, and linear enamel hypoplasia (LEH) were observed on the teeth and were utilized in the conjoining and identification process. One second molar and one third molar in the process of eruption were identified, along with one unerupted second premolar.

On the whole, the presence of caries and tooth loss attributable to caries was discernible in the dentition of all individuals. Notwithstanding this, the dentition of these individuals was notably white, robust, and intact. The sole deviation was observed in one individual, who exhibited pronounced deficiency in the enamel across all teeth (Image 4.2).

Table 4.24 Preservation of teeth

	Number
Tooth in socket	55
Isolated tooth	12
Tooth lost *ante mortem*	9
Tooth lost *post mortem*	12
Total preserved teeth	67
Total preserved sockets	76

Image 4.2 Presence of enamel hypoplasia on one teeth row

4.2 Biological information obtained from single bone elements

Sex assessment

From the exposition in the preceding section, it is evident that the assemblage comprises four adult individuals and one subadult individual. Prior to conducting a more comprehensive assessment, the initial step entails estimating the sex of the four adults.

The state of the cranial bones permitted only limited observation, rendering it challenging to evaluate the overall robustness of the crania, with the exception of one complete skull that exhibited masculine characteristics. Utilizing the methods delineated in Chapter 3 on the residual fragments, it was observed that the four mandibles possessed masculine traits, while the remainder of the morphological features that could be observed exhibited a range from smooth and neutral to feminine (refer to Table 4.25). The indeterminate status of the crania is indicative of the youthful age of the three adults.

Regrettably, the destruction of the pubis precluded the assessment of critical features of the pelvis such as the subpubic angle and subpubic concavities. The residual components of the four sets of pelvic girdles were all classified as either male or indeterminate (refer to Table 4.26).

Table 4.25 Sex determination by cranial features

Nr	Glabella	Supraorbital margin_L	Supraorbital margin_R	External occipital eminence	Mental eminence	Mastoid process_L	Mastoid process_R	Gonial angle_L	Gonial angle_R	Mandibular angle
1	3	5	5				3	M	M	M
2			2	3	1		2		M	
3		4		2	2		2	M	M	M
4	2		4		1			M		M

Key: 1 = hyperfeminine, 2 = feminine; 3 = indeterminate; 4 = masculine; 5 = hypermasculine; M= male, F= female

Table 4.26 Sex determination by pelvis

Nr	Ventral arc_L	Ventral arc_R	Arc composé_L	Arc composé_R	Sulcus preauricularis_L	Sulcus preauricularis_R	Greater sciatic notch_L	Greater sciatic notch_R
1		M	M	M	indeterminate	indeterminate	M	M
2				M	indeterminate	indeterminate		M
3	M	M	M	M	indeterminate	indeterminate		
4		M			indeterminate	indeterminate		

Age-at-death

The age of the individuals was estimated through an examination of pertinent morphological features of the pelvis and ribs, the stage of union, dental attrition, and a comparison of measurements, in accordance with the methodologies delineated in Chapter 3. Among the four adults, it is evident that one individual is in a transitional phase and is several years senior to the other three. The three younger adults were evaluated to be of a similar age (refer to Table 4.27). It is imperative to acknowledge that various methods yielded divergent and, at times, incongruent results. Given that the conflicting methods were applied to the same pelves, such discrepancies are unlikely to stem from commingling of bones, but rather suggest that all individuals are in their pubertal phase, during which the precision of all methods is diminished. In summary, the assemblage comprises one adult aged approximately 25-28 years, one aged around 23 years, and two others in the vicinity of 20 years. Accounting for potential errors, the results exhibit consistency.

Table 4.27 Age estimation of the adult individuals

Nr	Suchey & Brooks	McKern & Gilbert	Lovejoy 85	Buckberry & Chamberline	Iscan et al.	Stage of union	Dental wear
1	21-46 yrs	22-28 yrs	25-29 yrs	21-38 yrs	19-33 yrs	>25 yrs	20-24 yrs

Nr	Suchey & Brooks	McKern & Gilbert	Lovejoy 85	Buckberry & Chamberline	Iscan et al.	Stage of union	Dental wear
2	NM	NM	20-24 yrs	21-38 yrs	18-26 yrs	18-21 yrs	18-22 yrs
3	19-34 yrs	17-21 yrs	20-24 yrs	NM	18-26 yrs	18-21 yrs	20-24 yrs
4	19-34 yrs	18-21 yrs	25-29 yrs	NM	18-26 yrs	18-23 yrs	20-24 yrs

Table 4.28 Age estimation of the subadult

Nr	Ubelaker	Stage of union	Metrics	Iscan et al.
1	15 yrs ± 30 ms	13-15 yrs*	13-15 yrs	< 16 yrs

*: except for the humeri and ulnae, which are more mature and assessed to be 15-18 yrs

The age estimation methods employed consistently indicated the age of the subadult (refer to Table 4.28; the original data is not included in the main text due to space constraints). While it can be confidently asserted that this individual is approximately 14 years old, it is noteworthy that the developmental stage of the humeri and ulnae of the same individual is assessed to be between 15 and 18 years old. However, as the Minimum Number of Individuals (MNI) for all elements (as demonstrated in the preceding section) does not permit the inclusion of a sixth individual, and the obviously more mature appearance of other individuals negates the possibility of misclassification, it must be concluded that this subadult possessed upper limb bones that were developmentally advanced relative to his chronological age. A plausible explanation for this discrepancy could be the engagement in extensive physical activity involving the upper limbs during the individual's lifetime.

Stature estimation

Stature of the individuals were estimated by the formulae given by Trotter (1970), as they are recognized to be one of the most accurate formulae for Caucasians. Calculation was done in an element-by-element manner for all six limb bones (Table 4.29-4.35).

Table 4.29 Stature estimate by humerus

	Measurement (mm)	Trotter_male (cm) (± 4.05 cm)	Trotter_female (cm) (± 4.45 cm)
L_1	NM		
R_1	335	173.6	170.5
L_2	320	169.0	165.5
R_2	332	172.7	169.5
L_3	323	169.9	166.5
R_3	329	171.8	168.5
L_4	313	166.9	163.1
R_4	316	167.8	164.1
L_5	310	165.9	162.1
R_5	NM		

Table 4.30 Stature estimate by radius

	Measurement (mm)	Trotter_male (cm) (± 4.32 cm)	Trotter_female (cm) (± 4.24 cm)
L_1	248	172.8	172.5
R_1	NM		
L_2	NM		
R_2	NM		
L_3	248	172.8	172.5
R_3	248	172.8	172.5
L_4	NM		
R_4	223	163.3	160.6
L_5	NM		
R_5	NM		

The estimation showed that the three taller adults were above average in height, at approximately 174.7 cm, 173.6 cm, 171.9 cm (if male), or 172.4 cm, 171.5 cm, 169.2 cm (if female). In terms of height, they were more likely to be male. The different elements gave roughly consistent height figures, except for the tibia, which gives estimation results higher than others. This phenomenon may be the result of Trotter's formulae not being fully applicable to the subjects of the present study. For more accurate estimation results, anthropological data from the same period in Poland need to be consulted. In any case, for the purpose of this study, i.e., to obtain the approximate height of the subjects and thus help analyze the sex, age, identity, and health of the individuals, the present accuracy and precision are sufficient.

Table 4.31 Stature estimate by ulna

	Measurement (mm)	Trotter_male (cm) (± 4.32 cm)	Trotter_female (cm) (± 4.30 cm)
L_1	265	172.1	170.9
R_1	NM		
L_2	257	169.1	167.5
R_2	NM		
L_3	269	173.6	172.6
R_3	270	174.0	173.1
L_4	NM		
R_4	243	164.0	161.5
L_5	255	168.4	166.6
R_5	NM		

Table 4.32 Stature estimate by femur

	Measurement (mm)	Trotter_male (cm) (± 3.27 cm)	Trotter_female (cm) (± 3.72 cm)
L_1	469	173.0	169.9
R_1	NM		
L_2	460	170.9	167.7
R_2	461	171.1	168.0
L_3	463	171.6	168.5
R_3	459	170.7	167.5
L_4	410	159.0	155.4
R_4	410	159.0	155.4
L_5	466	172.3	169.2
R_5	NM		

The shortest of the four adults was approximately 163.8 cm tall if it is male, or 160.7 cm if it is female. Such a number is not unusual for a male, considering average body height of European males in the 1920s. However, it should be noted that the cranium of this individual also had a neutral morphology in terms of observable features. In addition, although all pelves were identified as male, the number of features for which we made a judgment was actually not sufficient. In summary, there is a slight possibility that this shortest individual is female. A different sex determination brings down the lower limit of the age estimation based on the degree of fusion, but does not affect the overall age estimation obtained by combining the methods.

Table 4.33 Stature estimate by tibia

	Measurement (mm)	Trotter_male (cm) (± 3.27 cm)	Trotter_female (cm) (± 3.66 cm)
L_1	391	177.2	177.4
R_1	390	176.9	177.1
L_2	381	174.6	174.5
R_2	380	174.4	174.2
L_3	393	177.7	178.0
R_3	394	177.9	178.3
L_4	355	168.1	167.0
R_4	350	166.8	165.5
L_5	391	177.2	177.4
R_5	393	177.7	178.0

Table 4.34 Stature estimate by femur+tibia

	Measurement (mm)	Trotter_male (cm) (± 2.99 cm)	Trotter_female (cm) (± 3.55 cm)
L_1	860	175.1	172.7
R_1	NM		
L_2	841	172.6	170.1
R_2	841	172.6	170.1
L_3	856	174.6	172.2
R_3	853	174.2	171.8
L_4	765	162.7	159.5
R_4	760	162.1	158.8
L_5	857	174.7	172.3
R_5	NM		

Stature of the subadult in the assemblage was also roughly estimated with Trotter's formulae, although in the original literature the formulae are applicable only to adults aged 18-30. Averaging all the calculations based on different elements results in a body height of about 171 cm if it is male, or 169 cm for a female. It is also shown that the humerus length of the juvenile is distinctly less than the length he should have for his height. This shortening corresponds to the premature fusion of the epiphyses of the humerus (see Table 4.28). Judging from the height, the juvenile is more likely to be male.

Table 4.35 Stature estimate by fibula

	Measurement (mm)	Trotter_male (cm) (± 3.29 cm)	Trotter_female (cm) (± 3.57 cm)
L_1	NM		
R_1	NM		
L_2	NM		
R_2	NM		
L_3	NM		
R_3	385	175.0	172.4
L_4	347	164.8	161.3
R_4	NM		
L_5	NM		
R_5	NM		

Health

As is presented in the tables in the previous section, no signs of disease were found on the human remains, except for a few isolated cases that will be elucidated below. There were no severe alterations in any skeletal morphology, nor were any traumas or fractures from the *peri mortem* phase found, with one possible exception described in the following paragraph. In addition, joint disease was extremely minimal or nearly absent. Neither *Cribra Orbitalia* (pitting on the superior wall of the orbit) nor *porotic hyperostosis* (thickening of the internal table of the frontal bone) are found on the observable remains, which implies a low likelihood of iron deficiency or metabolical diseases among them (Waldron, 2009).

One noteworthy pathological change was seen on one left ulna and its conjoining radius, that the proximal epiphysis of the radius is about one half of the size of the right radius, and the ulna is bent laterally and does not possess a distinct radial notch. The cause for such alteration can be various. One most straightforward and likely scenario is that at some point of the growth, the individual experienced a dislocation between the ulna and radius due to trauma or disease. The result is a deviation in skeletal development and the absence of the radial notch on the ulna. Two other cases of suspected healed fractures were seen on a mandible and a humerus. In addition, two suspected inflammatory changes were seen on a clavicle and an ilium. The cases of healed fractures are indicative of the experiences of these individuals during their lifetime, but there is no evidence that they are associated with violence or possible conflict, but most likely accidents. A list of all pathological changes can be found in the appendix. All of the skeletal changes presented in this paragraph are not, from the evidence we have, associated with serious health problems or cause of death.

Several non-metric traits such as lambdoid ossicles, mastoid foramen exsutural, bridged hypoglossal canal are also present on the remains, and were recorded according to BABAO guidelines. However, the variety of non-metric traits is small; their morphology is not prominent, and it is difficult to say that there are any statistical trend. A record of all non-metric traits can be found in the forms in the appendix.

The condition of the teeth gives us some additional information about the health and diet of these individuals. A total of 67 sites-at-risk of caries were found on 27 teeth. Among the sites-at-risks, 17 are mesial, 39 are occlusal and 11 are distal. The total presence rate is 19.3% (supposing each individual has 28 teeth). Dental calculus was present on 41 teeth, with 7 moderate to severe cases. The total presence rate is 29.3%. Enamel hypoplasia or dental defect was present on 21 teeth from 3 mandibles and 2 maxillae, with total presence rate of 15%. Furthermore, the overall *ante mortem* tooth loss rate is more than 6.4%, which is a bit high for the young age of the individuals. Based on the data recorded, we know that the dental attrition of these individuals according to Smith (1984) is slight to moderate and even can be lower than the age corresponding values obtained according to other age estimation methods (Table 4.27). It should also be noted that the alveolar resorption for all teeth was recorded as sharp, or no disease, according to the coding method by Ogden (2008), which can be interpreted as a good oral hygiene. As dental calculus often results from fibrous plant material in diet, it can be inferred that these individuals had a high sugar and alkaline (vegetable) diet during their lifetime, with the above information combined. Their diets were also refined. In addition, these individuals had a habit of cleaning their mouths. The above inference is consistent with the historical background of sugar industry, food processing industry and dentistry, which had already emerged in the nineteenth century and already became prevalent in the early twentieth century.

One interesting example worth mentioning is the enamel defect of one individual. The enamel defect was found on the teeth row of one mandible. The shape alteration was severe, and the teeth were almost mulberry-shaped. However, the appearance of the crown morphology of these teeth are different from typical Hutchinson teeth, thus ruled out the likelihood of congenital syphilis. Apart from that, there was no color change in these teeth, and the excavation site was not in a heavy metal mining area, making the possibility of heavy metal poisoning excluded. According to Hillson (2001) and other authors, cause of enamel hypoplasia may be hereditary, may due to fluorosis, or most commonly developmental. In conclusion, cause of this change in enamel morphology, generally referred to as a developmental dental defect, may be diverse and may have an influence on the overall developmental status (e.g., may affect body height).

Trauma

Within the entire assemblage, the sole morphological alteration suggestive of a fatal injury was a perforation observed on one occipital bone (refer to Image 4.3). This perforation is nearly circular, possesses well-defined edges devoid of secondary fractures, and measures 8 mm in diameter. Taking into account the prevalent rifle cartridge sizes during the period surrounding World War I, notably the 7.92×57mm Mauser, this puncture is highly likely to be a gunshot wound (GSW). A comparison with photographic data of gunshot and other penetrating wounds further substantiates this hypothesis.

It is important to note that based on visual observations, the bullet appears to have entered through the occipital bone and exited through the face. Such trajectories are atypical in combat casualties but are plausible. Certain scholars have conducted simulations of such trajectories (Mahoney et al., 2018). An alternative possibility is that the individual was executed post-capture.

Given the porosity observed on the inner surface of the adjacent bone to the occipital bone and the markedly low survivorship of the facial bone of this individual, there is reason to posit that the gunshot resulting in the perforation was fatal. However, no bullet-like metal objects were recovered among the small metal artifacts retrieved from the excavation. This suggests that the bullet likely passed through the skull and remained in the field, and was consequently not interred alongside the remains.

Image 4.3. Zoomed view of the perforation

It is worth reiterating that, apart from this singular perforation, no other blunt or sharp force trauma was detected on any of the bones. This negates the possibility that the five young men were battle-hardened veterans. Nonetheless, the data presented in this section suggests that overall these five individuals were healthy. In conjunction with historical epidemiological data, it is also improbable that they succumbed to sudden epidemics. In fact, considering that one among the five may have perished due to gunshot wounds, it can be inferred that all five met their demise through acts of violence. Although no trauma was observed on the remaining bones, literature on battlefield archaeology indicates that it is not uncommon for cold weapons to inflict wounds without leaving discernible marks on bones (Nicklisch et al., 2017).

4.3 Combining the data - reconstruction and osteobiographies for each individual

MNI and reconstruction

Through the systematic organization and analysis of bone elements, characteristics of each bone fragment were observed. Through visual inspection, bone elements were roughly grouped according to the individuals they likely belonged to. Essential measurements and characterizations of each bone, including teeth, were documented. The final distinction of individuals was achieved through a combination of methods such as articulation, feature comparison, and measurement comparison. Estimates for the overall preservation of several key skeletal units across different individuals were obtained (refer to Table 4.36). A minor portion of ribs, vertebrae, and bone fragments smaller than 2 cm could not be identified. From a scientific perspective, the inability to identify this minor fraction is inconsequential in terms of acquiring the necessary bioarchaeological data. Additionally, from a non-scientific standpoint, the absence of this small portion has negligible impact on the overall aesthetic and visual completeness of the skeletons.

By separating bone fragments of different individuals according to the protocol outlined in Chapter 3, and reassembling the individuals, the Minimum Number of Individuals (MNI) for this sample group was determined to be 5. Building on this, the osteobiographies of the five individuals, which will be discussed subsequently, were established.

Table 4.36 Survivorship of Each Individual (Selected Units)

# individual	Skull	Pelvis	Vertebrae	Ribs (NISP)	Limbs
LD-01	80.8%	56.7%	54.2%	28	74.3%
LD-02	20.8%	53.3%	56.7%	31	71.0%
LD-03	22.4%	46.7%	50.8%	36	80.7%
LD-04	21.6%	40.0%	36.7%	30	75.0%
LD-05	22.9%	20.0%	36.7%	21	69.3%

Table 4.37 Biological profile of individuals excavated from Ligota Dolna

# individual	Site	Age (±2 yrs)	Sex	Stature (cm)	Cause of death
LD-01	Ligota Dolna	26	male	174.7	violence
LD-02	Ligota Dolna	20	male	171.9	violence
LD-03	Ligota Dolna	20	male	173.6	violence
LD-04	Ligota Dolna	23	probably male	163.8	violence
LD-05	Ligota Dolna	14	probably male	174.9	violence

LD-01

The individual designated as LD-01, whose skull was initially transported in container No. 4, exhibited the most robust bones among the assemblage. The skeleton is characterized by a pale earthy color and is exceptionally well-preserved. The high preservation rate (refer to Table 4.36) facilitated a reliable estimation of the individual's sex and age (refer to Table 4.37).

LD-01 is a male who was approximately 26 years old at the time of death, with a stature of around 175 cm and a strong body. It is evident that LD-01's economic status was suboptimal prior to his demise, as indicated by the presence of multiple caries and two cavities on his teeth. Adjacent to two teeth with multiple sites at risk, there are two sockets where teeth were lost ante mortem. It is plausible that the tooth loss was a consequence of more advanced caries. Additionally, moderate to severe dental calculus and prominent Linear Enamel Hypoplasia (LEH), manifested as grooves on the teeth, indicate a lack of adequate oral hygiene.

LD-01 might have held a position within the insurgent forces. This speculation is supported by the discovery of metal and materials resembling leather in close proximity to his skull, which are suggestive of military attire. Determining the precise cause of LD-01's demise proves to be challenging.

LD-02

Individual LD-02's skull fragments were housed in container No. 2. Despite the bone measurements being akin to those of LD-01, LD-02 exhibits a notably darker hue, appears to be more hydrated, and is younger.

LD-02 is a male who was approximately 20 years old at the time of death, with a height of approximately 172 cm and a robust physique. In contrast to LD-01, LD-02 had a healed injury, as evidenced by the deformation of the ulna and radius, and exhibited better oral health with only moderate caries and minimal dental calculus. The absence of Linear Enamel Hypoplasia (LEH) in LD-02 suggests a higher economic status.

The cause of death for LD-02 is speculated to be a gunshot wound, supported by the presence of a potential bullet hole on the occipital bone.

LD-03

Individual LD-03, with skull fragments originating from container No. 1, bears a striking resemblance to LD-02 in numerous aspects, including the discernible bone fusion lines. However, LD-03's long bones are better preserved and the lower body is less hydrated. Additionally, LD-03's joints are noticeably wider compared to the other individuals.

LD-03 is identified as a male, estimated to be around 20 years old at the time of death, with a height of approximately 174 cm. Similar to LD-02, LD-03's oral health indicates a relatively higher economic status compared to LD-01. However, LD-03 exhibits Linear Enamel Hypoplasia (LEH) spanning from the left canine to the right canine, suggesting a potentially more stressful childhood. This could also imply that LD-03 had greater resilience compared to LD-02.

Determining the precise cause of death for LD-03 is challenging.

LD-04

Similar to individual LD-01, the skull fragments of individual LD-04 were discovered in container No. 4. A notable characteristic of LD-04 is its significantly shorter stature compared to the other individuals.

LD-04 is assessed to be probably male, approximately 23 years old at the time of death, with a height of around 164 cm. It is pertinent to highlight that LD-04 appears to have endured a challenging childhood. LD-04 exhibits well-fused epiphyses and dense bone tissue, and the dental examination reveals slight to moderate dental calculus on the remaining teeth. Additionally, there are sites at risk for caries on two teeth, with one exhibiting a large cavity. Notably, LD-04 had four teeth lost ante-mortem and an unerupted second premolar situated adjacent to two of the ante-mortem lost teeth. Furthermore, LD-04 exhibits severe linear enamel hypoplasia, characterized by a deep furrow on the incisors and canines, extending over the right and left premolars and molars. This condition may be attributed to nutritional deficiencies or stress experienced during childhood. The relatively shorter stature of LD-04 may also be indicative of the stress endured during this period.

Ascertaining the exact cause of death for LD-04 remains elusive.

LD-05

The cranial fragments of the juvenile individual LD-05 were initially scattered in container No. 3. The most distinguishing feature of LD-05 is its significantly younger age compared to the other individuals. Additionally, LD-05 was the least preserved among all, which may be attributed to its juvenile state.

LD-05 is assessed to be likely male, approximately 14 years old at the time of death, with a height of around 175 cm. Indications of an active lifestyle are evident in LD-05, as evidenced by two presumed healed fractures on the left humerus and mandible. Additionally, two ante-mortem lost teeth are possibly associated with the healed fracture on the mandible. The overall robustness of the bones and good oral hygiene, despite the tooth loss, reflect LD-05's favorable living conditions.

Given LD-05's tender age, it is plausible that he may have served as a page within the insurgent forces. Determining the precise cause of death for LD-05 is challenging.

Chapter 5 Discussion

5.1 Application of the protocol

The analysis of human remains from the Ligota Dolna excavation exemplifies the application of the protocol proposed in Chapter 3 of this thesis. Essentially, each step was executed as anticipated, demonstrating the protocol's reasonableness and feasibility. However, there are additional considerations regarding the details.

In practice, the rigorous implementation of the protocol posed certain challenges. The high degree of resemblance among individuals (in our case, three individuals) rendered the differentiation based on measurement data exceedingly difficult. Through the integration of joint morphology, attrition, and the extent of bone fusion, we managed to segregate similar individuals. Fortuitously, due to this high degree of resemblance, the outcomes of the differentiation do not impinge on the accuracy of the osteobiographical profiles of all individuals presented in this section.

Photos

The importance of taking photos cannot be overemphasized. There are three key moments in the process of analyzing that the skeletal remains should be photographically documented. They are at the time of excavation, at the time of packing the boxes, and at the end of the sorting and reconstruction. In the present study, the number of photographs was considerably insufficient and, in particular, the photographs at the time of excavation were not saved at all. A similar situation like ours would be detrimental for future reconstruction of the spatial relationship of the skeletons and the burials.

Recording

In this excavation, the human remains were not assigned individual codes for each bone fragment. Nonetheless, for more extensive and significant archaeological endeavors, it would be advantageous to meticulously package and assign codes to the excavated bone fragments based on their location at the time of excavation. Ideally, each bone fragment should be allocated a logical and unique code. Consequently, the raw data for bone identification can be incorporated into an electronic inventory, facilitating subsequent analysis, whether conducted on an element-by-element basis or by individual.

Reconstruction

Reconstruction has proven to be challenging. For elements with well-preserved joints, pairing is achieved through visual observation and comparison of measurements. In more comprehensive studies, this approach could be enhanced through the utilization of 3D scan matching. In instances where joints are not well-preserved, reliance on indirect methods is necessary. For instance, if the Minimum Number of Individuals (MNI) has been determined from a well-characterized portion of the human remains (e.g., pelvis), this number can serve as a basis for attempting to categorize other elements (e.g., femur). Additionally, once adjacent elements are paired, articulation of two sets of elements (such as femur and pelvis) can be attempted. In the present analysis, the initial step in reconstruction involved pairing of limb bones, a choice dictated by the superior preservation of these bones in our assemblage. However, under different circumstances, it might be feasible to commence with other well-preserved elements or to adhere to anatomical order. Owing to identification challenges, as well as constraints in time and resources, over a hundred small bone fragments were not subjected to analysis. In future research, such fragments could be incorporated in the analysis of fragmentation degree, burial conditions, and other factors.

Age assessment

Attempting to sort commingled bones by age proved to be overly optimistic. Firstly, there is a likelihood that the individuals are of similar age, particularly considering common causes of commingling such as the reutilization of burial sites, anthropogenic interference and disturbances, among others. Additionally, the techniques employed for estimating age have inherent limitations, and the outcomes may not consistently facilitate successful ordering by age. This study was not exempt from these challenges, and ultimately, only grouping by age was achieved. In future research, the approach of ordering by age will still be employed, but it is anticipated that other more precise metrics such as bone mineral density, will be incorporated.

5.2 Influence of methodology and methods on the results and possible source of error

Identification

As described in *Chapter 3, Section 3.1*, numerous bioarchaeologists and zooarchaeologists have acknowledged the potential for misidentification of bone fragments. In the current study, the identification primarily relied on qualitative methods such as visual observation, and the sources of error predominantly stemmed from three factors: the condition and degree of preservation of the bones, which encompassed erosion and fragmentation; inherent deviations of the individuals from the population mean; and the expertise of the researchers. Fortuitously, the burial sites involved in this study were limited in scale, and the aggregate number of bone fragments was also relatively small, which allowed for the establishment of an upper limit for the number of each bone element at the inception of the analysis. Through assiduous and meticulous comparison, collaborative discussions with colleagues, and validation through measurements, the majority of the larger fragments were accurately identified, as detailed in *Chapter 4, Section 4.1*.

MNI estimation

The estimation of the Minimum Number of Individuals (MNI) is contingent upon the maximum count of recurring bone elements. Consequently, there are two principal factors that contribute to the margin of error in MNI estimation. The first is misidentification, the underpinnings of which have been elucidated in the preceding subsection. The second pertains to the methodology employed in determining the MNI. The potential for underestimation of the number of individuals attributable to the latter has been cogently demonstrated by Boz and Hager (2014) in their investigation of commingled skeletons at Çatalhöyük. In the current study, the disparate elements were correlated and consistently indicated an MNI of 5. Taking into account the context of the burial under study, it is also improbable that diminutive bone fragments from additional individuals could have been intermixed. The likelihood of an error in the MNI estimation is exceedingly negligible.

Sex estimation

Generally, in the context of extensive commingled skeletal assemblages, the estimation of sex culminates in an array of sex ratios that are contingent upon the methodological approach and anatomical region employed in the estimation. Analogous to complete skeletons, potential inaccuracies may emanate from inherent limitations of the methodologies employed, deviations of the individuals from the normative standards, and incorrect ascertainment of ancestry. In the present study, the commingling of bones amplifies all three of these sources of error, thereby introducing additional uncertainty to the estimations. Ideally, the incorporation of quantitative methodologies such as DNA analysis would enhance the precision of the results. Furthermore, in the case of more extensive burials, the utilization of sophisticated statistical methodologies would prove advantageous.

Age-at-death estimation

The sources of error in estimating age-at-death bear resemblance to those encountered in sex estimation. Independent age assessment for each bone element yields an array of corresponding age distributions, or distributions pertaining to the number of bone fragments associated with each age cohort. In addition to the challenges intrinsic to age determination in the context of complete skeletons, the precision of estimation is attenuated in instances of commingled skeletons. This is due to the fact that the age range cannot be refined through cross-verification between bone elements of the same individual, or may be erroneously refined due to inaccuracies in the reconstruction process. This can also exacerbate the difficulty in arranging the ages in a sequential order. To address this issue, the incorporation of more robust reconstruction methodologies may prove beneficial.

Stature estimation

Given that a mathematical approach was employed to estimate stature, both the precision and accuracy were dependent upon not only the intrinsic error of the regression equation but also the potential misalignment between the equation and the applicability to the study group in question. Enhanced results are attainable when there is a well-preserved complete skeleton (in which case the Fully method can be employed) or a more refined regression equation. In essence, the stature estimation in this study should be regarded as an approximation.

Ancestry and ethnicity

The notion of ethnicity is situated within the cultural domain, whereas ancestry is rooted in biological underpinnings. In the context of this study, given that the ancestry of the participants in the uprising is anticipated to exhibit close biological affinity, there was no endeavor to employ more granular methods for ancestry delineation.

Based on the observations thus far, the reconstructions of human remains, along with their osteobiographies, do not present any incongruence with the identities of the Silesian insurgents as inscribed on the cover of the symbolic grave in proximity to their burial site.

Health, trauma, and cause of death

In the context of commingled human remains, pathological alterations or trauma can typically be analyzed on an element-by-element basis, accounting for the total instances and disparities among bone elements. Comparative analysis of occurrence frequencies with control groups is feasible. However, meticulous scrutiny is imperative when conducting an integrated health assessment of reassembled skeletons. Reconstruction inaccuracies can lead to erroneous estimations of individual pathologies. For instance, joint lesion counts may be over or underestimated due to bone mismatches. Additionally, disparate lesions, traumas, or developmental anomalies could be inaccurately correlated or overlooked due to reconstruction errors. Compounded with potential misalignment arising from the osteological paradox, this could culminate in conclusions that are diametrically opposed to reality.

Chapter 6 Conclusion

6.1 Conclusion

This study constructs osteobiographies for five individuals involved in the Third Silesian Uprising, based on human remains excavated from Ligota Dolna. The individuals were male, aged between 14-26 years, with heights ranging from 164-175 cm, generally in good health, with no evidence of war-related injuries or joint diseases. Dental analysis revealed variations in socioeconomic status and developmental history among the individuals.

Notably, the average height was relatively high, and the prevalence of enamel hypoplasia indicated a more varied spectrum of health profiles during childhood than anticipated. The age range of 20-30 years aligns with historical accounts of the uprising participants, and their relatively good health is indicative of the uprising's transient nature.

Intriguingly, among the group was a subadult, approximately 14 years old. This is noteworthy considering Poland's Cadet Day(Dzień Kadeta), a military holiday (Minister Obrony Narodowej: T. Siemoniak, 2013) for the youngest known fallen cadet, Karol Chodkiewicz, a 16-year-old cadet who was the youngest person to perish in the Cadet Corps.

The precise circumstances surrounding the demise of these insurgents remain ambiguous. The group could have been part of a five-person patrol, with the youngest serving as a messenger. Post-conflict, they were interred at the site of their demise (Leśniewski, 2021).

The type of burial artifacts, the orderly arrangement of the graves, and the relatively well-preserved state of the burial suggest that the insurgents were clad in uniforms and interred with respect. This implies a favorable disposition of the local populace towards the insurgents.

The aforementioned conclusion is predicated on the assumption that the reconstructed individuals accurately represent the actual individuals. Given that the skeletons in this study were commingled, there is a possibility that the findings may diverge from reality. Moreover, considering that the individuals in question hail from early 20th century Poland, the applicability of the reference methods and tables, which are predicated on data from populations geographically distinct from Upper Silesia, may have influenced the results.

A protocol, adapted from the procedures outlined by Nikita et al. (2019), is critically evaluated based on the empirical evidence gathered from this case study. The protocol was employed on a small-scale mass grave characterized by commingled and moderately fragmented bones (generally exceeding 5cm in size). It is anticipated that this procedure can be effectively scaled to accommodate larger samples while maintaining an acceptable margin of error. For cases involving more extensively fragmented bones, the approaches outlined by Osterholtz (2019) or Nikita et al. (2019) may be more appropriate. Nonetheless, it is strongly advised that all parties involved in the excavation process should endeavor to minimize post-exhumation fragmentation and commingling. Additionally, it is recommended that excavators meticulously document the original spatial distribution of the bones. The utilization of computerized spreadsheets is suggested for systematic recording and analysis at each stage of the process.

6.2 Further Discussion

The authors have not evaluated the potential implementation of the laboratory protocol from this study on commingled bones on a larger scale, but it is anticipated to offer several practical benefits:

- Efficiency in time management, as it initially assembles fragments, records data in bone element units, preserves the spatial relationships of original fragments, and reduces time spent on recording bone fragments.
- Digitization facilitates easy revisions and adjustments.
- Comprehensive data collection without loss.

- Facilitates collaboration among team members.

Furthermore, in this study, the analysis was conducted by a single researcher. For larger-scale studies, collaboration among multiple researchers is not only inevitable but also beneficial. A critical component for successful collaboration is the establishment of a well-defined protocol outlining descriptive and discriminative criteria. When multiple researchers are engaged in the analysis, suitable statistical tools can be employed to mitigate discrepancies arising from inter-researcher variability. Additionally, when resources allow, the utilization of advanced technologies such as 3D scanners and sophisticated database software is advisable.

Bibliography

Adams, B. (2014). Commingled remains: Field recovery and laboratory analysis. *Encyclopedia of Global Archaeology*, 1575–1580. https://doi.org/10.1007/978-1-4419-0465-2_144

Adams, B. J., & Byrd, J. E. (2014). *Commingled human remains: Methods in recovery, analysis, and identification*. Elsevier Academic Press.

Adams, B. J., & Konigsberg, L. W. (2008). How Many People? Determining the Number of Individuals Represented by Commingled Human Remains. In B. J. Adams & J. E. Byrd (Eds.), *Recovery, analysis, and identification of commingled human remains* (pp. 241–255). essay, Humana Press.

Alexander, D. H., Novembre, J., & Lange, K. (2009). Fast model-based estimation of ancestry in unrelated individuals. *Genome Research*, *19*(9), 1655–1664. https://doi.org/10.1101/gr.094052.109

Anastopoulou, I., Karakostis, F. A., Harvati, K., & Moraitis, K. (2021). Accurate and semi-automated reassociation of intermixed human skeletal remains recovered from bioarchaeological and forensic contexts. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-99962-x

Asala, S. A. (2001). Sex determination from the head of the femur of South African whites and blacks. *Forensic Science International*, *117*(1-2), 15–22. https://doi.org/10.1016/s0379-0738(00)00444-8

Baccino, E., Ubelaker, D. H., Hayek, L.-A. C., & Zerilli, A. (1999). Evaluation of seven methods of estimating age at death from mature human skeletal remains. *Journal of Forensic Sciences*, *44*(5). https://doi.org/10.1520/jfs12019j

Bass, W. M. (1995). *Human osteology: A laboratory and field manual*. Missouri Archaelogical Society.

Baustian, K. M. (2010). *Health status of infants and children from the Bronze Age tomb at Tell Abraq, United Arab Emirates* (thesis). UNLV Theses, Thesiss, Professional Papers, and Capstones. 355. http://dx.doi.org/10.34917/1598650

Baustian, K., & Anderson, C. (2015). Linking health and marriage practices among commingled assemblages: A case study from Bronze Age tell Abraq, UAE. *Theoretical Approaches to Analysis and Interpretation of Commingled Human Remains*, 207–218. https://doi.org/10.1007/978-3-319-22554-8_10

Baxter, J. E. (2005). 3 The Cultural Creation of Childhood: The Idea of Socialization. In *The Archaeology of Childhood: Children, gender, and material culture* (pp. 27–38). essay, AltaMira Press.

Bednarek, J., Bloch-Bogusławska, E., & Śliwka, K. (2002). Wykorzystanie zmian morfologicznych zachodzących w spojeniu łonowym do oceny wieku mężczyzn w populacji polskiej. *Archiwum Medycyny Sądowej i Kryminologii*, 52(4), 295-304.

Bennett, K. A. (1993). *A field guide for human skeletal identification*. C.C. Thomas.

Bower, B. (2010). Massacre at sacred ridge: A violent pueblo incident sparks debate regarding prehistoric genocide. *Science News*, *178*(10), 22–26. https://doi.org/10.1002/scin.5591781023

Boz, B., & Hager , L. D. (2014). Making Sense of Social Behavior from Disturbed and Commingled Skeletons: A Case Study from Çatalhöyük, Turkey. In A. J. Osterholtz, K. M. Baustian, & D. L. Martin (Eds.), *Commingled and disarticulated human remains: Working toward improved theory, method, and Data* (pp. 17–33). essay, Springer.

Brickley, M., & McKinley, J. I. (2004). *Guidelines to the standards for recording human remains*. BABAO, Dept. of Archaeology, University of Southampton.

Brooks, S. T. (1955). Skeletal age at death: The reliability of cranial and pubic age indicators. *American Journal of Physical Anthropology*, *13*(4), 567–597. https://doi.org/10.1002/ajpa.1330130403

Brooks, S., & Suchey, J. M. (1990). Skeletal age determination based on the OS pubis: A comparison of the ACSÁDI-Nemeskéri and Suchey-Brooks Methods. *Human Evolution*, *5*(3), 227–238. https://doi.org/10.1007/bf02437238

Brothwell, D. (1969). The study of archaeological materials by means at the scanning electron microscope: an important new field. In *Science in archaeology: a survey of progress and research* (pp. 564-566).

Buckberry, J. L., & Chamberlain, A. T. (2002). Age estimation from the auricular surface of the ilium: A revised method. *American Journal of Physical Anthropology*, *119*(3), 231–239. https://doi.org/10.1002/ajpa.10130

Buikstra, J. E., & Mielke, J. L. (1985). Demography, diet and health. In R. I. Gilbert & J. H. Mielke (Eds.), *The analysis of prehistoric diets* (pp. 359–422). essay, Academic Press.

Buikstra, J. E., & Ubelaker, D. H. (1994). *Standards for data collection from human skeletal remains*. Arkansas Archeological Survey.

Castillo, R. F., & López Ruiz, M. del. (2011). Assessment of age and sex by means of DXA Bone Densitometry: Application in Forensic anthropology. *Forensic Science International*, 209(1-3), 53–58. https://doi.org/10.1016/j.forsciint.2010.12.008

Citino, R. M. (2005). *The german way of war: From the Thirty Years' War to the Third reich*. (pp. 245-248). University Press of Kansas.

Clark, G. (1972). *Star Carr: A case study in Bioarchaeology* (Ser. McCaleb module in anthropology). Addison-Wesley.

Cox, M., & Mays, S. (Eds.). (2000). *Human osteology in archaeology and forensic science*. Cambridge University Press.

Cunha, E., Baccino, E., Martrille, L., Ramsthaler, F., Prieto, J., Schuliar, Y., Lynnerup, N., & Cattaneo, C. (2009). The problem of aging human remains and living individuals: A Review. *Forensic Science International*, *193*(1-3), 1–13. https://doi.org/10.1016/j.forsciint.2009.09.008

Demart. (2019). Trzecie Powstanie Śląskie (2 V-5 VIII 1921 r.). *Atlas historyczny do liceum ogólnokształcącego i technikum* (pp. 125). map, Warszawa; Demart.

DiGangi, E. A., Bethard, J. D., Kimmerle, E. H., & Konigsberg, L. W. (2009). A new method for estimating age-at-death from the first rib. *American Journal of Physical Anthropology*, *138*(2), 164–176. https://doi.org/10.1002/ajpa.20916

Dix, J. (2000). *Color atlas of forensic pathology* (pp. 77). CRC Press.

Falys, C. G., & Lewis, M. E. (2010). Proposing a way forward: A review of standardisation in the use of age categories and ageing techniques in osteological analysis (2004-2009). *International Journal of Osteoarchaeology*, *21*(6), 704–716. https://doi.org/10.1002/oa.1179

Falys, C. G., Schutkowski, H., & Weston, D. A. (2006). Auricular surface aging: Worse than expected? A test of the revised method on a documented historic skeletal assemblage. *American Journal of Physical Anthropology*, *130*(4), 508–513. https://doi.org/10.1002/ajpa.20382

The Federal Republic of Germany and the Republic of Poland. (1990, November 14). *Treaty between the Federal Republic of Germany and the Republic of Poland on* *the confirmation of the frontier between them*. Retrieved August 25, 2022, from https://www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TREATIES/DEU-POL1990CF.PDF

Fetner, R. A. (2019, July 19). The Manual for Recording Human Remains. Warsaw; Department of Bioarchaeology, Institute of Archaeology, University of Warsaw.

Fox, S. C., & Marklein, K. (2014). Primary and Secondary Burials with Commingled Remains from Archaeological Contexts in Cyprus, Greece, and Turkey. In A. J. Osterholtz, K. M. Baustian, & D. L. Martin (Eds.), *Commingled and disarticulated human remains: Working toward improved theory, method, and Data* (pp. 193–211). essay, Springer.

Gifford-Gonzalez, D. (2018). Chapter 9 Identification: Sorting Decisions and Analytic Consequences. In *An introduction to zooarchaeology* (pp. 169–183). essay, Springer.

Gilbert, B. M., & McKern, T. W. (1973). A method for aging the female os pubis. *American Journal of Physical Anthropology*, *38*(1), 31–38. https://doi.org/10.1002/ajpa.1330380109

Gill, G. W., & Rhine, S. (Eds.). (1990). *Skeletal attribution of Race: Methods for forensic anthropology* (Ser. Anthropological Paper No. 4). Maxwell Museum of Anthropology.

Gregoricka, L. A. (2021). Moving forward: A bioarchaeology of mobility and migration. *Journal of Archaeological Research*, *29*(4), 581–635. https://doi.org/10.1007/s10814-020-09155-9

Grove, M. A., & Lancy, D. F. (2018). Chapter 5 Cultural Models of Stages in the Life Course. In S. Crawford, D. M. Hadley, & G. Shepherd (Eds.), *The Oxford Handbook of the Archaeology of Childhood* (pp. 90–103). essay, Oxford University press.

GUS. (2011). *Ludność - struktura według ekonomicznych grup wieku. Stan w dniu 31.03.2011 r.* Urząd Statystyczny W opolu / dane O województwie / województwo / ludność. Retrieved August 25, 2022, from https://opole.stat.gov.pl/dane-o-wojewodztwie/wojewodztwo-1016/ludnosc-wyznania-religijne/

Halcrow, S. E., & Tayles, N. (2008). The bioarchaeological investigation of childhood and social age: Problems and prospects. *Journal of Archaeological Method and Theory*, *15*(2), 190–215. https://doi.org/10.1007/s10816-008-9052-x

Herrmann, N. P., & Devlin , J. B. (2008). Assessment of Commingled Human Remains Using a GIS-Based Approach. In B. J. Adams & J. E. Byrd (Eds.), *Recovery, analysis, and identification of commingled human remains* (pp. 257–269). essay, Humana Press.

Hillson, S. (2001). Recording dental caries in archaeological human remains. *International Journal of Osteoarchaeology*, *11*(4), 249–289. https://doi.org/10.1002/oa.538

Hosek, L., & Robb, J. (2019). Osteobiography: A platform for Bioarchaeology Research. *Bioarchaeology International*, *3*(1), 1–15. https://doi.org/10.5744/bi.2019.1005

Institute of National Remembrance. (2022, January 12). *Polish forces during the third uprising. numbers, structure, leaders*. Institute of National Remembrance. Retrieved September 1, 2022, from https://ipn.gov.pl/en/digital-resources/articles/9181,Polish-forces-during-the-Third-Uprising-Numbers-structure-leaders.html

İşcan, M. Y., Loth, S. R., & Wright, R. K. (1984). Metamorphosis at the Sternal Rib End: A new method to estimate age at death in white males. *American Journal of Physical Anthropology*, *65*(2), 147–156. https://doi.org/10.1002/ajpa.1330650206

Kancelaria Prezydenta. (2021, July 4). *Obchody 100. Rocznicy Zakończenia III powstania śląskiego*. Oficjalna strona Prezydenta Rzeczypospolitej Polskiej. Retrieved August 25, 2022, from https://www.prezydent.pl/aktualnosci/wizyty-krajowe/obchody-100-rocznicy-zakonczenia-iii-powstania-slaskiego,2800

Kastelik, S. (2022, July 18). *Autonomia dla górnego śląska? "Chcemy Być Szanowani. My Nie Bydymy Polokami"* . SILESIA24. Retrieved August 25, 2022, from https://silesia24.pl/wiadomosci/szczegoly/autonomia-dla-gornego-slaska-chcemy-byc-szanowani-my-nie-bydymy-polokami-wideo-37483

Klales, A. R., & Kenyhercz, M. W. (2014). Morphological assessment of ancestry using cranial Macromorphoscopics. *Journal of Forensic Sciences*, *60*(1), 13–20. https://doi.org/10.1111/1556-4029.12563

Klepinger, L. L., Katz, D., Micozzi, M. S., & Carroll, L. (1992). Evaluation of cast methods for estimating age from the os pubis. *Journal of Forensic Sciences*, *37*(3). https://doi.org/10.1520/jfs11988j

Krogman, W. M., & İşcan Mehmet Yaşar. (1986). *The human skeleton in Forensic Medicine*. Thomas.

Kunos, C. A., Simpson, S. W., Russell, K. F., & Hershkovitz, I. (1999). First Rib Metamorphosis: Its possible utility for human age-at-death estimation. *American Journal of Physical Anthropology*, *110*(3), 303–323. https://doi.org/10.1002/(sici)1096-8644(199911)110:3<303::aid-ajpa4>3.0.co;2-o

Landsmannschaft der Oberschlesier. (2017, January 27). *Volksabstimmung in Oberschlesien am 20. März 1921*. Retrieved August 25, 2022, from https://web.archive.org/web/20170121151033/http://home.arcor.de/oberschlesien-bw/abstimmung/gross-strehlitz.htm

Leśniewski, M. (2021, July 7). *Ceremonia Pogrzebowa Powstańców śląskich – Kalinów, 6 LIPCA 2021*. Instytut Pamięci Narodowej. Retrieved September 1, 2022, from https://ipn.gov.pl/pl/upamietnianie/biezaca-dzialalnosc-biu/146813,Ceremonia-pogrzebowa-Powstancow-Slaskich-Kalinowo-6-lipca-2021.html

Liczbińska, G., Czapla, Z., Nowak, O., & Piontek, J. (2016). Body mass index values of conscripts in the Polish lands under Prussian rule in the late 19th and early 20th centuries. *Economics & Human Biology*, *21*, 75–83. https://doi.org/10.1016/j.ehb.2015.11.007

Liversidge, H. M., & Molleson, T. (2004). Variation in Crown and root formation and eruption of human deciduous teeth. *American Journal of Physical Anthropology*, *123*(2), 172–180. https://doi.org/10.1002/ajpa.10318

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. https://doi.org/10.1002/ajpa.1330680105

Lovejoy, C. O., Meindl, R. S., Mensforth, R. P., & Barton, T. J. (1985b). Multifactorial determination of skeletal age at death: A method and blind tests of its accuracy. *American Journal of Physical Anthropology*, *68*(1), 1–14. https://doi.org/10.1002/ajpa.1330680102

Lovejoy, C. O., Meindl, R. S., Pryzbeck, T. R., & Mensforth, R. P. (1985a). 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. https://doi.org/10.1002/ajpa.1330680103

Lovell, N. C. (1989). Test of Phenice's technique for determining sex from the OS pubis. *American Journal of Physical Anthropology*, *79*(1), 117–120. https://doi.org/10.1002/ajpa.1330790112

Mahoney, P., Carr, D., Harrison, K., McGuire, R., Hepper, A., Flynn, D., Delaney, R. J., & Gibb, I. (2018). Forensic reconstruction of two military combat related shooting incidents using an anatomically correct synthetic skull with a surrogate skin/soft tissue layer. *International Journal of Legal Medicine*, *133*(1), 151–162. https://doi.org/10.1007/s00414-018-1802-z

Mall, G., Hubig, M., Büttner, A., Kuznik, J., Penning, R., & Graw, M. (2001). Sex determination and estimation of stature from the long bones of the arm. *Forensic Science International*, *117*(1-2), 23–30. https://doi.org/10.1016/s0379-0738(00)00445-x

Mansourvar, M., Ismail, M. A., Herawan, T., Gopal Raj, R., Abdul Kareem, S., & Nasaruddin, F. H. (2013). Automated Bone age assessment: Motivation, taxonomies, and challenges. *Computational and Mathematical Methods in Medicine*, *2013*, 1–11. https://doi.org/10.1155/2013/391626

Martrille, L., Ubelaker, D. H., Cattaneo, C., Seguret, F., Tremblay, M., & Baccino, E. (2007). Comparison of four skeletal methods for the estimation of age at death on White and Black Adults. *Journal of Forensic Sciences*, *52*(2), 302–307. https://doi.org/10.1111/j.1556-4029.2006.00367.x

McKern, T. W., & Stewart, T. D. (1957). Skeletal age changes in young American males analysed from the standpoint of age identification. *Natick, MA: Quartermaster Research and Development Command Technical Report*, *EP-45*. https://doi.org/10.21236/ad0147240

mindat.org, & Hudson Institute of Mineralogy. (2019, May 11). *Ligota Dolna, Gmina Strzelce Opolskie, Strzelce Co., Opole Voivodeship, Poland*. MINDAT. Retrieved August 25, 2022, from https://www.mindat.org/loc-246654.html mindat.org, & Hudson Institute of Mineralogy. (2021, June 27). *Gmina Strzelce Opolskie, Strzelce County, Opole Voivodeship, Poland*. MINDAT. Retrieved August 25, 2022, from https://www.mindat.org/loc-246653.html

Minister Obrony Narodowej: T. Siemoniak. (2013, December 27). *Decyzja Nr 432 / Mon Ministra Obrony Narodowej z dnia 24 grudnia 2013 r.* Dziennik Urzędowy Ministerstwa Obrony Narodowej. Retrieved August 31, 2022, from https://www.dz.urz.mon.gov.pl/zasoby/dziennik/pozycje/tresc-aktow/pdf/2013/12/Poz._387_dec__Nr_432.pdf

Miranker, M. (2016). A comparison of different age estimation methods of the adult pelvis. *Journal of Forensic Sciences*, *61*(5), 1173–1179. https://doi.org/10.1111/1556-4029.13130

Moorrees, C. F. A., Fanning, E. A., & Hunt, E. E. (1963). Age variation of formation stages for ten permanent teeth. *Journal of Dental Research*, *42*(6), 1490–1502. https://doi.org/10.1177/00220345630420062701

Mulhern, D. M., & Jones, E. B. (2004). Test of revised method of age estimation from the auricular surface of the ilium. *American Journal of Physical Anthropology*, *126*(1), 61–65. https://doi.org/10.1002/ajpa.10410

Nicklisch, N., Ramsthaler, F., Meller, H., Friederich, S., & Alt, K. W. (2017). The face of war: Trauma analysis of a mass grave from the battle of lützen (1632). *PLOS ONE*, *12*(5). https://doi.org/10.1371/journal.pone.0178252

Niedźwiedzki Robert. (2012). *Kamienne Skarby ziemi annogórskiej: Przewodnik Geologiczny* (pp. 33-34). Imagine Design Group.

Nikita, E., Karligkioti, A., & Lee, H. (2019). *Excavation and study of commingled human skeletal remains. Guide no.2*. Nicosia: The Cyprus Institute.

Norton, H. L., Quillen, E. E., Bigham, A. W., Pearson, L. N., & Dunsworth, H. (2019). Human races are not like dog breeds: Refuting a racist analogy. *Evolution: Education and Outreach*, *12*(1). https://doi.org/10.1186/s12052-019-0109-y

Nowak, O. (2011). *Wysokość i Masa Ciała Młodych mężczyzn W okresie przemian historycznych I Społeczno-Gospodarczych Drugiej Połowy Xix I początku Xx wieku na ziemiach polskich*. Wydawn. Naukowe UAM.

Ogden, A. (2008). Advances in the paleopathology of teeth and jaws. In R. Pinhasi & S. Mays (Eds.), *Advances in human palaeopathology* (pp. 283–307). essay, John Wiley & Sons.

Osterholtz, A. J. (2015). Bodies in motion: Identity and migration in cyprus during the bronze age. *Theoretical Approaches to Analysis and Interpretation of Commingled Human Remains*, 31–46. https://doi.org/10.1007/978-3-319-22554-8_3

Osterholtz, A. J. (2019). Advances in documentation of commingled and fragmentary remains. *Advances in Archaeological Practice*, *7*(1), 77–86. https://doi.org/10.1017/aap.2018.35

Osterholtz, A. J. (2019). Advances in documentation of commingled and fragmentary remains. *Advances in Archaeological Practice*, *7*(1), 77–86. https://doi.org/10.1017/aap.2018.35

Osterholtz, A. J., Baustian, K. M., Martin, D. L., & Potts, D. T. (2014). Commingled Human Skeletal Assemblages: Integrative Techniques in Determination of the MNI/MNE. In A. J. Osterholtz, K. M. Baustian, & D. L. Martin (Eds.), *Commingled and disarticulated human remains: Working toward improved theory, method, and Data* (pp. 34–50). essay, Springer.

Osterholtz, A. J., Martin, D. L., & Baustian, K. M. (Eds.). (2014). *Commingled and disarticulated human remains: Working toward improved theory, method, and Data*. Springer.

Oxford Languages. (n.d.). *Bioarchaeology: Meaning & definition for UK English*. Lexico Dictionaries | English. Retrieved August 25, 2022, from https://www.lexico.com/definition/bioarchaeology

Palmiotto, A., Brown, C., & LeGarde, C. (2019). Estimating the number of individuals in a large commingled assemblage. *Forensic Anthropology*, *2*(2). https://doi.org/10.5744/fa.2019.1002

Pałys, P. (2019). Kozacy w szeregach 1 Dywizjonu Ułanów Górnośląskich. *Studia Śląskie*, (84), 121–127.

Państwowy Instytut Geologiczny. (2004). *Objaśnienia Do Mapy Geośrodowiskowej Polski 1:50 000 Arkusz Strzelce Opolskie (875)* . Centralna Baza danych geologicznych. Retrieved August 25, 2022, from http://bazadata.pgi.gov.pl/data/mgsp/txt/mgsp0875.pdf

Phenice, T. W. (1969). A newly developed visual method of sexing the OS pubis. *American Journal of Physical Anthropology*, *30*(2), 297–301. https://doi.org/10.1002/ajpa.1330300214

Piontek, J., & Śmiszkiewicz-Skwarska, A. (1994). Metrical and Non-Metrical Analysis of Polish Crania from Early Midieval to Modern Times. *Anthropologie*, *XXXII*(1), 77–84.

Policja Opolska. (2022, June 7). *Czy Wiedzieliście że...?* Policja Opolska. Retrieved August 25, 2022, from https://opolska.policja.gov.pl/op/aktualnosci/69660,Czy-wiedzieliscie-ze.html

Quo vadis Silesia. (2021). *Volksabstimmung in Oberschlesien 20 März 1921*. Volksabstimmung in Oberschlesien - 20 März 1921. Retrieved August 25, 2022, from https://silesia-plebiscite.netlify.app/de/map.html

Raxter, M. H., Auerbach, B. M., & Ruff, C. B. (2006). Revision of the fully technique for estimating statures. *American Journal of Physical Anthropology*, *130*(3), 374–384. https://doi.org/10.1002/ajpa.20361

Rissech, C., Estabrook, G. F., Cunha, E., & Malgosa, A. (2006). Using the acetabulum to estimate age at death of adult males. *Journal of Forensic Sciences*, *51*(2), 213–229. https://doi.org/10.1111/j.1556-4029.2006.00060.x

Robb, J., Inskip, S. A., Cessford, C., Dittmar, J., Kivisild, T., Mitchell, P. D., Mulder, B., O'Connell, T. C., Price, M. E., Rose, A., & Scheib, C. (2019). Osteobiography: The History of the Body as Real Bottom-Line History. *Bioarchaeology international*, *3*(1), 16–31. https://doi.org/10.5744/bi.2019.1006

Rogers, T. L. (2009). Sex determination of adolescent skeletons using the distal humerus. *American Journal of Physical Anthropology*, *140*(1), 143–148. https://doi.org/10.1002/ajpa.21060

Safont, S., Malgosa, A., & Subirà, M. E. (2000). Sex assessment on the basis of long bone circumference. *American Journal of Physical Anthropology*, *113*(3), 317–328. https://doi.org/10.1002/1096-8644(200011)113:3<317::aid-ajpa4>3.0.co;2-j

Saul, F. P. (1972). The human skeletal remains of Altar de Sacrificios. An osteobiographic analysis. *PAP. PEABODY MUS.*, *63*(2), 3-123.

Schaefer, M., Scheuer, L., & Black, S. M. (2009). *Juvenile osteology a laboratory and Field Manual*. Academic.

Scheuer, L., Black, S., & Christie, A. (2010). *Developmental juvenile osteology*. Elsevier.

Schoeninger, M. J., & Moore, K. (1992). Bone Stable Isotope Studies in archaeology. *Journal of World Prehistory*, *6*(2), 247–296. https://doi.org/10.1007/bf00975551

Schutkowski, H. (1993). Sex determination of infant and juvenile skeletons: I. Morphognostic features. *American Journal of Physical Anthropology*, *90*(2), 199–205. https://doi.org/10.1002/ajpa.1330900206

Scott, D. D., & McFeaters, A. P. (2010). The Archaeology of Historic Battlefields: A History and Theoretical Development in conflict archaeology. *Journal of Archaeological Research*, *19*(1), 103–132. https://doi.org/10.1007/s10814-010-9044-8

Sládek, V., Galeta, P., & Sosna, D. (2012). Measuring human remains in the field: Grid technique, total station, or microscribe? *Forensic Science International*, *221*(1-3), 16–22. https://doi.org/10.1016/j.forsciint.2012.03.018

Smith, B. H. (1984). Patterns of molar wear in hunter-gatherers and agriculturalists. *American Journal of Physical Anthropology*, *63*(1), 39–56. https://doi.org/10.1002/ajpa.1330630107

Smith, B. H. (1991). 8 Standards of human tooth formation and dental age assessment. In M. A. Kelley & C. S. Larsen (Eds.), *Advances in dental anthropology* (pp. 143–168). essay, Wiley-Liss Inc.

Sojka, E. (2021). Decolonizing Upper silesia: Reclaiming and validating a hybrid culture in scholarly and literary discourses. *Cultural Change in East-Central European and Eurasian Spaces*, 169–193. https://doi.org/10.1007/978-3-030-63197-0_11

Stevenson, J. C., Mahoney, E. R., Walker, P. L., & Everson, P. M. (2009). Technical note: Prediction of sex based on five skull traits using decision analysis (CHAID). *American Journal of Physical Anthropology*, *139*(3), 434–441. https://doi.org/10.1002/ajpa.21042

Stevenson, P. H. (1924). Age order of epiphyseal union in man. *American Journal of Physical Anthropology*, *7*(1), 53–93. https://doi.org/10.1002/ajpa.1330070115

Todd, T. W. (1920). Age changes in the pubic bone. i. the male white pubis. *American Journal of Physical Anthropology*, *3*(3), 285–334. https://doi.org/10.1002/ajpa.1330030301

Tooley, T. H. (1988). German political violence and the border plebiscite in Upper Silesia, 1919–1921. *Central European History*, *21*(1), 56–98. https://doi.org/10.1017/s0008938900012668

Trotter, M., & Gleser, G. C. (1952). Estimation of stature from long bones of American Whites and Negroes. *American Journal of Physical Anthropology*, *10*(4), 463–514. https://doi.org/10.1002/ajpa.1330100407

Trotter, M., & Gleser, G. C. (1958). A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. *American Journal of Physical Anthropology*, *16*(1), 79–123. https://doi.org/10.1002/ajpa.1330160106

Ubelaker, D. H. (1987). Estimating age at death from immature human skeletons: An overview. *Journal of Forensic Sciences*, *32*(5). https://doi.org/10.1520/jfs11176j

Ubelaker, D. H. (1999). *Human skeletal remains: Excavation, analysis, interpretation*. Taraxacum.

Ubelaker, D. H., & Volk, C. G. (2002). A test of the Phenice method for the estimation of sex. *Journal of Forensic Sciences*, *47*(1). https://doi.org/10.1520/jfs15200j

The University of York . (2010, July 30). *Policy and guidance on the deposition of personal, confidential and sensitive data*. Archaeology Data Service. Retrieved August 31, 2022, from https://archaeologydataservice.ac.uk/advice/sensitiveDataPolicy.xhtml

Viciano, J., Alemán, I., D'Anastasio, R., Capasso, L., & Botella, M. C. (2011). Odontometric Sex discrimination in the Herculaneum Sample (79 AD, Naples, Italy), with application to juveniles. *American Journal of Physical Anthropology*, *145*(1), 97–106. https://doi.org/10.1002/ajpa.21471

Vora, R. K., & Patel, S. M. (2019). Determination of sex from epicondylar breadth of femur. *Academia Anatomica International*, *5*(1). https://doi.org/10.21276/aanat.2019.5.1.17

Waldron, T. (2009). *Palaeopathology*. Cambridge University Press.

Walker, P. L. (2005). Greater Sciatic Notch Morphology: Sex, age, and population differences. *American Journal of Physical Anthropology*, *127*(4), 385–391. https://doi.org/10.1002/ajpa.10422

White, T. (1953). A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. *American Antiquity, 18*(4), 396-398. doi: 10.2307/277116

White, T. D., & Folkens, P. A. (2005). 18.6 Metric Acquisition and Analysis. In *The human bone manual* (pp. 340–344). essay, Elsevier Academic Press.

White, T. D., Black, M. T., & Folkens, P. A. (2011). *Human osteology*. Academic Press.

Wood, J. W., Milner, G. R., Harpending, H. C., Weiss, K. M., Cohen, M. N., Eisenberg, L. E., Hutchinson, D. L., Jankauskas, R., Cesnys, G., Katzenberg, M. A., Lukacs, J. R., McGrath, J. W., Roth, E. A., Ubelaker, D. H., & Wilkinson, R. G. (1992). The osteological paradox: Problems of inferring prehistoric health from skeletal samples [and comments and reply]. *Current Anthropology*, *33*(4), 343–370. https://doi.org/10.1086/204084

Zejdlik, K. J. (2014). Unmingling Commingled Museum Collections: A Photographic Method. In A. J. Osterholtz, K. M. Baustian, & D. L. Martin (Eds.), *Commingled and disarticulated human remains: Working toward improved theory, method, and Data* (pp. 173–192). essay, Springer.