Traumatology in a Human Sample from the Necropolis of Shahr-i Sokhta

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Abstract

The site of Shahr-i Sokhta is located in south-eastern Iran, in the region of Sistan-Baluchistan, and represents one of the most important Iranian protohistoric sites. During the three MAIPS campaigns (2017, 2018, 2019) we studied 69 individuals in good condition brought to light by the Iranian team's excavations. The sample consisted of 41 female and 28 male individuals, which were examined for the presence of antemortem and perimortem traumas. The presence of antemortem but not perimortem traumas was detected in 16 individuals (8 males and 8 females), among whom the traumas were accidental in 11 individuals and intentional in the remaining 5. Given the lack of fatal injuries, the picture that emerges from this preliminary study of bone traumas, admittedly based on a limited sample, is consistent with the traditional view of the site and its inhabitants as being generally nonviolent.

1. Introduction

The site of Shahr-i Sokhta is located in south-eastern Iran, in the region of Sistan-Baluchistan, and represents one of the most important Iranian protohistoric sites, with a long occupation from 3550-2000 BC (Ascalone - Fabbri 2019). From the original nucleus located in the current eastern residential area, the settlement shifted westwards in the late I and early II Periods, experiencing gradual growth until reaching its maximum extension during Phase 3 of the III Period (making it one of the largest settlements in the entire Near and Middle East). The end of the III Period saw a rearrangement of the settlement layout in its central and eastern parts, followed in the IV Period by a phase of decline that lasted until life in the settlement abruptly ceased (Ascalone - Fabbri 2019). Shahr-i Sokhta, along with major settlements in the Indus valley, ceased to exist, the victim of a crisis that archaeological research has attributed, not without uncertainty, to radical and sudden climate change, critically damaging to settlements whose subsistence relied on the region's water resources. During its 14 centuries of life, the city may have seen a succession of up to 97,000 inhabitants, with an average of 1,550 and a peak of 5,000-10,000 in the central centuries of its existence (Ascalone - Fabbri 2019).

Unlike contemporary Bronze Age sites (Harappa and Mohenjo Daro, associated with the Indus culture, and Gonur Depe, associated with the Bactria-Margiana archaeological complex), Shahr-i Sokhta does not feature any defensive structures (Tosi 1968), suggesting that the population tended to be nonviolent or at least did not feel threatened by external elements.

2. Materials and methods

In 50 years of research, the only recorded burial area discovered at the site is that of the currently investigated necropolis, occupying an area of about 20-25 ha (Sajjadi 2015). From 1972 until 2015, excavations, conducted first by Italian and later Iranian researchers, brought to light approximately 1,100 burials from an estimated 40,000 inhumations (Pardini - Sarvari - Negahban 1976; Sajjadi

2015; Ascalone - Fabbri 2019). Significant variability in the state of conservation of the skeletons from the necropolis was documented. They include optimally preserved individuals still featuring both tissues and hair (Lorentz 2010), as well as individuals recorded either in fragmentary condition or with extensive forms of corrosion (Sajjadi 2015; Ascalone - Fabbri 2019).

For the purpose of this study, adult specimens in a good state of preservation from primary burials were selected. Sex was determined with reference to hipbone characteristics and measurements conducted using Phenice's visual method (1969), DSP (Murail *et al.* 2005), the presence and morphology of the preauricular sulcus (Bruzek 2002) and the greater sciatic notch (Walker 2005). Age was estimated from the morphology of the pubic symphysis (Todd 1920), the auricular surface (Buckberry-Chamberlain 2002; Lovejoy *et al.* 1985) and epiphyseal fusion (Ferembach - Schwidetzky - Stloukal 1977). Data related to the analysed individuals, their sex and estimated age are presented in Table 1.

The sample consists of 41 females (59.42%) and 28 males (40.58%), percentages that are in line with site data. In the study of 105 individuals by Macchiarelli and Passarello (1988), 46% of the sample were male and 54% female; likewise, in the work by Abdolkarim *et al.* (2017) of 349 individuals 41% were male and 59% female.

The sample analysed here was divided into four age groups: adults, i.e. individuals who had reached skeletal maturity with fused secondary ossification centres but lacked other elements for age estimation; young adults, i.e. individuals aged between 18 and 35; middle-aged adults, i.e. individuals aged between 36 and 50; and old adults, i.e. individuals with an estimated age of over 50 (Tab. 2). For the purpose of this study, macroscopically visible *antemortem* and *perimortem* traumas were documented. *Antemortem* is defined as a trauma showing evidence of bone regeneration (Walker 2001). *Perimortem* traumas are defined as injuries that may have occurred either before death, but show no signs of healing, or shortly after death when the bone is still fresh and retains its viscoelastic nature (Buikstra - Ubelaker 1994; Ubelaker - Adams 1995). Bone, like any material, has a tendency to break in a predictable manner depending on the forces applied, creating various types of fractures (Lovell 1997) that reflect their aetiology. A fracture represents an abrupt interruption of a segment and can be traumatic (i.e. caused by external forces applied to the bone) or spontaneous, the latter resulting from pathological processes (Ortner 2003; Kimmerle - Baraybar 2008; Lovell 1997; Agnew - Bolte 2012). In medicine, the word *injury* refers to damage caused by a trauma and *trauma* refers to an accidental or intentional injury caused by *hard contact with the environment* (Stedman 1982). Accidental injuries are defined as all those injuries resulting from events that occur unexpectedly, whereas the concept of violent injuries carries with it the implication of human intentionality with the use of physical force intended to injure, harm or kill third parties (Walker 2001; Martin - Harrod 2015).

The most common accidental injuries are from falls or are directly connected to the lifestyle of the individual (Agnew - Bolte 2012).

With injuries from falls, the traumas are often concentrated on the upper limbs, involved in breaking a fall by extending the arms forwards so as to reduce impact with the hard surface (Meena *et al.* 2014). Indicative of this type of mechanics are radius fractures such as the Galeazzi fracture, involving the junction of the middle and distal thirds of the diaphysis, or Colles' fracture, involving the distal diaphysis and the articular surface of the radius (Lovell 1997). As for the clavicle, these cases affect the junction of the middle and lateral thirds (Lovell 1997). In 21.5% of cases the lower limbs are involved (mainly tibia and fibula fractures resulting from ankle sprains) and head injuries feature in only 2.5% of cases (Gelbard *et al.* 2014). In falls from heights, the most common injuries are rib fractures, followed by head, spine, lower limb, upper limb and finally pelvis fractures (Petaros *et al.* 2013). Indicative of this type of fall are vertebrae subject to crushing injuries created by vertical force transmitted along the spine following a fall on the feet or pelvis (Adams - Hamblen 1999).

Other than fall fractures, which have well-codified trauma patterns, the remaining accidental injuries arising from collisions have no univocal interpretation and can be distinguished from intentional injuries by the lack of traumas concomitant with typical patterns of violence (Walker 2001). As mentioned earlier, rib fractures are often related to trauma from a fall, but it should be noted that ongoing strain on the rib cage leads to stress fractures, usually as a result of habitual work or of persistent coughing or vomiting (Lovell 1997). Other common accidental injuries are those of the second metacarpal (caused either by a direct blow or by compressive force) and femoral diaphysis (Lovell 1997; Haughton *et al*. 2012).

Areas where fractures caused by intentional injuries are often found are the skull, the ulna (parry fracture) and the metacarpals (boxer's fracture) (Lovell 1997; Djuric *et al*. 2006; Soong - Got - Katarincic 2010).

As for the skull, studies of modern specimens have shown that in cases of interpersonal violence there is a prevalence of injuries to the splanchnocranium and that the most frequently affected area is that of the nose and cheekbones (Walker 2001; Lovell 1997; Komar - Lathrop 2006). In blunt force traumas, the most frequently affected area is in contrast the neurocranium, particularly the frontal bone. In these cases, the fracture is quite often localised on the left side due to a predominance of right-handed aggressors (Lovell 1997; Djuric *et al*. 2006; McNulty 2016). The presence of a skull fracture may not by itself be indicative of intentional injury, since in cases of interpersonal violence, concomitant injuries affecting areas of the postcranial skeleton are almost always recorded (Djuric *et al*. 2006).

The term 'parry' is used to describe a fracture of the ulna near the mid or distal diaphysis that does not involve the radius (Jurmain 1999; Judd 2008). This type of fracture is often used as direct evidence of interpersonal violence, given that the trauma results from an attempt to avoid a blow to the head with a blunt weapon (Grauer - Roberts 1996; Lovell 1997; Adams - Hamblen 1999; Jurmain 2001; Walker, 2001). However, these fractures may also be the result of accidental injuries (such as a fall on to an outstretched hand). Thus, in order to define the type of injury (whether accidental or intentional), it is always desirable to assess the presence of concomitant traumas (Judd 2008).

In cases of interpersonal violence, the metacarpals are involved and are fractured by the impact of a closed fist on a hard surface (hence the term 'boxer's fracture'). Fractures of the fourth and fifth metacarpals are typical, mainly affecting the distal end, while fractures of the second and third metacarpals are far less common (Soon - Got - Katarincic 2010; Gudmundsen - Borgen 2009).

Comparison between samples of the number and location of traumas is difficult due to differences in sample composition, particularly concerning age and social origin, and the non-homogeneity of the survey methods. With these limitations in mind, a bibliographical review was carried out for evidence of traumas in the populations of the region including the Jiroft culture, the Bactria-Margiana area and the Indus valley civilisation. For the Jiroft culture, to which Shahr-i Sokhta belongs, no anthropological data is available. For the Indus Valley, a sample consisting of a minimum 252 individuals including immatures was analysed at Harappa (Robbins Schug *et al*. 2012; Lovell, 2014). Also in the Indus Valley, a sample of 35 individuals was investigated at Farmana (Mushrif-Tripathy *et al*. 2012), together with another 37 at Rakhigarhi (Woo *et al.* 2018). Data is also recorded for Lothal (Sarkar 1972) and Kalibangan (Sharma 1999), both of which are cited in Lovell (2016). For the Bactria-Margiana area, the only available site is Gonur Depe, where evidence of traumas on adults and immatures has been published in a series of papers (Babakov *et al*. 2001; Dubova - Rykushina 2007; Kufterine - Dubova 2013). The study carried out at Kerma (Judd 2004), a geographically distant site with slightly later dating (1750-1550 BC) located in present-day Sudan, was also considered for two reasons: the analysed sample consists of adult individuals of known sex with complete or nearly complete skeletons, like those of Shahr-i Sokhta; during the examined period the site was involved in a number of conflicts, the trauma study confirming a high degree of interpersonal violence.

3. Discussion

To evaluate possible differences in the number and types of injuries experienced by the male and female individuals it is necessary to consider their demography, given that the probability of having suffered a trauma increases with age and thus, all other things being equal, an older sample will experience more traumas than a younger one. Demographic evaluation is hindered however by the percentage of adults whose age was undetermined, about a quarter of the sample, the percentage being higher among males (35.7%) than females (19.5%); Table 2. In order to include the adults of undetermined age, the latter were assumed to be equally distributed across the three different age groups. Table 3 shows the data from the adults of known age combined with the redistributed data from the adults of undetermined age. The Fisher Exact Test produced a value of 0.21, indicating that the difference between the male and female samples is not statistically significant, making it possible to compare them and to assess whether there are sex-related differences in the recorded traumas.

Of the 69 analysed individuals, 16 (23.2%) showed trauma outcomes, none of which occurred *perimortem*. In 11 cases, the documented traumas can be classified as accidental (Tab. 4) and in 5 cases as intentional (Tab. 5). Comparing the raw data, no differences between male and female individuals are noted in either the former (5 males, 6 females) or the latter (3 males and 2 females). However, if we take into account the fact that the male sample (n = 28) is numerically inferior to the female sample (n = 41), we see that the percentage of males affected by traumas is higher than females (Tab. 6). Although the difference between males and females is not statistically significant, the prevalence of intentional traumas is more than twice as high in the former as the latter. As for individuals with multiple traumas, there is no big difference between males (3/28 = 10.7%) and females (6/41 = 14.6%).

Regarding the topography of the individual traumas (n = 34), these are shown in Table 7, along with those of the Kerma sample (Judd 2004).

Traumas were documented mainly on the trunk and upper limbs, which together account for almost three-quarters of all those observed. The difference with respect to the distribution recorded at Kerma is close to the threshold of statistical significance ($p = 0.0775$).

Among the Indus culture sites, the largest sample was documented at Harappa (n = 252, Robbins Schug *et al.* 2012, Lovell 2014), although detailed comparisons are not possible due to the fact that this also includes immature and incomplete skeletons. However, it is interesting to note (i) that 34.8% (8/23) of the traumatised individuals had suffered multiple injuries compared to the 10.1% in Shahr-i Sokhta, (ii) that most of the traumas, 58.1% (18/31), were located on the skull compared to 14.7% recorded in the sample under review and (iii) that in the five individuals presenting *perimortem* traumas, violence was probably the cause of death while no cases of *perimortem* violence were recorded in Shahr-i Sokhta. Of the 35 individuals from Farmana (Mushrif-Tripathy *et al*. 2012), a single head trauma was recorded whereas no evidence of trauma was detected in the 37 individuals from Rakhigarhi (Woo *et al*. 2018). Based on Lovell 2016, in both the samples from Lothal (Sarkar 1972) and Kalibangan (Sharma 1999), one *perimortem* blunt force trauma is reported.

Of the 304 individuals from Gonur Depe (Babakov *et al*. 2001), only two traumas were found, one of which was *perimortem* and consisted of an arrowhead in the spine. The relatively small number of traumas is justified by the authors with reference to the poor state of preservation of the remains, but later studies (Dubova - Rykushina 2007; Kufterin - Dubova 2008, 2013) increased the number of traumas observed at the site, including two more cases of *perimortem* wounds.

4. Conclusions

The lack of defensive structures at the site suggests that the population of Shahr-i Sokhta was not threatened by external enemies to the extent that fortifications were necessary. This does not exclude that in the absence of external threats, internal forms of violence could have existed between different groups occupying the site. In order to analyse these aspects, the best indicator is osteological data, as human remains provide direct evidence of interpersonal violence (Walker 2001; Doretti - Snow 2003; Kimmerle 2004). Traumatic injuries are not subject to the interpretative difficulties posed by literary sources, such as historical documents and ethnographic reports (Walker 2001). In Shahr-i Sokhta, from a sample of 69 individuals, 34 *antemortem* injuries were found in 16 individuals, none of which were attributable to sharp force traumas. *Perimortem* injuries are absent and therefore none of the examined individuals died as a direct and rapid consequence of violence. Furthermore, no differences were found in the prevalence of traumas between men and women, neither for traumas interpreted as accidental nor as intentional. The latter were generally of low intensity, with the possible exception of a male individual from grave 3912. In contrast, cases of lethal violence and stab wounds are seen in other osteological samples from the region, in particular the Indus valley, even in small samples such as those from Lothal (Sarkar 1972) and Kalibangan (Sharma 1999). The traumas detected and the context of discovery led Robbins Schug *et al*. (2012) to conclude that there were socially differentiated forms of violence at Harappa, although subsequent analysis by Lovell (2014; 2016) does not support this hypothesis. A number of cases of *perimortem* (Dubova - Rykushina 2007) and sharp force traumas (Babakov *et al*. 2001; Dubova - Rykushina 2007) were also observed in Gonur Depe.

From this preliminary study of bone traumas in the necropolis of Shahr-i Sokhta, despite the limited number of analysed samples, a picture emerges that is consistent with the traditional view of the site as hosting a nonviolent society: most of the detected traumas can be interpreted as accidental and there are no cases of *perimortem* or sharp force traumas. In contrast, the latter are not absent in less numerous samples from the Indus Valley sites and Gonur Depe.

Fig. 1: rib fracture in external view.

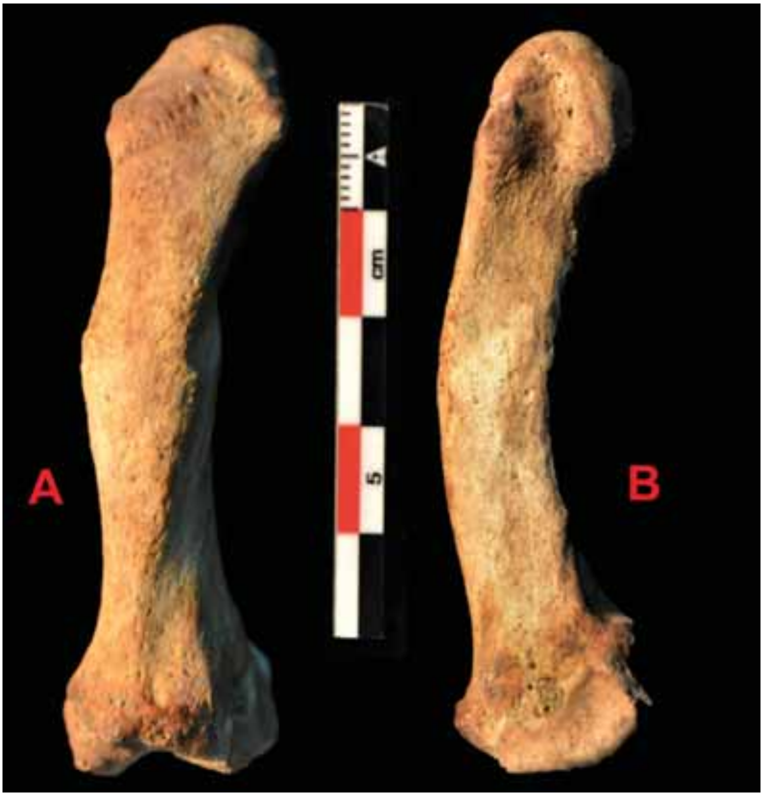

Fig. 2: 2nd metacarpal in dorsal view (left) and lateral view (right).

Fig. 4: Left: femur in anterior view. Right: magnification of the fracture in medial view; extensive osteomyelitis can be seen on the surface of the bone.

Fig. 3: radius in medial view, with Galeazzi fracture.

Fig. 5: depressed oval-shaped fracture on the frontal bone.

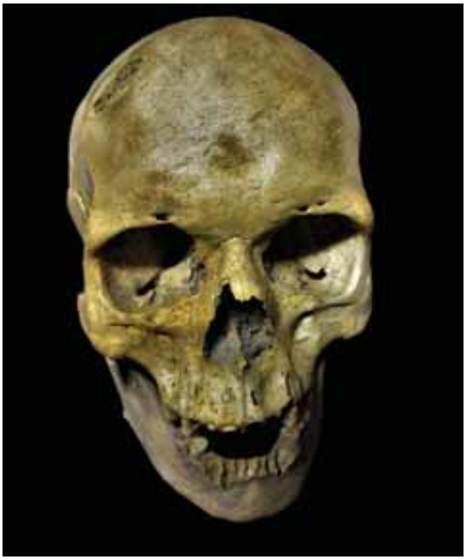

Fig. 6: depressed fracture on the left side of the frontal bone.

Fig. 8: right first rib, sternal manubrium, sternum, and rib fragments in anterior view. In the inset A), right first rib in anterior view; B) deformation of the articular surface of the right first rib.

Fig. 7: fracture on the right zygomatic.

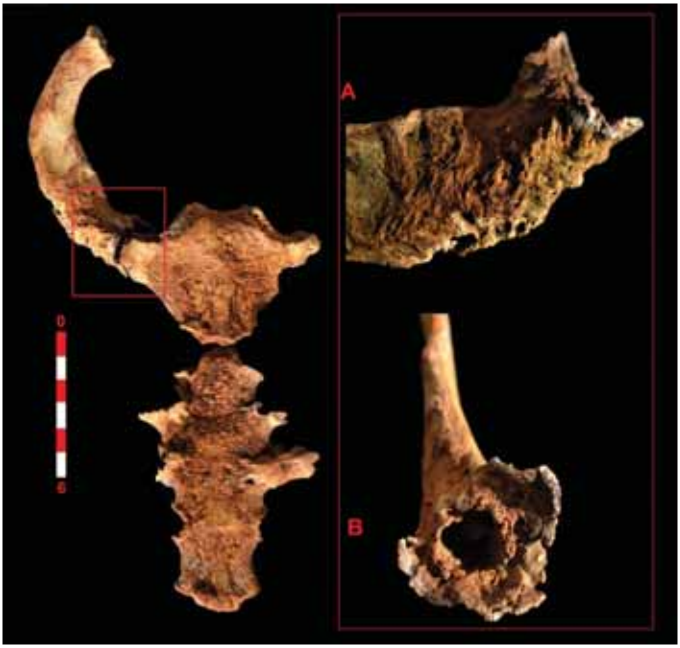

Fig. 9: right ulna, parry fracture in anterior view.

Fig. 11: 5th metacarpal, boxer's fracture, in lateral view (left) and dorsal view (right).

Fig. 10: 2nd metacarpal in dorsal view (left) and lateral view (right).

Individual	Square	Sex	Age
725	IUP	F	YOUNG ADULT
745	IUP	M	ADULT
1302	IUC	M	ADULT
1400	IUG	F	ADULT
1411	IUG	M	YOUNG ADULT
1609	IUK	F	MIDDLE-AGED ADULT
1610	IUK	F	MIDDLE-AGED ADULT
1703	IUA	F	ADULT
1705	IUA	F	ADULT
2702	HTR	F	MIDDLE-AGED ADULT
2706A	HTR	M	ADULT
2802	IUF	M	YOUNG ADULT
2903	HYJ	M	YOUNG ADULT
3100	IUM	M	OLD ADULT
3109	IUM	M	MIDDLE-AGED ADULT
3201	IUR	M	MIDDLE-AGED ADULT
3208	IUR	F	YOUNG ADULT
3211	IUR	F	YOUNG ADULT
3309	IUH	F	MIDDLE-AGED ADULT
3310	IUH	F	ADULT
3400	IPV	F	OLD ADULT
3401	IPV	F	MIDDLE-AGED ADULT
3402	IPV	F	MIDDLE-AGED ADULT
3502	IPW	M	MIDDLE-AGED ADULT
3903	IPU	M	MIDDLE-AGED ADULT
3909	IPU	F	MIDDLE-AGED ADULT
3912	IPU	M	MIDDLE-AGED ADULT
4215	NTY	F	OLD ADULT
4301	HYI	F	MIDDLE-AGED ADULT
4403	IUS	M	ADULT
4408	IUS	F	MIDDLE-AGED ADULT
4502	IUN	F	MIDDLE-AGED ADULT
4603	MID	M	YOUNG ADULT
4700	MII	F	YOUNG ADULT
5100	HYM	F	YOUNG ADULT

5116	HYM	M	MIDDLE-AGED ADULT
5203	IPP	M	OLD ADULT
5207	IPP	F	MIDDLE-AGED ADULT
5604	HYR	F	MIDDLE-AGED ADULT
5802	MDX	F	YOUNG ADULT
5806	MDX	F	YOUNG ADULT
5902	HOJ	M	ADULT
6703	MJN	F	MIDDLE-AGED ADULT
6705	MJN	F	YOUNG ADULT
6904	NFR	F	YOUNG ADULT
7005	NFM	M	YOUNG ADULT
7702	NAM	F	ADULT
7704	NAM	F	ADULT
7705	NAM	F	OLD ADULT
7907	NFC	M	ADULT
7917	NFC	M	ADULT
8308	MJO	F	YOUNG ADULT
8309	MJO	M	YOUNG ADULT
8615	MJT	F	YOUNG ADULT
8617	MJT	F	YOUNG ADULT
8619		F	ADULT
8725	MJJ	F	MIDDLE-AGED ADULT
8808	NFK	F	YOUNG ADULT
9016	NFP	M	YOUNG ADULT
9022	NFP	M	OLD ADULT
9029	NFP	M	ADULT
9209	NFQ	F	ADULT
9211	NFQ	M	YOUNG ADULT
9213	NFD	M	ADULT
9216	NFQ	F	MIDDLE-AGED ADULT
9321	NFA	F	MIDDLE-AGED ADULT
9408	MJE	M	ADULT
9417	MJE	F	MIDDLE-AGED ADULT
9613	NAQ	M	YOUNG ADULT

Tab. 1: sample studied: number, square, sex (F females, M males) and age of finds.

	M		F	
	n	%	N	%
Young Adult (20-35)	9	32.1%	12	29.3%
Middle-aged Adult (36-50)	6	21.4%	18	43.9%
Old Adult (50+)	3	10.7%	3	7.3%
Adult n.d.	10	35.7%	8	19.5%
	28		41	

Tab. 2: distribution of individuals by sex and age class.

	M		f		m+f	
	N	%	n	%	n	%
Young adult (20-35)	14	50.0%	15	36.4%	29	41.9%
Middle-aged adult (36-50)	9	33.3%	22	54.5%	31	45.9%
Old adult (50+)	5	16.7%	4	9.1%	9	12.2%
Total	28		41		69	

Tab. 3: age composition of the sample from Shahr-i Sokhta.

Individual	Age	Sex	Period	Conservation	Trauma
3502	MA	M	3?	Incomplete	Healed fracture on right parietal
4408	MA	F	1,2	Complete	Healed fractures on 4 ribs
4301	MA	F	2	Complete	Healed fracture on rib (Fig.1) Crushing injury on eighth thoracic vertebra
3201	MA	M	2	Complete	Healed fracture on rib Healed fracture on 2nd metacarpal (Fig. 2) Healed fracture on proximal half of left fibula
5604	MA	F		Complete	Healed fracture on acromial half of right clavicle
9022	OA	M		Incomplete	Healed fracture on distal end of right ulna
3402	MA	F	2	Complete	Healed Galeazzi fracture on left radius (Fig. 3)
3903	MA	M	2?	Incomplete	Healed Colles' fracture on left radius
3909	MA	F	1,2	Complete	Healed Colles' fracture on left radius Healed mid-diaphysis fracture on left femur
2702	MA	F	1	Incomplete	Healed fracture in centre of left femur diaphysis (Fig.4) Healed fractures on 4 cervical vertebrae
5116	MA	M		Incomplete	Healed fracture on proximal half of right tibia

Tab. 4: accidental traumas found on individuals from Shahr-i Sokhta: YA = young adult; MA = middle-aged adult; OA = old adult; A = adult of undetermined age; F = female; M = male. Periods are taken from the literature (Sajjadi, 2007; Sajjadi *et al.* 2003; Sajjadi *et al*. 2006).

Individual	Age	Sex	Period	Conservation	Trauma
5207	MA	F		Complete	Healed depressed fracture on frontal (Fig. 5) Healed fracture mid-diaphysis on 2nd right metacarpal
1302	A	M	1	Incomplete	Healed fracture on zygomatic process Healed depressed fracture on frontal (Fig. 6)
3208	YA	F	2	Complete	Healed fracture on right zygomatic (Fig. 7) Healed fracture in centre of diaphysis 5th right metacarpal
3912	MA	M	1,2	Complete	Sternum rib synostosis (Fig. 8) Healed parry fracture on right ulna (Fig. 9) Healed fracture mid-diaphysis on 2nd right metacarpal (Fig. 10)
1411	YA	M	?	Complete	Healed fracture on distal end of right 5th metacarpal (Fig. 11)

Tab. 5: intentional traumas found on individuals from Shahr-i Sokhta: YA = young adult; MA = middle-aged adult; OA = old adult; A = adult of undetermined age; F = female; M = male. Periods are taken from the literature (Sajjadi, 2007; Sajjadi *et al*. 2003; Sajjadi *et al*. 2006).

	Individuals	with traumas	% with traumas		p
M+F	69	16	23.2%		
M	28	8	28.6%	All traumas	0.4001
F	41	8	19.5%		
M	28	6	17.9%	Accidental	0.3337
F	41	5	14.6%		
M	28	3	10.7%	Intentional	0.3892
F	41	2	4.9%		

Tab. 6: traumas on individuals from Shahr-i Sokhta.

	Shahr-i Sokhta	%	Kerma	%
Skull vault	3	8.8%	20	14.8%
Face	2	5.9%	6	4.4%
Torso	14	41.2%	25	18.5%
Upper arm	11	32.4%	60	44.4%
Lower arm	4	11.8%	24	17.8%
Total	34		135	

Tab. 7: trauma distribution in Shahr-i Sokhta and Kerma (Judd 2004).

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