

Dimensions of Health and Social Structure in the Early Intermediate Period Cemetery at Villa El Salvador, Peru

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ABSTRACT This paper examines relationships between the social structure of a community and the health of its members, based on analysis of human skeletal remains (N = 64) from Villa El Salvador XII (100 BC–AD 100), a prehistoric cemetery located in the lower Lurín Valley, Peru. The ambiguity of social status as conventionally inferred from archaeological context is among the principal complicating factors in such an inquiry. We use multidimensional scaling of skeletal markers to identify the presence of patterned health-based heterogeneity in our sample, without making a priori assumptions about underlying social structure at Villa El Salvador. This procedure situates every skeleton relative to all others in the sample on the basis of multiple health markers, eliciting health groups. Once recognized, the relevance of those groups to social structure can be evaluated by comparison with a broad range of presumptive archaeological status indicators. We test the hypothesis that the dis-

tribution of stress indicators in human skeletons covaries with archaeological indicators of social differentiation. Based on multivariate analysis of skeletal indicators, we conclude that the cemetery at Villa El Salvador was utilized by two social groups with different geographic affinities: one of local coastal origin, and the other probably from the upper Lurín Valley or adjacent higher altitudes. These groups differ in skeletal characteristics related to childhood health, probably reflecting systematic contrasts in the growth environments of the studied individuals. This same division is independently supported by the distribution of cranial deformation, a possible marker of ethnicity. We also document some inequality in the distribution of labor among male individuals, as reflected by the relative advancement of degenerative joint disease, and congruent with differences in the number and quality of associated funerary offerings. *Am J Phys Anthropol* 131:218–235, 2006. © 2006 Wiley-Liss, Inc.

Among humans and other social animals, social structure influences many aspects of an individual's health (Marmot, 2001; Sapolsky, 2004). Growth curves and rates of maturation, as well as the frequencies of deficiency and overload diseases, are affected by unequal distribution of resources among members of social groups (Bielicki and Welton, 1982; Goodman et al., 1987; Brabin and Brabin, 1992; Reddy, 1993; Bennike et al., 2005). The intensity and frequency of psychological stress suffered by low-ranked individuals have a profound effect on the endocrine system and consequently on cardiovascular performance, the immune system, and other physiological functions, resulting in greater susceptibility to various illnesses (Kaplan et al., 1991; Sapolsky and Share, 1994; review in Sapolsky 2004). The directionality of aggressive and affiliative behavior also results in an unequal distribution of injury among animals of differing ranks (Whitten and Smith, 1984; Blanchard et al., 2001; Zumpe and Michael, 1989). For humans, disparities in the amount of physical labor performed and contrasts in daily routine among individuals of unequal status likewise contribute to systematic health differences within a stratified community (Rathbun and Steckel, 2003; Powell, 1991; Robb et al., 2001; Jankauskas, 2003; Walker and Hewlett, 1990).

Although an interconnection between social status and health is well-documented for both historic and contemporary humans, as well as nonhuman primates, studies of ancient skeletal samples often suggest a lack of clear association between observed variation in health markers and the apparent social status of individuals

(Powell, 1991; Palkovich, 1984; Cucina and Işcan, 1997; Knüsel et al., 1997; Robb et al., 2001; Scott Murphy, 2004; Tung and Del Castillo, 2005). Lack of correlation between inferred health and inferred status was variously attributed to the powerful effects of shared environment, differences in individual susceptibility to disease, or widely acknowledged ambiguities in the interpretation of skeletal markers, as well as in the assessment of status from the context and associations of archaeological remains.

The use of funerary settings as proxies for the social standing of individuals is specifically construed as problematic (Rothschild, 1979; Storey, 1992; Cucina and Işcan, 1997; Robb et al., 2001; Jankauskas, 2003; Scott Murphy, 2004; Tung and Del Castillo, 2004; Rodrigues, 2004). Funerary context may be affected by numerous factors, not all of which are necessarily related to the social standing of the deceased. Competition for control over territory, status, and prestige among the living, as well as the manner and cir-

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cumstances of death, can influence the wealth and location of a specific burial (Binford, 1971; Saxe, 1971; Goldstein, 1981; O'Shea, 1984, p. 36; Buikstra, 1995). In different archaeological traditions, the parameters defining a funerary context may relate to multiple aspects of social structure, not necessarily reducible to a hierarchy of power (Tainter, 1975; Tainter and Cordy, 1977; Morris, 1987; Rowe, 1995; Carmichael, 1995; Härke, 2000; Carr, 2004). The location of a burial or tomb, its form, the orientation and treatment of the body, the number, type, and quality of grave goods, whether those offerings were imported or produced locally, and the overall energy invested in burial construction may have different culturally dependent meanings. While certain aspects of a funerary arrangement might be influenced by the power or wealth of the deceased individual, others are affected more specifically by affiliations that may cross-cut social hierarchy, such as ethnicity, occupation, belief system, or kinship, as well as the sex and age of the deceased (Rothschild, 1979; O'Shea, 1984; Morris, 1987; Carmichael, 1995; Härke, 2000).

Social status itself is not static during life and can change in accordance with occupation, marriage, family size, and other experiences. Therefore, it is not surprising that when significant correlations between funerary context and health indicators are reported, these tend to involve late-onset pathologies, such as musculoskeletal stress markers (Robb et al., 2001; Rodrigues, 2004), diffuse idiopathic skeletal hyperostosis (Jankauskas, 2003), and those oral pathologies that progress with age (Sakashita et al., 1997; Cucina and Tiesler, 2003). Health indicators that reflect morbidity during childhood often show no clear association with inferred social status (Powell, 1991; Cucina and Işcan, 1997; Robb et al., 2001; Tung and Del Castillo, 2005).

Considering the aforementioned difficulties in accurately recognizing social status from funerary contexts, it is not clear whether the lack of significant correlation between social and biological status reported in many case studies reflects an actual lack of systematic health differences among prehistoric status groups. In our analysis of the Villa El Salvador skeletal collection, we pursue an alternative approach. Given that considerable health differences between status groups are observed among historic humans and other social animals, we can hypothesize that the constraints and opportunities imposed by social hierarchy in prehistoric communities should also result in systematic differences in health. However, when particular health indicators are each considered separately, individual differences in susceptibility and pathogenesis apparently overshadow health differences between status groups.

The purpose of this study is to test the hypothesis that archaeological indicators of social status are related to health differences, as reflected by the distribution of stress indicators on human skeletons. Multivariate approaches are powerful tools for recognizing patterns behind the noise of individual variation (e.g., Corruccini and Shimada, 2002). Here, we employ multidimensional scaling of skeletal health markers to evaluate the presence of discrete health groups or health gradients that potentially correspond to social entities that existed within a prehistoric community. We do not make a priori assumptions about the social structure of the community as a whole or the status of any specific member. Instead, once patterns of biological variation are established, we test their possible relevance to social structure by com-

parison with archaeological indicators presumed to be related to social differences.

VILLA EL SALVADOR XII: AN EARLY INTERMEDIATE PERIOD CEMETERY ON THE CENTRAL COAST OF PERU

The lower Lurín Valley is an intensively irrigated oasis in the Sechura Desert, just west of the Andes, on the central coast of Peru. Fog is common, especially during the winter, but rainfall is virtually nonexistent. Above the valley floor, the microclimate changes rapidly with the steep gradient of the mountains (Earle, 1972; Burger and Salazar-Burger, 1991; Burger, 1992). From the coast, several environmental zones can be traversed on foot within a day, starting from the littoral and flood plain, above which are the *lomas*, areas with a seasonal vegetation composed mostly of epiphytes, which survive on moisture absorbed directly from the air. Above 500 m are dry slopes covered with xerophytic plants and crossed by narrow ravines.

Villa El Salvador is a district within the lower Lurín Valley, located just south of Lima at 12°15'00" South latitude and 76°56'23" East longitude (Fig. 1). Situated 1 km northwest of the famous site of Pachacamac, the area encompasses a group of ancient cemeteries dating to the beginning of the Early Intermediate period in the standard chronological sequence used for coastal and highland Peru. Villa El Salvador was excavated originally by Stothert and Ravines (1977; see also Stothert, 1980), and more recently by Delgado (1992, 1994). The skeletal material examined in the present study stems from fieldwork carried out by Delgado (1992, 1994) at Villa El Salvador XII.

Villa El Salvador XII is a rectangular cemetery area of approximately 1,600 m², defined by adobe walls (Fig. 2). Most of the individuals buried there were interred in a sitting position, frequently facing west or southwest, toward the ocean. Some bodies were wrapped in grass mats or textiles. The funerary offerings recovered were relatively sparse and usually consisted of a few simple ceramic vessels, sometimes accompanied by animal bone, marine shell, snuffing tablets, beads, copper plaques that were placed on or inside the mouth of the deceased, and other small metal objects, a few of which were gilded or silvered (Delgado, 1992).

All skeletons considered in our analysis were associated with pottery of the white-on-red (*blanco sobre rojo*) ceramic tradition. This material corresponds to the Miramar phases described by Patterson (1966; see also Earle, 1972; Córdova Conza, 2003), and dates to ca. 100 BC–AD 100, near the beginning of the Early Intermediate period (Stothert, 1980; Delgado, 1992; Makowski, 2002). The absence of ceramic ware bearing the interlocking designs of the developed Lima culture suggests that the cemetery was abandoned by the later half of the Early Intermediate period. Thus, the skeletal sample from Villa El Salvador XII pertains to a crucial period of sociopolitical restructuring, when the apparent end of highland linkages that accompanied the decline of Chavin influence was followed by regional diversification and the rapid rise of new polities on the Peruvian coast (Makowski, 2002). This time frame was marked by general population dispersal in the region and the formation of independent polities in each valley, perhaps as an outgrowth of irrigation management (Patterson, 1966; Earle, 1972).

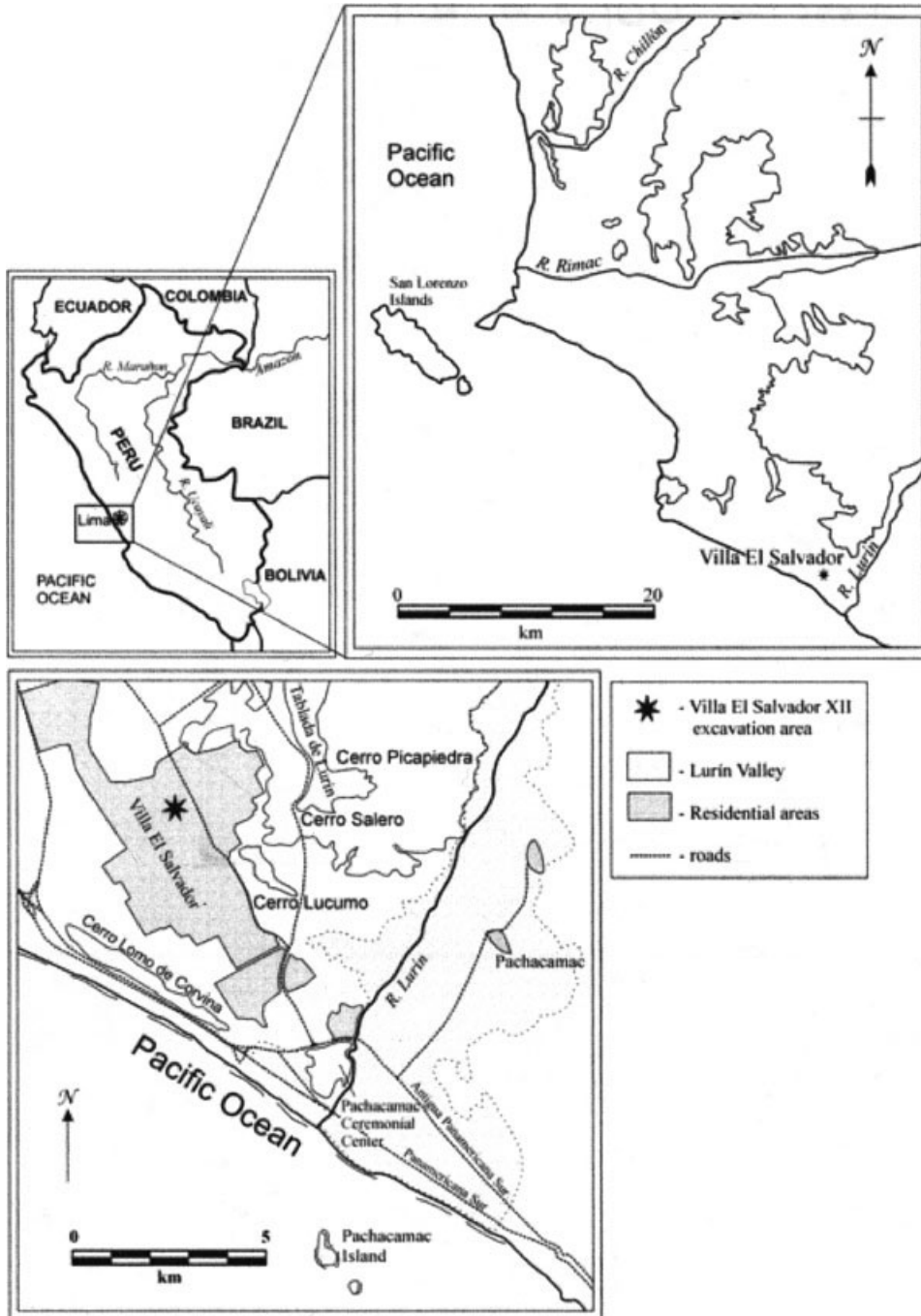


Fig. 1. Location of Villa El Salvador XII excavation area on central coast of Peru.

The choice of the Villa El Salvador XII skeletal collection for this analysis was determined by a number of factors. The beginning of the Early Intermediate period is a crucial time frame for our understanding of the emergence of hierarchical societies in the region, but is underinvestigated archaeologically (DeLeonardis and Lau, 2004). The skeletal sample recovered by Delgado (1992) exhibits a range of burial treatments, suggesting that status differences were being asserted at death, if not necessarily ascribed from birth. This provides a good opportunity to test the covariation of archaeological indicators of status and health differences for a community where social position still remained at least somewhat fluid during the lifetime of an individual, a context simi-

lar to that discussed in a number of other studies (Powell, 1991; Cucina and Işcan, 1997). Although our sample is relatively small, both the stratigraphy of the site and the stylistic uniformity of the pottery included as grave goods suggest a fairly restricted interval of use, minimizing the possible effect of chronological differences among burials.

MATERIALS AND METHODS

Analysis of human skeletons

The analysis presented here is based on health markers recorded from 64 adult skeletal individuals with



Fig. 2. Contiguity-based burial groups at Villa El Salvador XII.

completely fused epiphyseal plates on the long bones. Inferior preservation of subadult skeletons from the same cemetery largely precludes multivariate analysis of their health markers. Therefore, this paper considers only adult skeletal remains. Pelvic morphology was used as the primary criterion for sex assignment. Thirty-three skeletons were attributed to males, and 31 to females. Morphological changes in the pubic symphysis, auricular surfaces, and sternal rib end were used to estimate age at death (Lovejoy et al., 1985; Saunders et al., 1992; McKern and Stewart, 1957; Gilbert and McKern, 1973; İşcan et al., 1984a,b). Ectocranial suture closure could be affected by artificial cranial deformation, and thus was considered an unreliable indicator of age for specimens from the Villa El Salvador XII sample. Although the male subsample includes a somewhat greater proportion of young adults than the female subsample, this difference in age composition is not statistically significant (Table 1).

A wide range of skeletal indicators affected by morbidity, physiological stress, aging, or mechanical loads was recorded according to a standard protocol (Buikstra and Ubelaker, 1994; Goodman and Clark, 1981; Stuart-Macadam, 1987) (Table 2). For the sake of simplicity, these are collectively referred to as health markers. Though evaluated from adult remains, these indicators become imprinted on the skeleton at different stages of development. Cribrum cranii (porotic hyperostosis), cribrum orbitalia, linear enamel hypoplasias (LEH), and Harris lines are early-onset skeletal markers, and can be construed as indicators of subadult health (Ortner and Putschar,

TABLE 1. Age and sex composition of Villa El Salvador sample¹

Estimated age	Males		Females	
	N	%	N	%
20–24	5	15.2	8	25.8
25–29	12	36.4	3	9.7
30–39	8	24.2	10	32.3
40–49	5	15.2	7	22.6
50+	3	9.1	3	9.7
Total	33	100.0	31	100.0

¹ $\chi^2 = 6.59, 4 \text{ df}, P = 0.16, \text{ ns.}$

1985; Goodman and Armelagos, 1985; Harris, 1931). Long bone length in adults, while finally resulting from longitudinal growth during adolescence, is also affected by nutrition and morbidity during childhood. Other skeletal indicators, such as periosteal lesions, carious lesions, bone loss, and degenerative joint disease (DJD), progress during adulthood. Therefore, these are considered indicators of adult morbidity, mechanical stress, and senescence.

Following Stuart-Macadam (1987), radiographs of skulls were used to verify diploe expansion in suspected cases of porotic hyperostosis. Artificial cranial deformation frequently results in lesions that can be mistaken for porotic hyperostosis at the locus of applied pressure (Gerszten et al., 1998). Therefore, only macroporosity with pore coalescence, accompanied by hyperostosis that was widespread and extended beyond the focus of deformation, was recorded as an indicator of anemia in our

TABLE 2. Development of health- and activity-related skeletal indicators in Villa El Salvador sample

	Males			Females			Significance ¹	
	N	Mean	SD	N	Mean	SD	<i>t</i>	<i>P</i>
Humerus length	32	301.3	14.1	31	276.9	14.8	6.69	0.000
Femur length	30	410.5	18.8	27	387.1	20.2	4.72	0.000
Tibia length	31	344.4	18.4	27	323.7	15.8	4.54	0.000
Relative cortical thickness	30	0.57	0.09	27	0.51	0.11	2.17	0.034
	N	Frequency	SE	N	Frequency	SE	χ^2 (1 df)	<i>P</i>
Cribriform orbitalia, all	30	0.60	0.09	31	0.45	0.09	1.35	0.246
Cribriform orbitalia, severe	30	0.11	0.07	31	0.19	0.08	0.50	0.478
Porotic hyperostosis, all	30	0.53	0.09	31	0.65	0.09	0.79	0.375
Porotic hyperostosis, severe	30	0.23	0.09	31	0.06	0.05	3.45	0.063
Caries per tooth	583	0.12	0.01	726	0.27	0.02	44.87	0.000
Individuals with caries	28	0.71	0.05	30	0.90	0.09	3.25	0.071
Teeth with LEH	200	0.42	0.03	262	0.65	0.03	11.75	0.001
Individuals with LEH	29	0.66	0.09	22	0.82	0.08	1.67	0.196
Harris lines	30	0.13	0.06	25	0.36	0.10	3.88	0.049
Generalized periosteal lesions	30	0.43	0.07	29	0.13	0.09	5.45	0.019
Cranial trauma	30	0.20	0.03	31	0.10	0.09	1.29	0.256
Postcranial trauma	32	0.22	0.07	27	0.29	0.09	0.46	0.496
Degenerative joint disease								
Elbow	29	0.72	0.09	30	0.50	0.08	3.11	0.078
Knee	27	0.79	0.09	30	0.47	0.09	3.28	0.070
Cervical vertebrae	31	0.68	0.09	30	0.60	0.09	0.28	0.596
Thoracic vertebrae	31	0.48	0.09	30	0.33	0.09	1.43	2.232
Lumbar vertebrae	31	0.77	0.08	29	0.76	0.08	0.02	0.887

¹ Highlighted values are significant at $P < 0.05$.

study. Cranial deformation was scored on the basis of a classification previously established for the Andean area (Dembo and Imbelloni, 1938; Weiss, 1972; Blom, 2005). Types of cranial deformation were classified as: frontal-occipital with tabular-erect and tabular-oblique subtypes; annular; or cuneiform (occipital flattening only).

Skeletons were measured in accordance with the protocol of Martin and Saller (1957): limb bone lengths were used as proxies for stature and limb proportions, while diameters were used to estimate robusticity. Composite scores for upper body robusticity were based on vertical diameter of the humerus head and maximal breadth of the distal humerus epiphysis, plus nine midshaft measurements: medio-lateral and antero-posterior diameters, as well as circumferences, of the humerus, ulna, and radius ($q = 11$). Lower body robusticity was calculated from midshaft medio-lateral and antero-posterior diameters and circumferences of the femur and tibia, along with maximal diameter of the femur head ($q = 7$). Relative cortical thickness was estimated by the difference between the respective diameters of the femur diaphysis and medullary cavity, as measured at midshaft from medio-lateral and antero-posterior X-ray images.

Archaeological indicators of social status

Funerary contexts were evaluated on the basis of the excavation report by Delgado (1992). Location of a burial within the cemetery, orientation of the body, and funerary offerings might be affected by the social status of the deceased. Three aspects of offerings were considered. The total number of grave goods is a count of all pieces of raw material, unmodified animal bone, shell, or mats, and other artifacts associated with an interment. Non-perishable man-made offerings were also counted separately, because their preservation is relatively consistent among burials, perhaps more accurately indicating the

effort invested in preparing the burial. Rare items such as decorated pottery and gilded or silvered metal objects might be expected to mark burials of higher social status. Therefore, the quality of funerary offerings was ranked in accordance with the presence or absence of these objects. A score of 0 was assigned to burials lacking nonperishable offerings entirely; a score of 1, to burials with common objects only, such as undecorated pottery, shells and beads, or small copper plaques and tools; a score of 2, to burials with at least one rare object; and a score of 3, to burials with rare objects from more than one category, e.g., both gilded metalwork and decorated ceramic ware.

Spatial relationships among interments were evaluated according to the grid location of each burial, as well as their apparent contiguity, although large looted areas in the southern, central, and northwestern parts of the cemetery complicate this analysis. As shown in Figure 2, burials were divided into eight groups according to their provenience. These include burials 29–41, associated with the western corner of the cemetery (group I); burials 80–99, associated with the southwestern wall and clustering at the probable entrance area (group II); burials associated with a natural elevation along the northwestern wall (group III); burials 222–226, located at the very top of the elevation (group IV); unassociated burials located between the western corner of the cemetery and the elevation (group V); burials located toward the center of the cemetery (group VI); the cluster of burials 169–171 in the southern corner (group VII); and all other unassociated burials (group VIII).

Statistical treatment

The choice of method for multivariate analysis was guided by several requirements. First, a comprehensive study of pathologies on skeletal remains always deals

with a combination of traits measured using ordinal, nominal, interval, and ratio scales. Therefore, the method should allow for combining them. Second, the method has to be robust for accommodating missing values. In prehistoric skeletal collections, partial preservation results in data sets where most cases and variables have at least one missing value. Unless one wants to confine a multivariate analysis to perfectly preserved skeletons or a very limited subset of possible skeletal markers, individuals with missing elements must form a part of the sample. Third, the method should not presume or impose structure on the data, but rather should be able to recognize the presence of heterogeneity or lack thereof. Multidimensional scaling performed on a matrix of the similarity indices of Gower (1971) satisfies all of these requirements.

The composite similarity index of Gower (1971) allows combining continuous, nominal, and binary variables:

$$G_{12j} = \frac{\sum_{j=1}^p \omega_{12j} s_{12j}}{\sum_{j=1}^p \omega_{12j}} \quad (1)$$

In this equation, G_{12j} denotes the similarity between the first and second item (skeleton) on the j th dimension. The contribution of variable j (s_{12j}) is computed from a formula appropriate for variable j . The weight of variable j (ω_{12j}) can be assigned by the user; otherwise, it is set to one if the comparison between the two cases is valid, and zero if missing values render the comparison between the two cases invalid. The purpose of the $\sum_{j=1}^p \omega_{12j}$ denominator is to compute the average similarity for all possibilities (Quinn and Keough, 2002, p. 413–415).

With the index of Gower (1971), most similarity measures maintain an ordinal relationship to one another. Therefore, any convenient similarity measure can be used to compare specific variables. Here, for interval and ordinal variables, including long bone length, cortical thickness, and osteophyte counts on the three segments of the vertebral column, we used the similarity of Gower (1971):

$$s_{12j} = 1 - \frac{|x_{1j} - x_{2j}|}{x_{\max} - x_{\min}} \quad (2)$$

For nominal variables, including evidence of cranial and postcranial traumas, anemia indicators, degenerative joint disease, and generalized periosteal lesions suggestive of infectious diseases, s_{12j} is one if the two cases have the same attribute state, e.g., if the pathology is present in both cases or absent in both cases. Otherwise, s_{12j} is zero. In order to avoid the overestimation of similarity between skulls lacking rare skeletal indicators, similarities for pathologies with a frequency of less than 0.25 were measured by the procedure of Jaccard (1908). For these rare indicators, s_{12j} is one only if the condition is present in both cases. When a condition is absent in both cases, the similarity is assumed invalid, and ω_{12j} is zero. Where a rare condition is present only in one case, s_{12j} is zero, while ω_{12j} is one, indicating the validity of the comparison. This treatment gives heavier weight to the coincidence of rare conditions, and ignores similarity based on the absence of a rare condition.

Nonmetric multidimensional scaling (MDS) was used to explore the data structure, as based on the similarity matrix of Gower (1971). Multidimensional scaling is a powerful method that can recognize, but does not pre-

sume, the existence of discrete groups in a data set (Kruskal and Wish, 1978; Young, 1987; Shepard, 1980). This procedure graphically represents the relationships among cases in a reduced space. The number of dimensions can be determined by Kruskal's stress of final configuration, which measures how well the resulting configuration represents an observed distance matrix. It is desirable to select a dimensionality that results in a Kruskal's stress value below 0.2, and ideally below 0.1 (Quinn and Keough, 2002, p. 478).

Vector interpretation of every dimension was accomplished by computing its correlation with each skeletal indicator. Again, since different variables in our analysis were measured on different scales, several different measures of correlation were employed. Pearson product moment correlation was used for the analysis of continuous variables, and Spearman rank order correlation was used for discrete variables. The nonrandomness of a binary variable distribution along the vector of a dimension was tested by variance analysis, with each binary variable serving as a grouping variable.

The relationship between health status and social status was examined by plotting available archaeological indicators over the MDS final configuration. Spearman rank order correlations between MDS weights and each archaeological indicator as measured on an ordinal scale were used to interpret the axes. Analysis of variance was used to compare the difference of MDS weights among groups outlined by nominal or binary archaeological indicators.

RESULTS

Multivariate analysis

MDS, based on health-related skeletal indicators, yielded a good three-dimensional solution for the distribution of those characteristics in the Villa El Salvador collection (Fig. 3). Kruskal's stress was within the acceptable range (0.15 for males and 0.14 for females), indicating that the three-dimensional solution adequately represents the underlying data structure (Kruskal and Wish, 1978). Both male and female specimens are divided into two more or less discrete subgroups by the first dimension (Fig. 3, dashed lines).

The specific correlations between skeletal indicators used in MDS and the weights for each of the resulting three dimensions help interpret these dimensions as vectors of covarying health markers (Tables 3 and 4). The vectors defining each dimension are surprisingly similar for male and female subsamples. Weights on the first dimension correlate significantly with indicators reflecting childhood morbidity and longitudinal growth, including the development of porotic hyperostosis, cribra orbitalia, and long bone length. The second-dimension weight is most strongly affected by the markers of mechanical stress and aging.

While the first-dimension weights represent similar vectors of health in males and females, these vectors are not entirely equivalent. Some skeletal markers that correlate significantly with the first dimension are different in males and females, and may not have been related to sub-adult health. In males, these include generalized periosteal lesions, while in females it is robusticity of the lower body.

The second-dimension weights correlate significantly with activity- and senescence-related skeletal indicators in both males and females (Tables 3 and 4). These indicators include the development of DJD on the elbows, knees, and all segments of the vertebral column, as well as fractures and carious lesions. For females, but not for

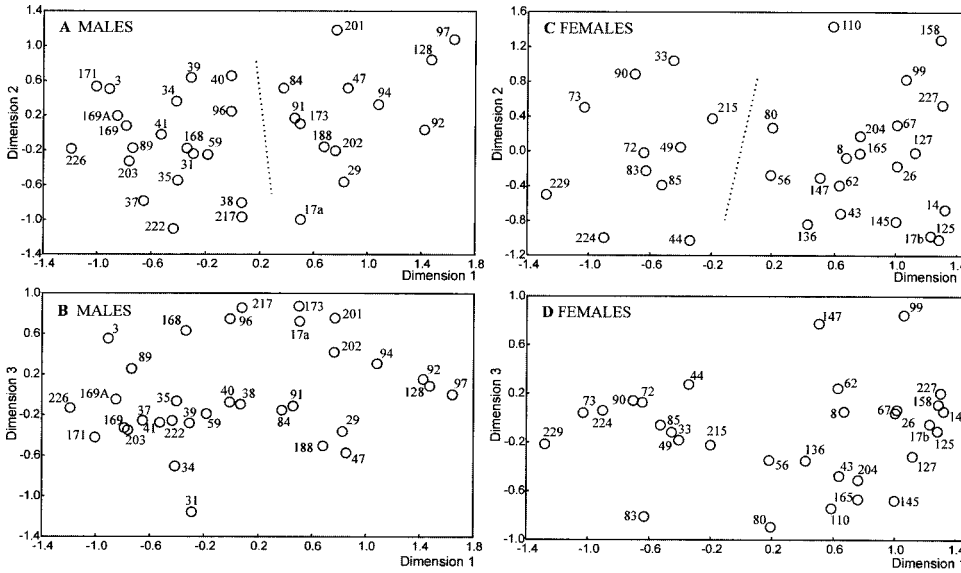


Fig. 3. Final configurations obtained by MDS of Villa El Salvador XII burials, based on skeletal health indicators. Dotted lines indicate subjective partitioning. Numbers on chart represent inventory number of funerary context associated with each skeleton. **A, B:** Males. **C, D:** Females.

TABLE 3. Correlations of weights obtained in multidimensional scaling analysis with skeletal indicators of diet and health: male individuals¹

	Male skeletons						
	N	Dimension 1		Dimension 2		Dimension 3	
		r	P	r	P	r	P
Humerus length	32	0.55	0.001	0.03	0.848	0.13	0.477
Femur length	30	0.47	0.008	0.04	0.843	0.30	0.109
Tibia length	31	0.66	0.000	0.09	0.615	0.22	0.229
Upper body robusticity	29	-0.15	0.443	0.51	0.005	0.07	0.703
Lower body robusticity	28	-0.24	0.276	0.08	0.697	-0.11	0.569
Cortical thickness	30	0.00	0.962	0.12	0.512	0.01	0.972
	N	Rho	P	Rho	P	Rho	P
Cribræ orbitalia	30	0.77	0.000	0.13	0.465	0.58	0.000
Porotic hyperostosis	30	0.37	0.047	-0.08	0.679	0.45	0.012
Caries	28	-0.05	0.795	0.55	0.002	-0.05	0.795
LEH	22	0.36	0.101	-0.05	0.834	0.23	0.288
Harris lines	30	-0.19	0.318	-0.07	0.732	0.18	0.331
Degenerative joint disease							
Elbow	29	0.12	0.538	0.75	0.000	-0.15	0.428
Knee	27	0.14	0.468	0.54	0.004	-0.33	0.085
Cervical vertebrae	31	0.30	0.111	0.81	0.000	-0.10	0.578
Thoracic vertebrae	31	0.19	0.284	0.76	0.000	-0.11	0.559
Lumbar vertebrae	31	-0.03	0.850	0.75	0.000	-0.31	0.080
	N	F (df 1, 2)	P	F (df 1, 2)	P	F (df 1, 2)	P
Periosteal lesions	30	7.54	0.010	0.08	0.782	2.17	0.151
Cranial trauma	30	0.93	0.343	0.14	0.713	5.86	0.022
Postcranial trauma	32	0.11	0.911	6.96	0.013	1.02	0.319

¹ r and rho have N - 1 degrees of freedom; highlighted values are significant at P < 0.05.

males, this dimension is negatively correlated with cortical thickness of the femur.

In part, these vectors are explained by underlying physiological causes shared by certain skeletal markers, such as anemia-related red bone marrow hyperplasia as the primary instigator of both cribræ cranii and cribræ orbitalia (Angel, 1966, 1978). However, not all skeletal indicators contributing to the first and second dimensions have the same physiological origin. For instance,

there is nothing about having red bone marrow hyperplasia that should cause an individual to develop greater bone length or generalized periostitis. Therefore, correlation of the first dimension with a broad range of skeletal indicators probably reflects the presence of some external environmental force affecting a wide range of physiologically unconnected health markers in the population.

Regarding interpretation of the final configuration, patterns in two or three dimensions can be more inform-

TABLE 4. Correlations of weights obtained in multidimensional scaling analysis with skeletal indicators of diet and health: female individuals¹

Skeletal indicators	N	Female skeletons					
		Dimension 1		Dimension 2		Dimension 3	
		r	P	r	P	r	P
Humerus length	31	0.70	0.000	-0.26	0.151	0.08	0.653
Femur length	27	0.73	0.000	-0.16	0.377	0.09	0.613
Tibia length	27	0.55	0.003	-0.17	0.385	-0.15	0.455
Upper body robusticity	27	-0.33	0.189	-0.26	0.134	0.11	0.600
Lower body robusticity	28	-0.38	0.046	-0.47	0.012	0.33	0.083
Cortical thickness	27	0.14	0.489	-0.39	0.049	0.50	0.008
		Rho	P	Rho	P	Rho	P
Cribriform orbitalia	31	0.73	0.000	0.00	0.986	0.40	0.024
Porotic hyperostosis	31	0.78	0.000	-0.01	0.943	0.14	0.762
Caries	30	0.00	0.986	0.71	0.000	0.04	0.833
LEH	29	0.00	0.998	-0.14	0.467	-0.20	0.396
Harris lines	25	-0.39	0.055	-0.06	0.759	0.06	0.742
Degenerative joint disease							
Elbow	30	-0.29	0.122	0.58	0.000	-0.39	0.031
Knee	30	0.15	0.419	0.42	0.021	-0.74	0.000
Cervical vertebrae	31	0.02	0.927	0.72	0.000	0.30	0.097
Thoracic vertebrae	30	0.07	0.691	0.85	0.000	0.10	0.631
Lumbar vertebrae	29	0.02	0.888	0.87	0.000	-0.02	0.909
		F (df 1, 2)	P	F (df 1, 2)	P	F (df 1, 2)	P
Periosteal lesions	29	2.93	0.098	0.72	0.404	1.40	0.247
Cranial trauma	31	2.33	0.137	0.22	0.640	10.47	0.003
Postcranial trauma	27	0.31	0.582	27.99	0.000	0.00	0.999

¹ r and rho have N - 1 degrees of freedom; highlighted values are significant at P < 0.05.

ative than vector interpretation of each dimension separately (Shepard, 1980). For males, when the first and the third dimensions are considered together, the presence of an additional group in the upper right-hand side of the chart is apparent (Fig. 3B). The third-dimension weights for males correlate significantly with the development of porotic hyperostosis and cribriform orbitalia, which also correlate significantly with first-dimension weights (Table 3). Therefore, these dimensions seem to reflect a similar set of underlying causes.

Health status and indicators of social structure

MDS plots (Fig. 3) imply the presence of more or less discrete health groups in the Villa El Salvador XII sample. This heterogeneity might be related to social-status differences affecting health. At the same time, it could have been caused by other factors, including heritable differences in frailty between families or lineages, year-to-year climatic changes resulting in stress disparity among individuals born in different years, or environmental and behavioral differences among households. The relationship of a vector representation of health heterogeneity to social structure is addressed here by analysis of the correlation between the MDS-obtained weights and possible archaeological indicators of social status (Table 5). Spearman rank order correlations were used for the analysis of ordinal variables; ANOVA was employed when the variables are binary or nominal.

It should be noted that unlike Tables 3 and 4, which examined the correlation of MDS dimensions with those skeletal indicators that were used to compute the original similarity matrix, Table 5 summarizes the relation-

ship of the same dimensions with archaeological and biological characteristics that were not a part of the MDS analysis. These latter indicators include burial location, the number and quality of associated offerings, the presence of elaborate or rare items in a funerary context, orientation of the body, and presence or absence of artificial cranial deformation. Because second-dimension weights correlate significantly with a wide array of age-related skeletal indicators and were likely affected by age, the effect of age on this dimension was removed by linear regression. The relationship of the age-adjusted second-dimension weights with indicators of social status is also examined in Table 5.

For both males and females, weights of the first or "sub-adult health" dimension differed significantly between individuals with and without artificial cranial deformation (P < 0.001) (Table 5). Weaker but significant differences of the first-dimension weights were also observed among the defined burial groups. For males, the first dimension showed significant differences depending on the orientation of the body (west, southwest, or northwest). For females, significant correlation was found between first-dimension weight and the quality of burial offerings.

For both sexes, weights of the second or "mechanical stress and aging" dimension displayed significant correlation with estimated age (Table 5). For males, this dimension also showed a significant negative correlation with the number of grave goods (rho = -0.36, 32 df, P = 0.041). When the second dimension is adjusted for age, significant negative correlations are also observed with the number of man-made offerings and the quality of offerings. Significantly lower age-adjusted weights are found for males buried with gilded objects. Among females, age-adjusted second-dimension weights do not correlate

TABLE 5. Correlations between weights obtained in multidimensional scaling analysis and indicators presumed to be related to social status¹

Possible indicators of social status	N	Dimension 1		Dimension 2		Age-adjusted d ² ²		Dimension 3	
		Rho	P	Rho	P	Rho	P	Rho	P
Males									
E-W coordinate	33	0.05	0.768	0.09	0.606	0.02	0.894	0.39	0.023
N-S coordinate	33	0.02	0.893	0.38	0.027	0.35	0.047	0.01	0.975
Number of burial goods	33	0.15	0.403	-0.36	0.041	-0.45	0.011	0.05	0.777
Man-made offerings	33	0.24	0.171	-0.21	0.246	-0.43	0.011	0.14	0.438
Quality of offerings	33	0.10	0.585	-0.18	0.328	-0.38	0.030	-0.11	0.527
Age	33	0.19	0.300	0.60	0.000	0.10	0.567	0.18	0.304
	N	F	P	F	P	F	P	F	P
Deformation (1 df)	30	16.76	0.000	0.02	0.878	0.16	0.694	3.79	0.062
Burial group (7 df)	32	3.11	0.020	2.51	0.048	2.02	0.100	3.57	0.012
Body orientation (2 df)	24	4.45	0.024	1.59	0.228	3.94	0.035	2.60	0.098
Elaborate goods (1 df)	33	0.33	0.572	0.33	0.570	3.59	0.067	0.88	0.357
Gilded objects (1 df)	33	0.05	0.823	0.37	0.546	5.75	0.022	0.00	0.978
Sculpted pottery (1 df)	33	1.23	0.276	0.65	0.425	0.60	0.444	0.54	0.466
Females									
E-W coordinate	31	0.25	0.188	0.10	0.603	-0.16	0.388	0.05	0.807
N-S coordinate	31	-0.05	0.803	0.30	0.097	0.27	0.138	-0.14	0.425
Number of burial goods	31	-0.03	0.864	-0.21	0.253	-0.14	0.448	-0.27	0.133
Man-made offerings	31	-0.04	0.793	-0.10	0.601	-0.26	0.161	-0.31	0.089
Quality of offerings	31	0.37	0.040	0.18	0.313	-0.05	0.795	-0.42	0.019
Age	31	-0.21	0.253	0.66	0.000	0.01	0.969	-0.17	0.342
	N	F	P	F	P	F	P	F	P
Deformation (1 df)	31	34.64	0.000	0.41	0.525	0.06	0.813	1.44	0.240
Burial group (7 df)	31	5.08	0.001	1.51	0.213	2.45	0.049	0.76	0.618
Body orientation (1 df)	27	1.42	0.243	2.69	0.113	0.16	0.689	0.00	0.978
Elaborate goods (1 df)	31	0.87	0.427	0.50	0.609	1.18	0.287	1.07	0.357
Gilded objects (1 df)	31	0.03	0.866	0.02	0.893	0.11	0.742	0.15	0.699
Ornithomorphic pottery (1 df)	31	1.23	0.276	0.65	0.425	0.61	0.441	0.55	0.466
Sculpted pottery (1 df)	31	2.93	0.097	0.71	0.406	0.95	0.337	0.32	0.571

¹ Correlations with $P < 0.05$ are bold. Rho has $N - 1$ degrees of freedom. E-W, east-west; N-S, north-south.

² Second-dimension residuals of regression, controlling for age.

significantly with either the number or quality of grave goods. For males, third-dimension weights show significant association with both the east-west coordinate and burial group. Third-dimension weights show a negative correlation with the quality of offerings associated with individual females.

Cranial deformation. By far the strongest correlation was between the weights of the first or "subadult health" dimension and artificial cranial deformation, significant for both males and females, with $P < 0.001$. Cranial deformation was a common trait of individuals buried at Villa El Salvador XII, about equally distributed between males and females, with 62.3% of skulls in the collection at least mildly affected. The preponderant forms of deformation were tabular-erect and occipital, sometimes so slight that it could be an unintended consequence of strapping a child to a cradle board (Fig. 4A–C). A few skulls showed stronger tabular oblique deformation (Fig. 4D–F). A wide area of flattening and the bilobate expansion on several skulls suggest that this deformation was produced by hard, flat devices as opposed to the use of flexible bandages. In two cases, the superior part of the deforming device was placed on the very top of the head, so that maximal pressure was focused on the area around bregma (Fig. 4E). This mode of deformation resulted in short, wide heads, with a characteristic flat-

tening at the top and an extended occipital area. Annular deformation was not found on any of the skulls examined from Villa El Salvador XII.

Figure 5, which superimposes the presence or absence of cranial deformation over the final configuration, shows almost precise correspondence between cranial deformation and the grouping of individuals suggested by the first dimension of the multivariate analysis (the first and the third for males). Individuals with artificially deformed skulls, marked by diamonds, aggregate in the right half of Figure 5.

Artificial cranial deformation usually does not affect a child's health, and special precautions were taken in this study to distinguish between deficiency-related porotic hyperostosis and macroporosity invoked by pressure from a deforming device. Therefore, the nonrandom distribution of cranial deformation along the first dimension allows us to suggest a relationship between the subadult health differences reflected by this dimension and group affiliation marked by the presence or absence of artificial cranial deformation. Apparently, specific group affiliation during infancy, as evidenced by cranial deformation, had considerable effect on longitudinal growth and the likelihood of developing porotic hyperostosis. Individuals subjected to cranial modification exhibited anemia indicators more frequently, but grew to become taller adults than the individuals with unmodified skulls.

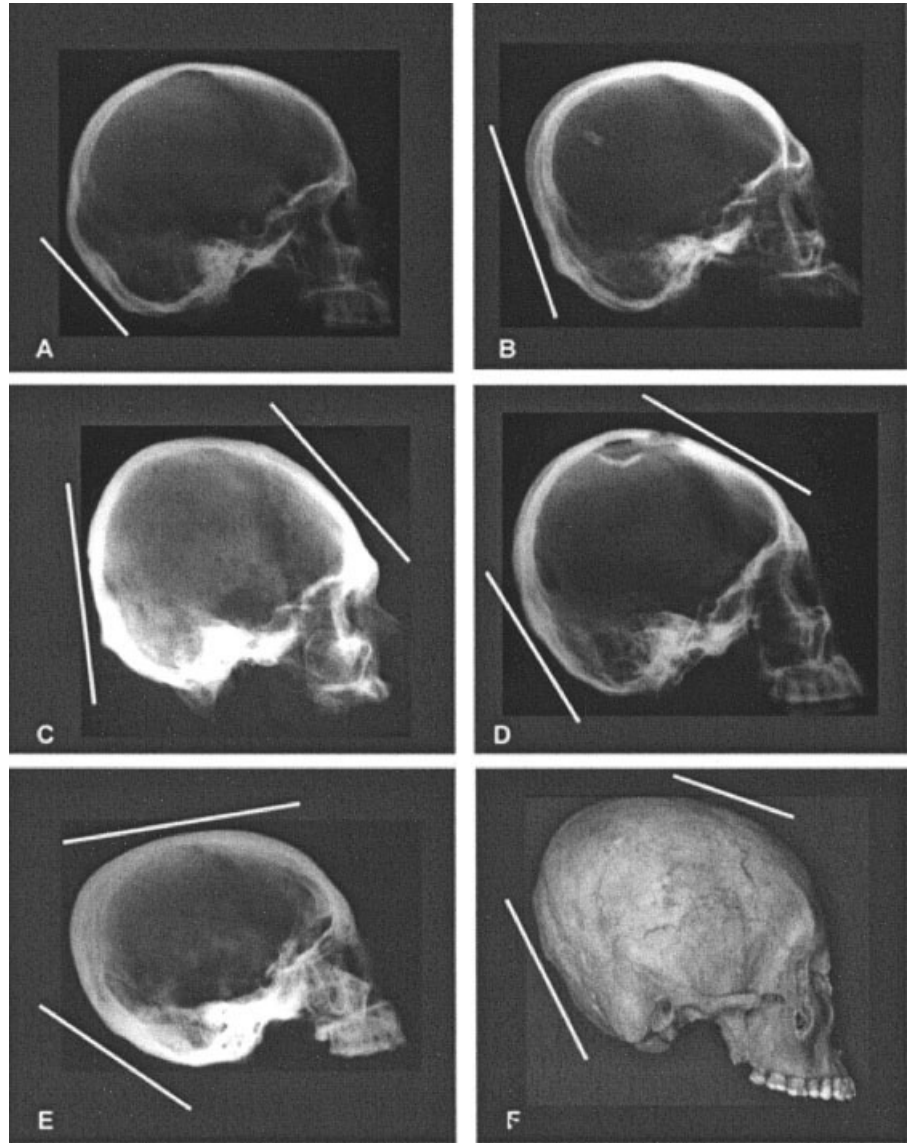


Fig. 4. Types of artificial cranial deformation. Examples from Villa El Salvador XII skeletal collection. **A:** Tomb 224, no artificial deformation, slight occipital flattening. **B:** Tomb 99, slight occipital or cuneiform deformation. **C:** Tomb 202, pronounced tabular-erect deformation. **D:** Tomb 125, slight tabular-oblique deformation, trephinations of parietal bones. **E:** Tomb 147, slight tabular-oblique deformation, with superior portion of deforming device applied at area around bregma. **F:** Tomb 91, tabular-oblique deformation.

Funerary offerings. As mentioned previously, funerary offerings at Villa El Salvador XII were generally meager. In contemporaneous burials excavated at the nearby site of Tablada de Lurín Necropolis, males were associated with greater numbers of objects than females (Makowski, 2002). At Villa El Salvador XII, this pattern seems to be reversed: on average, females were supplied with slightly more grave goods than males (3.1 vs. 2.4, respectively, $t = 1.25$, 62 df, $P > 0.05$, ns). At the same time, female burials seem to be more uniform in their inventory, with none particularly rich, and with two lacking grave goods entirely (Fig. 6). Offerings accompanying female burials at Villa El Salvador commonly include beads, shells, and undecorated pottery. Two female burials each contained a gilded plaque, while five had sculpted or decorated pottery, including anthropomorphic and ornitomorphic shapes as well as double-spouted vessels. Male burials seem to reflect greater disparities in wealth, and the inventory of male burials is more diverse. Elaborate vessels with ornitomorphic appendages appear in four male burials. One grave (202) was particularly rich, containing 16 items, several of which are

rare, including a bird-beak headdress, a double-spouted decorated vessel, a gilded mace, a gilded copper plaque, and a snuffing tablet (Fig. 7).

A negative correlation between offering quality and second-dimension weights shows that individuals from richer burials had a weaker development of activity- and age-related skeletal markers, suggesting they were less likely than others in the community to have engaged in strenuous labor over the long term (Table 5). In order to test whether the negative correlation of offering quality with second-dimension weights actually reflects unequal funerary treatment according to status, the residuals of the second dimension controlling for age were analyzed (see the “age-adjusted d2” column in Table 5). Negative residuals indicate that DJD and other age-related alterations in a skeleton were less developed than would be expected for a given biological age. Therefore, individuals in the Villa El Salvador sample with negative second-dimension residuals are presumed to have had a more leisurely lifestyle than others in the community, and probably were of higher social status. If status determined funerary treatment, the correlation of offer-

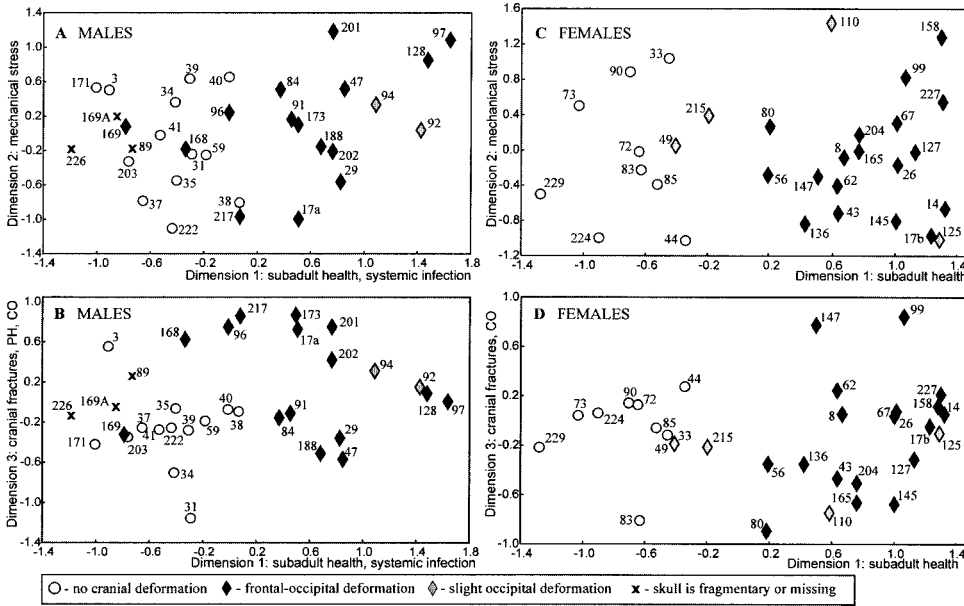


Fig. 5. Presence/absence of cranial deformation superimposed on final configurations. **A, B:** Males. **C, D:** Females.

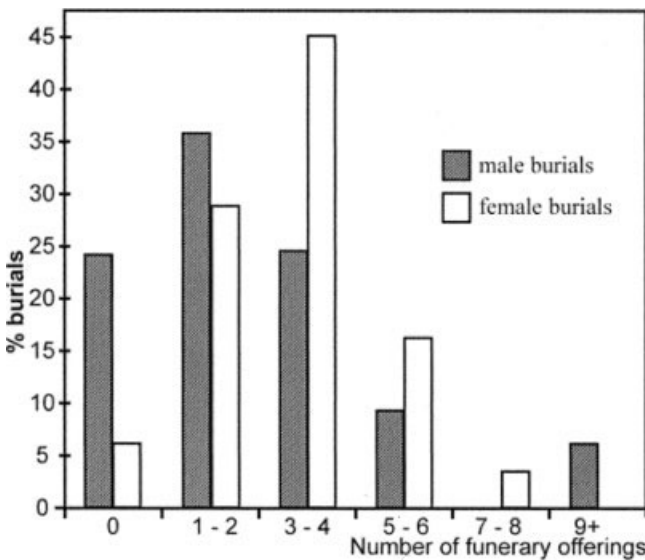


Fig. 6. Grave goods distribution among male and female burials.

ing quality with second-dimension residuals should be stronger than with the second dimension itself.

The correlation between burial wealth and second-dimension residuals ($\rho = -0.45$, 32 df, $P = 0.011$) is indeed greater than with the second dimension itself ($\rho = -0.36$, 32 df, $P = 0.041$) (Table 5). The smallest second-dimension residual was found for the skeleton from the wealthiest known burial (T 202), the remains of an apparent principal individual. Moreover, age-adjusted second-dimension weights show significant association with the number of man-made objects, the presence of gilded copper, and the offering quality score; all of these are aspects of the funerary assemblages that did not correlate significantly with the nonadjusted second dimension. No such relationship was observed for females, for

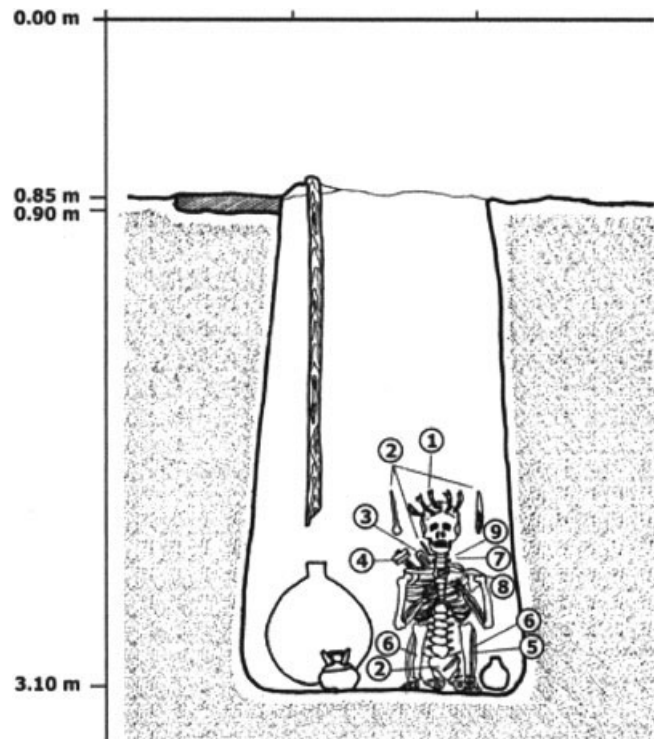


Fig. 7. Principal burial (T 202). 1, bird beak headdress; 2, bone tools; 3, snuffing tablet; 4, club; 5, yellow pigment; 6, stone spheres; 7, shell bead; 8, gilded plaque; 9, sodalite bead. Modified from Delgado (1994).

whom second-dimension residuals exhibit a low and statistically insignificant correlation with both the number and quality of grave goods (respectively, $\rho = -0.14$, $P = 0.45$, and $\rho = -0.05$, $P = 0.80$, 30 df, ns).

Figure 8 presents the second-dimension weights plotted against estimated age. The diameter of each circle is proportional to the number of goods accompanying the corresponding burial. Circles with dark shading mark

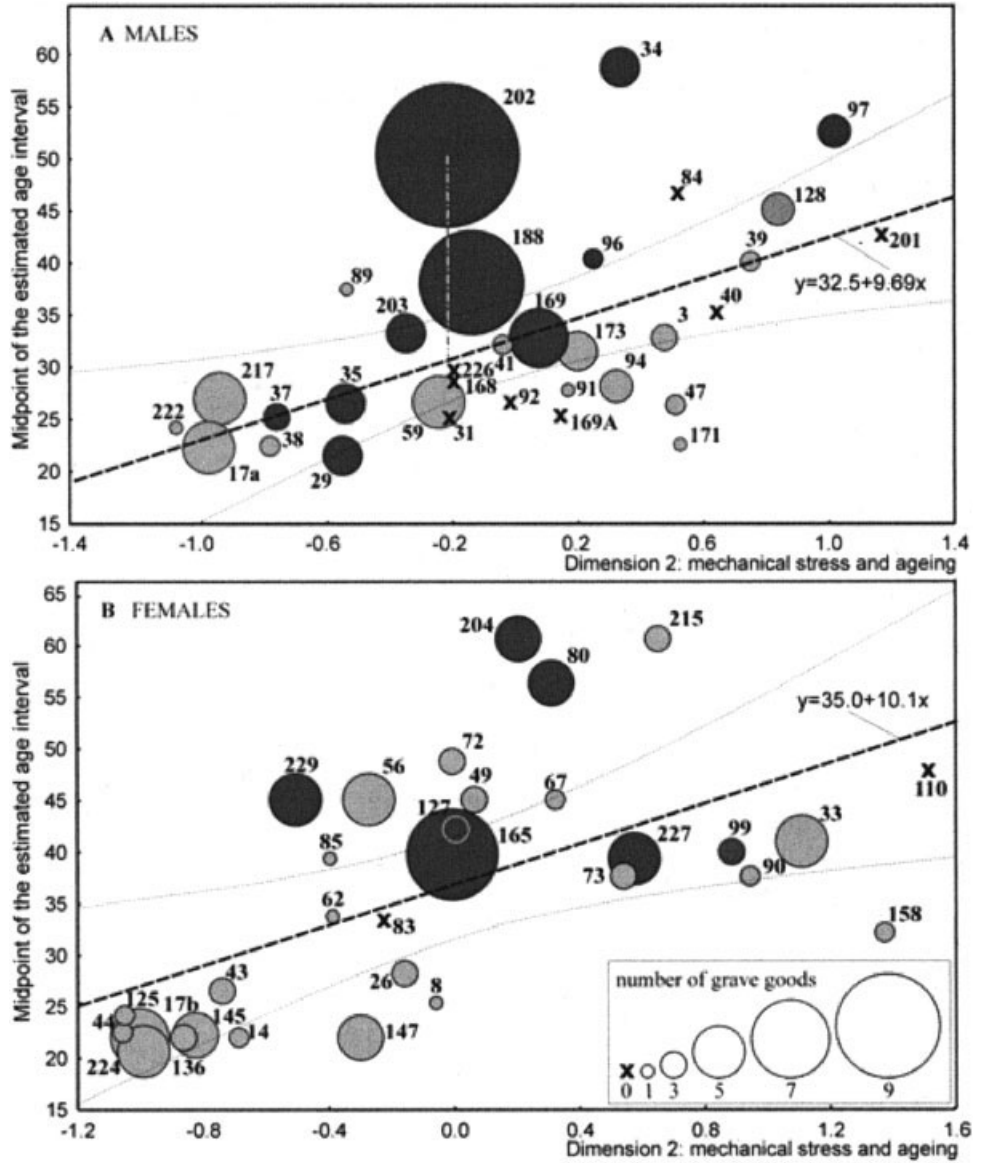


Fig. 8. Weights on second MDS dimension plotted against central tendency of estimated age interval for each skeleton. Diameters of circles are proportional to number of grave goods in respective interments. Dark shading marks burials containing rare and/or elaborate goods, including sculpted vessels and gilded or silvered metal objects. Lighter shading marks burials with no such objects.

assemblages that included at least one rare item. Burials with no grave goods are marked with an “x.” Seven of eight male burials lacking offerings are positioned below the regression line on the chart (Fig. 8A), as their estimated age is less than would be predicted by the advancement of degenerative processes seen on the skeletons. The principal individual (burial 202) is located considerably higher than the trend line. The distribution of other individuals relative to the same regression line appears more random. Two burials associated with rare objects are found below the regression line.

For females, age appears to have had an effect on the quality of offerings (Fig. 8B). The estimated age of all females from burials containing sculpted or decorated pottery, and/or gilded copper, was over 30, and their average age was significantly higher than the average age of females buried without rare goods ($F = 4.03, 1 \text{ df}, P = 0.028$). Very young females (e.g., from burials 44, 136, and 224) sometimes received multiple pots, but undecorated and of simple form. No such distinction by age

among burials with and without rare objects was found for males ($F = 1.38, 1 \text{ df}, P = 0.267, \text{ns}$).

Location and orientation of burials. First-dimension weights differed significantly among the defined burial groups for both male and female subsamples (Table 5). Although male and female skeletons were analyzed independently, the first-dimension weights of both sexes appear to reflect similar vectors of variation for health markers. Therefore, for illustrative purposes, they are plotted together on the map of the Villa El Salvador XII excavation area (Fig. 9). On this map, male burials are marked by triangles, and female burials by circles. The shading of triangles and squares corresponds to the MDS first-dimension weight: burials with positive first-dimension weights are in dark shading, and those with negative first-dimension weights are unshaded. Grey shading corresponds to weights approximating zero.

The distribution of first-dimension weights, and consequently of health markers on the map of the cemetery,

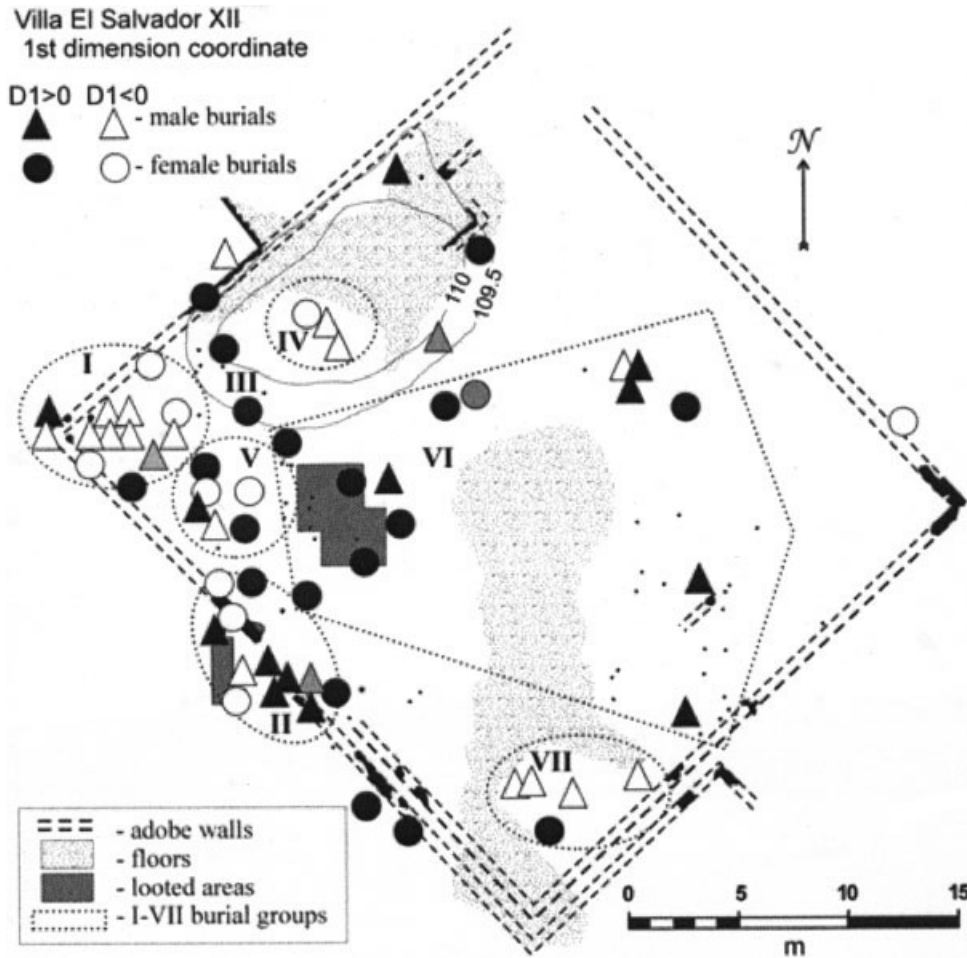


Fig. 9. First or “subadult health” dimension superimposed on topography of Villa El Salvador XII excavation area. Burials of male individuals are marked by triangles; burials of females, by circles. Dark shading corresponds to positive first-dimension weights. Grey shading corresponds to weights close to zero. No shading indicates negative first-dimension weights.

appears to be nonrandom (Fig. 9). All male burials from group VII and, with one exception, burials from group I, as well as all individuals in group IV at the top of the elevation, have negative first-dimension weights. Positive first-dimension weights prevail for burials from the central portion of the cemetery (group VI) and those associated with the elevation along the northwestern wall (group III). Groups II and V each include a mix of individuals with positive and negative first-dimension weights.

For males, some significant differences in first-dimension weight according to the orientation of the body were found (Table 5). Only three different orientations were recorded: west, southwest, and northwest, with the latter found for only two burials (43 and 17a). A western orientation was prevalent in group II, near the probable entrance to the cemetery through the southwestern wall. Most of the other interments were made facing southwest. These observed differences in body orientation may have been affected to some degree by locational circumstances within the defined space, such as the proximity of the walls or the entrance.

DISCUSSION

None of the presumed archaeological indicators of social status used in this study mapped perfectly onto the final configuration plot of skeletal health markers for the human remains recovered from the cemetery at Villa

El Salvador XII. Nevertheless, all showed significant correspondence with the integrated measures of health elicited through multivariate analysis. Consequently, the pattern of health heterogeneity revealed by MDS seems likely to have been related in some way to social differences among members of the community buried there.

The first dimension obtained in our analysis can be identified as reflecting differences in morbidity and stress during early childhood. This dimension is principally constructed from variation in the development of porotic hyperostosis and long bone length. Porotic lesions on the cranial vaults of precontact Native Americans are commonly interpreted as manifestations of red bone marrow hyperplasia in response to acquired anemia (Hill and Armelagos, 1990; Hill, 2001, p. 30), although scurvy, systemic infection, osteoporosis, and some other conditions may sometimes also result in similar lesions (Ortner et al., 1999; Ortner and Putschar, 1985; El-Najjar, 1979; Wapler et al., 2004). These lesions can develop only during the first few years of an individual's life, when the cranial bones still have sufficient plasticity to accommodate expanding marrow (Ortner and Putschar, 1985; Stuart-Macadam, 1987, 1992; Steckel et al., 2002; Blom et al., 2005; Hrdlička, 1914). Variation in long bone length, while partially owed to genetic differences among individuals, can be strongly affected by environmental stress throughout childhood and adolescence (Johnston et al., 1976; Malina et al., 1985; Larsen, 1995; Cohen and Armelagos, 1984). Continuous or periodic starvation

and chronic illness can result in growth arrest or abstraction, leading to a lower achieved adult stature.

A probable key to interpretation of the first dimension is that it is based on indicators of subadult health already demonstrated to differ considerably between populations from the contrasting environmental zones of coastal Peru and the adjacent Andean uplands. Body size and proportions of the residents of both modern and prehistoric Andean communities were found to differ systematically in accordance with altitude (Stinson and Frisancho, 1978; Greksa, 1986; Stinson, 1990; Weinstein, 2005). Hyperostotic lesions are reported as being significantly more frequent in a number of skeletal collections from the coast and lower valleys than on human remains recovered from sites at higher altitudes (Ubelaker and Newson, 2002; Blom et al., 2005; Hrdlička, 1914, p. 57). Heavy parasitic loads prevailing in coastal settlements, parasites contracted from fish and from water polluted by communities living upstream, and greater reliance on cultivated plant foods with a low iron content were found to result in frequent anemia among children growing up on the coast (Blom et al., 2005; Tung and Del Castillo, 2005). Intestinal parasites contracted from fish further exacerbate health problems among fishermen (Walker, 1986; Reinhard and Urban, 2003).

Consequently, the first dimension in our analysis likely reflects health differences between regionally determined natal groups, rather than variation defined by any localized hierarchy of power. Based on the pattern of health variation described for other prehistoric communities, we propose that Villa El Salvador XII skeletons with positive first-dimension weights are of local coastal people, tall in stature and evidencing a high frequency of porotic hyperostosis. Individuals with negative first-dimension weights, shorter in stature and exhibiting low frequencies of porotic hyperostosis and periosteal lesions, might have spent their early years in the upper Lurín Valley or adjacent highlands, where cleaner water was available, but their growth might have been impeded by periodic food scarcity. For individuals residing in places above 2,500 m above sea level, hypoxia is known to impede their longitudinal growth.

The patterned distribution of frontal-occipital cranial deformation along the first dimension supports an interpretation of this dimension as reflecting the presence of members of at least two geographically defined or ethnic groups among the burials at Villa El Salvador XII. In aboriginal South America, cranial deformation was a common ethnic marker. The lack of intentional modification, or contrasting deformation techniques, often typified geographically defined communities or cultural entities (Hrdlička, 1914; Tessmann, 1999 [1930], p. 441; Allison et al., 1981; Weiss, 1972; DeBoer, 1990; Hoshower et al., 1995; Torres-Rouff, 2002; Verano, 2003; Schijman, 2005). Considerable differences in the specific types of deformation practiced and the devices used to produce these results in particular areas allow the reconstruction of migration and colonization patterns, as well as the delineation of probable areas of influence (Hoshower et al., 1995; Blom et al., 1998; Torres-Rouff, 2002; Blom 2005).

The correspondence between age-adjusted second-dimension weights and various aspects of funerary offerings for males, but not for females, suggests certain differences in gender roles among the population buried at Villa El Salvador XII. Males of higher status, as marked by the number and quality of associated grave goods, appear to have enjoyed less strenuous work loads, as de-

generative processes of their skeletons progressed more slowly with age than for other males. On the other hand, females buried at Villa El Salvador XII appear to have achieved higher status only toward the end of their reproductive period, since only women older than 30 merited rare items to accompany their burials. A similar pattern of burial goods distribution was reported for Wari females (Tung and Cook, 2006).

One of the advantages of the method favored in this analysis is the possibility of visualizing differences among individual skeletons and not just between groups. At Villa El Salvador XII, only two male burials (T 202 and T 188) stood out as exceptionally rich. Although when considered separately they cannot comprise a statistically valid sample, they may be usefully compared with the other skeletons through multivariate analysis. The males from these two burials show weaker development of age-related degenerative processes on their skeletons than would be expected according to their estimated ages (Fig. 9). Males from burials with no offerings or with just a single associated item tend to show more evidence of strenuous labor and frequent postcranial traumas.

Social structure at Villa El Salvador: Broader implications

The social organization of many Andean communities during prehistory was likely a multilayered phenomenon, not limited to a simple vertical hierarchy of ascribed or achieved power, but also composed of more or less discrete occupational and ethnic/geographical entities (Hoshower et al., 1995; Bawden, 1995; Julien, 1993; Lozada Cerna, 1998). This "horizontal" stratification was particularly significant in the context of the prehistoric Andes, where communities were frequently defined by hierarchical integration of several geographically defined groups that each maintained their internal social integrity.

According to the ethnohistoric model of vertical integration in Murra (1968, 1970, 1972), Andean peoples attempted to control as many microenvironments as possible in order to compensate for generally scanty resources and the unequal productivity of different zones throughout the year. More recent ethnohistoric and ethnographic research suggests that vertical integration could take many forms, including transhumance, complementarity between two or more ethnic groups, *ayllu* (traditional small-scale Andean socio-political unit) organization, symbiotic relationships between farmers and fishermen or farmers and herders, and colonization (Brush, 1977; Murra, 1975, 1985; Orlov, 1977; Rostworowski, 1972, 1975, 1985). Complementarity among communities residing in different environmental zones or pursuing different modes of production is apparent in the archaeological record for some prehistoric Andean communities, although in ways often functionally different from those described in the ethnohistoric models (Aldenderfer, 1989, 1998; Marcus et al., 1999; Moseley, 1992; Moseley et al., 1991; Morris, 1985; Mujica, 1985; Van Buren, 1996; Buikstra et al., 2005).

The prevailing social structure of the first Early Intermediate period communities in the Lurín Valley is unclear (DeLeonardis and Lau, 2004). This epoch was marked by general population dispersal on the coast of Peru. Most of the pertinent archaeological sites in the area are relatively small and unagglutinated, presenting

little material evidence of social stratification, and little to indicate the development of regional hierarchies (Patterson, 1966; Earle, 1972). Elaborate artifacts are rare finds, and the overwhelming majority of pottery is undecorated. According to Makowski (2002), some degree of heterogeneity in the burial rituals observed at the Tablada de Lurín Necropolis suggests an emergence of new occupational groups and the rise of local elites. Delgado (1994) saw increasing gender differences and status distinctions as also apparent from qualitative analysis of the contemporaneous Villa El Salvador burials.

Interactions between coastal and inland communities from different altitudes throughout the extent of the Lurín Valley were inferred from analyses of pottery assemblages and settlement patterns (Paulsen, 1976; Dillehay, 1979; Patterson et al., 1982; Makowski, 2004). Based on pottery analysis, Patterson et al. (1982) proposed the existence of two distinct social formations in the Lurín Valley during the Early Intermediate period, which interacted by sending colonists into the intervening frontier areas. Intensification of long-distance exchange with communities of the north coast was proposed by Delgado (1994), as evidenced by the presence of imported gilded objects at Villa El Salvador. Design features shared between Miramar (*blanco sobre rojo*) pottery from the central coast and Chongos ceramics from the Cañete and Pisco Valleys also suggest sporadic contacts with the south coast (Patterson, 1966, p. 98–99). At Villa El Salvador, the presence of double-spout and bridge bottles and a vessel with an ornitomorphic appendage resembling those of the Paracas style implies contact with more southerly populations (Delgado, 1994). On the other hand, Makowski (2002) ascribed a central coastal origin to similar forms, on the basis of some typically local design features.

The analysis of human skeletal remains presented here suggests that social differentiation was sufficiently well-established to produce detectable patterned heterogeneity in health among the individuals buried at Villa El Salvador XII. At least two dimensions of societal organization are inferred from the results of multivariate analysis of those burials: one corresponding to group affiliation as marked by cranial deformation, and the other to status hierarchy as reflected in the relative wealth of associated funerary offerings. The former is evident predominantly in those health markers that develop early in the life of an individual. The latter is reflected in skeletal markers related mainly to activity patterns during adulthood and to aging.

Based on our analysis, a form of organization resembling systems described in the ethnohistoric accounts (Murra, 1985; Rostworowski, 1993) can be postulated. Of the individuals buried at Villa El Salvador XII, some appear to have grown up in the local coastal environment, and others were probably travelers or colonists from regions at higher elevations. At one level, the two groups seem to have been perceived as part of an integrated whole, with their members buried in the same cemetery, often side by side (Fig. 9, groups II and V). However, we cannot reconstruct the details of this unity or its underlying rationale.

Overall, an apparent hierarchy of wealth was well-defined for males, but was not detected for females by our method. Among females, status seems to have been achieved principally through longevity, because only older females merited the inclusion of elaborate artifacts in their burials, although only a few older women

received this preferential treatment. While a foreign origin of the gilded copper and some of the sculpted pottery found in the cemetery was proposed (Delgado, 1994), such objects seem to be randomly distributed between the two geographically defined groups buried at Villa El Salvador XII, unlike in the Osmore drainage, where a clear correspondence between type of cranial deformation and style of associated material offerings was observed (Lozada Cerna, 1998; Buikstra et al., 2005).

Multivariate analysis allowed visualization of the dynamic nature of the social structures affecting the health of community members at different ages. Considerable variation in the total pattern of health markers persisted within each inferred group. This is probably because the degree of stratification represented at Villa El Salvador XII was limited; all members of the community were exposed to the same pathogens and suffered the effects of environmental perturbation. However, the gradients of skeletal indicators as expressions of physiologically unrelated health conditions suggest that social factors affected multiple aspects of health.

CONCLUSIONS

Multivariate analysis of skeletal health markers for the Villa El Salvador XII collection demonstrates the covariance of stress indicators on human skeletons with recognized, culturally salient symbols of social status and ethnicity (e.g., Buikstra et al., 2005; Lozada Cerna, 1998; Blom, 2005; Tung and Del Castillo, 2005), the most relevant of which seem to be artificial cranial modification and the number and types of funerary offerings. Using multivariate analysis of health markers as a starting point for examining possible relationships between social status and health in a prehistoric community has several advantages. Integrated indicators elicited via such analysis are highly sensitive in recognizing patterned heterogeneity in a sample, as they are based on commonalities in the variation of multiple health markers. This approach also avoids initial assignment of rigid social boundaries based on subjectively interpreted archaeological criteria. Instead, the relevance of each possible social indicator is independently tested, based on its correspondence to health heterogeneity.

This analysis of a skeletal series from Villa El Salvador XII allows us to tentatively diagnose certain aspects of community structure in the lower Lurín Valley during the Early Intermediate period. The patterned distribution of stress markers related to subadult health suggests the presence of two geographically defined groups in the cemetery. During childhood, members of these groups were subjected to different levels of pathogens and experienced disparities in nutrition and diet that resulted in considerable differences in their achieved adult stature and the frequency of anemia indicators. Members of one group were apparently marked by cranial deformation. Differences in the onset of DJD and the incidence of postcranial traumas, along with the correspondence of these factors with burial wealth for males, suggest a hierarchy of wealth affecting the distribution of labor effort within the community. This hierarchy is not as clearly evident for females, implying gender role differences.

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