



ARTICLE

## **Rib trauma in a Late Medieval urban community, Portugal (13th – 16th century): anthropological insights about disease and survival in the past**

Susana J. Garcia<sup>a\*</sup>

<sup>a</sup> Centro de Administração e Políticas Públicas, Instituto Superior de Ciências Sociais e Políticas, Museu Nacional de História Natural e da Ciência, Lisboa, Portugal.

\*Corresponding author: [susanagarcia@campus.ul.pt](mailto:susanagarcia@campus.ul.pt)

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### ABSTRACT

The analysis of how people's bodies were affected by trauma can increase our understanding of daily life and suffering in past populations. Although rib fractures are common and can provide useful insights about morbidity and mortality in past populations, they are seldom investigated in archaeological populations. This study focusses on rib fractures in 94 adults recovered from the churchyard of the São Martinho Medieval church (Leiria, Portugal). The prevalence of rib fractures was 32.8% and 66 out of 1169 macroscopically observed ribs had fractures (17.7%). Males had more broken ribs than females and older individuals had more broken ribs than younger individuals, but the differences in prevalence were only significant for age. Among females, rib fractures were associated with pathological conditions such as osteoporosis; among males, the association with osteoporosis was rarer, but rib fractures were found to be associated with fractures on other bones.

Thirteen individuals had fractures on other bones besides the ribs, including the skull, ulna and hand bones, which can be related to interpersonal violence.

*Keywords: fracture; paleopathology; ribs; interpersonal violence; Leiria.*

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## RESUMO

O estudo sobre a presença de traumas ósseos no corpo humano pode ajudar-nos a compreender a vida do dia-a-dia e o sofrimento das populações pretéritas. Embora as fracturas nas costelas sejam comuns, e tenham implicações significativas na morbidade e mortalidade das populações, têm sido raramente estudadas em contexto arqueológico. Este estudo tem como objectivo pesquisar a prevalência das fracturas nas costelas em 94 adultos recuperados do cemitério medieval associado à igreja de São Martinho (Leiria, Portugal). Nesta comunidade, a prevalência das fracturas nas costelas era de 32,8%, e 66 das 1169 costelas macroscopicamente observadas tinham fracturas (17,7%). Os homens tinham mais costelas fracturadas do que as mulheres, assim como os indivíduos mais velhos. Contudo, as diferenças apenas são estatisticamente significativas para a idade. Nas mulheres, as fracturas estavam possivelmente ligadas a condições patológicas como a osteoporose. Por sua vez, nos homens, a ligação com a osteoporose era mais rara, mas a associação com fracturas noutros ossos era mais comum. Treze indivíduos tinham fracturas noutros ossos para além das costelas, incluindo no crânio, na ulna e nos ossos das mãos o que poderá estar relacionado com violência interpessoal.

*Palavras-chave: fracturas; paleopatologia; costelas; violência interpessoal; Leiria*

## Introduction

**T**he analysis of skeletal trauma can enhance our knowledge of daily life and suffering in the past. Ribs are fragile bones, but protect vital organs, so rib trauma can be used as an indicator of trauma patterns in past populations. Rib trauma is common, but seldom investigated in archaeological populations ([Brickley, 2006](#); [Matos, 2009](#);

[Assis, 2007](#); [Garcia, 2007](#)), probably due to poor preservation of the thoracic region.

Rib fractures may heal without serious complications, but can also be life-threatening, depending on the number of ribs affected, the age of the individual (morbidity increases significantly with age) and which rib was fractured. Flail chest, pneumonia, hemothorax and pneumothorax are possible

rib fracture complications ([Lovell, 1997](#); [Brickley, 2006](#)). Trauma on the first and second ribs can affect vital anatomical areas, are potentially life-threatening and are associated with the worse clinical outcomes ([Richardson et al., 1975](#); [Luceri et al., 2018](#)).

Adopting a quantitative and qualitative approach is crucial to interpret trauma in its sociocultural context ([Lovejoy and Heiple, 1981](#)) and rib fractures are no exception. The objectives of this study are twofold: firstly, we intend on investigating rib fracture distribution by sex and age, and secondly, identify rib fracture context (*e.g.* falls, occupational trauma, intrinsic bone fragility, interpersonal violence, or other).

## Material and Methods

The skeletal material analysed in this study comprises 94 adult skeletons exhumed from a Late Medieval cemetery in Leiria (Central Portugal). According to historical records, the cemetery was associated with the São Martinho church, constructed in the 13<sup>th</sup> century and destroyed in the beginning of the 16<sup>th</sup> century ([Gomes, 1990](#); [Filipe et al., 2003](#)). Radiocarbon analyses corroborate this historic information. Moreover, the coins found in association with the skeletal remains were in circulation between 1248 and 1481 ([Filipe et al., 2003](#)).

In the adult sample, 45 individuals were females and 49 were males ([Table 1](#)). Sex determination followed the methods based on the hip bone, long bones and skull ([Bruzek, 2002](#); [Albanese, 2003](#); [Albanese et al., 2005](#); [Walrath et al., 2004](#)). Adults were divided into

four age groups according to Falys and Lewis ([2011](#)), except for the first age group, which was defined between the ages of 18 and 25 instead of 20 to 25. The age groups are: young adults (18-25 years); middle-aged adult (25-35 years); mature adults (35-45 years); old adults (46+ years) and undetermined adults (adult). To estimate age at death, methods based on dental wear ([Miles, 1963](#); [Brothwell, 1981](#)); morphology of the pubic symphysis ([Brooks and Suchey, 1990](#)); auricular surface ([Lovejoy et al., 1985](#); [Buckberry and Chamberlain, 2002](#)); and sternal rib ends ([Iscan et al., 1984, 1985](#)) were used. The preservation state of the sample was estimated according to Dutour ([1989](#)) and Garcia ([2005/2006](#)).

All ribs (or rib fragments) were macroscopically observed according to the Mann and Murphy ([1990](#)) recommendations to differentiate fractures from pseudo-fractures. Fractures were identified based on bone appositions and the presence of a bony callus. The position of the fracture (vertebral end/shaft/sternal end), the state of healing (healed/healing) and additional observations (*e.g.* non-union/ bony bridge) were recorded. The number of ribs per individual were calculated using two approaches: N(min), which represents the highest total number of rib heads for each side; N(est), which represents the estimated number of ribs calculated after laying an individual's entire set of ribs down. All skeletons were studied at least twice at different times. All statistical analyses were done with the SPSS® v.25 software.

**Table 1 - Age and sex distributions in the adult sample.**

Age (years)	Female		Male		Total	
	n	%	n	%	n	%
18-25	8	17.8	8	16.3	16	17.0
25-35	12	26.7	9	18.4	21	22.3
35-45	10	22.2	13	26.5	23	24.5
> 46	8	17.7	11	22.4	19	20.2
Adult*	7	15.6	8	16.3	15	16.0
Total	45	47.9	49	52.1	94	100.0

\*No assigned age group.

## Results

The preservation state of the São Martinho osteological sample was good. On average, 48.0% of the bones were preserved for each skeleton. However, the range covered by the preservation states is wide. On poorly preserved skeletons, only 5% of the bones were present, but in some skeletons, 98% of the bones were recovered. At least two ribs were preserved for 68.1% (64/94) of the adults. We obtained a N(min) of 1025 ribs and a N(est) of 1169 ribs.

Rib fractures are common in this sample, affecting 32.8% adults (21/64). Rib fractures are more common in males (12/36, 33.3%) than in females (9/28, 32.1%), but this difference is not statistically significant ( $X^2 = 0.10$ ,  $d.f. = 1$ ,  $p > 0.920$ ). Out of the 1169 ribs observed, 66 presented fractures: 24 ribs on females and 42 ribs on males. On average, males had more rib fractures per individual than females (3.5 against 2.7, standard deviation = 2.87). Two males sustained more than 5 fractured ribs and one male had more than 10 fractured ribs (Table 2). When analysed by age (younger and older than 35

years), we found significant differences in the sample ( $X^2 = 7.985$ ,  $d.f. = 1$ ,  $p = 0.005$ ), but when analysed separately by sex and age, the results were only significant for females ( $X^2 = 7.985$ ,  $d.f. = 1$ ,  $p = 0.005$ ). 62.5% (5/8) females and 36.4% (4/11) males with rib fractures were older than 46 years (Table 3). In males, at least one fracture was present in all age groups, while in females, fractures were only found for individuals older than 25 years. No significant results were found for the correlation between sex and the number of fractures ( $X^2 = 7.499$ ,  $d.f. = 7$ ,  $p = 0.379$ ). However, significant results were observed for the correlation between age (younger and older than 35 years) and the number of fractures ( $X^2 = 14.31$ ,  $d.f. = 7$ ,  $p = 0.046$ ).

The fractures were located along the ribs' longitudinal axes (vertebral end, shaft, or sternal end) and in some cases, more than one rib was fractured. One rib could also present multiple fractures. For most individuals, fractures healed without severe complications. Only two cases showed open fractures and a third case showed the presence of a bony bridge uniting several ribs (Figures 1 and 2).

Table 2 - Raw prevalence of rib fractures by sex and age

Age (years)	Females			Males		
	<i>n</i>	<i>nF</i>	%	<i>n</i>	<i>nF</i>	%
18-25	4	0	0.0	7	1	14.3
25-35	7	1	14.3	5	2	40.0
35-45	9	3	33.3	12	5	41.7
> 46	8	5	62.5	11	4	36.4
Adult	-	-	-	1	0	-
<b>Total</b>	<b>28</b>	<b>9</b>	<b>32.1</b>	<b>36</b>	<b>12</b>	<b>33.3</b>

*n*, number of individuals with left and right ribs; *nF*, number of individuals with rib fractures.

Table 3 - Absolute prevalence rates of fractures by sex and age

Age (years)	Females			Males		
	<i>n</i>	<i>nF</i>	%	<i>n</i>	<i>nF</i>	%
18-25	84	0	-	132	1	0.76
25-35	123	2	9.3	106	5	4.72
35-45	170	9	5.3	232	7	3.02
> 46	114	13	11.4	199	29	14.6
Adult	0	0	-	9	0	-
<b>Total</b>	<b>491</b>	<b>24</b>	<b>4.9</b>	<b>678</b>	<b>42</b>	<b>6.2</b>

*N*, number of individuals with left and right ribs; *nF*, number of individuals with rib fractures.



Figure 1 - Ribs presenting fractures and bony bridges, São Martinho Anthropological Collection, MUHNAC (loan from Câmara Municipal de Leiria). PRL63 (Photograph by S. Garcia © ULisboa-MUHNAC).



Figure 2 - Ribs presenting fractures, São Martinho Anthropological Collection, MUHNAC (loan from Câmara Municipal de Leiria). PRL13 (Photograph by S. Garcia © ULisboa-MUHNAC).

## Discussion

Traumatic injuries are one of the most common identifiable pathologies in archaeological populations. However, it is important to remember that the prevalence and frequency recorded in osteological samples are lower than the actual frequencies in these once living populations. First, we rarely have the opportunity to observe complete skeletons; and second, we can usually only observe healing or healed fractures. Fractures that occur around the time of death can be easily missed.

Even with these limitations, rib trauma analyses in this sample generated some

unexpected results. First of all, the prevalence in this population is rather high, especially if we consider that medieval urban inhabitants are generally less prone to traumatic injuries than their country folk counterparts ([Judd and Roberts, 1998, 1999](#); [Agnew et al., 2015](#)). In comparison with the work also done on urban populations by [Brickley \(2006\)](#) and [Assis \(2007\)](#), our overall prevalence seems high. More individuals presented rib trauma and sustained a higher number of rib fractures. This difference can mean that the medieval inhabitants of Leiria faced a higher number of daily perils related to occupation or violence, for instance, but other explanations could also be put forward. One important factor to

consider is the age distribution of the São Martinho sample: 20.2% of the individuals were estimated as being older than 46 years old. Older individuals are more prone to fractures or other pathological conditions. On the other hand, the sample is well preserved. The São Martinho churchyard excavation was done by osteologists and the taphonomic agents present at the site were not particularly aggressive. More than 64 of the 94 individuals had at least 2 ribs present, and all ribs were recovered for 23 individuals.

The distribution of rib fractures by sex and age in the São Martinho sample is very similar to the pattern observed by Brickley (2006). Older age is a crucial factor in rib trauma expression, especially for females. Males older than 35 years also had a higher number of rib fractures than younger males, but no difference in the number of rib fractures was found between mature (35-46 years) and old males (>46 years old). The age at which fractures occurred cannot be known, but clinical studies found that age is associated with an increase in bone fragility and the occurrence of rib fractures. A fall can result in more rib fractures if the individual is older, and complications at age 45 can be very severe, even in modern populations (Holcomb *et al.*, 2003). Younger males presented more rib fractures than younger females (<35 years), but older females presented more fractures (47.1%) than older males (39.1%) (>35 years). Additionally, more males exhibited fractures in other bones besides the ribs than females (9 males against 3 females).

In bioarchaeology, identifying the cause of a traumatic injury is challenging. However,

studies have highlighted different explanations for the occurrence of fractures in archaeological populations, such as daily risks associated with occupation (Lessa, 2011a, 2011b; Agnew *et al.*, 2015), environment/terrain (Kilgore *et al.*, 1997; Mays, 2006), social status and interpersonal violence (Lessa, 2004; Judd, 2004). In modern populations, rib fractures are frequently caused by blunt force trauma to the chest resulting from motor vehicle accidents, falls, assaults and work-related accidents (Brickley, 2006). The most probable cause for most of the traumatic injuries observed in the Leiria Medieval population would be accidents resulting from falls or work-related activities. Although medieval Leiria was already considered an urban setting, with people engaged in specialized crafts or service industries, agriculture and animal production activities existed in backyards or in the outskirts of the town. Rib fractures are much more common for both sexes in medieval populations than in contemporary populations, which can reflect differences in occupation, transport or leisure pursuits (Waldron, 2008).

On the other hand, if we consider that cranial injuries, direct-force ulnar fractures, hand fractures, and multiple injuries are an injury pattern associated with interpersonal violence (Judd, 2006; Tung, 2007), it could be a possible cause of rib fractures for at least three middle-aged males and two females. Lovell (1997) also considered that rib fractures were often the result of interpersonal violence. Three individuals presented with trauma in the cranium, three with trauma in the ulna and two with hand trauma.

Corroborating Tung (2007), males displayed more wounds on the anterior cranium, while females showed no difference in trauma distribution. However, the frequencies for these multi-site traumas for both males and females are very low. Another male suffered fractured ribs ( $n=8$ ) and ulna, but the distribution of the fractures, which also includes the right clavicle, fusion of the left wrist and the amputation of the left foot, is more suggestive of a severe accident. Severe accidents often occurred in medieval times. For instance, Gomes (1999) mentioned that a man was run over by an ox-cart in Leiria during that time.

Some trauma patterns suggest fractures occurred at different periods of the life of the individual. For instance, a single individual (SM13) had thirteen fractured ribs, some of which were still healing, but the fractures in the ulna, second metacarpal and proximal phalanx were completely healed. Out of 18 individuals with fractures in more than one bone, 13 involved the ribs (5 females and 8 males). We could also see that 6 out of 12 individuals presented fractures in several bones, but did not present any rib fractures, despite the good preservation of the thoracic cage.

## Conclusion

The distribution of rib fractures by sex and age in the São Martinho sample reflects the expression of other traumatic lesions. Males have more fractured ribs than females, but the difference is not sufficiently high to convey statistical significance. Rib fractures

seem to be age-related, affecting older rather than younger individuals. Rib trauma has different aetiologies. The main explanations for the high rate of rib fractures in medieval samples compared to modern populations are high numbers of falls and accidents related to work activities. However, interpersonal violence cannot be discarded as a possible cause when rib fractures are associated with other traumatic injuries, for instance in the skull, ulna and hands, as it was the case in at least 5 of the 21 individuals in our sample. Among females, multiple rib fractures emerge in association with osteoporosis, so the main cause of rib fractures in females may be bone frailty. Independently of their causes, even a single fractured rib can have a huge impact on the well-being of the affected individual. Trauma is one of the most common pathologies recorded in past human populations, but more attention should be given to rib fractures and other less-studied anatomical areas such as the hands, feet and vertebrae. The association between rib fractures and interpersonal violence should be studied more scrupulously.

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## References

Agnew, A. M.; Betsinger, T. K.; Justus, H. M. 2015. Post-cranial traumatic injury patterns in two Medieval Polish populations:

- the effects of lifestyle differences. *PLoS ONE*, 10(6): e0129458.
- Albanese, J. 2003. A metric method for sex determination using the hipbone and the femur. *Journal of Forensic Sciences*, 48(2): 1-11.
- Albanese, J.; Cardoso, H. F. V.; Saunders, S. R. 2005. Universal methodology for developing univariate sample-specific sex determination methods: an example using the epicondylar breadth of the humerus. *Journal of Archaeological Science*, 32(1): 143-152.
- Assis, S. 2007. *A memória dos rios no quotidiano dos homens: contributo de uma série osteológica proveniente de Constância para o conhecimento dos padrões ocupacionais*. MSc dissertation in Human Evolution. Departamento de Antropologia, Faculdade de Ciências e Tecnologia, Universidade de Coimbra.
- Brickley, M. 2006. Rib fractures in the archaeological record: a useful source of sociocultural information? *International Journal of Osteoarchaeology*, 16(1): 61-75.
- Brooks, S.; Suchey, J. M. 1990. Skeletal age determination based on the os pubis: a comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. *Human Evolution*, 5(3): 227-238.
- Brothwell D. R. 1981. *Digging up bones: The excavation, treatment and study of human skeletal remains*. 3<sup>rd</sup> edition. New York, Cornell University Press.
- Bruzek, J. 2002. A method for visual determination of sex, using the human hip bone. *American Journal of Physical Anthropology* 117(2): 157-168.
- Buckberry, J. L.; Chamberlain, A. T. 2002. Age estimation from the auricular surface of the ilium: a revised method. *American Journal of Physical Anthropology*, 119(3): 231-239.
- Dutour, O. 1989. *Hommes fossiles du Sahara. Peuplements holocènes du Mali septentrional*. Marseille, Éditions du CNRS.
- Falys, C. G.; Lewis, M. E. 2011. Proposing a way forward: a review of standardisation in the use of age categories and ageing techniques in osteological analysis (2004–2009). *International Journal of Osteoarchaeology*, 21(6): 704-716.
- Filipe, I.; Brazuna, S.; Matos, V.; Freitas, J. 2003. Necrópole de S. Martinho: análise preliminar dos dados arqueológicos e antropológicos. *Era*, 5: 54-79.
- Garcia, M. S. J. 2007. *Maleitas do corpo em tempos medievais: indicadores paleodemográficos, de stresse e paleopatológicos numa série osteológica urbana de Leiria*. PhD dissertation in Biological Anthropology, Departamento de Antropologia, Faculdade de Ciências e Tecnologia, Universidade de Coimbra.
- Garcia, S. 2005/2006. Conservação diferencial dos esqueletos humanos da série medieval de S. Martinho (Leiria): implicações para a paleodemografia e para a paleopatologia. *Antropologia Portuguesa*, 22-23: 273-294.
- Gomes, S. 1990. A Praça de S. Martinho de Leiria do Século XII a 1546. *Mundo da Arte*, 2(14): 57-78.
- Gomes, S. A. 1999. Higiene e saúde na Leiria medieval. In: Câmara Municipal de Leiria (eds.). *III Colóquio sobre a história de Leiria e da sua região*. Leiria, Câmara Municipal de Leiria: 9–43.
- Holcomb, J. B.; McMullin, N. R.; Kozar, R. A.; Lygas, M.; Moore, F. A. 2003. Morbidity from rib fractures increases after age 45. *Journal of the American College of Surgeons*, 196(4): 549-555.
- Işcan, M.Y.; Loth, S.; Wright, R. 1984. Age estimation from the ribs by phase analysis: white males. *Journal of Forensic Science*, 29(4): 1094–1104.
- Işcan, M.Y.; Loth, S.; Wright, R. 1985. Age estimation from the rib by phase analysis: white females. *Journal of Forensic Science*, 30(3): 853–863.
- Judd, M. 2004. Trauma in the city of Kerma: ancient versus modern injury patterns. *International Journal of Osteoarchaeology*, 14(1): 34-51.
- Judd, M. A. 2006. Continuity of interpersonal violence between Nubian communities. *American Journal of Physical Anthropology*, 131(3): 324-333.
- Judd, M. A.; Roberts, C. A. 1998. Fracture patterns at the Medieval Leper Hospital in Chichester. *American Journal of Physical Anthropology*, 105(1): 43-55.
- Judd, M. A.; Roberts, C. A. 1999. Fracture trauma in a Medieval British farming village. *American Journal of Physical Anthropology*, 109(2): 229-243.
- Kilgore, L.; Jurmain, R.; Van Gerven, D. 1997. Palaeoepidemiological patterns of trauma in a medieval Nubian skeletal population. *International Journal of Osteoarchaeology*, 7(2): 103–114.
- Lessa, A.; Mendonça de Souza, S. 2004. Violence in the Atacama Desert during the Tiwanaku period: social tension? *International Journal of Osteoarchaeology*, 14(5): 374-388.
- Lessa, A. 2011a. Daily risks: a biocultural approach to acute trauma in pre-colonial coastal populations from Brazil. *International Journal of Osteoarchaeology*, 21(2): 159-172.
- Lessa, A. 2011b. Spondylolysis and lifestyle among prehistoric coastal groups from Brazil. *International Journal of Osteoarchaeology*, 21(6): 660-668.
- Lovejoy, C. O.; Heiple, K. G. 1981. The analysis of fractures in skeletal populations with an example from the Libben site,

Ottawa County, Ohio. *American Journal of Physical Anthropology*, 55: 529-541.

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

Lovell, N. C. 1997. Trauma analysis in paleopathology. *Yearbook of Physical Anthropology*, 40(S25): 139-170.

Luceri, R. E.; Glass, N. E.; Bailey, J. A.; Sifri, Z. C.; Kunac, A.; Bonne, S. L. ... & Livingston, D. H. 2018. First rib fracture: A harbinger of severe trauma? *The American Journal of Surgery*, 216(4): 740-744.

Mann, R. W.; Murphy, S. P. 1990. *Regional atlas of bone disease: a guide to pathologic and normal variation in the human skeleton*. Springfield, Charles C. Thomas Publisher.

Matos, V. 2009. Broken ribs: paleopathological analysis of costal fractures in the human identified skeletal collection from the Museu Bocage, Lisbon, Portugal (late 19th to middle

20th centuries). *American Journal of Physical Anthropology*, 140(1): 25-38.

Mays, S.; Turner-Walker, G.; Syversen, U. 2006. Osteoporosis in a population from medieval Norway. *American Journal of Physical Anthropology*, 131(3): 343-351.

Miles, A. E. W. 1963. The dentition in the assessment of individual age in skeletal material. In: Brothwell, D. R. (ed.). *Dental anthropology*. Oxford, Pergamon: 191-209.

Richardson, J. D.; McElvein, R. B.; Trinkle, J. K. 1975. First rib fracture: a hallmark of severe trauma. *Annual Surgery*, 181(3): 251-254.

Tung, T. A. 2007. Trauma and violence in the Wari Empire of the Peruvian Andes: warfare, raids, and ritual fights. *American Journal of Physical Anthropology*, 133(3): 941-956.

Walrath, D. E.; Turner, P.; Bruzek, J. 2004. Reliability test of the visual assessment of cranial traits for sex determination. *American Journal of Physical Anthropology*, 125(2): 132-137.

Waldron, T. (2008). *Palaeopathology*. Cambridge, Cambridge University Press.