Review

Human Mobility in the Central and Eastern Mediterranean during Hellenistic and Roman Times: The Potential and Limitations of Bioarchaeological Research

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ABSTRACT: This paper offers a review of bioarchaeological research on human mobility during the Hellenistic and Roman period in the Central and Eastern Mediterranean. This period was marked by significant connectivity amidst the establishment of major political entities. The paper begins with an overview of bioarchaeological methods used to study past mobility, including biodistance, isotopic and ancient DNA analyses. It then examines published studies that have utilized these methods to explore mobility during the Hellenistic and Roman periods. The paper concludes by critically assessing the current research limitations and proposing directions for future studies. These suggestions emphasize the importance of conducting additional research to investigate human mobility in neglected areas, as well as at different temporal and spatial scales. Integrating mobility data with other sources of evidence, such as historical accounts, paleoenvironmental data and osteobiographic information is another important future direction of research. Finally, relevant research should be more theoretically informed and its contemporary implications should be effectively communicated within and beyond the academic community. An enhancement of our understanding of the nature and impact of mobility is crucial in today's society, where misconceptions linking immigration to the decline of the Roman Empire can perpetuate biases against contemporary mobility.

Keywords: Paleomobility; Isotopes; Ancient DNA; Biodistance; Greco-Roman

1. Introduction

This paper offers an overview of paleomobility studies in the Central and Eastern Mediterranean during the Hellenistic and Roman period, a period renowned for its widespread interconnectedness. The Central and Eastern Mediterranean region has been chosen because it was largely part of both the Hellenistic and the Roman world. The aim is to assess the extent to which human mobility, a major driver of connectivity and interaction, has been explored bioarchaeologically; hence, through the most direct evidence of past people in motion, their skeletal remains. By identifying gaps in current knowledge, the article proposes a roadmap for future research initiatives.

In order to discuss the movement of people in the Hellenistic and Roman periods, it is essential to first clarify the difference between "mobility" and "migration." Various definitions have been proposed, typically based on the distance traveled and the duration of the journey [1]. In this study, mobility is defined as a broad term encompassing all forms of human movement, while migration specifically refers to more permanent and long-distance relocation. However, it is recognized that distinguishing between migration and other types of mobility can be challenging, as human movement occurs on a spectrum.

The Hellenistic and Roman periods witnessed an unprecedented level of connectivity across the Mediterranean, facilitated by internal trade, efficient transportation systems, military campaigns, and relatively unrestricted movement of people [2]. The intricate web of connectivity that characterized the Hellenistic and Roman societies largely shaped the political landscape of Europe and the Mediterranean that we see today. Given its importance, scholars have extensively examined human mobility during this period through the analysis of written records (especially epigraphic and papyrological evidence) and archaeological findings.

In what concerns the motivations of mobility, numerous studies have identified two main factors: the desire to escape from unfavorable circumstances (referred to as "push" factors) and the attraction of better opportunities elsewhere (known as "pull" factors). Throughout history, individuals have often been compelled to move in order to survive and reconstruct their lives in the aftermath of disasters such as epidemics, natural disasters and warfare. This phenomenon was also observed during the Hellenistic and Roman periods, where military campaigns resulted in the displacement of certain segments of the population who either participated in these operations, sought refuge, or were taken as slaves. The state's exigencies dictated the recruitment and deployment of individuals from specific groups to particular destinations, with occasional relocations and the resettlement of veterans occurring as well. Nonetheless, there were instances of people returning to their original homes [3–5]. The slave trade also facilitated movement to specific destinations, with certain locations being favored for sourcing slaves at different points in time. As urban networks developed, the preferred slave trade destinations also shifted [5]. Additionally, historical records indicate that natural disasters and epidemics during the Hellenistic and Roman periods likely prompted human mobility, although the specifics of disaster-induced movement are not well-documented. In terms of factors that attract individuals to relocate voluntarily, it is reasonable to assume that settlers would be drawn to regions that provide improved economic prospects and safety [2].

With regard to the extent of human mobility, the overall picture that emerges is one of substantial interconnectedness at a smaller, local level, while connectivity diminished considerably on a larger scale [6]. It seems that mobility was predominantly regional in nature, with only a small number of individuals undertaking long distance journeys [2,5]. The movement of individuals between neighboring regions was common for purposes such as seasonal employment, marriage, and commerce. In contrast, individuals who traveled over longer distances were typically those with specialized skills, military personnel, or slaves [5,6]. This pattern of limited long-distance movement coupled with strong regional interconnectivity holds great significance. As per network theory, even minimal interaction between closely interconnected systems at a localized scale can yield significant consequences [6], while even a small number of individuals traveling long-distance could have promoted considerable connectivity [5].

Special mention should be made to the mobility of demographic groups under-represented in textual sources, such as women. The movement of women during the Hellenistic and Roman periods has primarily been studied within the framework of the slave trade, where it has been recognized that a significant number of women were relocated as slaves. Other forms of female mobility have received limited attention from ancient historians. Marriage must have instigated female mobility as women would typically move into their husband's or his father's household, although normally such marital mobility was regional [2]. Nonetheless, women accompanied to some extent their husbands, for example, when these were relocated for military service or settled at veteran colonies [7]. A dissertation specifically focused on female mobility in the Hellenistic world has additionally highlighted the significant role that women played in the colonization initiatives of the period. Although most females moved due to their male relatives' activities (mercenaries, soldiers, exiles, refugees), some women had their own reasons for traveling. For example, increasing specialisation in urban manufacture, especially the textile industry, provided new opportunities for Hellenistic women to travel in search of work. Women involved in professions such as healthcare or sex work were especially mobile, with many being slaves or metic women. Women also traveled for artistic, athletic, and religious pursuits, contributing to the cultural longevity of the Hellenistic kingdoms [8].

Although textual data offer valuable insights, they present inherent biases that can skew our understanding of Hellenistic and Roman mobility patterns when used as the sole source of information. Funerary epitaphs, for example, may overemphasize the presence of foreigners due to a tendency to mention individuals who died away from their place of origin. Conversely, the extent of mobility may be downplayed in such sources as many individuals likely returned to their hometown before their death [5]. Therefore, it is important to integrate diverse lines of evidence to explore Hellenistic/Roman mobility. Tracy Prowse [9] made a strong case for the integration of isotopic evidence with historical, epigraphic and archaeological data. This paper seeks to expand upon the bioarchaeological evidence that can provide insights into past mobility by focusing not just on isotopic analysis, but also on biodistance analysis and ancient DNA (aDNA). Isotopes can identify so-called nonlocals and offer some potential options for their point of origin, biodistances offer insights to population structure and history, while aDNA can reveal ancestry patterns. Therefore, these bioarchaeological approaches provide crucial complementary information.

Although the historical significance of human mobility has long been recognized, particularly in shaping the character of the Hellenistic and Roman societies, recent decades have emphasized the negative aspects of mobility, eliciting strong emotional responses in certain segments of society [10]. This shift in perception coincides with increased connectivity in the modern world. In light of Tim Cresswell's [11] assertion that understanding contemporary mobilities requires an understanding of past mobilities, this paper seeks to analyze the bioarchaeological evidence related to mobility in the Hellenistic and Roman periods, to define where we stand and where we should be heading in terms of understanding this complex phenomenon and its implications in the past and present.

2. Bioarchaeological Methods to Approach Paleomobility

This section will provide a concise overview of the bioarchaeological methodologies utilized in investigating past mobility patterns. These methodologies can be categorized into three main groups: biodistance analysis, isotopic analysis, and ancient DNA (aDNA) analysis. Each of these methods offers unique perspectives on past mobility and complements the others.

Biodistance analysis utilizes skeletal phenotypic traits to infer information about individuals' genotype and assesses the biological relatedness between different individuals and groups [12]. This analysis is grounded on the premise that cranial and dental shape and size are partly determined genetically. Studies have reported varying levels of heritability for different phenotypic traits, with an average estimate of 0.5, indicating that approximately half of the observed phenotypic variability can be attributed to genetic factors [13]. Therefore, individuals or groups sharing similar cranial and dental characteristics have a small biodistance and are likely to be genetically related. Conversely, individuals or groups with different phenotypes are likely to have a larger biodistance [14]. A small biodistance may indicate common ancestry, mobility (and resulting gene flow), or other factors. As such, biodistance analysis has been used to explore past population structure, that is, affinity patterns among contemporary populations, and population history, that is, biodistance patterns among populations over time [15]. Biodistances can be calculated for individual or group comparisons, with phenotypic data being converted into distance values that indicate similarity or dissimilarity [16,17]. Various distance measures, such as adaptations of Mahalanobis' generalized distance [18,19], the Mean Measure of Divergence [16,20], and the Gower similarity coefficient [21], are used depending on the type of phenotypic variables being analyzed.

Biodistance analysis has the advantage that it is non-destructive and easily applicable, as it does not require specialized equipment for data capture or analysis. A limitation of this method is that the interpretation of the results is not straightforward; a small biodistance may not necessarily indicate mobility, but could instead suggest a shared ancestry or other factors. Even when a small biodistance is the result of mobility, the timing of the mobility event(s) cannot be definitively determined solely through biodistance data. Therefore, it is crucial for researchers to consider historical, archaeological, or other contextual information when formulating research questions and interpreting results.

Isotopes are variants of natural elements with the same number of electrons and protons but differing numbers of neutrons [22]. Oxygen ($\delta^{18}O$) and strontium ($^{87}Sr/^{86}Sr$) isotopes have been extensively utilized in the examination of past human mobility. The incorporation of these isotopes into bones and teeth is primarily attributed to the ingestion of food and liquids containing them [23]. The oxygen isotopes present in skeletal remains are largely ingested from local water sources, reflecting the oxygen composition of the precipitation in the region [24]. The $\delta^{18}O$ composition in precipitation exhibits consistent geographical patterns worldwide, and researchers have constructed maps depicting the average $\delta^{18}O$ values in contemporary precipitation at various regional levels [25,26]. When the oxygen isotope ratios detected in an individual's skeletal remains align with the anticipated values in the region of burial, the individual is categorized as "local"; conversely, if the values diverge, the individual is designated as "nonlocal" [24]. Strontium is introduced into the human body through dietary intake, and the proportion of isotopes present in the consumed foods is connected to the $^{87}Sr/^{86}Sr$ ratios found in the soils that produced them [27]. Due to the potential influence of environmental factors on strontium levels in soils, researchers conducting isotope studies rely on estimated "bioavailable" $^{87}Sr/^{86}Sr$ values obtained from non-migratory animals or contemporary plants [28]. Similar to the analysis of oxygen isotopes, the comparison of $^{87}Sr/^{86}Sr$ ratios between dental samples and the surrounding environment of a buried individual allows for the determination of geographic origin; if the values are consistent, the person is considered "local", while a mismatch indicates a "nonlocal" classification [27]. In the above cases, the distinction between "local" and "nonlocal" is contingent upon the skeletal tissues under examination. When analyzing strontium isotopes, dental enamel is the only suitable tissue to analyze, providing insight into whether individuals spent their childhood (when tooth crown formation occurred) at the location where their remains were discovered [29]. On the other hand, oxygen isotopes can be measured in enamel, dentine, or bone. Enamel analysis can offer information on early life mobility patterns, while dentine and bone, which undergo continual remodeling, can indicate mobility over several years leading up to an individual's death [24]. Researchers may also sample multiple tissues from the same individual, with different formation and remodeling rates, as well as conduct incremental analysis on the same tissue to gain a nuanced understanding of an individual's mobility at different stages of their life [30,31].

Isotope analysis is the most direct method for determining past mobility and it is especially useful for identifying first-generation migrants. However, it is costly, requires access to specialized laboratories, and is destructive to samples. In addition, the results obtained from isotopic analysis cannot definitively pinpoint a person's origin, as multiple regions could share similar isotopic signatures [9,32]. Moreover, isotopic analyses are limited in their ability to account for short-term residency or frequent movements. As explained above, most isotopic studies examine residence/mobility during early life stages or prior to death, assuming a single mobility event. This limitation can be partly mitigated by analyzing multiple samples from teeth and bones of the same individual or conducting incremental analysis of the same tissue [33]. Finally, the intricacy of human behavior in the past can introduce variations in isotopic findings. For instance, individuals may consume water that does not possess the same isotopic composition as the local precipitation. This can occur for example when water is sourced from other areas through aqueducts [34]. Additionally, food preparation activities such as brewing or boiling can affect the $\delta^{18}O$ values of liquids consumed by individuals [35]. Strontium isotopes may also be affected by factors such as the sea-spray effect in coastal regions, pollution, use of fertilizers, sand-blown dust, and other natural and human-induced influences, altering their bioavailable values [36,37].

The analysis of ancient DNA (aDNA) can provide insights into intergenerational human movement in historical populations through changes in genetic ancestry [38]. Studies in this area typically assess the extent of shared ancestry among individuals or groups across various geographical and temporal contexts, while algorithms have also been developed to interpolate the spatiotemporal distribution of genetic ancestry [39]. Researchers have targeted different components of the genome in relevant analyses, with mitochondrial DNA (mtDNA) often favored for exploring female-driven mobility due to its abundance and high mutation rate [40]. Nuclear DNA, including the paternally inherited Y chromosome, has also become increasingly important in ancient population research following advancements in decontamination, authentication, extraction, and sequencing techniques [41,42].

The use of ancient DNA as an analytical tool has seen unique advancements, but it is a costly and destructive method that requires access to highly specialized laboratories. Additionally, its applicability is limited in certain environmental contexts where the preservation of genetic material is minimal. Importantly, ancient DNA analysis can only provide information about genetic ancestry and not directly determine mobility. To fully understand mobility events, it is necessary to consider other forms of evidence in conjunction with the ancestry data provided by ancient DNA analysis.

3. Palaeomobility Studies in the Hellenistic and Roman World

A review of bioarchaeological research on Hellenistic and Roman mobility in Central and Eastern Mediterranean yielded 52 results, including academic papers, book chapters, excavation reports, conference presentations, and graduate theses. The map of Figure 1 depicts the sites that have been examined in the context of the above research, and the following sections will briefly present selected studies to demonstrate the development of research in this region from the 1980s to the present day, as well as highlight areas where further work is needed.

3.1. Early Studies (1980s–1990s)

All studies included in this review, which date back to the 1980s, focused on Jewish remains. These studies primarily examined cranial metric and/or cranial and postcranial nonmetric variation and provided detailed descriptive tables and comparisons with other sites. However, an explicit biodistance analysis was not conducted. For example, Arensburg and Smith [43] studied the Jewish population of Jericho from 100 BCE to 70 CE. They provided a comprehensive description of the remains, including information on demography, pathology, stature, and craniometrics. The craniometric data is particularly relevant to paleomobility studies. The authors presented tables with summary statistics for various cranial measurements in Jericho, as well as comparative assemblages from Hellenistic and Roman period sites in Israel. They found that there was a general similarity in cranial shape among Second Temple populations, but differences compared to earlier and later period remains. However, they did not discuss the implications of these patterns for the mobility and connectivity of the Hellenistic-Roman groups. Similarly, Smith and Zias [44] provided craniometric data on a Late Hellenistic assemblage from the French Hill Tomb in Jerusalem, along with demographic and pathological information. Although they did not explicitly conduct a biodistance analysis, they compared their craniometric data descriptively to other contemporary assemblages in Israel and found an overall similarity.

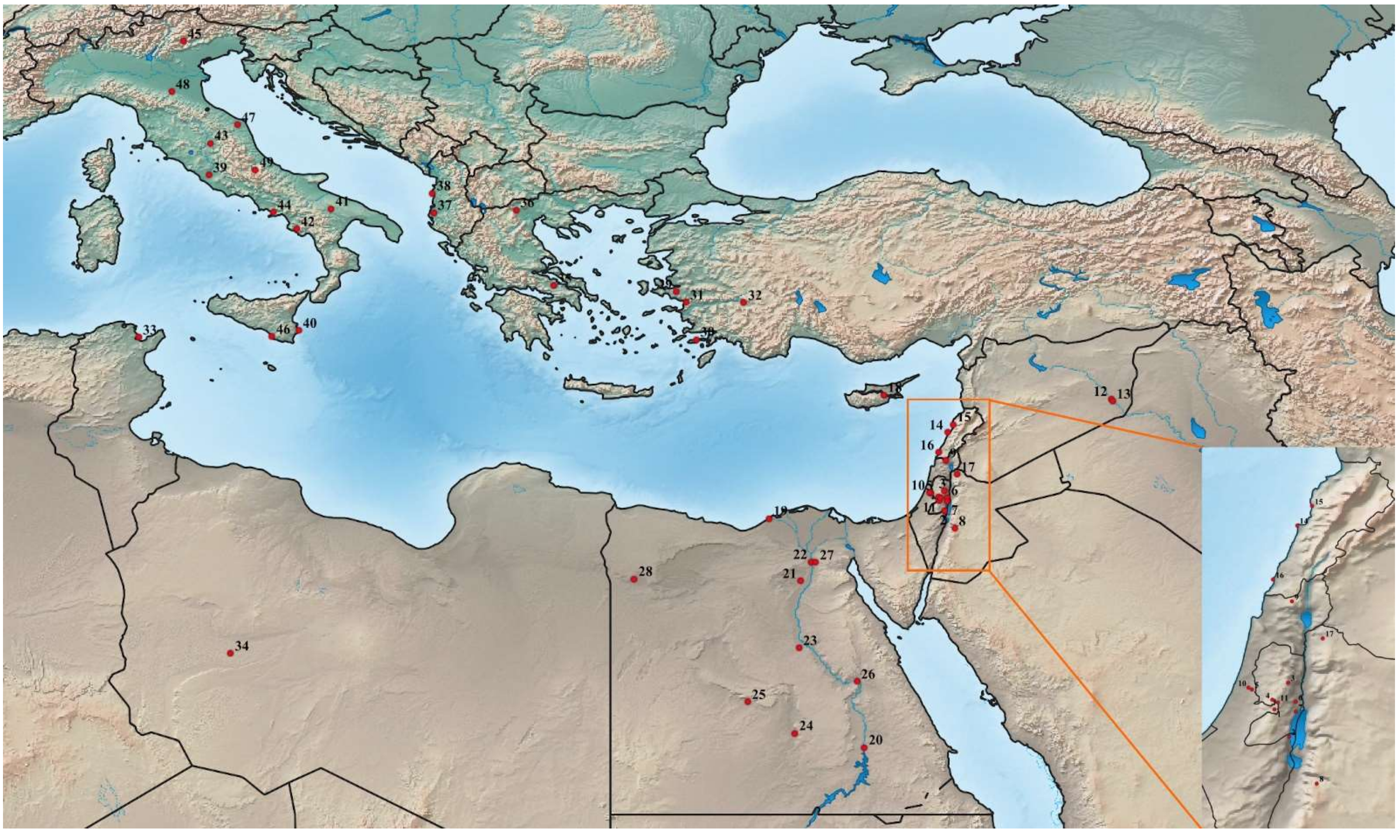

Figure 1. Map depicting Hellenistic and Roman period sites in the Central and Eastern Mediterranean that have been examined in the context of paleomobility studies. Key: 1. Jerusalem, 2. Ein Gedi, 3. Gifne, 4. Bira Dawali, 5. Shoham, 6. Jericho, 7. Qumran, 8. Khirbet edh-Dharih, 9. Meiron, 10. Tel Hadid, 11. Tell en-Naşbeh, 12. Tell Masaikh, 13. Jebel Mashtale, 14. Beirut, 15. Byblos, 16. Tyre, 17. Barsinia, 18. Mağara Tepeşi, 19. Alexandria, 20. el-Hesa, 21. Hawara, 22. Saqqara, 23. Manfalut, 24. Douch, 25. Dakhleh Oasis, 26. Denderah, 27. Shurafa, 28. Siwak, 29. Cevizcioğlu Çiftliği, 30. Datça-Burgaz, 31. Ephesus, 32. Hierapolis, 33. Carthage, 34. Garama, 35. Akraiphia, 36. Edessa, 37. Apollonia Illyria, 38. Epidamnus/Dyrrachion, 39. Rome (including ANAS necropolis, Casale del Dolce, Centocelle Necropolis, Mausoleo di Augusto, Necropoli of Monte Agnese, Monterotondo, Palestrina, Via Paisiello Necropolis, Viale Rossini Necropolis, Quarto Cappello del Prete, catacombs of Saints Peter and Marcellinus, Isola Sacra, Lucus Feroniae, Casal Bertone, Castellaccio Europarco, Castel Malnome), 40. Syracuse, 41. Vagnari, 42. Velia, 43. Plestia, 44. Pompeii, 45. Lamon, 46. Passo Marinaro (Kamarina), 47. Civitanova Marche, 48. Bologna, 49. Sulmona.

The final two studies conducted in the 1980s had a specific focus on metric and nonmetric variability, rather than considering it as part of a broader bioarchaeological study. Arensburg et al. [45] examined the metric variability present in Jewish cranial morphology during the Hellenistic, Roman, and Byzantine periods. While they did not estimate the biodistance between the different groups studied and relied solely on descriptive statistics, the authors explicitly concentrated on the population history of the Jewish people and concluded that there has been a significant level of similarity and stability over several centuries. Similarly, Goldstein et al. [46] directed their attention towards Jews from the Hellenistic and Roman periods, but this time focusing on cranial and postcranial nonmetric traits. Their objective was descriptive in nature, providing extensive tables displaying the frequency of various traits. However, they did not conduct any biodistance analyses, despite acknowledging the potential of such data as indicators of biological affinity.

In the 1990s, scholarly research in the field continued to be predominantly descriptive, with a primary emphasis on compiling detailed tables of craniometric data. However, there was a noticeable shift towards incorporating statistical analysis and utilizing various biodistance measures. Furthermore, studies began to encompass a wider geographical scope within the region of interest. A representative example is Billy's [47] study, wherein a significant resemblance in cranial morphology and associated affinity was observed between the population inhabiting the Roman era Douch in the Kharga Oasis, Egypt, and urban populations residing in the Nile valley. This finding was based not only on a descriptive evaluation of similarities and dissimilarities, but also on the statistical examination of the morphological diversity in Egyptian and Nubian groups. Another study of this period that utilized biodistance data in conjunction with historical and archaeological evidence is by Manzi et al. [48]. The study focused on dental metric and nonmetric traits from two distinct assemblages: one from the rural town of Lucus Feroniae, primarily inhabited by slaves and war veterans, and the other from the Isola Sacra necropolis at Portus Romae, representing an urban "middle class" group.

The findings revealed greater variability in dental dimensions and morphology in Lucus Feroniae, indicating a higher level of heterogeneity compared to the assemblage from Portus Romae. This pattern was attributed to the unique population compositions and histories of the two sites, with the authors linking them to human mobility and genetic admixture during both pre-Roman periods and Rome's military and political expansion. In the same direction of using biodistance analyses to examine specific and testable research hypotheses but focusing on issues with a much broader time span, Rubini et al. [49] examined the population history of ancient Sicily spanning the 2nd and 1st millennium BCE, with a focus on the impact of Greek colonization. By studying cranial nonmetric traits in archaeological assemblages from eastern Sicily, their findings indicated that the initial biological influence of Greek settlers in the region may have originated in the Bronze Age.

Even during the 1990s, there have been studies that have provided significant descriptive data that could be used in biodistance analysis, but have not been utilized for this purpose. For instance, Brin et al. [50] presented craniometric data for Hellenistic Jews from Ein Gedi and compared them to other groups, yet they did not conduct biodistance analysis and instead interpreted their findings in relation to environmental factors rather than issues of mobility and ancestry. Similarly, Henneberg et al. [51] provided craniometric, odontometric, and osteometric data for a skeletal collection from the House of C Iulius Polybius in Pompeii, dated to 79 CE, but did not further analyze or discuss them.

3.2. Later Studies (2000s–2010s)

The number of Hellenistic-Roman biodistance studies increased notably after 2000. Similarly, the geographic span covered by paleomobility studies expanded, as did the methodological repertoire used, with an explosion in the use of isotopic analysis, and a limited use of aDNA analysis, which was much more common for prehistoric assemblages.

Biodistance studies continued to be utilized extensively in these more recent periods, incorporating both traditional and advanced statistical methods. Joel Irish has been among the pioneers in this direction and his study of population affinities in ancient Egypt is a representative example [52]. By examining dental morphological traits in Egyptian populations spanning from the Neolithic era to the Roman period, Irish calculated phenotypic similarities using various biodistance measures. The findings of his study indicated a population continuity over time. Besides Irish's work, North Africa received a lot of attention in terms of biodistance analyses during that period. In their study, Nikita and colleagues [53,54] utilized cranial nonmetric traits and geometric morphometrics to investigate patterns of gene flow between the Garamantes, a civilization that thrived in the Sahara Desert from 900 BCE to 500 CE, and other populations in North Africa. The comparative groups included, among others, individuals from the Ptolemaic and Roman periods in Alexandria, as well as the Punic and early Roman inhabitants of Carthage. The findings indicated that the Garamantes displayed distinct physical characteristics, suggesting a degree of biological isolation despite their participation in trans-Saharan trade networks. On the other hand, the individuals from Alexandria and Carthage were found to be closely related, along with Soleb and Algerians, indicating movement along the Mediterranean coast and the Nile River. Haddow's [55] thesis is another example of a biodistance study focused on North Africa, examining the population structure of Ismant el-Kharab (ancient Kellis, Dakhleh Oasis, Egypt) during the late Ptolemaic to late Roman period. By recording dental nonmetric traits on individuals from Kellis and comparing them to groups from various regions in Africa, Haddow's study challenged previous anthropological and archaeological interpretations and suggested that the Kellis population had limited genetic exchange with neighboring communities. Another doctoral dissertation focusing on Egyptian biodistances was by Kindschuh [56] and investigated the population structure of the late Roman to early Christian el-Hesa community. Located on the border between Egypt and Nubia, el-Hesa was expected to exhibit significant gene flow and thus a diverse population. The craniometric analysis supported this hypothesis, revealing a phenotypically diverse population with connections to both Egyptians and Nubians. A final biodistance study in North Africa examined Nubians from the Mesolithic era to the Christian period [57]. This study identified extensive interactions between Romans and Nubians, which the authors believed contributed to the high levels of gene flow observed in the biodistance patterns.

Beyond North Africa, the Near East has also been the focus of biodistance studies during this period. One study examined the affinities of the Roman population in Datça-Burgaz to Anatolian groups dating from the Early Bronze Age to the early 20th century. This study utilized nonmetric cranial traits and revealed complex patterns of population continuity and discontinuity over a significant period of time [58]. Another study with a wide temporal scope investigated population affinities in the middle Euphrates valley from the Early Bronze Age to modern times using dental nonmetric traits [59]. The findings indicated continuity until recent times, when northern Mesopotamia was depopulated due to the Mongolian invasion in the 13th century and later repopulated by Bedouin tribes in the 17th century, leading to changes in the genetic makeup of the region. A final biodistance study focused on dental nonmetric traits from the Hellenistic and Roman French Qumran collection. The Qumran collection was compared to Near Eastern groups from various time periods, as well as a sample of Native Americans. The biodistance analysis identified the Native American sample as an outlier, as expected, while the samples from the Near East showed relatively close relationships. However, the authors of the study correctly noted that the sample size from Qumran was too small to draw definitive conclusions [60].

In Italy, Hens and Ross [61] examined the biodistance among three imperial Roman assemblages: Isola Sacra and Velia, primarily inhabited by middle-class tradesmen and merchants, and Castel Malnome, where freed slaves and heavy laborers resided. Using geometric morphometrics to analyze cranial morphology, the researchers found significant differences in cranial shape between Isola Sacra and Velia, which they attributed to the strong Greek influence in southern Italy. In contrast, Castel Malnome did not show significant differentiation from the other sites, likely due to the diverse geographic origins of the freed individuals in this community. Another noteworthy biodistance study on Italian archaeological remains from this era focused on the skeletons from the Passo Marinaro (Kamarina) Classical-Hellenistic cemetery, as part of a larger biocultural investigation. Sulosky Weaver [62] compared the frequency of cranial and dental nonmetric traits between the Passo Marinaro site and other skeletal collections from Greece, Sicily, and Southern Italy. While the dental traits did not provide conclusive evidence of gene flow at Passo Marinaro, as they were common in both Italian and mainland Greek populations, the cranial nonmetric traits indicated a close connection between Passo Marinaro and other Greek populations in Sicily. Additionally, two crania from the sample displayed morphological characteristics consistent with individuals of sub-Saharan African descent.

Two biodistance studies conducted in Cyprus and Greece on a regional level merit attention. Harper and Tung [63] estimated the biodistance between Hellenistic–Roman individuals at Mağara Tepeşi and Frankish–Venetian individuals at Athienou-Malloura and found a lack of population continuity in the region. The authors associated this discontinuity with natural selection, genetic drift, and the influx of a new population into the Malloura Valley between the Roman and Venetian periods. In Greece, Nikita and colleagues [64] examined the Archaic to post-Roman population in Akraiphia, Boeotia. By analyzing biodistances using dental nonmetric traits, the researchers identified a biological affinity among Archaic, Classical and Hellenistic individuals, as well as between Roman and post-Roman individuals, but divergence between these two groups. The discontinuity observed between the earlier (Archaic, Classical, Hellenistic) and later (Roman, post-Roman) phases of the cemetery aligns with the Pax Romana program initiated by Augustus, which promoted unrestricted movement, thus increased gene flow during Roman times.

Despite advancements in biodistance studies with more sophisticated methods and specific research hypotheses, there are still instances in the literature where descriptive studies using single traits are used to draw conclusions about past population history and structure based on relative frequencies [65]. Additionally, there are studies that highlight "exceptional" traits within broader bioarchaeological analyses without discussing their significance [66]. Some publications also present frequencies of nonmetric traits, recognizing their limited utility for biodistance analysis currently but suggesting potential for future research [67].

In addition to biodistance analyses, paleomobility studies conducted in the 2000s and 2010s increasingly utilized isotopic data. The methods employed varied in complexity, including the use of single or multiple chemical elements, bulk or incremental analyses, and the examination of different skeletal or dental tissues with varying rates of remodeling. For example, one study focused on strontium isotopes in third molar enamel to investigate human mobility in Late Roman/Byzantine Barsinia, Northern Jordan, finding that all individuals were likely local to the site [68]. Similarly, strontium isotopes were used to investigate the presence of political refugees at Khirbet edh-Dharih after the Roman annexation of the Nabataean Kingdom in the 2nd century CE, with only one definite non-local individual identified [69]. Bulk strontium isotope analysis was also used to study mobility in Roman and Byzantine Hierapolis, Turkey, revealing the presence of non-local individuals in the Byzantine population linked to the site's history of pilgrimage, while the preceding Roman population showed more homogeneity and lacked distinct nonlocals [70].

An early paper of this period examined oxygen and nitrogen isotope ratios to study migration patterns at the Kellis 2 cemetery in the Dakhleh Oasis, Egypt, around 250 CE [71]. The findings revealed the presence of at least two individuals who were not from the local area, possibly originating from the Nile Valley or Nubia. Notably, one individual, who exhibited distinct isotopic values, was found to have suffered from leprosy, leading the authors to suggest that this individual may have been an exile. Additionally, all individuals with higher oxygen isotopic values were male, indicating their likely involvement in caravan trade. A more complex isotopic study from this period focused on oxygen isotope ratios in first and third molar teeth of individuals buried in the necropolis of Isola Sacra near Rome, Italy, during the 1st to 3rd centuries CE [72]. Analysis of the sample revealed that approximately one-third of the individuals had first molar values that fell outside the range observed in the modern data, suggesting a significant number of nonlocal individuals, which aligns with historical records. Furthermore, the study showed that many individuals had migrated during their childhood, before the third molar crown had completely formed. This finding indicates that migration involved entire families rather than solely adult males. Analysis of the isotopic values from the third molars also indicated that a quarter of the sample had moved to Portus sometime after their childhood or adolescence. The nonlocal individuals were likely from regions located to the East and North of Rome, with one individual possibly originating from North Africa. This pattern of a substantial number of nonlocal individuals originating from various regions is consistent with the multinational nature of port cities like Portus.

Another important rather early isotopic study from Italy was Killgrove's [73] PhD thesis. Among other analyses, the author examined the mobility patterns in the two Imperial assemblages from Casal Bertone and Castellaccio Europarco. Strontium isotope analysis applied to 105 individuals identified two nonlocals in Castellaccio Europarco and five at Casal Bertone. Oxygen isotope analysis was performed on a subsample of 55 individuals and identified 12 nonlocals at Casal Bertone and four in Castellaccio Europarco. The nonlocal individuals identified in the study exhibited isotopic values indicative of various regions within and outside of Italy. More recently, oxygen and strontium analyses of a small sample (n = 6 for strontium and 4 for oxygen) from Castellaccio Europarco dating to the Republican period revealed the presence of one individual identified as a likely nonlocal through strontium isotopes, as well as two individuals potentially categorized as nonlocals based on oxygen isotopes [74].

Also in Italy, Milella et al. [75] utilized a multi-isotope methodology incorporating strontium, oxygen, nitrogen, and carbon to examine the relationship between funerary practices, geographical provenance, and dietary patterns in Bologna from the 1st to the 4th centuries CE. The findings indicated a lack of discernible correlation between these factors, implying that the diversity in funerary practices was influenced by multiple heterogeneous elements and did not correspond to varying geographic origins.

Finally, this period also witnessed the combined use of different bioarchaeological proxies of paleomobility. Stark's [76] thesis examined mobility patterns at the imperial Roman sites of Isola Sacra and Velia, and the Rue Jacques Brel Necropolis in Saintes, France. The study involved the analysis of strontium and oxygen isotope ratios alongside nonmetric characteristics. The isotopic data revealed the presence of several individuals who were not local to the sites, including females and children [77,78]. Additionally, biodistance analysis indicated a general similarity in the biological background of the populations at the three sites, likely due to the widespread movement of individuals to and from Rome. However, there were also distinct biological populations present at each site, underscoring the diversity of the Roman population. Another interesting multi-proxy study also focused on Italian material. Prowse et al. [79] utilized a combination of isotopic and DNA analysis on Roman Vagnari to ascertain the origins of the inhabitants at the site. Results from oxygen isotope analysis on 23 individuals indicated the presence of six nonlocals, while genetic analysis on a subset of ten individuals revealed ancestral connections to populations from sub-Saharan Africa and Asia in two cases. In a subsequent investigation conducted by Prowse [9], an additional 30 individuals were studied and the relationship between migrant status and burial offerings was examined in order to identify any potential disparities in the treatment of nonlocal individuals. The results of oxygen isotope analysis showed that 91% of the sample were likely native to the Vagnari region, confirming the findings of the initial study in 2010 that the labor force at this imperial estate primarily consisted of local residents rather than imported slaves or freedmen from other regions of the Roman Empire. The nonlocal individuals were of varying age and sex. Significantly, the nonlocals were interred with similar grave goods as those found in the tombs of local residents, and the positioning of their graves in the cemetery indicated no segregation from the rest of the community. Emery's [80] thesis and subsequent publications [81,82] performed additional isotopic and ancient DNA research at Vagnari. The mitochondrial DNA data suggested a closer genetic affinity of Roman Italians with Neolithic, Bronze Age, and Armenian Iron Age populations in western and central Eurasia, compared to Iron Age Italians, Ptolemaic and Roman Egyptians. Most of the Vagnari population appeared to be local, with only two individuals belonging to an eastern Eurasian haplogroup, indicating maternal migration. Additionally, isotopic data revealed a small percentage (7%) of non-local individuals at the site.

3.3. The Past Five Years (2020–2024)

In recent years, starting from 2020, there has been a sustained focus on human mobility in the Hellenistic-Roman period, with ongoing utilization of diverse methodologies and increased exploration of geographical areas that had previously been overlooked.

Biodistance studies have increasingly focused on addressing specific research inquiries rooted in historical data. For instance, Cilli [83] conducted a study on the influence of the Roman road network on facilitating connectivity and gene flow in Abruzzo, Italy. By analyzing biodistances among five populations spanning from the 9th century BCE to the 12th century CE, the author revealed a close biological affinity among these groups, indicating a shared ancestry among the local populations in Abruzzo. Furthermore, the study demonstrated that populations residing near the primary Roman communication routes exhibited higher levels of admixture compared to those situated farther away from the road system, suggesting greater genetic isolation. Thus, the research underscored the significance of the Roman road network in enhancing connectivity in a region characterized by challenging terrain, such as the Apennines mountain range.

Another notable biodistance study examined the influence of political integration of Phoenician coastal cities into the Roman Empire. Mardini et al. [84] utilized dental metric and nonmetric traits to estimate biodistances at both individual and group levels among the cities of Tyre, Beirut, and Byblos. The objective of the study was to determine whether the colonial status of Tyre and Beirut, in contrast to Byblos, was associated with increased population diversity and mobility. The findings demonstrated that Tyre and Beirut exhibited greater internal diversity, as indicated by greater intra-assemblage biodistances. Furthermore, the inter-assemblage biodistances revealed a close relationship between Tyre and Beirut, while Byblos appeared as an outlier in the dendrogram. This lend further support to the connectivity between the two coloniae and/or suggested that the nonlocals in these cities shared a similar origin. In contrast, Byblos appeared to have a predominantly local population, which distinguished it from the colonies. These results align with literary sources, which state that Beirut and Tyre, as prominent Roman colonies and commercial centers in the Eastern Mediterranean, experienced higher levels of mobility compared to other coastal cities, like Byblos.

The use of isotopic studies has continued to expand. A recent study also focused on Beirut, and combining strontium and oxygen isotope analysis, was by Kalenderian and colleagues [85]. The authors analyzed nineteen individuals. Despite Beirut's status as the initial Roman colony in the Near East, the isotopic findings identified only two potential newcomers and two definite migrants, including males and females, who came from various regions within the Empire. Additionally, an intriguing discovery was made regarding the absence of correlation between the graves' material culture and the geographic origin (local or nonlocal) of the individuals, highlighting the fact that the identity of migrants was not expressed through their burial practices.

In Greece, a recent isotopic analysis investigated the mobility of 16 individuals from Roman Edessa by examining oxygen isotopes [86]. Through the analysis of various skeletal and dental tissues, the researchers identified intricate mobility patterns in nine individuals who had moved to and from Edessa at different stages of their lives. In nearby modern day Albania, a multi-isotopic study (carbon, nitrogen, oxygen) focused on diet and mobility patterns from the Archaic-Hellenistic period to the Medieval period at two Greek colony sites: Epidamnus/Dyrrachion and Apollonia in Illyria [87]. The study revealed that while individuals from cemeteries outside the walls of Apollonia were local, two thirds of individuals from Epidamnus/Dyrrachion had likely spent their childhood elsewhere, highlighting the latter as a cosmopolitan port city founded by foreigners that attracted immigrants throughout its history.

A final isotopic study focused on reconstructing past osteobiographies using a multi-proxy bioarchaeological approach [88]. The authors combined isotopic analyses with dental calculus microscopy on eleven individuals from the Roman cemetery of San Donato and six individuals from the medieval cemetery of San Pietro, both in Lamon. The results indicated a diet consisting of a combination of C3 and C4 plants and high levels of animal protein consumption, with no significant differences between the two populations. The analysis of paleomobility indicated that the individuals likely resided locally or regionally, suggesting a continuity between the Roman and medieval populations.

The past five years have also witnessed the more generalized use of ancient DNA analysis in the study of ancestry, and by extension gene flow and mobility, in Hellenistic and Roman assemblages in the region. Some recent studies have focused on mitochondrial DNA, while others have used whole-genome sequencing. For example, Tepgec and Gorgulu [89] analyzed the mtDNA of three Hellenistic individuals from Ayasuluk Hill in Ephesus and found that they belonged to the T2b maternal haplogroup. This haplogroup is believed to have originated in Anatolia during the last Ice Age and spread during the Neolithic period. Italy has been a significant area of interest for aDNA analysis. A study investigating the mitogenome of Umbria in Central Italy examined both contemporary inhabitants of the city and 28 individuals from the necropolis of Plestia, Colfiorito, dating from the early 9th to the late 3rd century BCE. The results suggested a combination of local genetic continuity and inputs from various population sources, including gene flows from central-eastern Europe [90]. De Angelis et al. [91] successfully conducted a whole-genome study on seven individuals from Quarto Cappello del Prete, a rural site in Imperial Rome. The findings indicated a genetic similarity with present-day populations in the Southern Mediterranean and Southern Near East. In a larger-scale study, Antonio et al. [92] examined the whole genomes of 127 individuals from 29 archaeological sites in Rome and neighboring areas, covering a period of 12,000 years. The results supported two major prehistoric ancestral changes, while by the establishment of Rome, the genetic makeup of the region resembled that of modern Mediterranean groups. The Imperial period witnessed immigration as Rome attracted individuals from the Near East and later from Europe, aligning with its geopolitical affiliations and contributing to genetic diversity. In another large-scale study by Lazaridis and his colleagues [93], the genetic history of populations in the Southern Arc from the end of the Bronze Age until modern times was investigated. The research delved into various topics, but with a focus on the Roman era, it was discovered that individuals from the Imperial period of Rome shared genetic ancestry with individuals from Anatolia during the Roman/Byzantine period, whereas earlier Italians had distinct genetic backgrounds. Furthermore, Imperial Romans displayed genetic similarities with pre-Roman Anatolians, while individuals from Rome and its vicinity prior to the Imperial era were genetically distinct. These findings suggest a degree of population continuity in Anatolia, a region that played a significant demographic role within the expansive Roman Empire. This study also recognized the presence of migrants in the Southern Arc during various historical periods, including two individuals from the Roman era discovered in Samsun on the Black Sea.

Finally, a study by Salesse and colleagues [94] integrated isotopic analyses, dental morphology and ancient DNA to identify the first documented instance of an African-born migrant buried in a mass grave located in the catacombs of Saints Peter and Marcellinus in Rome. Analysis of the dental morphology data revealed variability within the overall collection, with two individuals exhibiting distinctive characteristics. Isotopic and genetic data subsequently verified the African ancestry of one of these individuals. While the precise circumstances of this individual's arrival in Rome, whether as a free person or an enslaved individual, remain unclear, this case study provides further evidence of long-distance migration that occurred throughout the Roman Empire and underscores Rome's cosmopolitan nature and appeal.

4. Limitations and Future Directions

The above overview of bioarchaeological studies examining paleomobility in the Hellenistic and Roman period within the Central and Eastern Mediterranean revealed several interesting patterns. Methodologically, initially studies focused on biodistances, but later research increasingly incorporated isotopic and aDNA analyses. This shift in methodology reflects the rapid advancement of biochemical and biomolecular techniques in recent years. Despite this shift, biodistance analyses have not been overshadowed, as they remain prevalent in the literature. The continued use of biodistance analyses can be attributed to their non-destructive nature, cost-effectiveness, and efficiency in analyzing every individual in a skeletal assemblage [12,95].

Over time, paleomobility studies have not only become more diversified methodologically but, importantly, there has been a shift towards addressing more sophisticated questions and interpreting the results in a more nuanced manner. This trend also agrees with global patterns in paleomobility analysis [96]. Initially, relevant studies were primarily descriptive in nature and did not have specific research questions. The focus was on listing metric and nonmetric variables as part of a broader description of skeletal remains. Occasionally, comparisons were made between different groups, leading to general conclusions about population continuity or discontinuity, but without rigorous data analysis. As time went on, paleomobility studies began to be designed with specific research questions in mind, often driven by archaeological or historical data. Complementary bioarchaeological methods were incorporated to address these questions, and the results were placed within their historical and archaeological context [97].

Beyond quality, the number of paleomobility studies has increased significantly over time, in line with the overall growth of bioarchaeological research in the region [98] and internationally [99]. This trend reflects the emergence of a more robust regional tradition in bioarchaeology, a discipline that initially developed in North America and Western Europe. In recent years, there has been a focus on training local scholars in relevant methodologies, establishing regional laboratories for skeletal, biochemical, and biomolecular analyses, and incorporating bioarchaeologists into the faculty of national universities to ensure the continuity of expertise in the field. Additionally, foreign scholars and missions continue to play a significant role in the region, collaborating with local authorities and institutions to further research initiatives [100].

Despite the promising trends mentioned above, bioarchaeological studies examining human mobility during Hellenistic-Roman times are scarce given the temporal and regional scale that needs to be covered. The limited available evidence, which mainly consists of case studies that vary in time, space, and methodology, prevents the formulation of generalizable conclusions. Figure 1 illustrates that certain regions have received considerable attention in paleomobility studies, while others have been neglected. Therefore, it is important to prioritize the neglected regions in order to enhance our understanding of human mobility over time and space [97]. Furthermore, it is necessary to conduct studies that explore both large-scale spatial and temporal patterns, as well as regional and local mobility, in order to unravel the complexities of this dynamic process [97,101].

The inherent limitations of each method (biodistance, isotopes, aDNA) are important to acknowledge, as discussed briefly in the section on bioarchaeological methods for investigating ancient mobility. While each approach offers valuable insights into patterns of mobility, there are significant challenges in interpreting the results obtained. For instance, small biodistances may indicate shared ancestry rather than more recent gene flow, and the timing of these events (e.g., the last common ancestor or specific episodes of gene flow) cannot be determined without additional corroborating evidence. Likewise, aDNA analysis reveals information about ancestry, indirectly informing our understanding of past mobility. Isotopic analyses can directly identify first-generation migrants and potentially reveal mobility events at different stages of an individual's life, but pinpointing the exact origin of nonlocal individuals is often hindered by the phenomenon of equifinality. In other words, multiple regions around the world may share similar baseline strontium and oxygen isotopic values, making it challenging to confidently identify the specific place of origin for nonlocal individuals. Even individuals who appear to be local may in fact have originated from a different region with comparable geological or hydrological characteristics.

The integration of biodistance, isotopic, and aDNA analysis can partially overcome the aforementioned limitations. However, in order to develop a more nuanced understanding of mobility, it is crucial to combine bioarchaeological data with additional contextual information such as textual sources, material culture, palaeoenvironmental data, and other forms of evidence [101]. Such contextualization constitutes a basic premise of bioarchaeology [102] and is particularly important in the Hellenistic-Roman period, which benefits from abundant textual and archaeological data. As shown above, recent paleomobility studies have begun testing research hypotheses based on historical and archaeological data and exploring the connection between non-local status and funerary practices, investigating whether foreigners were treated differently after death. These studies should become more common, incorporating additional lines of evidence such as archaeological data from associated settlements, textual data on historical events at different temporal and spatial scales, or even linguistic data [97,103,104]. An integration of such diverse evidence could also elucidate aspects of past mobility that are crucial but cannot be effectively approached exclusively through bioarchaeological data, such as the motivations of mobility and the factors that determined the interaction between locals and nonlocals. A significant obstacle to cross-disciplinary communication is that many bioarchaeologists in the region work with already excavated collections, leading to a lack of effective collaboration among different specialists from the beginning of the project. Additionally, by not participating in the excavation process, bioarchaeologists miss out on crucial taphonomic and contextual information [105].

An additional, yet often overlooked, aspect of data integration in the field of paleomobility is the necessity to merge studies on the movement of ancient populations with indicators of stress, disease, population demographics, physical activity, diet, and other aspects related to the daily lives of past individuals. By conducting such analyses, a more comprehensive understanding can be gained regarding the disparities in quality of life among various groups of people, including locals and nonlocals, as well as the influence of mobility on the biology of both newcomers and local communities. While some studies have already combined mobility and dietary isotopes, there is a need for further integration of osteobiographic markers [97].

The utilization of various paleomobility techniques and the integration of their findings with other osteological data, as well as historical and archaeological contextual information, are crucial in advancing knowledge beyond simplistic dichotomies of "local" versus "nonlocal" in studies of past mobility [106]. As explained above, this is the premise of isotopic studies, which offer the most direct evidence for past mobility. However, these dichotomies may lack practical significance. Besides the issue of equifinality outlined above, determining the threshold for categorizing individuals as "nonlocal" and the practical implications of this designation are important considerations. For instance, individuals originating from a location only a few kilometers away from the studied settlement may be considered "nonlocals" if the regional geology is diverse. Moreover, isotopic studies may only capture mobility events during a specific period of an individual's life, typically in childhood, thus potentially overlooking recurring or significant mobility events outside this timeframe [9].

In alignment with the trend towards more nuanced interpretations, it is crucial for studies on ancient human mobility to be grounded in theoretical frameworks, as advocated by Gregoricka [101]. Early archaeological perspectives considered human movement as a significant factor in driving cultural change within the culture-historical paradigm [107]. Processual archaeology critiqued this perspective by highlighting environmental adaptation and internal processes as primary drivers of change, largely overlooking the role of mobility [108]. Despite this, processual archaeology's emphasis on developing scientific methodologies played a key role in advancing paleomobility studies. Subsequently, post-processual archaeology emphasized the complexity of ancient mobility by stressing individual agency, multiple interpretations, and rejecting overarching narratives [109]. In the 21st century various new paradigms have emerged that are particularly pertinent to paleomobility studies [110]. For instance, greater engagement with actor-network theory and new materialism by bioarchaeologists could significantly enhance our understanding of past mobility. Actor-network theory views the world as interconnected networks of various actors, shifting the focus from individuals to the networks that shape our perceptions of people and objects [111]. Similarly, new materialism explores the interconnectedness of humans and objects, highlighting the active role of material in shaping the world [112]. Both theories aim to transcend dualistic perspectives and promote an ontology where humans and objects are equally significant. Additionally, postcolonial theory is crucial in framing research questions and interpreting patterns of ancient mobility. This theory examines how Western scholars often distort the cultures of Others to justify colonial inequalities [113]. Given that mobility, past and present, brings in contact people of different backgrounds, it is essential for bioarchaeologists to consider different perspectives and worldviews when interpreting the nature, motivations, and impacts of mobility.

Finally, it is important for paleomobility studies to be more explicit regarding their contemporary implications. A deeper understanding of the character and impact of past mobility is urgently required in light of the misinterpretation of archaeological and historical evidence in support of biased political rhetoric in discussions of the impact of migration on modern societies. Existing research demonstrates that mobility in the Greco-Roman world was highly diverse and context-specific. While this hampers the development of overarching narratives and broad conclusions, it does reveal that negative views of mobility are unfounded and misguided. Even small-scale case studies can contribute significantly to shedding light on the circumstances in which mobility could have been advantageous or detrimental, thereby challenging deterministic interpretations of past movement. To achieve this, it is essential for bioarchaeologists to communicate their findings widely, beyond academic circles, and to clearly articulate the implications of their work without resorting to sensationalism [102].

The current paper presented an overview of paleomobility studies employing bioarchaeological data for the Hellenistic and Roman world with a geographic focus on the Central and Eastern Mediterranean. Through the analysis of several case studies, the paper demonstrated the methodological and conceptual advancements made in relevant research from the 1980s to the present. Despite these advancements, there are still significant gaps in the coverage of studies in terms of both space and time, as well as challenges in effectively integrating and interpreting the results. To address these issues, future research should increase the number of studies, employ complementary bioarchaeological approaches to study mobility and broader osteobiography, and encourage active collaboration and dialogue between bioarchaeologists, archaeologists, and historians, as also suggested by previous scholars [101,114]. A greater engagement with theoretical paradigms and a more effective communication of research results and their implications are also necessary. While there are still many unknowns about human mobility in different parts of the Hellenistic and Roman world, bioarchaeology has proven to be a valuable tool in uncovering the mobility patterns of ordinary individuals and the evolving trends in research suggest that it will continue to play a crucial role in understanding human mobility in these historical periods.

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Informed Consent Statement

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The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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