Violence in the Atacama Desert during the Tiwanaku Period: Social Tension?

A. LESSA* AND S. MENDONÇA DE SOUZA
Escola Nacional de Saúde Pública/FIOCRUZ, Rio de Janeiro, Brazil

ABSTRACT  
Tiwanaku influence significantly affected the lifestyle of the prehistoric peoples of the Atacama Desert as it represented an important period of social and economic change. Such intense changes as social stratification and new religious and ideological influences have always been characterized as peaceful ones. Palaeopathological studies based on the violence-induced traumatic lesions of 64 well-preserved human skeletons from an excavated funerary site named Solcor-3 have facilitated a comparison between Pre-Tiwanaku and Tiwanaku periods. Results show an increase in violence between males represented by low-intensity skull traumas, arrow wounds and a high mortality rate between 20 and 30 years of age during the Tiwanaku period. The interpretation of this data is contrary to the model of peaceful acceptance of the changes that followed the Tiwanaku influence into the Atacama. At least for Solcor-3, economic and political factors should be re-considered in order to explain the emergence of social tension during the Tiwanaku period. In the future, more detailed studies will probably help to clarify if conflicts had also extended to other sites in San Pedro de Atacama under Tiwanaku influence. Copyright © 2004 John Wiley & Sons, Ltd.

Key words: palaeopathology; violence; trauma; Chile; Atacama; Tiwanaku

Introduction

In the last few years anthropological and palaeopathological research has emphasized studies on trauma and physical violence during prehistoric times. Such studies have challenged the old concept that the prehistoric societies lived peacefully, in perfect harmony with each other (Heckenberger, 1996, Wilkinson, 1997). Recent analysis encompassing those questions have shown that violence among the prehistoric Amerindians did not start after their contact with Europeans as many academics and laymen believe. The iconographic and archaeological evidence of defensive structures, weapons, and especially the osteological register showing signs of beatings and other physical violence, make the existence of antagonistic relationships inside and among different groups even more evident.

This paper sets out to clarify a possible increase in social tension during the expansion of the Tiwanaku Federation over the traditional cultures in San Pedro de Atacama, Chile. Human skeletons found in Solcor-3 cemetery, an archaeological site covering the two periods, were analysed from a paleoepidemiological perspective to compare the amount and distribution of the violence during both periods in that site.

Tiwannaku expansion and the emergence of social tension in the Atacama

In northern Chile a large desert area surrounds the Salar of Atacama where human prehistoric occupations flourished for millennia. During the last 2000 years, inhabitants living by horticulture have occupied a small oasis around what is now the San Pedro de Atacama village (Figure 1). The traditional culture of the so-called Atacamenean groups originated there and from that cultural
centre they extended their influence across a very wide region, from the coast to the Andes cordillera. Adapted to the desert, they transported goods and products by caravan between the plateau and the coast for centuries. This well-structured exchange system guaranteed that the items that were absent or scarce in the desert could be supplemented and a very prosperous supra-regional interaction with other groups took place (Llagostera, 1996). Although peripheral in relation to the large Andean societies, the Atacamenean were under very important external influences, both cultural and economical, mainly during the Tiwanaku expansion. The Tiwanaku Federation was placed in a urban ceremonial centre, by Lake Titikaka, in the southern Bolivian Plateau, and it is characterized by an unique style of architecture and sculpture.

The readily accepted model for regional prehistory shows that the relationship between the Atacamenean oasis and Tiwanaku Federation was still very insignificant during the Quitor phase, around AD 200 to 500. It intensified during the Coyo phase sometime around AD 500 to 900 (Llagostera et al., 1988). The Tiwanakús influence is very clearly represented by the increase in paraphernalia associated with the inhaling of hallucinogenic substances (*tabletas*, inhaling tubes,
spoons, spatulas and bags with typical iconography of Tiwanaku). The complexity of the funerary rituals also indicates the strength of the religious and political power of the local religious leaders (xamãs) and landlords (señorios), as well as the strong ideological penetration in the oasis (Núñez, 1992). During the Tiwanaku period, there may have been an expansion in traffic of llama caravans connecting the oasis with the coast, the south and northwest plateaux, including the northwest of Argentina and the Lake Titicaca region. San Pedro de Atacama was probably a distribution centre for such goods as corn, *algarrobo*, *chañar*, copper, semiprecious stones, wood, salt, dry food, animal skins, *aji*, and *quinoa* which were taken to Tiwanaku to be exchanged for many different items, including those which expressed the different social and religious status.

To some archaeologists, the relationship between Tiwanaku and the Atacamenean oasis was based on a liturgical strategy that helped to assure social harmony in the absence of military coercive tactics (Núñez & Dillehay, 1995). However, Berenguer et al. (1980), Berenguer & Dauelsberg (1989), Browman (1980, 1981), Thomas et al. (1985) and Orellana (1985) have proposed a different interpretation. They partially agree with the idea of a complementary system of exchanging goods and resources, but they are not unanimous about a peaceful acceptance of the social and economical changes that occurred during that period. The hierarchical process that took place during the Tiwanaku period may have privileged those individuals who organized and sustained the new alliances. Increasing religious power, the changes in the social relationships between landlords of local and other groups, and controlled access to certain goods seem to confirm that. It would be very unlikely that a new system of values could come about without social and political costs. Reorganizing forces and political links between local landlords, and/or landlords from adjacent regions, could strengthen some social alliances and disrupt others, causing conflicts. The most expressive presence of weapons in tombs of the Tiwanaku period (Llagostera et al., 1988) also suggests this. Despite the absence of archaeological evidence of war, it is relevant to ask if all the Atacamaneans would have equally accepted that growing process of social discrepancy.

Previous studies of the Atacama Desert populations suggest violence-induced lesions in different periods. For 74 Chinchorro skeletons of Morro 1, Standen et al. (1984) found one individual with depressed skull fractures, two with face/skull trace fractures and one with a perforated wound probably caused by an arrow, most of them in adult males. One female had a ‘parry’ fracture. Although those authors considered head wounds as accidental, modern literature considers them violent. In those papers ‘parry’ fractures and perforated head wounds were considered violent trauma. Munizaga (1991), describing paleopathological findings in 50 skeletons from the Loa River also associated four skull fractures with violence. In both cases the populations lived on the coast and are not related to the Tiwanaku period.

Hypotheses about bioarchaeological differences between the Tiwanaku and Pre-Tiwanaku period were also proposed in previous studies (Neves & Costa, 1998). Neves and colleagues (1996) proposed an increase in social tension during the Tiwanaku period but the results of their analysis were negative. Summing evidence of trauma from 161 adult skeletons from three different sites (Solcor-3, Quitor-6 and Coyo) these authors considered skull and ‘parry’ fractures to be the only indicators of violence, and found no increase in social tension during the Tiwanaku period. Two years later Costa-Junqueira et al. (1998) examined only depressed skull fractures in the same three samples. They also summed trauma in adults of both sexes and all ages for the three samples. They concluded that a higher frequency of violence-induced lesions occur during the Tiwanaku period. In a subsequent paper Neves et al. (1999) published further results on trauma from these sites. Considering the same 161 adults and adding 83 subadults, they estimated the frequency of non-skull fractures. Finding no fractures in subadult skeletons, and no statistically significant difference between the number of fractures in adult males and females, they proposed that except for the skull fractures, all bone trauma, parry fractures included, were accidental. Since these studies took into account pathology but not mortality rates, summed series and samples, instead of segregating them, and did not include
arrow wounds as violence indicators, the question of the occurrence of violence in prehistoric populations from San Pedro de Atacama remains partially unsolved.

This paper reviews the theme of social tension during the Tiwanaku period, taking into account the published literature and also our previous analysis of 34 adult skeletons from Solcor-3 and Quitor-6 (Mendonça de Souza et al., 1996). A paleoepidemiological analysis was performed for only one site, Solcor-3, comparing violent traumas in different periods as well as mortality prevalence. The meaning of the data was clarified by the segregation of the sample into age and sex categories. Bias was minimized by the exclusion of disturbed and badly preserved burials and those from undefined cultural contexts.

**Material and methods**

Solcor-3, held in Le Paige Museum collection, is the largest and best preserved series of skeletons representing the Pre-Tiwanaku and Tiwanaku periods. One section of this cemetery was unearthed during a road construction (Bravo & Llagostera, 1986) and was partially excavated by the Museu Le Paige team in 1986. The series of burials sums to 251 individuals of both sexes and all ages, but many of them are disturbed and not all skeletons as in good state of preservation. As with other cemeteries of the same region, Solcor-3 also had several tombs affected by subsequent prehistoric and historic occupations. In many cases the disturbance confused cultural contexts. The skeletons for this study were selected according to the field and laboratory archaeological data about the burial (grave goods), and the available data were produced by Agustin Llagostera, Maria Antonieta Costa and colleagues of the Instituto de Investigaciones Arqueológicas y Museo R. P. Gustavo Le Paige, S. J. Only those skeletons belonging to burials with clear Tiwanaku or Pre-Tiwanaku characteristics were considered. As a result, 64 adults of both sexes, 25.4% of the recovered individuals, had more than 70% of the skeleton preserved and clear cultural affiliation, were available for trauma analysis. Considering the demographic patterns of a natural population (Hassan, 1981), children and youths were underrepresented at Solcor-3, reaching no more than 50% of the adults. They were not included in the present study because violence against children, except under special circumstances is scarcely mentioned in the literature (Walker, 1989, 2001).

Along with the paleopathological literature (Steinbock, 1976; Ortner & Putschar, 1985; Merbs, 1989; Walker, 1989; Jurmain, 1991; Burbank, 1992; Martin & Frayer, 1997; Burns, 1999), epidemiological analyses, clinical reports and forensic studies have been useful in this search for specific signs of violence. According to the literature depressed skull fractures, broken facial bones, especially the nasal bones, fractures of the middle and distal ulnar shaft, as well as the presence of arrow points or lithic splinters stuck to bones are some of the most important signs of violence in the literature. Other kinds of fractures may be violent or not, depending on the context.

Among modern peoples, depressed skull fractures are most commonly associated with violent causes (Gurdjian, 1973). Many authors believe that this situation was the same for prehistoric populations (Walker, 1989; Wilkinson, 1997; Martin, 1997; Lambert, 1997; Robb, 1997; Smith, 1997). Differential diagnosis of violent skull fractures is generally based on anatomical features. Fractures are generally concentrated around the frontal bone and are expected to have a regular morphological pattern (circular, oval shaped) that may be matched to the common weapons. Accidental fractures can also occur on skulls, but they are generally represented by fracture lines, tend to be irregular in morphology and assume different anatomical locations (Walker, 1989, 1997). Contrary to most accidental fractures, violent fractures generally follow a differential pattern characterizing a specific age/sex segment of the society. Fractures of the facial bones, especially at the nose, are also generally the result of violence. One other reason to consider head fractures as violence induced is that during fights it is more usual to strike the head and the neck, although some cultural variation can also occur. The reason for this strategy is that wounds in these anatomical locations will be more painful and the sequellae can be easily seen, both helpful consequences to demonstrate domination over a wounded antagonist (Walker, 1997). The 'parry'
fracture of the ulna (Adams, 1976; Ortner & Putschar, 1985; Merbs, 1989; Jurmain, 1991; Webb, 1995) is usually associated with a defensive movement of raising the arm to fend off a blow but it may occur when someone falls on the arm or tries to protect the body against a falling heavy object. Projectile points in bone, besides clearly indicating violence (Jurmain, 1991; Lambert, 1997; Walker, 1997; Smith, 1997; Maschner, 1997; Keeley, 1997), can be helpful in reconstructing the spacial relations of victim and aggressor, penetration trajectory and the general situation during the attack. Mortality rate is an important violence indicator, especially when young males are the most affected because this is contradictory to the demographic profile of a natural population (Hassan, 1981). Segregating samples instead of summing them, despite reducing the number of individuals per category allows for a comparison of variation in violence rates among different groups. The confounding effect of medium values is eliminated and biocultural interpretation is improved (Waldron, 1994).

The identification of trauma in the bones was carried out based on the presence of new bone formation, bone absence and/or destruction and remnant fracture lines. Abnormalities in texture of the surface, form and size of the bones were also considered (Ubelaker, 1978; Steinbock, 1976). Lesions in teeth were beyond the scope of this research. Observations were limited to visual assessment, while the diagnosis was established using comparative criteria available in paleopathology. Radiology and histological testing were not carried out at San Pedro de Atacama village. Fractures were counted for each kind of bone or anatomical region resulting in a different number of individuals examined (N) for each case. Arrow wound lesions were quantified based on the number of individuals in each sample or subsample, since those lesions occurred in different parts of the skeleton. Perimortem fractures were registered but were not considered, because in the absence of precise information about burial context it should be very difficult to distinguish post-mortem causes.

The series were compared by cultural period, age and sex. The age groups were divided as follows: I, 18–30 years; II, 30–40 years; III, 40+ years. Chi square and Fisher exact tests were performed to assess the significance of the differences between samples.

## Results

Of the 64 Solcor-3 adult skeletons studied for violent trauma, 16 skeletons show bone lesions. Most of the skeletons exhibit just one lesion but four have two and one has four (Table 1). Only

<table>
<thead>
<tr>
<th>Individual</th>
<th>Period</th>
<th>Sex</th>
<th>Age</th>
<th>N° of lesions</th>
<th>Lesion</th>
<th>Anatomical location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1049</td>
<td>Tiw</td>
<td>M</td>
<td>II</td>
<td>1</td>
<td>Crushing fracture</td>
<td>Nasal bones</td>
</tr>
<tr>
<td>1080</td>
<td>Pré-Tiw</td>
<td>F</td>
<td>III</td>
<td>1</td>
<td>‘Parry’ fracture</td>
<td>Left ulna</td>
</tr>
<tr>
<td>1236</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>2</td>
<td>Depressed fracture</td>
<td>Frontal bone</td>
</tr>
<tr>
<td>1516</td>
<td>Tiw</td>
<td>F</td>
<td>II</td>
<td>2</td>
<td>Depressed fracture</td>
<td>Occipital bone</td>
</tr>
<tr>
<td>1528</td>
<td>Pré-Tiw</td>
<td>F</td>
<td>III</td>
<td>1</td>
<td>‘Parry’ fracture</td>
<td>Right ulna</td>
</tr>
<tr>
<td>2150</td>
<td>Pré-Tiw</td>
<td>M</td>
<td>III</td>
<td>1</td>
<td>Arrow penetration</td>
<td>Left rib</td>
</tr>
<tr>
<td>2269</td>
<td>Pré-Tiw</td>
<td>F</td>
<td>II</td>
<td>1</td>
<td>Depressed fracture</td>
<td>Frontal bone</td>
</tr>
<tr>
<td>3063</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>1</td>
<td>Depressed fracture</td>
<td>Occipital bone</td>
</tr>
<tr>
<td>3589</td>
<td>Tiw</td>
<td>F</td>
<td>II</td>
<td>1</td>
<td>Depressed fracture</td>
<td>Frontal bone</td>
</tr>
<tr>
<td>3599</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>4</td>
<td>Arrow penetration</td>
<td>Left ilium</td>
</tr>
<tr>
<td>3607</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>1</td>
<td>Depressed fracture (3)</td>
<td>Frontal bone</td>
</tr>
<tr>
<td>3611</td>
<td>Tiw</td>
<td>F</td>
<td>I</td>
<td>1</td>
<td>Arrow penetration</td>
<td>Right ilium</td>
</tr>
<tr>
<td>13111</td>
<td>Tiw</td>
<td>M</td>
<td>II</td>
<td>1</td>
<td>Arrow penetration</td>
<td>Sternum; T-7</td>
</tr>
<tr>
<td>13118</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>2</td>
<td>Arrow penetration</td>
<td>Left humerus</td>
</tr>
<tr>
<td>13156</td>
<td>Tiw</td>
<td>M</td>
<td>I</td>
<td>1</td>
<td>Arrow penetration</td>
<td>Right ribs II and VI</td>
</tr>
<tr>
<td>13586</td>
<td>Tiw</td>
<td>F</td>
<td>II</td>
<td>2</td>
<td>Crushing fracture</td>
<td>Nasal bones; mandible</td>
</tr>
</tbody>
</table>

Table 1. Distribution of acute violent traumatic lesions in the skeletal series of Solcor-3 site, San Pedro de Atacama, Chile
two skulls show perimortem lesions, one male from each period. The two main types of violent trauma are depressed cranial fractures and arrow wounds (Table 2). ‘Parry’ fractures were found in two females (Table 2).

Only one male (5.8%) and three females (23%) from the Pre-Tiwanaku period had suffered violent trauma, all of them in the oldest age group (Table 3). Of those from the Tiwanaku period, both males (47%) and females (23.5%) show violent trauma, most of them young adults, whose mortality was higher than in the previous period (Table 4). Depressed skull fractures are oval and regular, smooth, and healed, being restricted to the outer table with little variation in size (0.8–1.8 cm wide/0.4–2.5 cm long). There is no sign of infectious complication, and no death can be associated with them (Figures 2 and 3). Arrow point wounds are small and healed, having regular rounded margins, except in the case of #3611 female. Entire lithic points or splinters were found inside those wounds, either firmly stuck inside the bone callus or trapped in healed cavities (Figure 4). Seven in eight arrow wounds occur in males from the Tiwanaku period.

Depressed skull fractures occur in one of the 12 (8.3%) females and no men from the Pre-Tiwanaku period, while ‘parry’ fractures occur in two out of 13 (15.3%) females. Only one Pre-Tiwanaku male skeleton (5.8%) has an arrow point wound (Table 5). Of those from the Tiwanaku period, depressed skull fractures

<table>
<thead>
<tr>
<th>Individual</th>
<th>Period</th>
<th>Sex</th>
<th>Depressed and crushing fractures</th>
<th>Parry’ fracture</th>
<th>Arrow penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nasal Frontal Parietal Occipital Max/Mand</td>
<td>Ulna</td>
<td>Post-crani al bones</td>
</tr>
<tr>
<td>1049</td>
<td>Tiw</td>
<td>M</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1080</td>
<td>Pré-Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1236</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1516</td>
<td>Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1628</td>
<td>Pré-Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2150</td>
<td>Pré-Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2289</td>
<td>Pré-Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3063</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3589</td>
<td>Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3599</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3607</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3611</td>
<td>Tiw</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13111</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13118</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13156</td>
<td>Tiw</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13,586</td>
<td>Tiw</td>
<td>F</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
<td>1</td>
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<td></td>
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<td>2</td>
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<td></td>
<td></td>
<td></td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Distribution of acute violent traumatic lesions according to anatomical location in the skeletal series of Solcor-3 site, San Pedro de Atacama, Chile

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>n</td>
<td>%</td>
<td>N</td>
</tr>
</tbody>
</table>
| I   | 3    | 0 0%   | 2     | 0 0% | 5 0 0%
| II  | 8    | 0 0%   | 7     | 1 14.2% | 15 1 6.6%
| III | 6    | 1 16.6% | 4     | 2 50%  | 10 3 30%
| Total | 17   | 1 5.8% | 13   | 3 23%  | 30 4 13.3% |

(N) = number of individuals examined; n = number of individuals with lesion.

Table 3. Number of individuals from the Pre-Tiwanaku period on Solcor-3 site with acute violent traumas, distributed by age and sex groups

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>n</td>
<td>%</td>
<td>N</td>
</tr>
</tbody>
</table>
| I   | 8    | 6 75%  | 3     | 1 33.3% | 11 7 63.6%
| II  | 8    | 2 25%  | 9     | 3 33.3% | 17 5 29.4%
| III | 1    | 0 0%   | 5     | 0 0%  | 6 0 0%
| Total | 17   | 8 47% | 14    | 7 23.5% | 34 12 35.2 |

(N) = number of individuals examined; n = number of individuals with lesion.
Figure 2. Healed depressed fracture of the frontal bone, female #2269, Pre-Tiwanaku period.

Figure 3. Healed depressed fracture of the occipital bone, right side, male #3063, Tiwanaku period.
occurred in 26.6% (four out of 15) of the men and 18.7% (3 out of 16) of the women. No ‘parry’ fractures were found, but arrow points were identified in 35.2% of the men and 5.8% of the women (Table 6).

The Pre-Tiwanaku individual skull fracture was on the frontal. The male skull fractures during the Tiwanaku period are distributed as follows: nasal bone (14.2%), frontal bone (57.1%), left parietal bone (14.2%) and occipital bone (14.2%) for the

Table 5. Distribution of individuals from the Pre-Tiwanaku period on site Solcor-3, San Pedro de Atacama, Chile, according to type of violent traumatic lesion

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Male (N)</th>
<th>n</th>
<th>%</th>
<th>Female (N)</th>
<th>n</th>
<th>%</th>
<th>Total (N)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressed/crushing fractures</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>1</td>
<td>8.3</td>
<td>28</td>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>‘Parry’ fractures</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>2</td>
<td>15.3</td>
<td>29</td>
<td>2</td>
<td>6.8</td>
</tr>
<tr>
<td>Arrow penetration</td>
<td>17</td>
<td>1</td>
<td>5.8</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

(N) = number of individuals examined; n = number of individuals with lesion.

Table 6. Distribution of individuals from the Tiwanaku period on site Solcor-3, San Pedro de Atacama, Chile, according to type of violent traumatic lesion

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Male (N)</th>
<th>n</th>
<th>%</th>
<th>Female (N)</th>
<th>n</th>
<th>%</th>
<th>Total (N)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressed/crushing fractures</td>
<td>15</td>
<td>4</td>
<td>26.6</td>
<td>16</td>
<td>3</td>
<td>18.7</td>
<td>31</td>
<td>7</td>
<td>22.5</td>
</tr>
<tr>
<td>‘Parry’ fractures</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arrow penetration</td>
<td>17</td>
<td>6</td>
<td>35.2</td>
<td>17</td>
<td>1</td>
<td>5.8</td>
<td>34</td>
<td>7</td>
<td>20.5</td>
</tr>
</tbody>
</table>

(N) = number of individuals examined; n = number of individuals with lesion.
males; nasal bone (16.6%), frontal bone (16.6%), occipital bone (16.6%) and maxillary bone (50%) for the females. The small and shallow skull fractures, similar in males and females, suggests that the implements used were blunt and applied with limited force.

The trajectories of the arrows were estimated considering the standing position. In the only wounded Pre-Tiwanaku male the arrow entrance site is located at the upper front of the thorax. The Tiwanaku male skeletons show projectile trajectories from the back (50%), from above their heads (16.6%) and from both sides (33.3%) (Table 7). Although none of the men had anterior entrance sites for projectiles, the female skeleton, #3611, shows an anterior entrance at the sternum and the arrow is lodged in the seventh lumbar vertebra.

The \( \chi^2 \) test (5% significance level) indicates that the difference between the number of Pre-Tiwanaku individuals suffering violent trauma and the Tiwanaku individuals with similar lesions is statistically significant \( (\chi^2 = 4.04, \ p\text{-value} = 0.0445579) \). The difference between males and females for both periods was also tested. The results are statistically significant for males \( (\chi^2 = 7.19, \ p\text{-value} = 0.0073447) \), but not for females \( (\chi^2 = 0.00, \ p\text{-value} = 0.9772243) \). Fisher exact tests were also performed for age and sex subgroups but no significant differences could be found probably because of the reduced \( N \) values in these segregating samples.

### Table 7. Distribution of frequency of lesions caused by arrow points on individuals from the Tiwanaku period on the Solcor-3 site, San Pedro de Atacama, Chile, according to penetration trajectory\(^a\) (considering the orthostatic position)

<table>
<thead>
<tr>
<th>Sex</th>
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<td></td>
<td>N</td>
<td>T</td>
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<td>n</td>
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<td>M</td>
<td>6</td>
<td>6</td>
<td>—</td>
<td>—</td>
<td>3</td>
<td>50</td>
<td>1</td>
<td>16.6</td>
<td>2</td>
<td>33.3</td>
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<td>F</td>
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<td></td>
</tr>
</tbody>
</table>

\( N \) = number of individuals with lesion; \( T \) = total of the observed lesions; \( n \) = number of the observed lesions. \n\(^a\)It was considered just the lesions of which the trajectory of the arrow penetration could be inferred.

Discussion

The number of violent lesions in the Solcor-3 skeletons is greater in individuals from the Tiwanaku period (35.2%) than in the preceding one (13.3%). Lesions are also more prevalent in young men from the Tiwanaku period and the mortality of young men seems unusually high. Despite the absence of data on soft tissue lesions for the mummified bodies in the Atacama, precocious mortality suggests that the number of individuals subjected to violent acts was possibly higher than the bones can demonstrate, as is proposed in the literature (Ubelaker, 1978; Hassan, 1981; Machado, 1992; Mendonça de Souza, 1992/93). In the case of violence, there is a clear association between morbidity and mortality that helps to solve the apparent osteological paradox of the healthy deceased. Archaeological evidence in San Pedro de Atacama does not suggest warfare during the political transition to the Tiwanaku period, but the osteological analysis is testimony to increased social tension expressed as physical violence against young men of this site. The results reinforce the view that, at least at Solcor-3, the transition to the Tiwanaku period was followed by a period of social tension. Perhaps this is true for other Atacama settlements, as proposed by Costa-Junqueira et al. (1998).

The most common violent traumas in the Solcor-3 Tiwanaku sample are skull and face fractures, most of them healed lesions of the outer table with little variation in size. The similar oval/round morphology of the wounds as well as their prevalent frontal and parietal locations are consistent with club strikes to the forehead during hand-to-hand conflict. Although some skeletons have other bone traumas, three individuals have only face fractures, and one individual has only face and skull wounds, supporting a violent aetiology for these lesions. The two perimortem skull fractures could also represent lethal lesions, but their inclusion would not
change the comparative interpretation because they were equally distributed between Tiwanaku and Pre-Tiwanaku periods.

Women's depressed skull fractures have a similar morphological pattern and the same prevalence in both periods, but contrary to men's, they are not associated with premature death or arrow wounds. This suggests that the aetiology was probably also violent, and even the weapon could be the same, but the social explanation may be different. An Atacamenean prehistoric pattern of domestic abuse is also a possible cause.

Arrow penetration, one of the most universally accepted lines of evidence for violence (Jurmain, 1991; Ortner & Putschar, 1985; Lambert, 1997; Walker, 1997; Smith, 1997; Maschner, 1997), was frequent during the Tiwanaku period. The presence of lithic damage,1 shards, or entire lithic points in the bone leaves little doubt as to the differential diagnosis of violence. The Atacameans used very small arrows and the small flint points in the skeletons, measuring 1 to 2 cm, partially explain why most of the individuals completely recovered from these wounds, particularly since they had not occurred in vital areas of the body. Bennett (1946) considered Atacamean bows and arrows 'too small for effective use in warfare', but even small points can be very lethal, as proven by the female #3611. According to Chagnon (1992) the use of bow and arrows is generally associated with conflicts between groups that are not closely related. In the case of Solcor-3, this could point to social tension among distant Atacamean or other groups involved in the complex spheres of cultural and economic interactions during the Tiwanaku period.

'Parry' fractures were found in two women out of the total sample, despite the higher overall frequency of violent injuries against men during the Tiwanaku period. This indicates that at Solcor-3 the 'parry' fracture is not a good measure of social tension. The lack of association between 'parry' fractures and other violent trauma could possibly be explained by the fact that during masculine conflicts lifting arms was either not possible, or not useful as a defence. Another explanation is that combat techniques or special body protection avoided that type of trauma. Violent depressed head fractures are also less prevalent among women. The sex linked distribution of 'parry' fractures could be an indication of violence in domestic contexts (Lessa, 1999; Lessa & Mendonça de Souza, 2000), and not just accidental as proposed by Costa-Junqueira et al. (1998) and Neves et al. (1999).

Better models for paleopathology and more refined paleoepidemiological approaches, as proposed by Buikstra & Cook (1980), Waldron (1994) and others are progressively changing and detailing our interpretations. Standen et al.'s (1984) descriptions of depressed skull fractures in the Chinchorros considered them accidental, while 'parry' fractures were considered absolutely violent. In previous studies of San Pedro de Atacama 'parry' fractures were first considered violent (Neves et al., 1996) and in the following papers (Costa-Junqueira et al., 1998, Neves et al., 1999), non-violent trauma. Adjusting models by associating data and using a biocultural interpretation helps us to approach the most probable interpretation of trauma. Treating the 'parry' fracture as an absolute and independent indicator of violence can lead to misinterpretations, as can excluding them from violence-induced trauma.

The prevalence of violence among men is major during the Tiwanaku period when compared to the previous period, while, similar values were found for women in the two periods. According to Larsen (1997), the substitution of lesions caused by accidents for those caused by violence is frequently associated with a more complex social stratification at the human groups: according to Burbank (1992) this generally happens to men. Wrangham & Peterson (1996), using ethnographic reports, also highlight the fact that power, supported by political alliances, as well as participation in fights and combats, are essentially male attributes. Societies in which women are directly involved in conflicts between groups are very rare. At Solcor-3, the social changes during the Tiwanaku period, expressed in grave gifts, point to the introduction of a new ideology, to the expansion of the product exchange system, to property accumulation, and to the strengthening of the local

1Some healed stabbing scars on the bones, like the rib of Tiwanaku male #1236, suggest that atypical wounds could also have been caused by arrow penetration.
hierarchy associated with xamâ’s magic-religious activities and the sen˜orios’ political power (Llagostera et al., 1988; Berenguer & Dauelsberg, 1989; Llagostera, 1996). The rearrangement of power and values for the Atacamenean society would directly affect men in social performance and could explain increasing violence.

Ethnographic data propose that in Atacamenean society chieftainship was inherited via patri-lineal descent (Bennett, 1946). According to Wrangham & Peterson (1996) violence, like beating or raping, is usually practised by men from patrilineal societies even in a domestic context. According to Levinson (1989) women’s violent behaviour is usually ascribed to polygamous societies. According to these models unchanged levels of domestic abuse, performed by Atacamenean men against their women, might explain the violent scars in Solcor-3 women in both periods.

For the Tiwanaku period sample, 75% of the men with violent injuries died at less than 30 years and no one aged over 40 shows signs of violent trauma. On the other hand, during the Pre-Tiwanaku period, violent trauma was uncommon and sequellae were found at older ages. Here we have an interesting paleoepidemiological problem that could be more easily answered if we had more information about the time lapse and precise prehistoric meaning of the Solcor-3 mortality cohort. Contrary to what happened to the women, as well as to Pre-Tiwanaku men, violence against Tiwanaku men was not a low-lethality, equally distributed permanent risk. If so, violent sequellae would be more prevalent among the oldest individuals, considering its cumulative effect during one’s life (Lovejoy & Heiple, 1981). The violence mostly affected males dying between 20 and 30 years, and there is no accumulation of scars in the oldest individuals, some questions should be raised here. Perhaps the imbalance of mortality and the smaller number of individuals in age categories II and III could be explained as bias. If it is not bias, particularly in the case of Solcor-3, the sample might represent a special social segment recruited to deal with a violent period. So far we do not have absolute 14C dates for these skeletons. This is a problem for future investigation.

Despite the suggestive association between wounds and mortality, other possible explanations for premature deaths must be considered. The dry climate of the desert, the ‘white winds’ (Nuñez, 1992), frequent contacts with the Andean plateau groups, population crowding at the oasis, the use of low, dark and insulated houses and other epidemiological conditions favoured pulmonary tuberculosis (Allison et al., 1973; Buikstra & Willians, 1991; Ariazza et al., 1995; Salo et al., 1994; Prat & Mendonça de Souza, 2003). This infection could certainly be a cause of premature death, especially under conditions of higher stress (Buikstra & Williams, 1991). A parallel search for signs of primary and secondary infections in the form of periosteal reactions or lithic lesions of the ribs and vertebrae (Mendonça de Souza, 2000; Mendonça de Souza et al., 2003) was performed at Solcor-3, but skeletons of the young adults showed no bone foci or active periosteal reactions on the visceral face of the ribs (Kelley & Micozzi, 1984; Santos, 2000).

Considering the weapons, ethnographic data from Atacama refer to the bow and arrow, sling stones, knuckle-dusters and wooden clubs (Bennett, 1946). Stone and metal clubs and axes, also found, would be more like ritual weapons. The morphology of Solcor-3 skull lesions eliminates from consideration such weapons as stone and copper clubs and axes. Knuckle-dusters and wooden clubs match well to the fractures. The frontal and parietal position of most of the depressed skull fractures suggests a frontal close strike. Wilkinson (1997) suggests that such lesions could indicate the intention to hurt but not kill, sparing alliances, which could be lost in the case of a death. Although the hypothesis of distant fights cannot be ruled out, because the slings are typical Atacamenean weapons, the frontal depressed scars are more suggestive of ‘hand-to-hand’ fights (Lambert, 1997; Walker, 1997). The hypothesis of ritual duels (Chagnon, 1992; Walker, 1997), a cultural hallmark for the Andean plateau, must be considered here, especially because the Tiwanaku period coincides with an intensification of religious and ideological influences coming from the Andean plateau.
In the case of women's injuries the same weapons or any other domestic object with similar consequences could be used (Wrangham & Paterson, 1996; Lambert, 1997).

In a previous study of non-violent trauma (Lessa & Mendonça de Souza, 2001), a high prevalence of rib fractures (46.1%) were found in Pre-Tiwanaku women. This kind of lesion is usually associated with accidental trauma and was considered as accidental by Neves et al. (1999). However it is interesting to note that injuries to the chest are also very common during strikes (Walker, 1997). In the presence of such violence indicators, it is necessary to consider that part of the chest trauma in Solcor-3 observed in females may also be associated with domestic beating.

Arrow wounds indicate distant fights. Their presence in Solcor-3 skeletons point to possible conflicts between groups (Chagnon, 1992). They could be associated with ambushes that occurred when the victim was crossing a path or canyon. The Atacama landscape, the routine activities of the caravaneers and miners in the desert, crossing and stopping at unevenly grounded regions, would be compatible with this kind of risk. The hypothesis of strikes beyond the village limits could also explain the fact that at Solcor-3, such lesions would spare senile adults and women, who were probably not involved in external distant activities. Most of the arrow wounds are healed probably because they did not affect vital areas of the body and no deadly poison was used. Although ritualistic fights should not be excluded, strikes between members of Solcor-3 people and other groups must be considered, because of the rearrangement of political and religious power. Ember & Ember (1997) say that social tension is frequently related to economic and political strategies. Martin (1997) suggests that at La Plata Valley, New Mexico, immigration and population growth, imbalance of food supply, food control and enforced labour may have caused bursts of social tension. At Solcor-3 economic and political changes were occurring despite the absence of archaeological evidence for food scarcity or demographic growth (Nunez, 1992; Neves and Costa 1998). The rearrangement of political power can also be a matter of social tension.

The presence of special groups, like a Tiwanaku sacerdotal caste for instance, has also been proposed for the Atacama (Thomas et al., 1985), but the majority of archaeologists think there is no evidence to sustain it (Browman, 1980, 1981; Orellana, 1985; Berenguer & Dauelsberg, 1989), and the osteometric data from Solcor-3 (Llagostera et al., 1988) are not suggestive of ethnic heterogeneity.

It is more coherent to the historical and cultural Atacamenean context to consider that social tension may have arisen from new political alliances, from the search for prestige and power, or from general dissatisfaction created by change. The progressive social hierarchization and new ideological and religious influences that followed Tiwanaku presence in the area certainly unbalanced previous social links. According to Llagostera (1996), the political situation during the period of Tiwanaku's interaction must have been more complex, especially for men sharing power and decisions.

Data from Solcor-3 force us to rethink the interaction process between the Atacama oasis and Tiwanaku, considering that even in the absence of domination by strength, some violence could have occurred in some places. Interesting grave findings in the same cemetery are described as the ‘killing of the weapons’. These are represented by some weapons such as bow and arrows, or hand axes, that were intentionally broken or modified before being disposed with the dead (Bravo & Llagostera, 1986). Could this be part of the symbolic behaviour connected to those violent events?

The low frequency of violent lesions among Pre-Tiwanaku men may express a condition of social balance, fully guaranteed by stable political agreements and secular interaction in the region. Rearrangements resulting from the increasing participation of the powerful Tiwanaku Federation in the secular partnerships, in addition to the instability caused by a deeper social stratification may temporarily have broken the social bonds resulting in increasing violence.

From the point of view of paleoepidemiology (Waldron, 1994; Mendonça de Souza et al., 2003), segregation instead of summing of samples must be carefully considered, because results change especially if cultural transition periods
affecting the different sites are considered. The results presented here illustrate the Solcor-3 situation, and cannot be generalized to the entire Atacama Desert. Although no bone dating has been obtained for Solcor-3, archaeological evidence indicates that the skeletal samples (Tiwanaku and Pre-Tiwanaku) came from a minor cemetery sector and represent a short cohort population in a specific moment of time. Other cemeteries at the Atacama Desert should be studied before the results can be better understood in the prehistoric context of the region.

Conclusions

The comparison of Pre-Tiwanaku and Tiwanaku periods suggests that, during the later period, there was an outbreak of social tension affecting the people who were buried at the excavated section of the Solcor-3 cemetery. This is expressed by the significant increase in the prevalence of arrow wounds and head fractures characterizing interpersonal physical violence and also by the increase in mortality of young adults, primarily men, probably involved with contacts between groups and defensive activities. Violent trauma suggests two main types of aggression against men during the Tiwanaku period: hand-to-hand combat that could be either interpersonal confrontations or ritualistic duels; and distant strikes, probably between unrelated groups using bows and arrows. No increase in the frequency of lesions was observed in women, skeletons from both periods have similar prevalence of signs associated with daily violence. ‘Parry’ defensive fractures occur in the women, but not in the men, suggesting that these injuries are a good indicator of domestic violence but not of the violence that afflicted men during the Tiwanaku period. The burst of social tension in Solcor-3 is consistent with the strong social hierarchical organization, re-alignment of political, economic and religious power, and ideological penetration during the Tiwanaku Federation’s influence over Atacama. Differences in some subsamples are not significant, but the very small number of individuals certainly affects the results of the significance tests. The 64 adult skeletons used in this study represent but a small section of the Solcor-3 cemetery. These intriguing findings have to be tested in other archaeological series concerning the same cultural and economic transition.

Acknowledgements

Our thanks to Maria Antonieta Costa, Agostin Llagostera and Macarena Oviedo (Instituto de Investigaciones Arqueológicas y Museo R. P. Gustavo Le Paige S. J.) for their estimable collaboration during our stay at San Pedro de Atacama. We also thank the valuable suggestions and comments of the referees and editors, especially Dr Shelley Saunders.

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