Human Ecological Transitions in Ancient Sicily Analyzed by Bone Stress Markers

A.D. Messina¹, R. Miccichè¹, G. Carotenuto¹, L. Sineo¹

¹Laboratorio di Antropologia, Dipartimento di "Biologia ambientale e Biodiversità" Via Archirafi 18, 90123 Palermo.
E-mail: andreamess@gmail.com

KEY WORDS: status of health, palaeoecological transition, Sicily.

Introduction

Many heterogeneous variables influence humans adaptation to different ecologies and their fitness (Johnson and Earle, 1987; Levine, 1998). Abel and Step (2003) regard the study of human ecology as a very important way to gain further understanding even on our ancient cultural adaptation to different environments, and prehistorical and archaeological contests can provide very important information. The progressive transition from hunting to farming in different geographical areas, played a major role in the cultural evolution of humankind and in the development of human chronic and infectious diseases. For example, several metabolic issues arose with plant and animal domestication, as a consequence of genomic inadequacy of first farmers to effort a new subsistence ecology. Moreover, diet and food resources at the Neolithic transition, with the reduction of protein and carbohydrates has led to increased spread of some diseases like iron deficiency anaemia (Cameron, 1999), and osteoarthritis, presumably favored by agricultural work and anti-hygienic settlement. Different and new diseases developed from animal source once the humans established continuous contacts with the domesticated animals (Larsen, 2006). Furthermore, historical period nearly always signified a progress toward social complexity. This complexity usually meant increasingly sophisticated strategies for the control and the exploitation of the environment. Societies stated to be structured to achieve a greater food production, and the management of technological innovation, with consequent social stratification in urban aggregates (Armelagos, 2009). Roles in society changed with the need for greater specialization, particularly military roles (Dandecker, 1994). With the development of civilization, the birth and survival rates of infant increased for many well-fed civilization with each advancing century (Armelagos and Harper 2010). Anthropology and palaeoanthropology analysis are elective tools for the palaeoecological reconstruction and for the study of ancient human life history and lifestyles in populations from different periods. Skeletal markers of health have been the subject of research for a long time (Aufderheide and Rodriguez-Martín, 1998). The study of skeletal stress patterns is a means of investigating both the social and environmental factors affecting the economic choices of ancient population (Smith, 2001). Some studies use stress markers in bones (Roberts and Lewis, 2002; Sládek et al., 2007, Slaus, 2008) and teeth (Vodanovic et al., 2005; Temple and Larsen, 2007; Ireu et al., 2008) to indicate whether observed changes over time are the result of an improvement or decline in living condition. Such studies are frequently ineffective to discern whether the documented changes in a population are caused by events like mutation, natural selection, demic movements, evolutionary trends, or adaption due to environmental factor, because a specific difficulty, given the complexity of biological systems, related to the variety and multiplicity of factors that compose them.

A number of studies have addressed, with different results, the articulated transitions between different subsistence economies, and the potential effects they had on population biology. Slaus (2011) noted as the general trend of deteriorating health with the transition to the Early Medieval period in Dalmatia was observed when cribra orbitalia, linear enamel hypoplasia, non-specific periostitis and trauma frequencies were analyzed. It would appear that the political, social, economic and religious changes that characterized the Late Antiquity/Early Medieval transition in Dalmatia resulted in a clear discontinuity, not only from the cultural, but also from the biological point of view with an evident deterioration of oral health during the Early Medieval period. The comparative analysis of dento-alveolar lesions in the Tyrrenian region of central Italy from two Roman Imperial samples (1st–3rd centuries AD), to a Lombard Early Medieval sample (7th century AD) showed a significant increase of caries, alveolar abscesses and ante mortem tooth loss in the Lombard sample, suggesting a deterioration of living conditions towards Middle Age (Manzi et al., 1999). A data in partial contrast with another research conducted in Italy (Belcastro et al., 2007), that indicated substantial continuity of dietary habits and no ecological crisis in the analyses of dento-alveolar pathologies, cribra orbitalia and periostitis frequencies, in a similarly distributed sample (a Late Antiquite, 1st–4th centuries AD, and an Early Medieval, 7th century AD) in Molise region. The importance of skeleton markers and dental diseases must be carefully evaluated in the light of sample representative ness and punctual situations.
In the archaeological landscape of central Mediterranean a very important site for the study of recurring cultural transitions is Sicily island. Due to its geographical position in the Mediterranean basin, its vicinity to African northern coast, and to continental Europe, since the last Würm glaciation, Sicily had a very articulated continental ecology that repeatedly challenged human settlers. Furthermore the island early become the objective of consecutive migrations since the late Epigravettian times (D’Amore et al., 2009).

In this study we started from the initial consideration that ecological changes of ancient populations of Sicily, chronologically subdivided in Prehistoric, Protohistoric, and Historical groups, can supply a lot of information on the biology of ancient populations, their ecology and their paleodemography. Specifically, the aim of this report is to test the hypothesis that ecological parameters (environmental and cultural) influence the survival rates of individuals and the quality of life in terms of expectancy of survival, impairing diseases and fitness.

The tools for this investigation are the frequencies of arthritis (Weiss and Jurmain, 2007) periostitis (Auverheide and Rodríguez-Martín, 1998) and cribra orbitalia (Stuart-Macadam, 1991) that are considered important markers of health in skeleton biology, together with traumatic events, that can be interpreted in the light of palaeoecological reconstruction if presumably related to social stress or inter-population competition.

Materials and Methods

The sample has been investigated on the base of demographic and palaeopathological parameters. A total of 207 complete skeletons were examined in this study (Tab. 1).

<table>
<thead>
<tr>
<th>Group</th>
<th>Site/Necropolis</th>
<th>Dating</th>
<th>Num individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehistoric</td>
<td>Grotta dell’Uzzo (TP)</td>
<td>Mesolithic (9800-9460 BP)</td>
<td>12</td>
</tr>
<tr>
<td>Prehistoric</td>
<td>Grotta D’oriente (TP)</td>
<td>Mesolithic (8740-8390 BP)</td>
<td>3</td>
</tr>
<tr>
<td>Prehistoric</td>
<td>Grotta Molara (PA)</td>
<td>Mesolithic (8600±100 BP)</td>
<td>2</td>
</tr>
<tr>
<td>Protohistoric</td>
<td>Stretto Partanna (TP)</td>
<td>Early Bronze Age (1600±1400)</td>
<td>40</td>
</tr>
<tr>
<td>Protohistoric</td>
<td>Marcia (TP)</td>
<td>Middel Bronze Age (1500±1300)</td>
<td>40</td>
</tr>
<tr>
<td>Protohistoric</td>
<td>Polizzello (CL)</td>
<td>Iron Age (900-734 BC)</td>
<td>44</td>
</tr>
<tr>
<td>Historic</td>
<td>Caserma Tukory (PA)</td>
<td>Punic period (264-241 BC)</td>
<td>22</td>
</tr>
<tr>
<td>Historic</td>
<td>San Giovanni (TP)</td>
<td>Byzantine period (535-827 AD)</td>
<td>22</td>
</tr>
<tr>
<td>Historic</td>
<td>Monte Iato (PA)</td>
<td>Arab period (827/902 AD)</td>
<td>22</td>
</tr>
</tbody>
</table>

Tab. 1. Brief information about investigated population.

The estimated age was based on the degree of dental wear (Miles, 1963; Lovejoy, 1985), pubic symphysisal surface (Katz & Suchey 1986), the ilium auricular surface (Buckberry and Chamberlain, 2002); the epiphyseal union of long bones (Kroghman and Iscan, 1986), dental development (Ubelaker, 1989). In according to (Bulikstra and Ubelaker, 1994) we considered seven age classes: fetus (before birth), infant (0-3 years), child (3-12 years), adolescent (12-20 years), young adult (20-35 years), middle adult (35-50 years), old adult (50+ years). Cribra orbitalia were detected macroscopically in individuals with at least one orbital roof preserved. The degree of severity was scored according to the Stuart-Macadam (1982; 1991) scale. Periostitis was scored as absent or present when new superficial bone and fine striae were observable on the femur and tibia. In particular, we only scored the complete bone, although some small fragments and the proximal and distal ends may have been absent. Side and bilateral presence and, for the tibia, medial and/or lateral position were recorded. Bones with clear signs of fracture associated with periostitis were excluded (Auverheide and Rodríguez-Martín, 1998). Trauma were recorded following the indications of (Lowell, 1997). A fracture consists of an incomplete or complete break in the continuity of a bone. The most common types of fractures, such as transverse, spiral, oblique, and crush fractures, result from direct or indirect trauma. Each bone in respectively skeleton was carefully examined in according to Weiss and Jurmain (2007) to detect the presence of arthritis.

Palaeodemographic research has been intensely criticized for the past two decades, (Bocquet-Appel and Masset, 1982). Many of these criticisms focused on the inherent problems of a skeletal sample such as sampling bias, errors in estimating age at death, and hidden heterogeneity (Jacks, 1992). Abridged life tables were calculated using modern palaeodemographic methods (Alsan et al., 1999; Abbé, 2008).

The statistical analysis of health indicators in the sample was performed in according to Cox and Mays (2006). Fisher’s nonparametric test has been carried out (Madrigal, 1998). The use of this test is requested, in order to verify the presence of statistically significant difference between age classes, in relation to diseases, by the non-homogeneous consistency of the sample.

Results

In the Abridged life tables (Alsan et al., 1999) shows only two parameters Life expectancy (e⁻x, average number of years lived after exact age x, years) and Death (dx, fraction of population in age class x) (Tab. 2). The life expectancy, at birth, for the Prehistoric group, is of 26.6 years, with a cumulative percentage of mortality, within 12, of the 16.66%. Life expectancy at birth for Protohistoric group is 44, with 40.2% a cumulative percentage of mortality within 12
years. However, after this period in Historic group the life expectancy at birth is 29.4 with a cumulative percentage of mortality within 12, of age of the 21.9%.

<table>
<thead>
<tr>
<th>Age interval</th>
<th>Prehistoric (dx)</th>
<th>Protohistoric (dx)</th>
<th>Historic (dx)</th>
<th>Prehistoric (e(x))</th>
<th>Protohistoric (e(x))</th>
<th>Historic (e(x))</th>
</tr>
</thead>
<tbody>
<tr>
<td>infants (0-3)</td>
<td>11,111,111,111</td>
<td>22,106,908,888</td>
<td>13,863,216,27</td>
<td>26,652,777,778</td>
<td>43,989,632,79</td>
<td>29,421,187,922</td>
</tr>
<tr>
<td>child (4-12)</td>
<td>5,555,555,556</td>
<td>12,130,177,511</td>
<td>8,130,868,767</td>
<td>9,703,703,704</td>
<td>33,620,324,83</td>
<td>21,522,689,25</td>
</tr>
<tr>
<td>adolescent (13-20)</td>
<td>4,444,444,444</td>
<td>4,733,727,811</td>
<td>7,948,243,983</td>
<td>9,358,974,359</td>
<td>21,118,572,39</td>
<td>11,663,874,5</td>
</tr>
<tr>
<td>young adult (21-35)</td>
<td>3,333,322,222</td>
<td>11,538,615,4</td>
<td>57,301,239,39</td>
<td>6,389,530,33</td>
<td>13,436,430,96</td>
<td>8,426,290,552</td>
</tr>
</tbody>
</table>

Tab. 2. Abridged life table combined for both sexes Dx, absolute number of individuals dead at age x; e\(x\), number of years a person can expect to live beyond age x. (Abbé, 2006).

In the recognized frequencies of skeletal markers of health under examination for Protohistoric group, there is a significant difference for trauma (p-value of 0.0004), for arthritis (p-value 0.00003), for periostitis (p-value of 0.0415), and for cribra orbitalia (p-value 0.0012). Among classes of age in the Historic group there is a significant difference for trauma (p-value of 0.0011), for arthritis (p-value of 0.018), for cribra orbitalia (p-value 0.0012). No significant differences were observed between Prehistoric subadult and adult (Tab. 3).

**Discussion**

Paleodemographic and palaeopathological analysis of archeological populations provide direct evidence of life expectancy and mortality (Buikstra and Cook, 1980). In fact, cultural and economic transitions affect human life history in different ways, and life expectancy is deeply modified by ecological parameters like food availability and quality, infective diseases, antagonistic behaviors, and by more culturally mediated causes like wars, slavery, and deportation. The effects of these factors, that can leave a

<table>
<thead>
<tr>
<th>Adult</th>
<th>Sub Adult</th>
<th>Adult</th>
<th>Sub Adult</th>
<th>Adult</th>
<th>Sub Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehistoric</td>
<td>Prehistoric</td>
<td>P</td>
<td>Prehistoric</td>
<td>Prehistoric</td>
<td>P</td>
</tr>
<tr>
<td>N</td>
<td>n</td>
<td>%</td>
<td>N</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Trauma</td>
<td>15</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Arthritis</td>
<td>15</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Periostitis</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Cribra Orbitalia</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Tab. 3. Result of fisher test for arthritis, periositis, cribra orbitalia and trauma in the total sample.

![Graph 1. Percentage of the skeletal markers of health in the total sample.](image)
significant sign on the skeleton, are suitably tooled for the explanation of healthy status of ancient population. This study analyzes biological and demographic parameters in the very stimulating horizon of ancient Sicily, taking in consideration two main ecological transitions from Mesolithic period to the historical rise of early colonization (6800 BP - 902 AD), by relating four skeletal markers of health: arthritis, periosis and cribrum orbitale together with (generalized) trauma. In the graph 1 we illustrate the result in percentage of the pathological analysis.

The transition between the Prehistoric and Protohistoric times consists of a progressive transition from hunting and gathering to a more stationary ecology, based on agriculture and domestication. In this crucial transition we observe a considerable increase of life expectancy at birth, approximately of 60,6%, in the Protohistoric group; and mortality within the first twelve years greatly increases until 40,2%. This evidence of dramatic change in the demographic mechanisms, with an inexorable modification in patterns of population evolution (from small numbers of selectively resistant individuals to large numbers directionally selected) is accompanied by a high percentage of cribrum orbitale and periosis (respectively 0-63,7% and 0-87,9%). This stress markers accumulation could be caused both by poor hygienic conditions and by cohabitation with animals, otherwise associated to metabolic disorders caused by dietary changes. Ecological changes increase the potential for disease load as a consequence of the shift to primary food production. Sedentary lifestyle increases parasitic disease infection by increasing contact with human waste (Barnes, 2007). If semi-sedentarism did occur prior to Neolithic period in those areas with abundant resources such as marine products, the shift to agriculture necessitated a strict sedentary living or a seasonality in occupation of a site (Herrschner and Le Bras-Goude, 2010). The switch to the historical period offer to the analysis the decrease of the 45,6% of the mortality in the first 12 years of life, as like the decrease of cribrum orbitale and periosis; but a significant decrease of approximately the 32% of the life expectancy at birth. Such result can be related to other markers that has been pictured in this study: the high rate of traumatic injuries, and arthritis recorded in the Historic groups compared to the Protohistoric group (respectively 13,6-4,8% and 63,6-16,9%). Well documented (Finley, 2009; Roberts and Manchester, 1995; Holloway, 1991) violent population change took place when foreign settlers started their colonization of the island and with roman expansion in the Mediterranean Basin. The Greek-Punic wars (600 to 265 BC), and the first Punic war (B.C. 264-241) (Finley, 2009) have influenced the environmental and sociocultural contexts of indigenous populations increasing human forced delocalization and famine but resulting also in the increase in traumatic evidences. Also, arthritis increased in frequency, indicating increased exposure of populations to debilitating activities.

In according to the demographic data and the indicators examined, the general health status of the population during important transition show a worsening in life-condition (Bogatenkov, 2002). This is probably attributable to a combination of effects due to general environmental degradation, more centralized and isolated settlements, and disintegration of the social and political situation. Capasso and colleagues (2003) claim that high rates of immigration through the Mediterranean have begun to produce changes in the biological characteristics of the Italian population, especially with respect to demographics and disease. The collected data of Manzi (Manzi et al., 1999) suggest that the political, social and economic changes that characterized the Medieval transition in Central Italy population resulted in a deterioration of health status.

Our study analyzes variation of demographics parameters of the ancient Sicilian population across two transition. The first transition between the prehistory and protohistory, where the ecological factor that has played an important role in cultural innovation is the agriculture and domestication, we found high percentages of cribrum orbitale and periosis. The vast majority of researches agree that cribrum orbitale found in archaeological sample is the result of an acquired iron deficiency anaemia (Mensforth et al., 1978; Stuart-Macadam, 1992). Anaemia is also associated with increased pre and postnatal infant mortality (Orbetova and Thurzo, 2008). Periosis is a non-specific inflammation of bone (Steinbock, 1976) more commonly seen in settled communities prating agriculture (Resnick, 2002).

In the second transition between the protohistory and history, Sicily has played host to a continuous series of massive migrations and ethnic wars because of its central position in the Mediterranean. In the Early history of ancient Sicily (264-241 BC) frequent episodes of interpersonal aggression may be the norm (Finley, 2009). Frequently the most dramatic injuries are to the skull as, certainly in interpersonal/intergroup violence, the head if often the main target for blows (Ardill and Gidado, 2003). Arthritis are the most common degenerative diseases affect skeleton (Weiss and Jurmain, 2007). These alterations are generally related to mechanical stress, and tend to increase with age, with serious social and economic consequences (Rogers et al., 2004).

Conclusion

This study examines the palaeodemographic changes between three periods: Prehistoric, Protohistoric and Historic, and their possible interpretation through the frequency of detected skeletal markers of health. The results of our study indicate that there was substantial discontinuity of life conditions between three groups considered, indications that can be added to the previous knowledge of an important phases of socioeconomic and cultural transitions. Among the skeletal series, representative of groups employing different subsistence strategies and responsible of the populating the area of West Sicily, worst biological status was characteristic of the settled populations with agricultural occupation. Periodical nutritional deficit and possible spread of infection in their dense settlement made their living condition more demanding. The process of cultural hybridization resulting
from colonial expansion affect the health and well-being of provincial populations.

References


