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A Bioarchaeological and Biogeochemical Study of Warfare and Mobility in Andahuaylas, Peru (ca. AD 1160–1260)

D. S. KURIN,[a]* E. M. LOFARO,[b] D. E. GÓMEZ CHOQUE[c] AND J. KRIGBAUM[b]

[a] *Department of Anthropology, HSSB 1002, University of California, Santa Barbara, CA, USA*
[b] *Department of Anthropology, University of Florida, Gainesville, FL, USA*
[c] *Departamento de Ciencias Básicas y Humanidades, Universidad Nacional José María Arguedas, Jr., Andahuaylas, Apurímac, Perú*

ABSTRACT Warfare impacts how people and populations can move about the landscape. Ethnographers have posited that internal warfare, conflict that takes place within a single society, is strongly associated with female abduction. In contrast, external warfare, combat between different societies, is often accompanied by the in-migration of men for purposes of defence. To test this assertion, we evaluate human remains from one of the most violent eras in Andean prehistory, the Late Intermediate Period (AD 1000–1400). In the south-central highlands of Andahuaylas, Peru, this era witnessed the coalescence of two formidable polities, the Chanka and the Quichua. Ethnohistoric accounts describe internal warfare among the Chanka and external warfare between the Quichua and their neighbours. In this study, bioarchaeological and biogeochemical methods are marshalled to elucidate ancient patterns of violence and mobility with greater nuance. We employ strontium isotope analysis of tooth enamel apatite to inform on residential origin, and we reconstruct patterns of violent conflict through analysis of cranial trauma. In all, 265 crania were excavated from 17 cave ossuaries at two Chanka sites and one Quichua site. Data were collected on age, sex and cranial modification—an indicator of social identity and cranial trauma. A representative subsample of molars from 34 individuals subjected to strontium isotope analysis demonstrates that among the Chanka, violence was significantly directed towards social groups within society, marked by modified crania. The presence of two nonlocal women with signs of increased morbidity and mistreatment points to possible mobility-by-abduction. In contrast, among the Quichua, men have significantly more trauma, and wounds are concentrated on the anterior. Trauma on women is lower, nonlethal, and concentrated on the posterior. This divergent pattern is commonly observed in external warfare (raids and community defence), where men face attackers and women escape them. The presence of two nonlocal men supports a mobility model of strategic in-migration. In sum, osteological and isotopic data sets are shown to reveal divergent life-course experiences not captured by the archaeological data or historic records alone. Copyright © 2014 John Wiley & Sons, Ltd.

Key words: Andes; cranial modification; cranial trauma; locality; sex; strontium isotope analysis

Introduction

Different types of violence can impact how a population—or segments therein—move about the landscape. Warfare, armed lethal violence between groups (see Ferguson 1984; Arkush & Tung 2013), has been traditionally dichotomized by ethnographers as either *internal* or *external* in nature (Murdock, 1949; Otterbein, 1968; Ember & Ember, 1971; Divale, 1974; Ross, 1985). Internal warfare describes conflict that takes place within a single society. Examples include civil war, sectarian violence and even genocide (Ferguson, 2011). These forms of warfare are often characterised by the widespread and targeted killings of identifiable ethnic or social groups. Assailants single out those individuals whose affiliation can be determined through conspicuous, perceived somatic differences (Horowitz, 1985).

Eras of internal warfare are also strongly associated with female abduction, an especially sobering type of mobility (Ember & Ember, 1992; Taylor, 1999; Schott, 2011). Women tend to be captured opportunistically from foreign locales during raids or ambushes (Ferguson, 2003). Captors usually do not discriminate with respect to a potential abductee's ethnic, social or economic

* Correspondence to: Danielle S. Kurin, Department of Anthropology, HSSB 1002, University of California, Santa Barbara, CA 93106-3210, USA.
e-mail: dkurin@anth.ucsb.edu

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status, but age is a factor—late teens and young women of child-bearing ages are preferred (Taylor, 1999; Schott, 2011). Once abducted, women may be incorporated into home communities, albeit with a lower status as wives, concubines, servants or slaves, all of whom may be targeted for violence more frequently than natal members (Martin *et al*. 2010; Tung, 2012).

Other types of warfare are strongly associated with different mobility patterns (Ember and Ember, 1971; Divale, 1974; Ember, 1974; Hayano, 1974; Ember, 1975; Divale *et al*., 1976). External warfare has been used by ethnographers to describe combat between two different societies. This type of warfare often takes the form of raiding and community defence (Tung, 2012). With regard to mobility, men will willingly migrate into local communities where they can take up arms and form large war parties; these nonlocal men are linked by pan-societal affiliations, rather than lineage or natal community (Ferguson, 2003:65; Peregrine, 2001:39). This is especially true in enclave communities, where one society is surrounded by another.

Despite the strong proclivity in early ethnographic research to associate traditional societies with a single type of conflict and corresponding sex-directed mobility pattern, such broad categorizations are as problematic. Fortunately, bioarchaeological and biogeochemical methods have the potential to elucidate ancient patterns of violence and mobility with greater nuance. In this study, we employ strontium isotope analysis of dental enamel to inform on patterns of residential origin and mobility (Knudson & Price, 2007; Tung and Knudson, 2011), and we reconstruct patterns of violent physical conflict through analysis of cranial trauma (Larsen, 1997; Walker, 2001; Tung, 2012).

A turbulent milieu in Andahuaylas

In the prehistoric Andes, the highest levels of warfare occurred during a time known as the Late Intermediate Period (AD 1000–1400) (Arkush & Tung, 2013). Social instability during the era has been attributed to a mosaic of causes including the collapse of the Wari Empire, as well as increasing aridity and resource scarcity (Covey, 2008). These stressors were felt acutely in the south-central Peruvian province of Andahuaylas (Figure 1), where populations abruptly relocated to densely populated high-altitude hill forts (Bauer *et al*., 2010) and began to cache weapons (Gómez Choque, 2009). Two of the most notable polities that coalesced during this time were known as the Chanka and the Quichua.

The Chanka and the Quichua

Archaeological research has shown that the Chanka and the Quichua shared many common features including material culture assemblages and subsistence practices (Gómez Choque, 2009). Both polities, like many others in the Andes, also used cranial modification as a marker of social affiliation (Torres-Rouff, 2002). In Andahuaylas, cranial modification probably signalled an ethnic-like identity that was structured by descent and birth order (e.g., something akin to a kin category such as 'primogeniture') (Kurin, 2012). Yet, there are several key distinctions between the Chanka and Quichua.

Above all, warfare appears to have been a common—even defining—feature of Chanka society (Betanzos, [1557] 2004:244). The Chanka played a crucial role in official Inka history, making several forays towards Cuzco attempting to subdue the Inka until they themselves were ultimately vanquished in a decisive battle that initiated the Inka Empire. Most intriguing, alliances between politically autonomous Chanka communities—known as *ayllus*[1]—only appear to have coalesced when confronted by the Inka. Prior to that era, the Chanka fought among themselves (Pachacuti Yamqui Salcamaygua, [1613] 1993: 92).

Similarly, historical accounts describe great animosity between the Quichua and other local groups, including the Chanka (Cieza de Leon, [1554] 1996:111). Early colonial documents attest to the formation of small Quichua enclaves in Andahuaylas sometime during the early 11th century (cf. Maldonado, [1539] 2002), an assertion supported by recent biodistance analysis of Quichua crania (Pink, 2013). During the Late Prehispanic era, the Quichua allied with the Inka against the Chanka (Cieza de Leon, [1539] 1996:11).

Evaluating warfare through cranial trauma

Documentary evidence suggests that the Chanka were frequently engaged in internal warfare, which occurred among subpopulations within the society. In contrast, the Quichua, like other enclave communities, were apparently entangled in conflict with rivals outside of their small, circumscribed polity. These types of warfare can be identified by distinct patterns in cranial trauma (Martin & Frayer, 1997; Walker, 1997, 2001; Tung, 2012). If

[1] *Ayllus* are nested, hierarchical lineages of fictive and biological kin that share labour obligations and resources and claim descent from a common ancestor. They can encompass people of distinct ethnic-like or social categories (see Skar (1982) for a description of the Andahuaylas *ayllu* system). Chanka and Quichua polities are understood as maximal or macro-*ayllus* because they are composed of many smaller *ayllus*.

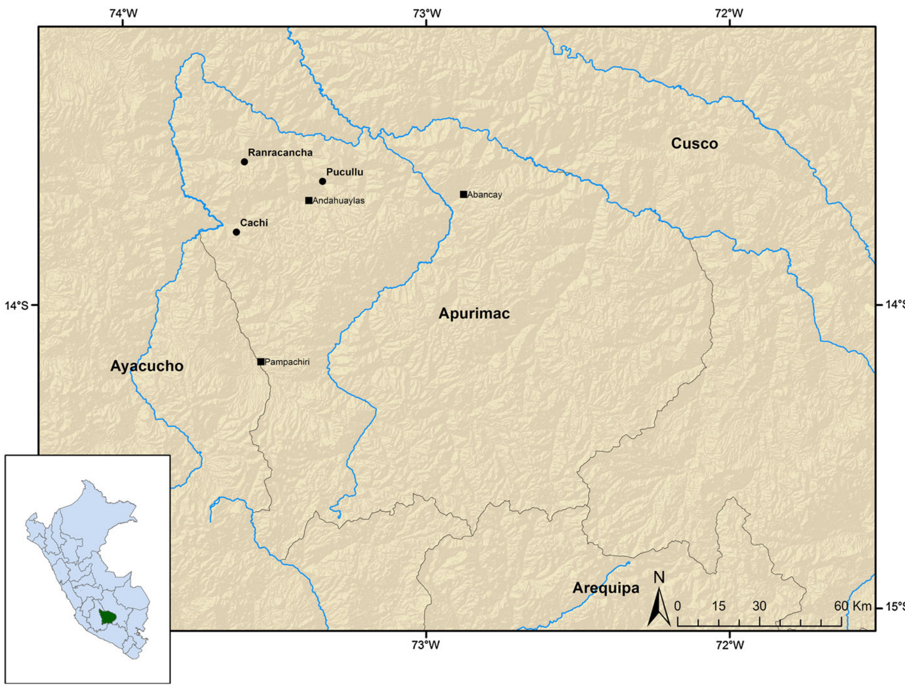

Figure 1. Map of the Andahuaylas region in south-central Peru. The skeletal samples derive from the Chanka sites of Ranracancha and Cachi and the Quichua enclave of Pucullu. This figure is available in colour online at wileyonlinelibrary.com/journal/oa.

internal warfare indeed impacted social groups within the Chanka polity, we would expect trauma to be significantly correlated with cranial modification, a key social marker. Correspondingly, if external warfare (primarily raiding and community defence) plagued the Quichua, then we expect divergent patterns in cranial trauma between the sexes: men often have significantly higher rates of trauma than women, with wounds concentrated on the front of the head, as opponents face off. In contrast, women attempt to escape assailants, and thus, blows tend to accumulate on the back of the head (Martin & Frayer, 1997; Walker, 2001; Tung, 2012).

Evaluating mobility using strontium isotope analysis

Strontium isotopic analysis of tooth enamel apatite allows us to determine the mobility and locality of first-generation individuals in relationship to the landscape (Ericson, 1985; Knudson *et al.*, 2004; Tung and Knudson, 2011; White, 2013). ^{86}Sr (strontium) occurs naturally in bedrock, whereas ^{87}Rb (rubidium) decays into ^{87}Sr over time (Faure & Powell, 1972; Faure 1986; Bentley, 2006). As it moves up the trophic chain, strontium substitutes for some of the calcium ions present in developing tooth enamel and bone, becoming embedded in hydroxyapatite (Likins *et al.*, 1960; Bentley, 2006). Although taphonomic processes such as groundwater contamination and diagenesis can impact strontium levels (Jørgensen *et al.*, 1999), the isotopic values of an individual's enamel are thought to reflect the biologically available strontium of the local geology during the formation of those teeth (Price *et al.*, 2002). Adult tooth enamel, the focus of this study, develops during childhood; the first, second and third molars form during early, middle and later childhood, respectively (between birth and 12 years) (Dean & Beynon, 1991; Reid & Dean, 2006).

When environmental baseline or faunal data are unavailable, highly variable, or imprecise (as in this case[2]), locally derived strontium isotopic values can be calculated using descriptive statistics. Evidence of mobility (or more precisely, nonlocal residential origin) is visible in the biogeochemical record via the presence of outlier strontium isotopic values gleaned from the enamel apatite (Wright, 2005).

[2] Two dog skulls (*Canis lupus familiaris*) excavated at Cachi had an average ^{87}Sr/^{86}Sr value of 0.7069115 (SD = 0.000166165). This average is significantly lower than the majority of human values from Andahuaylas (especially from Pucullu and Ranracancha, both located over 30 km away) and will be discussed further in an upcoming article. Future research aims to build a more comprehensive faunal baseline given the variability in south-central Andean geomorphology.

Methods

Recovery of human remains from Andahuaylas

This paper reports on crania recovered during excavations of intact and disturbed semi-subterranean cave ossuaries—called *machays*—at three sites in Andahuaylas, two Chanka and one Quichua. *Machays*, the primary mode of inhumation during the Late Intermediate Period (Gómez Choque, 2009), were typically used for about a century and contained five or six generations of individuals usually related through descent and marriage (Duviols, 1986; Kurin, 2012; Baca *et al*., 2012).

Cachi and Ranracancha (Chanka)

Cachi and Ranracancha are well-documented Chanka settlements (Maldonado, [1539] 2002; Hostnig *et al*., [1745] 2007; Gómez Choque, 2009). Cachi, in western Andahuaylas, is a 5 ha fortified habitation site with associated agricultural terraces and a large salt mine. Skeletal remains of 189 people were recovered from 15 *machays* and dated to the 12th through 13th centuries (accelerator mass spectrometry, 2σ). At Ranracancha, a Chanka village (<5 ha) about 30 km to the north of Cachi, the remains of 42 individuals were systematically recovered from a large *machay*. Accelerator mass spectrometry dates indicate that the cave was used for internment around AD 1160–1260 (2σ).

Pucullu (Quichua)

Human remains attributed to 34 people were systematically recovered from one small, disturbed *machay* at Pucullu, in central Andahuaylas, used between AD 1160 and 1260 (2σ). The cave is located along a rocky outcropping near the summit of a steep hill that rises above Laguna Pacucha. Thirty-four crania were recovered. There is strong documentary evidence that Pucullu was a resilient Quichua settlement (Maldonado, [1539] 2002; Hostnig *et al*., [1745] 2007; Bauer *et al*., 2010: 42).

Methods

Osteological assessment

Human remains were analysed following established data collection standards (Buikstra & Ubelaker, 1994). Sex was determined using dimorphic features of the cranium. Age was evaluated through dental development, tooth wear and cranial suture closure.

To better understand how warfare was experienced, trauma patterns were correlated with age, sex, local origin and cranial modification. The number, size, shape, type and location of fractures present on each crania were calculated and described (Lovell, 1997). Wound lethality was classified as either antemortem (signs of bone remodelling) or perimortem (no healing) (Lovell, 1997). To assign broad social groupings, crania were classified as either modified or unmodified. Prior research has not identified differences in trauma patterns among modified individuals with distinct head shapes (Kurin 2012). Finally, because there were no significant differences in demographic distribution, cranial modification styles or trauma patterns at Ranracancha and Cachi (Kurin 2012), crania from those sites were collapsed into one Chanka group and then compared with the smaller sample from the Quichua enclave at Pucullu.

Strontium isotope analysis

Thirty-four archaeological human molars were prepared and underwent strontium isotopic analysis at the University of Florida. Samples were chosen on the basis of associated teeth and crania, and the attempt was made for representative mortuary population selection. Only tooth enamel apatite was assessed, as bone and tooth dentin are more prone to diagenetic alteration (Kohn *et al*., 1999; Budd *et al*, 2000; Chiaradia *et al*., 2003; Bentley, 2006).

Samples were vertically sectioned and cleaned of surface contaminants and dentin using a high-speed Brasseler NSK UM50TM (Brasseler USA Dental Savannah, GA, USA) diamond tip dental drill under 10× magnification. Samples were ground in an agate mortar and placed in 5 mL plastic centrifuge tubes. A 50% NaOHCl solution was added for 16 h, to remove organics and humic acids, centrifuged and decanted. Samples were rinsed three times in distilled water and centrifuged until a pH of 7 was reached. A 0.2 molar CH_3COOH pretreatment solution was added to remove exogenous secondary carbonates and left to react for 15 h. Samples were rinsed to normal pH with distilled water until no odour was detected, and then freeze-dried. They were then placed in precleaned Teflon vials and dissolved in eight molar HNO_3 optima for 24 h and evaporated in a flow hood. Columns with a resin bed volume of ~100 μL were packed with Sr Spec resin (EI Chrom Part #SR-B100-S) and washed with 2.5 mL of quadruple distilled water (4× dH_2O) then equilibrated with 2 mL of 3.5 N HNO_3 optima. Approximately 20 mg of cleaned apatite was loaded in 3.5 mL of 50% 3.5 N HNO_3 optima and washed in 100 μL of 3.5 N

Table 1. Trauma frequencies between Chanka and Quichua males and females

Polity	Sex	No.	No. with trauma (%)	Mean no. wounds per wounded individual	Total traumatic impacts	No. lethal impacts	Highest concentration of total wounds (no.) %
Chanka	Males	82	47 (57.3%)	2.02	95	30	Anterior (37) 38.9%
	Females	90	57 (63.3%)	1.72	98	42	Anterior (24) 24.5%
Quichua	Males	15	12 (80.0%)	1.67	20	6	Anterior (11) 55.0%
	Female	10	3 (30.0%)	4.00	12	0	Posterior (8) 66.7%

HNO_3 optima four times. After a final wash of 1 mL of 3.5 N HNO_3 optima, 1.5 mL of 4× dH_2O was used to collect the strontium and evaporated overnight in a flow hood. Samples were analysed using a Nu Plasma multi-collector inductively coupled-plasma mass spectrometer. Kamenov & colleagues' (2006) time-resolved analysis was used, and the long-term reproducibility of the $^{87}Sr/^{86}Sr$ NBS 987 was 0.710246 ($2\ \sigma = 0.000030$). Descriptive statistics were employed to ascertain the presence of local and nonlocal individuals (Wright, 2005).

Results

Trauma patterns among men and women

In total, 200 late adolescent and adult crania from the two Chanka communities could be evaluated for evidence of blunt force trauma. The sample included 82 males, 90 females and 28 unsexed late adolescents/adults. Trauma frequency and wound locations between the Chanka men and women are almost identical. Fifty-seven percent (47/82) of men display trauma, whereas 63% (57/90) of women evince at least one wound (Fisher's exact, $p = 1.000$, $N = 172$).

At Pucullu, the contemporaneous Quichua enclave, 25 late adolescent/adult crania could be observed for evidence of trauma (Table 1). Eighty percent of men (12/15) exhibit trauma, whereas only 30% (3/10) of women have cranial trauma, a significant difference (Fisher's exact, $p = 0.0344$, $N = 25$). Wound distribution is also distinct (Figure 2). Among men, wounds overall were most common on the anterior (11/20 = 55%); they were facing opponents at the moment of impact. However, among women, the majority of wounds (8/12 = 66.7%) were directed to the back of the head, received when they were turned away from an assailant.

Trauma patterns in modified and unmodified crania

Among the Chanka, those with cranial modification have significantly higher rates of cranial trauma (Table 2). Of 167 individuals with modified heads, 93 (55.7%) had at least one traumatic wound. In contrast, only 13/43 (30.2%) unmodified crania had any trauma (Fisher's exact, $p = 0.0035$; $N = 210$). Wound distribution also suggests that modified individuals were singled out for violence (Figure 3). Although sample sizes are small, only modified individuals exhibit both antemortem and perimortem wounds (unambiguous signs of recidivism) (Lovell, 1997), ring fractures on the cranial base (associated with execution blows) and repetitive, lethal trauma, which obliterated much of the face and vault (see Ta'ala *et al.*, 2006; Kurin, 2012).

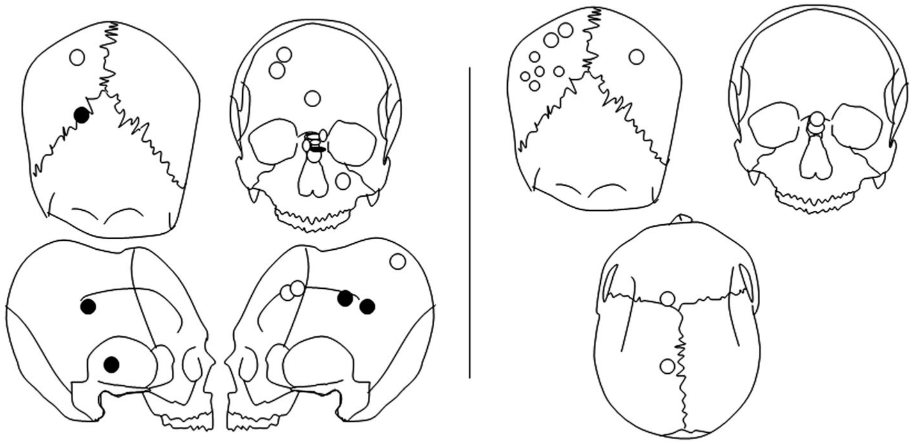

Figure 2. Trauma lethality and distribution between Quichua men (left) and women (right). White dots signal antemortem trauma; black dots indicate perimortem trauma. This figure is available in colour online at wileyonlinelibrary.com/journal/oa.

Table 2. Trauma frequencies between unmodified and modified Chanka and Quichua crania

Polity	Head shape	No.	No. (%) with trauma	Total no. traumatic impacts	No. (%) individuals w/ both ante and perimortem wounds	No. of individuals w/ ring fractures	No. (%) of individuals with >1 lethal vault wound
Chanka	Modified	167	93 (55.7%)	180	16 (17.2%)	7	15 (16.1%)
	Unmodified	43	13 (30.2%)	24	0 (0%)	0	1 (7.7%)
Quichua	Modified	17	10 (58.8%)	22	1 (10%)	0	0 (0%)
	Unmodified	9	5 (55.6%)	8	0 (0%)	0	2 (40%)

Unlike the Chanka, modified and unmodified Quichua crania display no significant differences in trauma rates, distribution or lethality. Five out of nine (55.6%) unmodified crania have trauma, and similarly, 10 out of 17 (58.8%) modified crania display wounds (Fisher's exact, $p = 1.000$; $N = 26$).

The local strontium isotope signature in Andahuaylas

The average $^{87}Sr/^{86}Sr$ value for all individuals in Andahuaylas is 0.707541, with values ranging from 0.70685 to 0.70826 (outliers absent) (Table 3; Figure 4). Variability between sites likely derives from differences in the local geomorphology (Marocco, 1975; see also Price *et al.*, 2002; Perello *et al.*, 2003; Hodell *et al.*, 2004) and potentially from imbibed rock salt from the Cachi mine (Wright, 2005). Nevertheless, there are four individuals with statistical outlier $^{87}Sr/^{86}Sr$ values. One is a female from Cachi, another is a female from Ranracancha and two are males from Pucullu (Table 4; Figure 5).

Discussion

Profiles of outliers in Chanka and Quichua communities

There are two Chanka individuals with nonlocal $^{87}Sr/^{86}Sr$ values. The first, RCC.01.01.07, is a female who died when she was 15–18 years old. Because her fully formed second molar was sampled and deemed nonlocal, her arrival in Andahuaylas must have occurred sometime after middle childhood, when this tooth forms. This female has cranial modification and a healed wound on the back of her head. Morbidity indicators include cribra orbitalia and porotic hyperostosis.

The other female, SON.02.03.21, is a young adult (20–35 years old) who also migrated after middle childhood. This female does not have a modified cranium; porotic hyperostosis was present. Importantly, contrary to every other unmodified Chanka individual, this female evinces a lethal penetrating wound on the back of her head, near the left inferior nuchal line; there is also a possible perimortem wound on the nasal bones.

At Pucullu, the Quichua enclave, both nonlocal individuals were males. One male, PCU.01.01.08, was an older adult (+50 years old), whereas the other, PCU.01.01.25, died during middle adulthood (35–50 years old). Both males have similar biocultural profiles. They both have slight cranial modification. There are no cranial lesions indicative of disease. The older adult has two well-healed injuries, one on the frontal bone and one on the right parietal boss. The middle adult does not have any trauma but evinces a healing trepanation, received sometime in the years before his death.

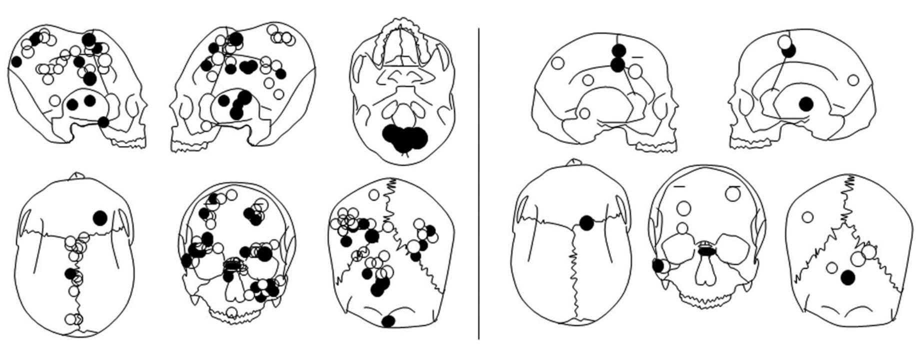

Figure 3. Trauma among Chanka individuals with modified crania (left) and unmodified crania (right). White dots signal antemortem trauma; black dots indicate perimortem trauma.

Table 3. Summary table of strontium isotope values in Andahuaylas

Affiliation	Site	Age of local bedrock (contributes to higher strontium values)	Cranial MNI	N	mean $^{87}Sr/^{86}Sr$ (Outliers absent)	SD (Outliers absent)	Outliers
Chanka	Cachi	Mesozoic–Early Cenozoic sedimentary sequences (~250–60 million years old)	189	14	0.707334946	0.00024505	1 Female
Chanka	Ranracancha	Late Paleozoic–Early Triassic Mitu group (~299–245 million years old)	42	9	0.707670667	0.000232437	1 Female
Quichua	Pucullu	Mesozoic–Early Cenozoic sedimentary sequences (~250–60 million years old)	34	8	0.707701857	0.000775211	2 Males

The case for internal warfare in Chanka communities

There is compelling evidence to suggest that internal warfare occurred within the Chanka polity. Those with cranial modification—a prominent marker of social affiliation within the *ayllu*—were singled out for excessive, repeated, often lethal violence. Internal warfare is also commonly associated with a sobering mobility pattern: female abduction. This may have occurred within Chanka society as well. That both nonlocal Chanka women have wounds directed to the back of the head is noteworthy; trauma in this region often points to attempted flight from captors in cases of abduction (Tung, 2012). The age of these females is also significant, as late teens and young adults are most often targeted for abduction (Schott, 2011). Both women spent middle childhood in distinct nonlocal areas before dying in Andahuaylas only a few years later. Moreover, one nonlocal woman has a modified vault, and the other does not, possibly suggesting that captors did not preferentially target a specific social group or geographic region. Signs of compromised health and lethal injury are also expected in cases of abducted females and indeed, these women show signs of increased morbidity and mistreatment following capture, as well as trauma patterns that are distinct from their peers (Martin *et al.*, 2010).

It is important to reiterate that if female abduction was occurring, it was probably not limited to groups like the Chanka, who were experiencing internal conflict. Warfare in general is often associated with assaults that aim to capture women and other resources. And female mobility itself is structured by many factors—not all of which are violent. Nevertheless, within the turbulent Chanka milieu, the presence of nonlocal women does not appear to have been the fruit of peaceful alliances but rather the result of violent abduction from disparate, distant villages.

External warfare in a Quichua enclave

Trauma patterns among the Quichua are different and suggest warfare with external neighbours in the context of raids and community defence. In this case, Quichua individuals with cranial modification were not singled out for violence. Rather, trauma patterns were most

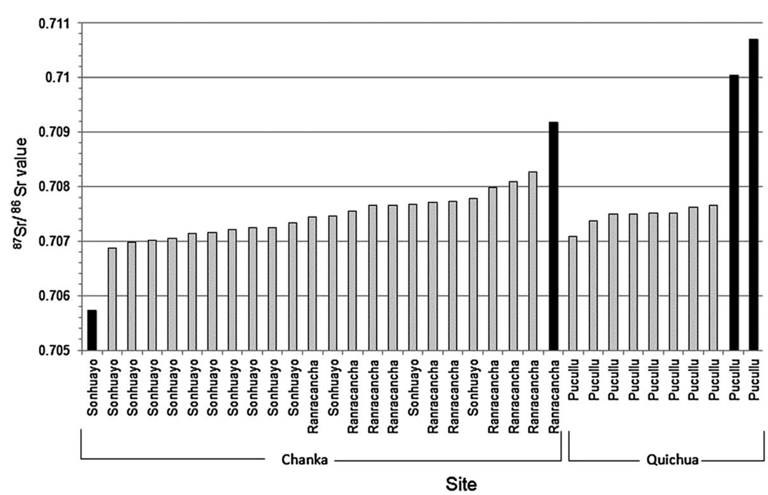

Figure 4. $^{87}Sr/^{86}Sr$ human tooth enamel apatite values at Cachi, Ranracancha and Pucullu, ca AD 1160–1260.

Table 4. Strontium isotope values of individuals sampled from Andahuaylas

Cultural affiliation	Site	Lab #	Skull #	Age category[a]	Sex	Cranial modification[b]	Trauma	Molar[c]	$^{87}Sr/^{86}Sr$ corrected
Chanka	**Cachi**	**A-11-1226**	**SON.02.03.21**	**YA**	**F**	**0**	**1**	**RM^2**	**0.705731**
Chanka	Cachi	A-11-1238	MPH.01.14	YA	M	0	1	RM^2	0.706865
Chanka	Cachi	A-10-1140	MCH.01.01.01	YA	F	0	1	LM^2	0.706982
Chanka	Cachi	A-10-1159	MSM.07.01	A	U	0	0	RM_2	0.707009
Chanka	Cachi	A-11-1237	MPH.01.13	YA	F	1	1	RM^1	0.707050
Chanka	Cachi	A-11-1236	MPH.01.02	MA	M	1	0	RM^2	0.707132
Chanka	Cachi	A-11-1239	MPH.01.10	MA	M	0	0	LM^2	0.707163
Chanka	Cachi	A-11-1225	SON.02.03.18	YA	M	0	1	LM^1	0.707208
Chanka	Cachi	A-10-1162	SON.01.rinc	OA	F	1	1	LM_1	0.707239
Chanka	Cachi	A-11-1219	SON.02.03.36	YA	F	0	1	RM_3	0.707241
Chanka	Cachi	A-11-1240	SON.07.01.02	MA	M	0	1	RM^2	0.707343
Chanka	Ranracancha	A-11-1235	RCC.01.01.14	YA	F	1	1	LM^2	0.707439
Chanka	Cachi	A-10-1149	SON.04.01	YA	F	1	1	LM^2	0.707467
Chanka	Ranracancha	A-10-1154	RCC.01.01.27	CH	U	1	1	LM^1	0.707547
Chanka	Ranracancha	A-11-1231	RCC.01.01.10	YA	M	1	1	LM^1	0.707650
Chanka	Ranracancha	A-10-1155	RCC.01.01.44	YA	F	1	1	RM^1	0.707653
Chanka	Cachi	A-11-1218	MCH.01.03.05	YA	M	1	1	RM^2	0.707673
Chanka	Ranracancha	A-10-1158	RCC.01.01.04	YA	M	1	1	LM^2	0.707712
Chanka	Ranracancha	A-11-1234	RCC.01.01.23	YA	F	1	1	LM^1	0.707728
Chanka	Cachi	A-10-1139	SON.02.04-1.57	MA	M	1	1	RM^2	0.707782
Chanka	Ranracancha	A-11-1232	RCC.01.01.06	JV	F	1	1	RM^2	0.707987
Chanka	Ranracancha	A-10-1156	RCC.01.01.03	YA	M	1	0	LM^1	0.708094
Chanka	Ranracancha	A-11-1233	RCC.01.01.24	YA	F	1	1	RM^1	0.708259
Chanka	**Ranracancha**	**A-10-1157**	**RCC.01.01.07**	**JV**	**F**	**1**	**1**	**RM^2**	**0.709186**
Quichua	Pucullu	A-11-1223	PCU.01.01.13	MA	M	1	1	RM^2	0.707086
Quichua	Pucullu	A-11-1224	PCU.01.01.16	YA	M	1	0	RM^2	0.707372
Quichua	Pucullu	A-10-1146	PCU.01.01.26	YA	M	1	1	RM^3	0.707488
Quichua	Pucullu	A-11-1220	PCU.01.01.22	JV	F	0	0	RM^1	0.707505
Quichua	Pucullu	A-10-1144	PCU.01.01.20	MA	F	1	1	RM^3	0.707508
Quichua	Pucullu	A-10-1145	PCU.01.01.19	CH	U	0	0	LM^1	0.707523
Quichua	Pucullu	A-10-1142	PCU.01.01.09	JV	F	0	0	LM^2	0.707615
Quichua	Pucullu	A-11-1221	PCU.01.01.03	JV	F	0	0	RM^2	0.707652
Quichua	**Pucullu**	**A-10-1143**	**PCU.01.01.08**	**YA**	**M**	**1**	**0**	**LM^1**	**0.710039**
Quichua	**Pucullu**	**A-11-1222**	**PCU.01.01.25**	**OA**	**M**	**1**	**1**	**LM^2**	**0.710691**

Boldface = outliers.
[a]CH (5–12 years); JV (12–20 years); YA (20–35 years); MA (35–50 years); OA (+50 years); A (20–50+ years).
[b]0 = No; 1 = Yes.
[c]R (right); L (left); superscript, maxillary molar number; subscript, mandibular molar number.

distinct between the sexes. Quichua males exhibited significantly higher trauma rates than females. In addition, wounds on males were concentrated on the anterior, a pattern common among men who participate in routs, raids, and community defence (Martin & Frayer, 1997; Tung, 2012). In sharp contrast, females—all of whom were local—only demonstrated sublethal injuries, which were largely concentrated on the back of the head. These wounds are commonly received during raids and ambushes as women attempt to evade assailants (Martin & Frayer, 1997; Tung, 2012). Given that Pucullu was an isolated Quichua enclave with little grazing and agricultural land nearby, it is not too far-fetched to propose that acrimonious confrontations with external neighbours may have taken place. Quichua men may have received injuries while defending their small community or while raiding nearby settlements (Skar, 1982). At the same time, Quichua women may have had to evade assailants in the course of raids at or around Pucullu (Skar, 1982).

In addition, the presence of two battle-scarred, nonlocal men at Pucullu suggests a distinct pattern of strategic mobility. In contexts of external warfare, men are often sought from outside the local community to provide additional security against neighbouring rivals. In Andean enclave communities, the in-migration of nonlocal males is especially crucial because clusters of natal wives—including sisters, consanguineal kin and affines—must watch over livestock in lands that tend to be located far away from home communities. Given the increased risk of ambush in these marginal, isolated subsistence zones, it is important to have a husband (and his kin) who will tend to and, most importantly, defend crops, people and property (Skar, 1982; Gómez Choque, 2009). As a circumscribed Quichua enclave with relatively recent roots in

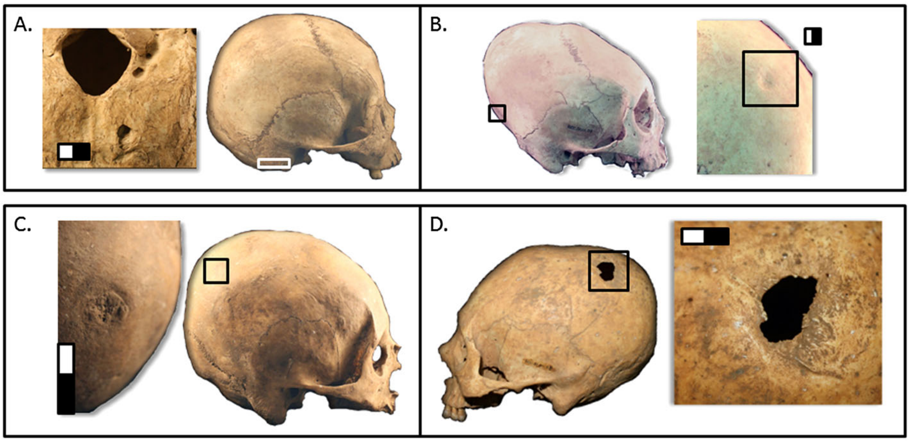

Figure 5. Nonlocal individuals in Andahuaylas. (A) SON.02.03.21, a young adult female with lethal cranial trauma; (B) RCC.01.01.07, a juvenile female with cranial modification and sublethal cranial trauma; (C) PCU.01.01.25, an old adult male with cranial modification and sublethal trauma; and (D) PCU.01.01.08, a middle adult male with cranial modification and a healing trepanation. This figure is available in colour online at wileyonlinelibrary.com/journal/oa.

Andahuaylas, locals apparently engaged amicably with distant communities. The fact that one nonlocal man has a healing trepanation further supports this model, for he was esteemed enough to merit surgical intervention sometime after his migration to the region (Kurin, 2013).

Conclusion: Warfare and mobility

To investigate ethnographic and historic assertions that different experiences of warfare may be associated with distinct patterns in mobility, we examined skeletal remains from two distinct Late Prehispanic polities in Andahuaylas, the Chanka and the Quichua. Both groups emerged in a theatre of endemic warfare likely spurred by political and economic instability, yet experiences of violence varied. Among the Chanka, violence was primarily directed towards groups within their polity. So too is there strong evidence of nonlocal female abduction and subsequent mistreatment, which often (though not exclusively) accompanies internal warfare. In contrast, trauma patterns on Quichua crania point to a distinct type of warfare, one that most often occurred with hostile external neighbours, likely in the context of raids. The in-migration of nonlocal males to the Quichua enclave may have been largely prompted by security concerns. In sum, although there is much yet to do in order to better identify and better understand the multiple intersections of group identity, social affiliation and collective violence, this initial foray shows the potential for osteological and isotopic datasets to reveal divergent life-course experiences not captured by the archaeological data or historic records alone.

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References

Arkush EN, Tung TA. 2013. Patterns of war in the Andes from the archaic to the late horizon: Insights from settlement patterns and cranial trauma. *Journal of Archaeological Research*: 1–63.

Baca M, Doan K, Sobcyzk M, Stankovic A, Weglenski P. 2012. Ancient DNA reveals kinship burial patterns of a pre-Columbian Andean community. *BMC Gen*. DOI: 10.1186/1471-2156-13-30.

Bauer BS, Kellett LC, Silva MA. 2010. The Chanka: Archaeological research in Andahuaylas (Apurimac), Peru. UCLA Cotsen Institute of Archaeology: Los Angeles.

Bentley AR. 2006. Strontium isotopes from the earth to the archaeological skeleton: A review. *Journal of Archaeological Method and Theory* **13**: 135–187.

Betanzos J. 2004 [1557]. Suma y narración de los Incas. Polifemo: Lima.

Budd P, Montgomery M, Barreiro B, Thomas RG. 2000. Differential diagenesis of strontium in archaeological human dental tissues. *Applied Geochemistry* **15**: 687–694.

Buikstra JE, Ubelaker DH. 1994. Standards for data collection from human skeletal remains. Proceedings of a Seminar at the Field Museum of Natural History. Arkansas Archaeological Survey Research Series, No. 44: Fayetteville.

Chiaradia M, Gallay A, Todt W. 2003. Different contamination styles of prehistoric human teeth at a Swiss necropolis (Sion, Valais) inferred from lead and strontium isotopes. *Applied Geochemistry* **18**(3): 353–370.

Cieza de Leon P. 1996 [1553]. La Crónica del Peru. Crónices de America 4: Madrid.

Covey RA. 2008. Multiregional perspectives on the archaeology of the Andes during the Late Intermediate Period (c. A.D. 1000–1400). *Journal of Archaeological Research* **16**: 287–338.

Dean MC, Beynon AD. 1991. Histological reconstruction of crown formation times and initial root formation times in a modern human child. *American Journal of Physical Anthropology* **86**(2): 215–228.

Divale WT. 1974. Migration, external warfare, and matrilocal residence. *Cross Cultural Research* **9**: 75–133.

Divale WT, Chamberis F, Gangloff D. 1976. War, peace, and marital residence in pre-industrial societies. *Journal of Conflict Resolution* **20**: 57–78.

Duviols P. 1986. Cultura andina y represión: procesos y visitas de idolatrias y hechicerias Cajatambo, siglo XVII. Centro de Estudios Rurales Andinos Bartolome de las Casas: Cuzco.

Ember M, Ember CR. 1971. The conditions favoring matrilocal versus patrilocal residence. *American Anthropologist* **73**: 571–594.

Ember CR. 1974. An evaluation of alternative theories of matrilocal versus patrilocal residence. *Cross Cultural Research* **9**: 135–149.

Ember CR. 1975. Residential variation among hunter-gatherers. *Cross Cultural Research* **10**: 199–227.

Ember CR, Ember M. 1992. Warfare, aggression, and resource problems: Cross-cultural codes. *Cross Cultural Research* **26**: 169–226.

Ericson JE. 1985. Strontium isotope characterization in the study of prehistoric human ecology. *Journal of Human Evolution* **14**: 503–514.

Faure G. 1986. Principles of Isotope Geology. John Wiley: New York.

Faure G, Powell JL. 1972. Strontium Isotope Geology. Springer-Verlag: New York.

Ferguson RB. 1984. Warfare, culture, and environment. Academic Press: Orlando, FL.

Ferguson RB. 2003. Introduction: Violent conflict and control of the state. In The State, Identity and Violence: Political Disintegration in the Post-Cold War World. RB Ferguson (ed.). Routledge: London, 9.

Ferguson RB. 2011. Tribal Warfare. In *The Encyclopedia of War*. Wiley Blackwell: New York.

Gómez Choque DE. 2009. Investigaciones en sitios de inhumación en Andahuaylas. Licensure thesis, Universidad Nacional de San Cristobal de Huamanga, Peru.

Hayano DM. 1974. Marriage, alliance, and warfare: A view from the New Guinea Highlands. *American Ethnologist* **1**: 281–293.

Hodell DA, Quinn RL, Brenner M, Kamenov G. 2004. Spatial variation of strontium isotopes ($^{87}Sr/^{86}Sr$) in the Maya region: A tool for tracking ancient human migration. *Journal of Archaeological Science* **31**(5): 585–601.

Horowitz DL. 1985. Ethnic Groups in Conflict. University of California Press: Berkeley.

Hostnig R, Palomino PD, Decoster JJ. 2007. Proceso de composición y titulación de tierras en Apurímac. Tomo I y II. Instituto de Investigaciones Jurídicas y Asesoramiento: Cuzco.

Jørgensen NO, Morthorst J, Holm PM. 1999. Strontium-isotope studies of "brown water" (organic-rich groundwater) from Denmark. *Hydrogeology Journal* **7**(6): 533–539.

Kamenov GD, Mueller PA, Gilli A, Coyner S, Nielsen SHH. 2006. A simple method for rapid, high-precision isotope analyses of small samples by MC-ICP-MS. *Eos Transactions AGU* 87, Fall Meeting Supplement, V21A-0542.

Kohn, M, Schoeninger MJ, Barker WW. 1999. Altered states: Effects of diagenesis on fossil tooth chemistry. *Geochimica et Cosmochimica Acta* **63**(18): 2737–2747.

Knudson KJ, Price TD, Buikstra JE, Blom DE. 2004. The use of strontium isotope analysis to investigate Tiwanaku migration and mortuary ritual in Bolivia and Peru. *Archaeometry* **46**: 5–18.

Knudson KJ, Price TD. 2007. Utility of multiple chemical techniques in archaeological residential mobility studies: Case studies from Tiwanaku- and Chiribaya-affiliated sites in the Andes. *American Journal of Physical Anthropology* **132**: 25–39.

Kurin DS. 2012. The Bioarchaeology of collapse: ethnogenesis and ethnocide in post-imperial Andahuaylas, Peru (AD 900–1250). Doctoral dissertation, Vanderbilt University.

Kurin DS. 2013. Trepanation in south-central Peru during the early Late Intermediate period (ca. AD 1000–1250). *American Journal of Physical Anthropology*. **152**(4):484–494.

Larsen CS. 1997. Bioarchaeology: Interpreting Behavior from the Human Skeleton. Cambridge University Press: Cambridge.

Likins RC, McCann HG, Possner AS, Scott DB. 1960. Comparative fixation of calcium and strontium by synthetic hydroxyapatite. *Journal of Biological Chemistry* **235**: 2152–2156.

Lovell N. 1997. Trauma analysis in paleopathology. *Yearbook of Physical Anthropology* **40**: 139–170.

Maldonado D. 2002 [1539]. Encomienda de Andahuaylas. In: Diego Maldonado y los Chancas. Julien C. *Revista Andina* **34**: 183–197.

Marocco R. 1975. Geología de los cuadrángulos de Andahuaylas, Abancay y Cotabambas. Instituto de Geología, Minería y Metalurgia: Lima.

Martin DL, Frayer T (eds.). 1997. Troubled Times: Osteological and Anthropological Evidence of Violence. Gordon and Breach: New York.

Martin DL, Harrod RP, Fields M. 2010. Beaten down and worked to the bone: Bioarchaeological investigations of women and violence in the ancient Southwest. *Landscape of Violence* **1**: 3.

Murdock GP. 1949. Social Structure. Macmillan: New York.
Otterbein KF. 1968. Internal war: A cross-cultural study. *American Anthropologist* **70**: 277–289.
Pachacuti Yamqui Salcamaygua JSC. 1993 [1613]. Relacion de las antiguedades deste reyno del Piru. Duviols P and Itier C. Institute Français d'Études Andines: Lima.
Peregrine PN. 2001. Matrilocality, corporate strategy, and the organization of production in the Chacoan world. *American Antiquity* **1**: 36–46.
Perello J, Carlotto V, Zarate A, Ramos P, Posso H, Neyra C, Caballero A, Fuster N, Muhr R. 2003. Porphyry-style alteration and mineralization of the Middle Eocene to early Oligocene Andahuaylas-Yauri Belt, Cuzco region, Peru. *Economic Geology* **98**: 1575–1605.
Pink CM. 2013. Striking out and digging in: A bioarchaeological perspective on the impacts of the Wari expansion on populations in the Peruvian central highlands. Doctoral dissertation, University of Tennessee.
Price TD, Burton JH, Bentley RA. 2002. The characterization of biologically available strontium isotope ratios for the study of prehistoric migration. *Archaeometry* **44**: 117–135.
Reid DJ, Dean MC. 2006. Variation in modern human enamel formation times. *Journal of Human Evolution* **50**(3): 329–346.
Ross MH. 1985. Internal and external conflict and violence cross-cultural evidence and a new analysis. *Journal of Conflict Research* **29**: 547–579.
Schott RM. 2011. War rape, natality and genocide. *Journal of Genocide Research* **13**: 5–21.
Skar HO. 1982. The warm valley people: Duality and land reform among the Quechua Indians of highland Peru. *Oslo Studies in Social Anthropology* **2** Oslo: Universitetsforlaget.
Ta'ala SC, Berg GE, Haden K. 2006. Blunt force cranial trauma in the Cambodian killing fields. *Journal of Forensic Sciences* **51**(5): 996–1001.
Taylor CC. 1999. A gendered genocide: Tutsi women and Hutu extremists in the 1994 Rwanda genocide. *Politcal and Legal Anthropology Review* **22**: 42–54.
Torres-Rouff C. 2002. Cranial vault modification and ethnicity in Middle Horizon San Pedro de Atacama, Chile. *Current Anthropology* **43**: 163–171
Tung TA. 2012. Violence, ritual, and the Wari Empire: A social bioarchaeology of imperialism in the ancient Andes. University of Florida Press: Gainesville.
Tung TA, Knudson KJ. 2011. Identifying locals, migrants, and captives in the Wari heartland: A bioarchaeological and biogeochemical study of human remains from Conchopata, Peru. *Journal of Anthropological Archaeology* **30**: 247–261.
Walker PL. 1997. Wifebeating, boxing, and broken noses: Skeletal evidence for the cultural patterning of violence. In Troubled Times: osteological and anthropological evidence of violence, DJ Martin, T Frayer (eds.). Gordon and Breach: New York.
Walker PL. 2001. A bioarchaeological perspective on the history of violence. *Annual Review of Anthropology* **30**: 573–596.
White WM. 2013. Geochemistry. Wiley Blackwell: New York.
Wright LE. 2005. Identifying immigrants to Tikal, Guatemala: Defining local variability in strontium isotope ratios of human tooth enamel. *Journal of Archaeological Science* **32** 555–566.

