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Physical Impairment and Care Estimation in Medieval Estremoz (Portugal): A Bioarchaeological Perspective

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ABSTRACT

This study aims to compare diet and skeletal health indicators between individuals with varying degrees of physical impairment and the general adult population from medieval Estremoz, Portugal, to assess their health status and their survival outcomes. Skeletal remains from 41 male adult individuals, including 8 with physical impairments and 33 from the general population, were analyzed. The impairment of these individuals was described, and their need for care was inferred considering the guidelines of the Index of Care and the Bioarchaeology of Disability approach. Skeletal lesions, physiological stress indicators, and estimated diet (using stable isotope analysis of bone collagen) were compared between individuals with and without signs of physical impairment. Individuals with physical impairments did not exhibit more frequent or more severe skeletal indicators of physiological stress or trauma than the general population. The survival into adulthood with good health of individuals with physical abnormalities or limiting conditions suggests consistent care, particularly in childhood and as needed throughout life. This study provides evidence that individuals with disabilities in medieval Estremoz do not seem to have been excluded from the community. These findings contribute to broader discussions on social support, resilience, and caregiving in historical populations. The sample size of impaired individuals is small, and osteological preservation may limit the identification of subtle stress indicators. Future work should explore disabilities and caregiving practices in other medieval populations, incorporating stable isotopic analysis to compare their adult and childhood diet with the general population.

1 | Introduction

Although evidence of care for the sick and impaired exists across cultures and historical periods (e.g., Phillips and Sivilich 2006; Tornberg and Jacobsson 2018; Dittmar et al. 2023) and even among other human species (e.g., Lordkipanidze et al. 2005) and nonhuman primates (e.g., Boesch et al. 2010), such care is not universal (Iezzoni 2011). Even today, for instance, individuals with disabilities in the United States experience poorer health outcomes, lower levels of education, reduced income, and higher unemployment rates compared to their nondisabled peers (Iezzoni 2011). Even where intervention was likely unavailable, support must have been provided, underlining the principle that the absence of cure does not preclude the presence of care (Micarelli et al. 2024). This perspective aligns with broader discussions in the bioarchaeology of care framework, particularly the osteobiographical approaches that foreground care as a relational, socially embedded process. Although empathy and altruism may have deep evolutionary roots, as suggested by research on primates (e.g., Boesch et al. 2010), this does not guarantee consistent caregiving across all social, cultural, or historical contexts (Dettwyler 1991).

Disability is a complex concept to define in bioarchaeology, as it is a socially constructed category, culturally specific, variable across time and space, and typically leaving no direct trace in the skeleton (Metzler 2013; Reid-Cunningham 2009; Tarlow 2000). Impairment, by contrast, refers to a more tangible medical or anatomical condition that may limit an individual's physical capabilities and is, in some cases, observable in the skeletal record. This distinction underpins the bioarchaeological value of studying impairment as a material proxy for investigating broader social attitudes toward disability. Inferring impairment and, more cautiously, disability from human remains allows bioarchaeologists to access a broader dimension of past human experiences, highlighting how individuals with physical limitations may have lived within their social and cultural environments (Roush 2017).

Tilley and Oxenham (2011), Tilley and Cameron (2014), and Tilley (2015) pioneered a "bioarchaeology of care" framework, later expanded by Bohling et al. (2022a) into a population-scale "Bioarchaeology of Disability" approach. Their work demonstrates that funerary treatment depended on community beliefs rather than impairment alone (Bohling et al. 2022a, 2023).

Although case studies remain central to the field (e.g., Keenleyside 2003), recent work emphasizes population-level analyses (e.g., Bohling et al. 2022a; Dittmar et al. 2023; Schrenk and Tremblay 2022). This broader scale is particularly informative for identifying patterns of systemic inclusion or exclusion, allowing researchers to assess whether impaired individuals experienced differential access to care, nutrition, or social participation. In this study, we adopt such an approach by comparing skeletal stress indicators and diet between impaired and nonimpaired individuals in medieval Estremoz, Portugal, to assess health disparities that go beyond survival alone.

2 | Historical Context

Medieval Portuguese society was shaped by a worldview deeply influenced by religiosity, where health and illness were interpreted as manifestations of divine grace or punishment. The state of the body, whether healthy or afflicted, was seen as a reflection of the soul's condition, corresponding to virtuous or sinful behavior (Oliveira 2015). Until the late 15th century, disability was predominantly regarded as a curse or divine retribution, reinforcing significant social stigma. Individuals with severe impairments, particularly those unable to work, were frequently marginalized and relegated to begging (Moreno 1985). Official records from the 14th century distinguish between "false beggars," deemed able-bodied and expected to work, and "true beggars," who were physically incapable of self-support. In 1349, King Afonso IV issued a decree stating that only those who were "old, crippled, blind, sick, and others [...] who have no bodies fit for any service" could legitimately beg (Moreno 1985, 30). This framework highlights the strong entanglement between religious, cultural, and socioeconomic factors in shaping the treatment and perception of illness and disability.

Estremoz, a medieval town in the Alentejo region of Portugal, occupied a strategically significant location near the Spanish border. Its elevated position offered extensive visual control over the surrounding territory, making it a desirable site for royal settlement and defense (Liberato 2012). First mentioned in 1211 and recorded as a small settlement with a church in 1250 (Silveira 1797), Estremoz was granted a royal charter in 1258. The town initially developed within the fortified castle and expanded rapidly in the late 13th century with the creation of the Santiago neighborhood (Liberato 2012). Its location placed it in the second line of defense for Lisbon and at the crossroads of major regional routes connecting Lisbon, Mérida, Santarém, and Évora (Figure 1). This strategic value contributed to its urban growth, royal privileges, and political importance.

Beyond its military and administrative relevance, Estremoz supported a diverse and productive agricultural economy. Historical sources describe extensive cultivation and livestock farming (Coelho 2023). Food production supported both subsistence and trade, and a variety of locally available resources are attested (Silveira 1797). Grain storage pits, milling infrastructure, and ovens suggest organized processing and bread production (Coelho 2023). Together, these elements point to a resource-stable community with strong economic integration and close ties to the Crown.

3 | The Rossio Marquês de Pombal Osteological Collection, Estremoz

The osteological assemblage includes 141 individuals from 84 graves dated to the 13th–15th centuries (Fernandes and Costa 2007). The full extent of the cemetery remains unknown, and the lack of an excavation report, with only grave drawings preserved, constrains our understanding of the site. Burials followed Christian rites, mostly in rock-cut anthropomorphic graves without grave goods. At least 17 graves were reused, often containing adults and children, possibly representing family units.

Osteological evidence suggests that this population experienced relatively low levels of physiological stress and generally favorable health (Curto et al. 2025). The assemblage has an unusually high number of individuals over 44 years old (Figure 1), possibly indicating good health and survivability. The frequency of skeletal markers, such as *cribra orbitalia* and *cribra cranii*, is low, suggesting adequate nutritional access and low exposure to chronic stressors (see Curto et al. 2025 for more details).

Nonadults displayed limited evidence of growth disruption (Curto et al. 2025), supporting the idea of a stable early-life environment. The few cases of mostly healed periosteal lesions further reinforce the impression of low frailty and resilience to disease. Interestingly, males exhibited slightly more stress indicators than females, possibly due to differences in early-life experiences or origins; some males may have been nonlocal (Curto et al. 2025). This is supported by stable isotope data, with a few, mainly male, individuals exhibiting distinct $\delta^{13}C$ and $\delta^{15}N$ values, possibly from different dietary inputs or geographic origins.

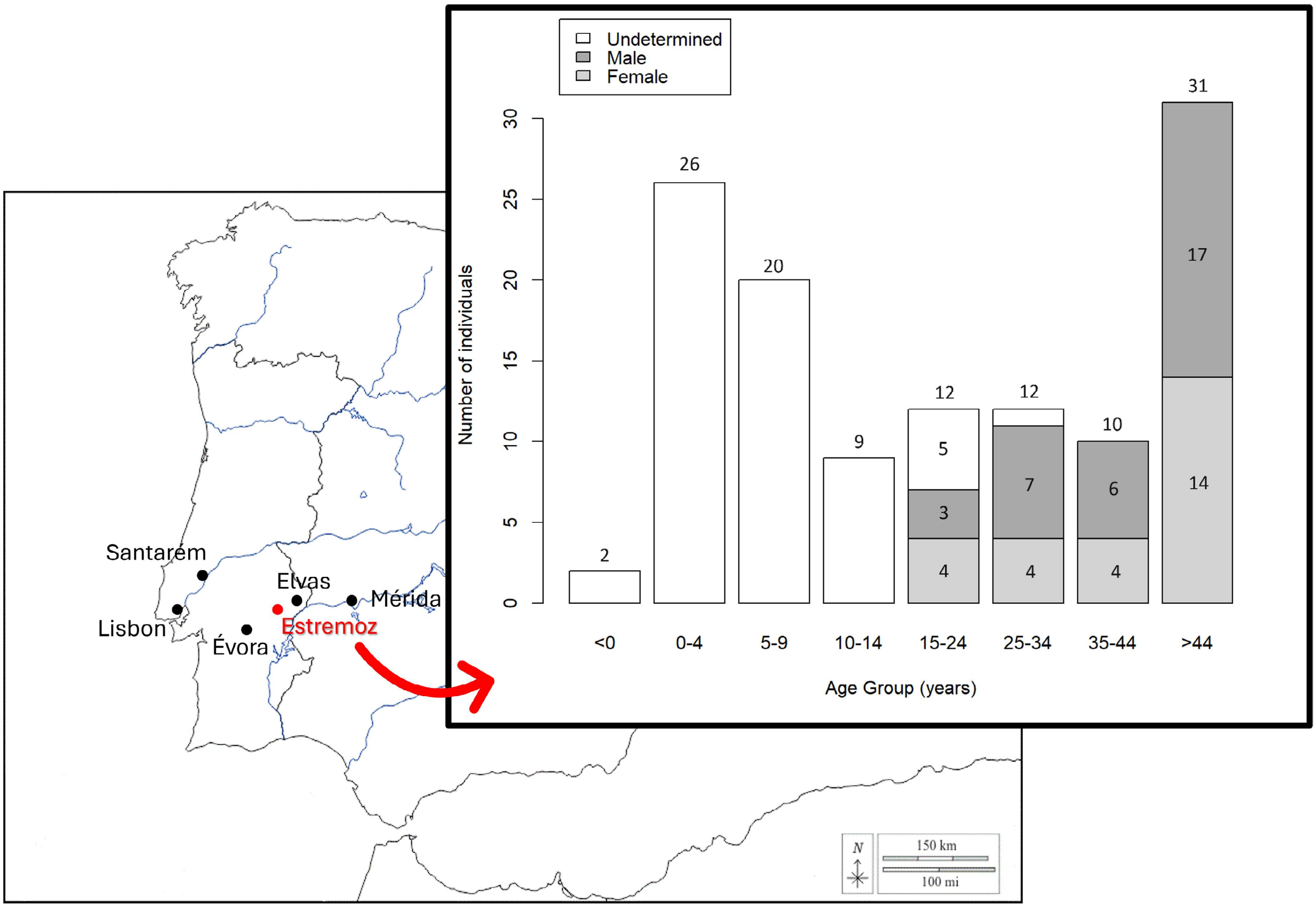

FIGURE 1 | Location of Estremoz in the Iberian Peninsula and distribution of individuals from the Estremoz osteological collection by age group and sex. Adapted from Curto et al. (2025). [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 | List of skeletons considered as having a physical impairment and the main pathology or lesion related to the impairment. A more detailed description of the lesions and pathologies can be consulted in the Supporting Information.

Skeleton ID	Sex	Age	Pathology/ Lesion	Trauma	Tibiae's periosteal lesion	Cribra orbitalia	Cribra cranii	References
RMPE-28oss1	Male	Adult	Kyphosis	—	—	No	No	—
RMPE-69	Male	30–45 years old	Slipped femoral head	Yes	—	No	No	—
RMPE-73	Male	30–45 years old	Klippel-Feil syndrome	No	No	No	No	Fernandes and Costa (2007)
RMPE-75	Male	30–45 years old	Talipes equinovarus	No	No	—	No	Curto and Fernandes (2022)
RMPE-112	Male	Adult	Assymetric sacrum	No	No	No	No	—
RMPE-117	Male	25–35 years old	Sliped femoral head	Yes	No	No	No	Fernandes et al. (2017)
RMPE-119	Male	20–20 years old	Assymetric humerii	No	No	—	No	—
RMPE-121	Male	23–57 years old	Madura foot	Yes	No	—	—	Curto and Fernandes (2016)
General male assemblage					4/25	6/25	1/31	Curto et al. (2025)

TABLE 2 | Summary of the care estimation provided following the recommendations of Tilley and Cameron (2014) and Bohling et al. (2022a). More detailed information about each individual can be found in the Supporting Information.

Individual ID	Impairment description	Visibility	Functional limitation	Symptoms	Estimated duration of the impairment	Activities affected	Likely care requirements	Estimated duration of the provided care	Survival implication	Differential burial treatment	Notes
RMPE-28oss1	Spinal deformities, reduced dorsal lordosis, kyphosis, possible congenital syndrome	Yes	Yes—mobility, posture, upper body movement	Likely chronic pain, fatigue, stiffness	Long-term (congenital or developmental)	Mobility, lifting, walking, prolonged sitting/standing	Adaptation, workload adjustment, possible assistance	Long-term	Lived to adulthood, suggests functional adaptation	No	Possible congenital syndrome; limited reconstruction due to commingling
RMPE-69	SCFE, hip arthrosis, vertebral degeneration, healed trepanation	Partial—gait and trepanation scar	Yes—mobility, balance, lifting	Chronic pain, stiffness, possible metabolic symptoms	Long-term (adolescent onset)	Walking, lifting, uneven terrain navigation	Support with mobility and recovery, workload adaptation	Likely intermittent with episodic support	Survived major surgery and long-term impairment	No	Evidence of care posttrepanation
RMPE-73	Klippel-Feil syndrome, Sprengel deformity, possible Goldenhar syndrome	Yes—craniofacial and spinal anomalies	Yes—upper body and neck mobility	Pain, stiffness, possible fatigue, sensory issues	Lifelong (congenital)	Neck rotation, lifting, hygiene, dressing	Assistance with ADLs, workload adjustment	Lifelong	Survived into adulthood with visible anomalies	No	Likely experienced social and functional limitations
RMPE-75	Talipes equinovarus (clubfoot), knee arthrosis, possible genetic syndrome	Yes—gait and foot/knee anomalies	Yes—walking, prolonged activity	Chronic joint pain, stiffness, fatigue	Lifelong (congenital)	Walking, manual labor, carrying loads	Mobility support, physical assistance	Lifelong	Reached adulthood, adapted gait	No	Crutch use inferred from wrist changes

(Continues)

TABLE 2 | (Continued)

Individual ID	Impairment description	Visibility	Functional limitation	Symptoms	Estimated duration of the impairment	Activities affected	Likely care requirements	Estimated duration of the provided care	Survival implication	Differential burial treatment	Notes
RMPE-112	Asymmetrical sacrum and os coxae, misaligned SI joint	Yes—likely visible through limping or altered posture	Yes—posture, spinal loading	Likely discomfort, impaired posture	Likely congenital or developmental	Bending, lifting, walking	Minor support, adaptation	Long-term or intermittent	Adapted functionally	No	Poor preservation limits confirmation
RMPE-117	SCFE, healed radial fracture, hand and foot amputation (perimortem)	Yes—amputations	Yes—mobility, bimanual tasks	Pain, stiffness, impaired coordination	Medium–long term	Walking, lifting, coordination	Recovery support, mobility aid	Likely intermittent with episodic support	Survived major injury and SCFE	Yes—perimortem amputations; possibly as punitive treatment	Severe trauma likely required care
RMPE-119	Marked humeral asymmetry, vertebral facet asymmetry	Partial—shoulder height difference	Yes—bilateral arm use, posture	Muscle imbalance, discomfort, reduced coordination	Lifelong or developmental	Lifting, overhead or bilateral tasks	Task adaptation	Likely intermittent	Adapted structurally	No	Asymmetry likely influenced daily activity
RMPE-121	Mycetoma in foot, spinal changes, trepanation	Yes—limping, possible head scar	Yes—mobility, prolonged activity	Chronic pain, swelling, fatigue	Long-term (chronic infection)	Walking, labor, hygiene	Long-term support, infection care	Long-term	Survived chronic illness and surgery	Yes—buried with 30; may suggest higher status or an outsider	Unusual burial; may reflect high status

Three young males recovered from this graveyard, presenting evidence of *perimortem* limb amputation, have been interpreted as possible victims of judicial mutilation, a punitive practice historically documented for certain crimes (Fernandes et al. 2017). Such findings support the notion that physical impairment was not only stigmatized but, at times, actively inflicted as a form of social control and punishment. Other case studies from this osteological assemblage include a male with Klippel-Feil Syndrome (Fernandes and Costa 2007), another one with clubfoot (Curto and Fernandes 2022), and one with a fungal infection (Curto and Fernandes 2016).

Overall, the combination of high adult longevity, low prevalence of skeletal pathologies, and consistent dietary signatures reflects a relatively healthy population. This likely resulted from favorable socioeconomic conditions, food security, and limited exposure to severe pathogens or malnutrition.

4 | Sample and Methodology

This study examines eight males exhibiting skeletal evidence of physical impairment (Table 1) from a 13th–15th century Christian cemetery in Estremoz, Portugal, and compares their diet and skeletal indicators of physiological stress with the remaining males from the same site ($N = 31$) who were previously studied (Curto et al. 2025). Four of the impaired individuals had already been described in earlier publications (Fernandes and Costa 2007; Curto and Fernandes 2016; Fernandes et al. 2017; Curto and Fernandes 2022) with lesion descriptions and differential diagnoses; however, they were reanalyzed in the present study.

Sex, age-at-death, and morphometric data were previously reported in Curto et al. (2025). Periosteal lesions on tibiae were scored following Steckel et al. (2006) (score ≥ 2), and *cribra orbitalia* and *cribra cranii* were recorded when porous lesions (score ≥ 1) were present (Rinaldo et al. 2019). Full methodological details are in Curto et al. (2025).

Adult diet was assessed using previously published carbon and nitrogen isotope data from rib collagen (Curto et al. 2025), which were further explored here to investigate potential dietary differences between impaired and nonimpaired males. As part of the new analyses in this study, we recorded the number of macroscopic enamel hypoplasias (LEH) per tooth, considering the maximum number per tooth as a proxy for the number of episodes of physiological stress during crown development. Canines, due to their extended formation period (AlQahtani et al. 2010), were used to estimate the age at which stress events occurred. This was done by measuring the distance from the cemento-enamel junction (CEJ) to each LEH defect and applying the regression formula provided by Cares Henriquez and Oxenham (2019). The first LEH was considered as a proxy of the earliest physiological stress episode. In addition to documenting the age of individual LEH, we calculated a mean hypoplasia age per individual, defined as the average of all estimated LEH formation ages recorded on the canine. This was then averaged across groups (e.g., impaired vs. nonimpaired males). Although we acknowledge that each hypoplastic groove reflects a unique stress event, the purpose of calculating the mean age was not to replace this chronological resolution but rather to explore broader tendencies in the timing of physiological stress. Specifically, we aimed to assess whether individuals with impairments tended to experience

TABLE 3 | Descriptive statistics of skeletal indicators of health and mean values for the individuals with impairment and the other males without signs of impairment.

Skeleton ID		Sex		Tibia length (mm)	LEH: Number of LEH per tooth	LEH: Age of the 1st LEH (in years)	LEH: Mean age of the LEH (in years)
RMPE (Nonimpaired)		Male	$\bar{x} \pm \sigma$	354.35 ± 20.19	3.48 ± 1.24	3.02 ± 0.58	3.65 ± 0.39
			N	20	23	19	19
Impairment	RMPE-28oss1	Male		—	2	3.24	3.67
	RMPE-69	Male		367.00	0	—	—
	RMPE-73	Male		360.00	2	3.89	4.28
	RMPE-75	Male		344.00	3	3.31	3.95
	RMPE-112	Male		—	2	—	—
	RMPE-117	Male		—	4	3.16	3.31
	RMPE-119	Male		355.00	4	2.02	4.21
	RMPE-121	Male		—	2	—	—
	Mean			356.50 ± 9.68	2.38 ± 1.30	3.12 ± 0.68	3.64 ± 0.49
	Mann–Whitney U test (impaired vs. nonimpaired)	W		43	137	40	49
		p value		0.85	0.04	0.62	0.94

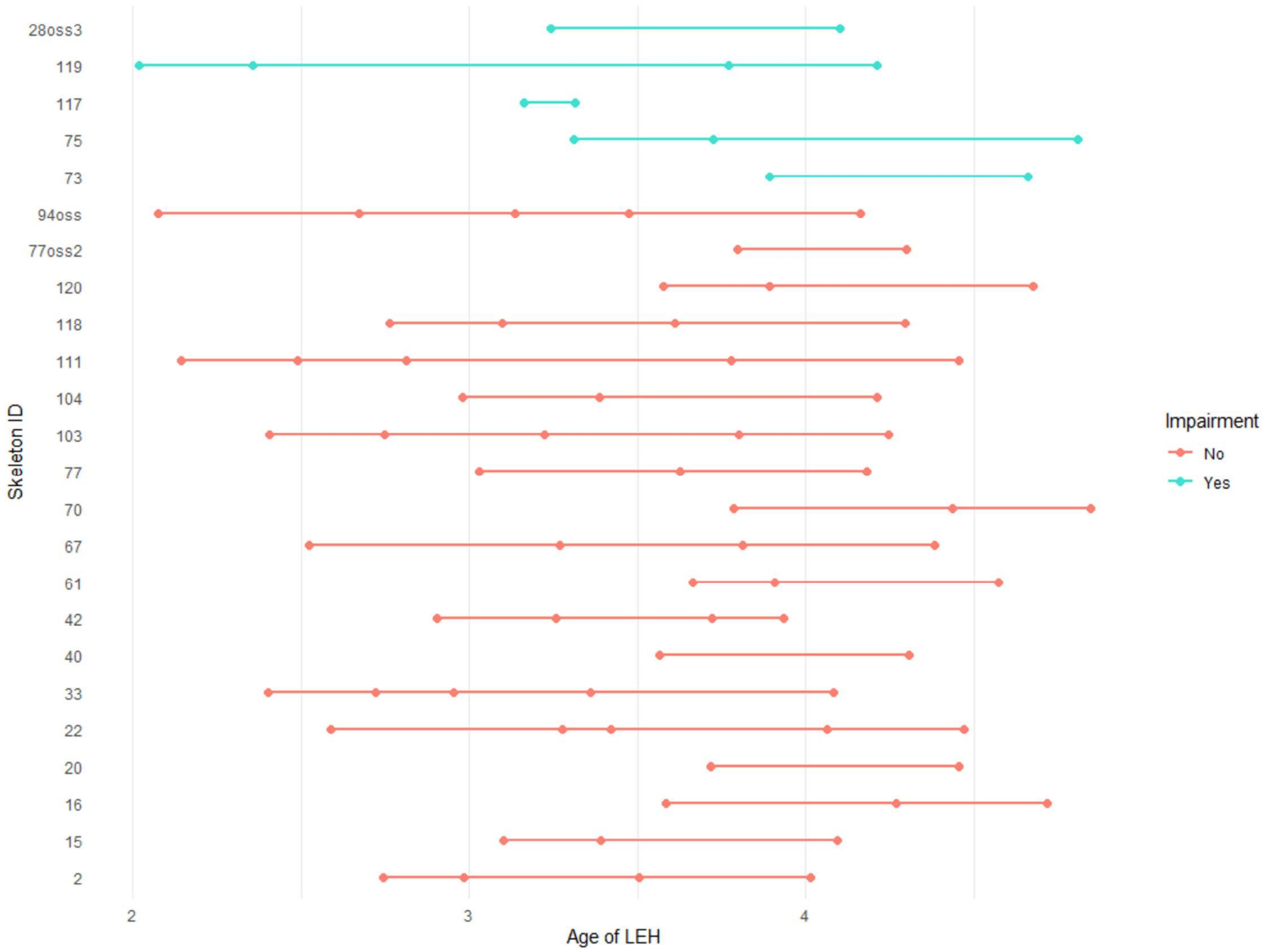

FIGURE 2 | Estimated ages at formation of linear enamel hypoplasias (LEH) in individuals with and without skeletal impairments. Each line represents one individual and the points indicate distinct episodes of physiological stress during crown development. [Colour figure can be viewed at wileyonlinelibrary.com]

stress episodes earlier or later in childhood compared to their peers.

To assess developmental stress, tibial length was used as a stature proxy, given its sensitivity to environmental and nutritional factors (e.g., Jantz and Jantz 1999; Bogin and Varela-Silva 2010).

Nonparametric tests evaluated differences between impaired and nonimpaired males ($N=8$ and $N=31$, respectively), with the aim of testing whether individuals with skeletal impairments exhibited significantly different patterns of physiological stress or dietary intake. This analysis explores the hypothesis that impaired individuals may have experienced greater stress exposure in childhood and/or adulthood due to their condition.

Impairment was defined as skeletal conditions likely to affect physical function and daily life, identified through macroscopic analysis and palaeopathological assessment. The evaluation followed the methodological frameworks outlined by Tilley and Cameron (2014) and Bohling et al. (2022a), which were adapted to ensure clarity and accessibility for a wider audience.

From Tilley and Cameron's (2014) bioarchaeology of care approach, three criteria were used to infer care: (1) survival with a condition that would likely limit autonomy; (2) functional impact inferred through clinical parallels; and (3) a model of care derived from the estimated physical limitations. Specifically, the Index of Care methodology assesses impairment impact on essential and instrumental activities of daily living (e.g., feeding, hygiene, and mobility), duration (short, medium, or long term), and probable care requirements (e.g., provisioning, assistance, and accommodation). Where appropriate, constants of care (e.g., hygiene, feeding, and monitoring) were used to explore potential caregiving scenarios.

From Bohling et al. (2022a), the definition of physical impairment required that the condition be visible (externally noticeable), functional (affecting movement or self-sufficiency), or symptomatic (e.g., pain and fatigue), with likely social implications. Impairments were categorized based on estimated duration: congenital, definitively long-term, medium-to-long term, or end of life. Only impairments with visible or functional impacts were included, as these are more likely to have influenced identity and required adaptation or support. Clinical literature supported the differential diagnosis and informed assumptions about the condition's impact and potential need for care.

Together, these frameworks allowed us to evaluate each case systematically, balancing osteological evidence with clinical and sociocultural context to assess whether the individual may have required support within their community.

As all individuals with signs of impairment in this study are male, comparisons were made exclusively with the general male sample from Estremoz. This approach was adopted to minimize potential bias related to sexual dimorphism in skeletal morphology and physiology. Previous analyses of the Estremoz collection (Curto et al. 2025) suggest that males and females may exhibit differing patterns in skeletal stress markers and body size. By restricting comparisons to males, we aimed to ensure more accurate and internally consistent assessments of impairment-related differences.

5 | Results and Discussion

5.1 | Impaired Individuals Versus General Population

Table 1 shows a list of the skeletons considered as having a physical impairment and Table 2 exhibits a summary of the lesions and estimated care provided to these individuals. A full description of these can be found in the Supporting Information, including figures illustrating the unpublished cases (Figures S1–S3).

All were male and showed no higher frequency or severity of skeletal stress or trauma than the broader sample (Tables 1 and 3). Fewer than half had trauma (3/7; RMPE-28oss1 excluded due to limited preservation), and two cases resulted from medical procedures. None exhibited tibial periosteal lesions ($N=6$), *cribra orbitalia* ($N=5$), or *cribra cranii* ($N=7$), despite at least six having impairments since childhood (Table 2). Periosteal lesions are nonspecific indicators of stress, often associated with repetitive biomechanical strain (e.g., Franklyn and Oakes 2015), vitamin deficiencies (e.g., Weston 2011), and pathogen-related infections (e.g., Klaus 2014). Their presence, particularly when active, can serve as a broad marker of disease, whether chronic or acute, as well as physiological stress. The presence of *cribra orbitalia* and *cribra cranii* can represent social and economic inequalities (e.g., Biehler-Gomez et al. 2023). In this study, their absence among impaired individuals does not imply the absence of disease or hardship, because many infectious and metabolic conditions leave no skeletal trace (Wood et al. 1992). However, the lack or low frequency of these lesions may tentatively suggest that these individuals were not exposed to the prolonged or recurrent stressors typically required for such skeletal manifestations to form and persist.

Tibial length, a proxy for growth-related physiological stress (e.g., Jantz and Jantz 1999; Bogin and Varela-Silva 2010), was only below the sample mean in RMPE-75, the male with clubfoot (Table 2). On average, males with impairments had similar tibia length (356.5 ± 9.68 mm, $N=4$, Table 3) to those without (354.4 ± 20.19 mm, $N=20$, Table 3). This suggests that impairments were not consistently linked to growth deficits resulting from early-life physiological stress. Linear growth is sensitive to factors such as infection, nutrition, and psychosocial conditions during childhood (e.g., Jantz and Jantz 1999; Bogin and Varela-Silva 2010), and smaller body size, which reflects chronic undernutrition and stress (Fried et al. 1998), correlates with increased mortality during epidemics (DeWitte and Hughes-Morey 2012). At Estremoz, the absence of reduced tibial length may point to adequate caregiving, reduced exposure to early-life adversity, or higher social buffering, enabling individuals with impairments to reach adult stature despite physiological challenges.

Males with impairments exhibited a significantly lower frequency of linear enamel hypoplasias (LEH; Table 3) (2.4 ± 1.30, $N=8$) than those without impairments (3.5 ± 1.24, $N=23$; $p=0.04$), suggesting fewer episodes of physiological stress during childhood. Only RMPE-117 and RMPE-119 presented LEH counts above the male mean (Table 3). In general, most LEH events occur between 2.5 and 4.5 years of age. On average, most of the individuals without impairment had their first LEH slightly earlier than those with impairment; these individuals had their first stress period after 3 years old, with the exception of RMPE-119 (Figure 2). Their stress periods also appear more concentrated in time, compared to those without impairment, who exhibit a wider spread of LEH ages, possibly reflecting prolonged or repeated stress. The mean age at formation was comparable between impaired (3.6 ± 0.49, $N=5$) and nonimpaired males (3.7 ± 0.39, $N=19$), corresponding to the typical weaning period (2–4 years; Miszkiewicz 2015), when individuals are particularly vulnerable to nutritional stress, dietary transitions, and pathogen exposure. These patterns are consistent with findings by Lorentz et al. (2021), who reported hypoplasia peaks during developmental windows of elevated stress risk. LEH formation reflects systemic disruptions during enamel development, associated with malnutrition, infection, or toxin exposure and has been linked to reduced longevity (Boldsen 2007). The lower LEH frequency in impaired males may reflect mitigating environmental or social factors, such as improved care or nutrition, particularly during critical developmental periods. However, this pattern may also reflect a selection effect: Individuals with both physical impairments and high early-life stress may have been less likely to survive into adulthood and thus are underrepresented in the sample. Additionally, congenital anomalies and impairments are harder to detect in nonadult skeletons due to incomplete expression or poor preservation. Cross-population standardization of LEH analysis could further clarify whether such trends reflect localized health conditions or broader postnatal stress responses.

Isotopic data of the overall population was previously discussed in Curto et al. (2025) with regard to the faunal baseline. Results indicate a primarily terrestrial adult diet, with possible contributions from C_4 plants and/or aquatic resources (Curto et al. 2025; Figure 3). Similar average $\delta^{13}C$ and $\delta^{15}N$ values were observed between individuals with ($\delta^{13}C$ $\bar{x} = -18.2‰ \pm 0.36‰$; $\delta^{15}N$ $\bar{x} = 11.0‰ \pm 1.05‰$; $N=6$) and without impairments ($\delta^{13}C$ $\bar{x} = -18.1‰ \pm 0.48‰$; $\delta^{15}N$ $\bar{x} = 11.0‰ \pm 0.87‰$; $N=12$). This indicates that individuals with physical impairments likely had access to comparable dietary resources, suggesting their social integration in terms of food provisioning and an absence of

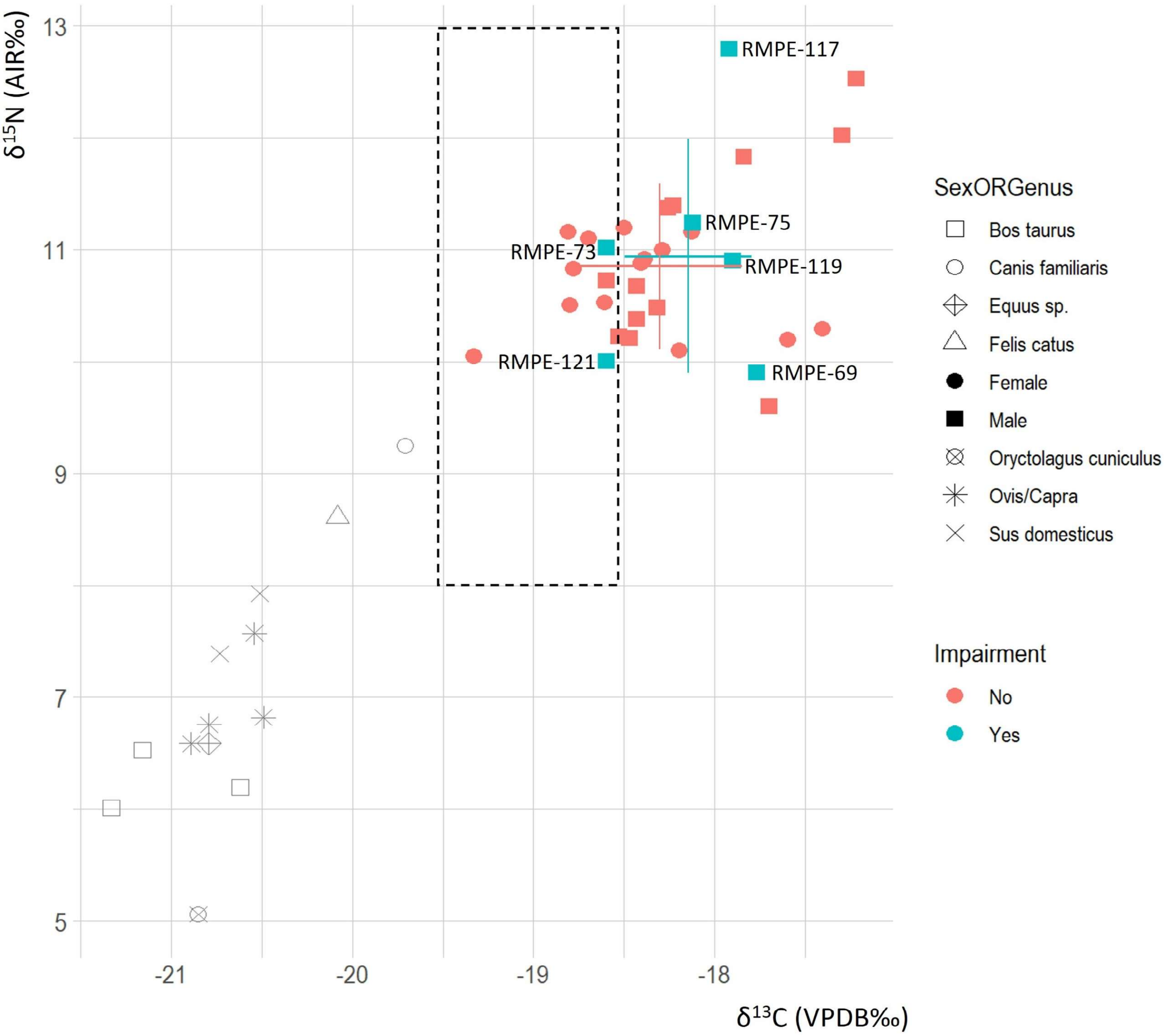

FIGURE 3 | Stable isotope values of fauna and human bone collagen. Lines indicate the mean and standard deviation for the general population (males and females; $\delta^{13}C = -18.29‰ \pm 0.48‰$; $\delta^{15}N = 10.85‰ \pm 0.73‰$) and those with impairment ($\delta^{13}C = -18.15‰ \pm 0.36‰$; $\delta^{15}N = 10.97‰ \pm 1.05‰$). The dashed rectangular area indicates expected values for the trophic level increases from the maximum and minimum values of the analyzed fauna (except the carnivores). [Colour figure can be viewed at wileyonlinelibrary.com]

marked dietary stratification based on physical ability. Similar patterns have been documented in France for a woman diagnosed with Treacher Collins syndrome and associated deafness, whose diet did not differ from that of the broader population and who exhibited no skeletal indicators of maltreatment (Miclon et al. 2021).

The highest $\delta^{15}N$ value was observed in RMPE-117 (12.8‰), an impaired individual with perimortem amputated hands and feet who may have been nonlocal (Fernandes et al. 2017), though no isotopic data confirm mobility or dietary profiles for the other amputees. The lowest $\delta^{15}N$ values among impaired individuals, yet still within the population range, were found in RMPE-69 (9.9‰) and RMPE-121 (10.0‰), two cases of trepanation (Figure S2 and Curto and Fernandes 2016), whereas RMPE-73 (KFS) and RMPE-75 (clubfoot) show $\delta^{15}N$ values near the population mean (Figure 3). Elevated $\delta^{15}N$ values typically reflect greater consumption of terrestrial or aquatic animal protein (e.g., Ambrose and Norr 1993; Chisholm et al. 1982, 1983), potentially linked to socioeconomic status. In this sample, $\delta^{15}N$ variation does not correlate with physical impairment presence, severity, or duration.

Previous research indicates that frail children in past societies were often viewed as less valuable than healthy individuals, leading to parental detachment (Tilley and Oxenham 2011). In Medieval Europe, disabled children were sometimes perceived as “changelings” (Kuuliala 2011), potentially harming familial status and justifying abandonment (Lewis 2006). In medieval Portugal, congenital conditions—attributed to maternal or birth complications—often defied treatment, leaving sufferers reliant on divine intervention (Oliveira 2015). Nevertheless, care was provided to children with physically limiting conditions like Klippel-Feil syndrome (KFS) and clubfoot. Despite their impairments, these individuals survived to adulthood without elevated physiological stress markers compared to peers in Estremoz, possibly due to enhanced childhood care, evidenced by fewer and later onset LEH.

Importantly, burial treatment did not differ markedly between impaired and nonimpaired individuals, reinforcing the argument that those with impairments were not socially excluded in death. Like recent studies (e.g., Cilione and Gazzaniga 2023; Bohling et al. 2022a; Bohling et al. 2022b; Bohling et al. 2023), our findings—including community burial—challenge the universal association of disability with exclusion in historical contexts.

This care may reflect Estremoz's favorable socioeconomic conditions (Curto et al. 2025), where stable resources facilitated support for vulnerable members, including preferential feeding or reduced labor demands. In historical contexts, communities with secure access to resources may have been more able and more inclined to support members with greater care needs. The generally low stress levels in the population further suggest protective social strategies (Curto et al. 2025). Parallels can be drawn with contemporary findings from the COVID-19 pandemic, where socioeconomic status significantly influenced health outcomes and mortality risk. Studies show that individuals from higher socioeconomic strata experienced lower mortality and better access to care during the pandemic, whereas more deprived populations faced disproportionate burdens due to structural inequalities (Mena et al. 2021; Khanijahani et al. 2021). This underscores how economic stability enables more equitable health outcomes, both historically and today.

6 | Limitations of the Study

Not all impairments leave skeletal traces; conditions like blindness or cognitive disabilities remain invisible in the record. Additionally, we are observing only those who survived into adulthood, who may have come from families with higher socioeconomic status and better access to care, thus biasing interpretations of social inclusion. The small sample size of impaired individuals and the lack of detailed contextual data (e.g., full excavation records) also limit broader generalizations. Finally, bone isotopic values capture long-term dietary trends but cannot detect short-term or episodic variation in nutrition. Although osteological and isotopic data offer indirect clues, estimating the nature and extent of care, or how individuals were socially treated, remains inherently challenging.

7 | Conclusion

Osteological evidence alone presents challenges in fully assessing past health conditions. The individuals studied required varying levels of care, potentially at different life stages, sometimes at a cost to caregivers' daily activities. This suggests a social framework that integrated impaired individuals with distinct identities. Notably, they displayed no greater physiological stress markers than their peers, enjoyed comparable adult diets and stature, and received high-quality care despite physical limitations from congenital conditions. Early-life indicators such as lower frequencies of linear enamel hypoplasias and average tibial length further suggest that social buffering and resilience were present from childhood, not just in adulthood.

Even today, societal inclusion remains inconsistent. Comparing these findings with modern disparities underscores that certain dynamics of care and inclusion may have existed in the past, particularly in resource-stable communities. This highlights the enduring role of socioeconomic conditions in shaping support systems across the life course.

Future research on childhood dietary patterns could further clarify early-life treatment. Ultimately, these insights challenge assumptions about disability in history and invite reconsideration of how past practices might inform more equitable approaches today.

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Ethics Statement

All analyses were conducted in accordance with Portuguese legislation governing archaeological human remains. The skeletal assemblage is curated at the University of Évora. Stable isotope analysis involved collagen extraction, with destructive sampling kept to a minimum and, whenever possible, using small bone fragments or previously detached material to reduce the impact on the specimens.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** Lordosis (a) of RMPE-28. oss1 with the fifth lumbar vertebra fused ((b) anterior view; (c) posterior view) and brachycephaly (d). **Figure S2:** Superior view of the RMPE-69 femora, with and without slipped femoral head (a). Posterior view of the proximal left femur and corresponding radiography (b). Healed trepanation on the right parietal (c). **Figure S3:** Anterior view of the RMPE-112 asymmetric sacrum and os coxae. **Data S1:** Supporting Information.