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DEPARTMENT OF ANTHROPOLOGY

AN EXAMINATION OF CHILDREN’S WELLBEING IN THE LATE NEOLITHIC AND BRONZE AGE OF EASTERN SPAIN

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ABSTRACT

This study examines the wellbeing of children in changing social contexts by analyzing human remains from archaeological sites in eastern Spain (Valencia and Alicante) dating to the Late Neolithic and Bronze Age (3,800 - 1,500 BC). During this period, farming societies were undergoing tremendous economic and social changes with the emergence of social complexity in the region. Through a combination of literature review, basic osteological analysis, and dietary reconstruction using stable isotope analyses, I assessed the wellbeing of children in the past. Cova de la Pastora is one of the best researched and documented burial caves in the Alicante region, but there were no AMS radiocarbon dates or isotopic data on the children interred at this location. For this reason, I used Cova de la Pastora as the case study to focus my analyses to then compare to other caves in the Alicante region. Based on the new AMS radiocarbon dates generated in this study, adults (males and females) and children were interred at this location throughout the Late Neolithic and into the Bronze Age. In addition, the $^{13}$C and $^{15}$N results of children and domestic animals indicate that children and adults had very similar diets throughout this period. This is also supported by the available information on bone pathologies due to illnesses or dietary deficiencies that indicate no difference between age or sex. This data suggests there was not a preference towards one sex or age group when burying individuals Cova de la Pastora. Furthermore, the relative wellbeing of children remained constant within the context of increasing social complexity and economic change at Cova de la Pastora. Comparison with other sites in the region indicate that the majority of the children did not have evidence of skeletal pathologies and all 12 children dated within the Late Neolithic to the Bronze Age.
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Chapter 1

Introduction

The Neolithic to the Bronze Age (5,600 - 1,300 BC) in eastern Spain was a time when farming societies were undergoing tremendous economic and social changes with the emergence of social complexity in the region. The objective of this thesis is to examine the wellbeing of children by characterizing their diets and evidence for overall health in these changing social contexts by analyzing human remains from archaeological sites in eastern Spain (Valencia and Alicante). Through a combination of literature review, AMS radiocarbon dating, and dietary reconstruction using stable isotope analysis, I was able to assess the health of children to compare to the adults from the burial site of Cova de la Pastora. I chose Cova de la Pastora as my case study because it is one of the best researched and documented burial caves dating from the Late Neolithic to the Bronze Age in the Alicante region (Figure 1). However, there were no AMS radiocarbon dates or isotopic data for the children conducted so far. For this reason, I wanted to focus my analyses on understanding the children’s diet, learning how they compared to the adults buried at Cova de la Pastora, then to see if there were other similarities to other burial caves in the Alicante region.

Figure 1. Map of the eastern region of Spain, highlighting Cova de la Pastora and surrounding sites in the Alicante and Valencia region (McClure, et al., 2010a).
My goals were to collect published data on the presence or absence of children in burial sites throughout the time period and conduct stable isotope analysis on a selection of samples from Cova de la Pastora to characterize prehistoric diets among children and possible changes through time. Stable isotope analysis (carbon and nitrogen) provided a measure of plant and animal protein in the diet. The AMS radiocarbon dates were necessary to increase the chronological control in order to understand when the children were buried at Cova de la Pastora since previous studies showed continued use of the site over a 1,500-year period.

One outcome of this project was the creation of a dataset focused on children that could be compared to other studies. The dataset can be used to observe trends of change or continuity in the diet of the children over a given time period with social and economic revolutions. The trends can be applied to other studies or situations when social and economic revolutions are occurring. This dataset would be applicable for studying chronology and isotopic analyses in the Iberian Peninsula or other parts of Europe. A third application would be to share data for comparison of the amount of animal and plant protein consumed by both children and adults in comparison to fauna remains (sheep/goats).

The number of children in the archaeological record is very small and as a result there have been few studies over time that focus explicitly on children’s remains (e.g., Romero, 2004; Waterman & Thomas, 2011). This is caused by several factors, such as children’s remains not preserving well, possibly due to shallow graves or having high soil acidity. Another explanation could be that it was more common for increased longevity in contrast to dying at a younger age of a child (in a given time period). Studying the children’s remains from Cova de la Pastora provides new information about the time periods in which they were being interred as well as the amount of animal and plant protein they consumed that was not known previously.
In the broader context, this thesis presents a comparative study for other research on children including the diet of the Iberian Peninsula during the Late Neolithic to the Bronze Age, using current AMS radiocarbon dating and isotopic methods. This is useful for subsistence studies and understanding the health of children in relation to their status in social contexts. Children are the most vulnerable people in societies and changes in health or mortality provide insights into the nature of social or economic shifts. For instance, changes in diet may indicate differential access to food resources due to social stratification in the population. Children are necessary to study to understand the population as a whole, rather than just the roles and health of the adults.
Chapter 2
Background

Over the past century there has been a large amount of research dealing with cave sites in the Alicante region of southeastern Spain (Diaz-Zorita, et al., 2012; Pérez Fernández & Solar Mayor, 2010; Soler Díaz, 2002). Many of the prehistoric cave sites that have been excavated examined a variety of aspects of life, including burial practices, socioeconomic levels, diets, and grave goods (Soler Díaz, 2002). There are 48 sites with child burials from the Neolithic to the Bronze Age in the Alicante region, including Cova de la Pastora (this case study), Cova de Sant Martí, Cova de la Sarsa, Cova de la Barcella, and Cova d’En Pardo (Soler Díaz, 2002). These sites show different durations of use as burial caves, spanning about 4,000 years. In the following, I present the variety of burial practices from the Neolithic to the Bronze Age, dietary reconstructions, and discuss the challenges of working with children’s remains.

Burials

The Neolithic is characterized by agro-pastoral people with sedentary lifestyles, subsisting mostly of farming and herding. In the Neolithic (5,600 – 3,000 BC), burials are most commonly found in natural caves (like at Cova de la Pastora) and open air sites, in which graves were dug into the underlying subsoil (Diaz-Zorita, et al., 2012). Grave goods included items that would have been in use in daily life such as ceramic pots, stone tools, beads and pendants made from stone or shell, and stone arrowheads (Diaz-Zorita, et al., 2012).

During the Chalcolithic (3,000 – 2,500 BC), a new form of burial practice is introduced throughout many parts of Europe, including sites in southeastern Spain (Diaz-Zorita, et al.,
Megalithic tombs with above surface architectural features constructed with large stones, appear at sites like Alberite (Cadiz province), Tremedal (Caceres province), and El Palomar (Sevilla province), and grave goods included items like metal artifacts and figure “idols” (Diaz-Zorita, et al., 2012).

A majority of the interments from the Bronze Age (2,200 – 1,500 BC) in the Valencia region were single and double inhumations (Pérez Fernández & Soler Mayor , 2010). Caves were continued to be used for these interments during this time period (Pérez Fernández & Soler Mayor , 2010). The AMS dates of the adults from Cova de la Pastora support the trend of reuse of the site as a burial cave throughout a 2,000-year time period (McClure, et al., 2010).a.

Dietary Reconstructions

Several studies have examined the diets of people living during the Neolithic through Bronze Age using stable isotope analysis (e.g., McClure, et al., 2010b; Soler Díaz, 2002; Pérez Fernández & Solar Mayor, 2010). Stable isotopes are used to assess the amount of carbon and nitrogen isotopes in the bone collagen of individuals. Carbon isotopes record the plant protein in a diet and nitrogen isotopes record the animal protein. Bone collagen needs to be extracted following the methods discussed in chapter 4.

Levels of δ¹³C indicate the amount and type of plant protein consumed by the individual and which type of plant (C3 – e.g., wheat, potatoes or C4 – e.g., corn, millet) was consumed. Similarly, nitrogen isotopes offer insights into the amount of animal protein in the diet, providing information on the trophic level of the individual (Hedges & Reynard, 2007). This idea refers to the “trophic level effect” in which there is a precise and continual enrichment of ¹⁵N and ¹³C
when individuals consume protein from animals and plants (Hedges & Reynard, 2007). For this study, I generated stable isotope data on several children and local herbivores to compare to existing data on adults in order to reconstruct past diets.

When humans consume animal protein, their $^{15}$N levels are typically enriched by 3 – 5‰, assuming the individual has a diet comprised of 60 – 80% animal protein (Hedges & Reynard, 2007). In order to understand the amount of protein consumed from plants, we use the herbivore diet as a proxy for local vegetation (Hedges & Reynard, 2007). On average, there is a 1‰ enrichment in humans when consuming plants for the $^{13}$C value compared to herbivores. One factor to consider is that younger mammals may have higher $^{15}$N results due to nursing, caused by the increase in intake of nitrogen from the breast milk (Hedges & Reynard, 2007).

Another method to estimate diet is to examine the bones for pathological diseases that leave markers on the skeleton. During the Chalcolithic, there is evidence of children having diseases relating to their diets, including cribrum orbitalia, enamel hypoplasia, and dental calculus (Diaz-Zorita, et al., 2012; McClure, et al., 2010b). Cribrum orbitalia are porosities on the orbits of human skulls, most likely caused by megaloblastic anemia, which is associated with $B_{12}$ deficiencies (Walker, et al., 2009). Enamel hypoplasia is a type of tooth pathology that is expressed as pitting in the enamel and furrowed enamel layers (Hillson & Bond, 1997). Dental calculus is more commonly known as dental plaque that is left on teeth if not properly taken care of (White, 1997). These diseases tend to occur when there is a dietary stress or the dental development was interrupted (Diaz-Zorita, et al., 2012).
Other pathologies that effect the wellbeing of remains include trepanations, cranial lesions, and traumatic injuries. Trepanations are carved circular holes found on the cranial vault, most likely to prevent swelling of the brain (Figure 2). Cranial lesions are traumas located specifically on the cranium (e.g. wound, disease, tumor). Traumatic injuries could be any form of a wound occurring on the skeleton (e.g. cut, break).

**Challenges of studying remains of children**

Studying the remains of children may entail several complicating factors. The children that were documented in studies, including in the Alicante region, had most likely died due to sickness and disease, based on the pathologies noted on the remains (Pérez Fernández & Soler Mayor, 2010). At Coveta Emparetà (Valencia) there is evidence of porotic hyperostosis (leaving similar lesions to cribra orbitalia on the orbital vault) on an individual 4 - 6 years old, suggesting the individual underwent phases of malnutrition (Pérez Fernández & Soler Mayor, 2010). We have to consider having a biased sample when looking at these children, causing this osteological paradox (Wood, et al., 1992). Of all the children that were alive during our time period, several died at a young age while the others continued to grow and live into adulthood. The children that passed away are the ones used in this analysis. We have to consider that these children passed away at this younger age due to illnesses or malnutrition, affecting their overall health. In this case, the number of children recorded having these pathologies is higher than reality. For
instance, if there were 20 children living in a population and five die young, then 15 live into adulthood. Of the five children that died, if only four were caused by illnesses then probability of children dying from the pathologies would be 80% (4 of 5 children). However, in reality the prevalence of illness among children is only 20% (4 of 20 children). This issue of differential mortality has been a point of debate for over 20 years (Wood, et al., 1992).

Another factor to consider is the possibility of preservation differences among the pathology-affected children and those unaffected. The children unaffected by the pathologies could have higher bone densities than the affected children, making bone preservation more favorable. External factors such as soil acidity or how deep the children were interred could influence the preservation of the remains as well. Furthermore, not all causes of death leave markers on the bones, allowing for other options for cause of death, undetectable to researchers today (Pérez Fernández & Soler Mayor, 2010). Some of the information that researchers can learn from children’s remains includes sex, age, signs of physical labor, physical characteristics, and illness based on the variety of stress that can leave markers on the bones (Pérez Fernández & Soler Mayor, 2010). Even though one can learn about an individual’s life from these markers, there may not be enough of the skeleton remaining to collect this information.

Most of the infant and children crania dated so far for the Alicante region date to the Chalcolithic and Bronze Age periods (Pérez Fernández & Soler Mayor, 2010). Factors that could potentially influence the number of remains discovered during each time period include the burial techniques or soil acidity in that given time. There were several methods to estimate the ages of the children including the stages of epiphyseal fusion of the clavicle (completely fused around 27 – 30 years old), epiphyseal fusion of long bones (metacarpals, femur, humerus, etc.), and the eruption of teeth (Pérez Fernández & Soler Mayor, 2010).
Chapter 3

Cova de la Pastora

In 1940, Cova de la Pastora was excavated by Pascual Vincent and he unearthed 46 crania and many grave goods associated with the remains (García, et al., 2012; Pérez Fernández & Solar Mayor, 2010). He was an untrained archaeologist at the time, but kept a diary documenting his finds. For each burial he encountered, Pascual also recorded three coordinates (X, Y, depth) to document the position of the crania and other material goods (García, et al., 2012). Pascual mentions that the material came from four main cultural levels: Late Neolithic, Chalcolithic, Bronze Age, and Iron/Roman period, but he thought the burials dated to the Late Neolithic (García, et al., 2012). Excavations continued in 1945 and 1950 by José Alcacer, who found six more crania and artifacts (García, et al., 2012).

Cova de la Pastora was excavated again in 2008 by Dr. Sarah McClure and Dr. Oreto García with the goal of obtaining new data to understand the sequence of the cave by using old excavation reports, diaries, and assemblages (García, et al., 2012). When they screened the back dirt piles, they discovered even more artifacts and human remains, but unfortunately these were out of their primary context (García, et al., 2012). They generated AMS radiocarbon dates and conducted stable isotope analyses on several of the crania to get estimations as to when the cave was used for burials and to characterize the adults’ diets (McClure, et al., 2010b). Overall there have been 75+ crania found at Pastora, several of them belonging to children. The majority of the samples so far date to the Late Neolithic and Bronze Age periods (McClure, et al., 2010b).
Each excavation at Cova de la Pastora provided new information about the use of the cave (Figure 3). The artifacts and human remains from all the excavations are stored at Museum of Prehistory in Valencia, Spain and Municipal Archaeological Museum in Alcoi (McClure, et al., 2010b). The more recent excavations conducted by Dr. Oreto García and Dr. Sarah McClure investigated several questions left unanswered from the two previous excavations. First, they wanted to obtain new data in order to increase their understanding the stratigraphic sequence using the old excavation reports, diaries, and assemblages (García, et al., 2012). The goal was to focus on the relationships between individuals looking at the role of the graves, their diets, social status, and health (García & McClure, 2008). The overall goal was to examine the social inequality that may have been present in the Iberian Peninsula societies (García, et al., 2012).

With state of the art laser scanning, they were able to generate a virtual image of the cave, including the stratigraphy and a 3D virtual environment with the hopes of reconstructing the previous excavations (García, et al., 2012). After analyzing the 3D models, AMS radiocarbon dates, the excavation documents of the past century, McClure and García were able to compare their results of where the crania were located in the cave to Pascual’s original phases (García, et al., 2012).

Phase one was the deepest part of the cave where Pascual noted a general disturbance, but there were no articulated human skeletons (García, et al., 2012). McClure and García generated
five AMS dates from the sample of 13 crania from phase one. (García, et al., 2012). In the second phase, Pascual noted 19 crania, metal artifacts, and Bell Beaker pots similar to context of ceremonial practices of Europe’s elite (García, et al., 2012). Bell Beaker pottery was found across Europe and is thought to have had a variety of uses (drinking, funerary, metal work), but they stand out due to their notable bell-shaped form. The presence of these artifacts was interpreted to support the idea that the cave had been in use for a long duration and more sporadically for funerary purposes during the Chalcolithic and Bell Beaker Transition period (García, et al., 2012). In Pascual’s plan, he noted 14 crania total in phase three (García, et al., 2012). The burials date to the Bronze Age based on two AMS dates, supporting the idea the cave was continuously used for burial practices into this time period (García, et al., 2012).

A total of 10 AMS radiocarbon dates were generated by McClure et al. (2010) and two dates were generated on trepanated skulls by Roca de Togores Muñoz and Soler Díaz, 2010 (Table 1) (Roca de Togores Muñoz & Soler Díaz, 2010). Five of these adults dated to the Late Neolithic (3,335 - 3,030 BC) including one of the trepanated skulls (McClure, et al., 2010b). The second trepanated skull dated to the Chalcolithic along with two other adult crania (3,011 – 2,635 BC) (McClure, et al., 2010b; Roca de Togores Muñoz & Soler Díaz, 2010). One skull dates to the Bell Beaker period (2,461 – 2,292 BC) and two other skulls date the Bronze Age (1,909-1,752 BC) (García, et al., 2012; Soler Díaz,
2002). Overall, the site was interpreted to have been used for burials for over 1,500 years (García, et al., 2012).

The isotopic values of the adults were consistent with a terrestrial diet, consisting of mostly C3 plants (Table 2) (McClure, et al., 2010b). There was no indication of marine food in their diets, nor were there significant differences between time periods or sexes (McClure, et al., 2010b). One interesting result was that some females had a lower nitrogen levels. This was attributed to the possibility that nursing may have been responsible for this result, or that women had less access to animal protein during this period (McClure, et al., 2010b). When women are breast feeding, their nitrogen levels tend to be lower than they normally would be since they are passing those nutrients on to their young (Hedges & Reynard, 2007). If there was less access to animal protein overtime, it would have been reflected in the decrease of $^{15}$N levels (Hedges & Reynard, 2007).

As noted in McClure et al. 2010, there was a minimum of 59 individuals: 15 females (25%), 21 males (36%), and 23 undetermined individuals (39%) (McClure et al. 2010b). The various age categories were made of: 29% mature adults (41-60) with 17 crania; 51% Table 28. Stable isotope values of adults from Cova de la Pastora (McClure, et al., 2010b).

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Skeletal Feature</th>
<th>$d_{13C}$</th>
<th>$d_{15N}$</th>
<th>%C</th>
<th>%N</th>
<th>C:N</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPM14 Human mandible</td>
<td>-19.5</td>
<td>9.0</td>
<td>41.1</td>
<td>14.7</td>
<td>3.26</td>
<td>Late Neolithic</td>
<td></td>
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<tr>
<td>LPM39 Human mandible</td>
<td>-19.0</td>
<td>10.0</td>
<td>43.9</td>
<td>15.7</td>
<td>3.26</td>
<td>Late Neolithic</td>
<td></td>
</tr>
<tr>
<td>LPM23 Human mandible</td>
<td>-19.1</td>
<td>9.7</td>
<td>46.8</td>
<td>16.7</td>
<td>3.27</td>
<td>Late Neolithic</td>
<td></td>
</tr>
<tr>
<td>LP3 Human mandible</td>
<td>-19.6</td>
<td>8.1</td>
<td>44.3</td>
<td>15.9</td>
<td>3.25</td>
<td>Late Neolithic</td>
<td></td>
</tr>
<tr>
<td>LP9 Human mandible</td>
<td>-19.5</td>
<td>9.7</td>
<td>43.1</td>
<td>15.3</td>
<td>3.29</td>
<td>Late Neolithic</td>
<td></td>
</tr>
<tr>
<td>LPM31 Human mandible</td>
<td>-19.3</td>
<td>10.6</td>
<td>37.2</td>
<td>13.0</td>
<td>3.34</td>
<td>Chalcolithic</td>
<td></td>
</tr>
<tr>
<td>LPM17 Human mandible</td>
<td>-19.6</td>
<td>9.5</td>
<td>44.6</td>
<td>15.6</td>
<td>3.34</td>
<td>Bell Beaker</td>
<td></td>
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<tr>
<td>LPM21 Human mandible</td>
<td>-19.4</td>
<td>8.3</td>
<td>44.5</td>
<td>16.1</td>
<td>3.22</td>
<td>Bronze Age</td>
<td></td>
</tr>
<tr>
<td>LPM6 Human mandible</td>
<td>-19.6</td>
<td>7.5</td>
<td>43.5</td>
<td>15.6</td>
<td>3.25</td>
<td>Bronze Age</td>
<td></td>
</tr>
</tbody>
</table>

Table 55. Age categories, number of individuals for each category, and the percent of the total population at Cova de la Pastora (data from McClure, et al., 2010b).
young adults (21–40) with 30 crania; and 8% sub adults consisting of one adolescent (13-19), one child (7-8), and one young child (<3) and 2 children (3-6) (Table 3) (McClure, et al., 2010b). For this project, I directly AMS radiocarbon dated and generated stable isotope data on the five children mentioned above; results are described in chapter 5.

The pathologies noted at Cova de la Pastora included caries, dental wear, antemortem tooth loss, periodontitis, and *cribra orbitalia*, trepanations, cranial lesions, and traumatic injuries (Table 4) (McClure, et al., 2010b). Of the total number of individuals, 13 exhibited signs of *cribra orbitalia* (22%) and four had evidence of porotic hyperostosis (7%) (McClure, et al., 2010b). *Cribra orbitalia* and porotic hyperostosis (porosities on the outer cranial vault) have been thought to be caused by iron-deficient anemia since the 1950’s (Walker, et al., 2009). Walker et al. (2009) suggests that these porosities on the orbital roof are most likely the result of vitamin B12 deficiencies and unhygienic living conditions (McClure, et al., 2010b; Walker, et al., 2009).

Other pathologies include traumatic injuries, trepanations, and cranial lesions (McClure, et al., 2010b). There is evidence such as bone remodeling around the hole suggesting a prolonged survival after the procedure (McClure, et al., 2010b). There were four cases of trepanations (7%), performed by drilling or scraping the bone (McClure, et al., 2010b). Interestingly, they were all performed on adult males between 20 – 40 years old (McClure, et al., 2010b). The size and shape

<table>
<thead>
<tr>
<th>Pathology</th>
<th>#</th>
<th>% Population</th>
<th>% Male</th>
<th>% Female</th>
<th># Male</th>
<th>% Male</th>
<th># Female</th>
<th>% Female</th>
<th># Indet.</th>
<th>% Indet.</th>
</tr>
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Table 82. List of pathologies that left markers on the crania (data from McClure, et al., 2010b).
of the hole are roughly the same among these crania (excluding skull 17) forming similar patterns with the trepanated crania at Cova d’En Pardo (McClure, et al., 2010b; Roca de Togores Muñoz & Soler Díaz, 2010). There were two skulls that had cranial lesions (3%) and four skulls with traumatic antemortem injuries (7%) (McClure, et al., 2010b). Overall, these various cranial pathologies were found in 54% of the individuals including all sexes and ages (McClure, et al., 2010b).
Chapter 4

Methods

Since the children’s remains from Cova de la Pastora were found out of the original burial context in the back dirt piles, I processed samples from five children, (two humeri, two parietals, one femur) for AMS dates to identify the time period in which they were buried. Samples were prepared in the Human Paleoecology and Isotope Geochemistry Laboratory at Penn State directed by Dr. Douglas Kennett.

The Longin method was used to extract bone collagen and purify it for stable isotope and C\textsuperscript{14} analyses (McClure, et al., 2010b; following Brown, et al., 1988). Bone samples were initially cleaned using an X-ACTO \textregistered blade in order to remove any sediment adhering to the exposed surfaces. Samples (500 – 700 mg) were demineralized for 24 – 36 hrs. in 0.5 N HCL at 5°C followed by a brief (<1 hr.) alkali bath in 0.1 N NaOH at room temperature to remove humates. The pseudomorph was rinsed to neutrality in multiple changes of NanoPure H\textsubscript{2}O, followed by being gelatinized for 12 hours in 0.01 N HCL at 60°C. The gelatinized solution was pipetted into precleaned Amicon Centriprep \textregistered 30 ultrafilters (retaining >30kDa molecular weight gelatin), and centrifuged three times for 30 minutes, diluted with NanoPure H\textsubscript{2}O, and centrifuged three more times for 30 minutes to desalt the solution. Ultrafilter collagen was lyophilized and weighed to determine percent yield to determine the degree of bone collagen preservation. At the Penn State University Light Isotope Laboratory, the carbon and nitrogen concentrations and stable isotope ratios were measured using Costech EA (ECS 4010), Thermo Finnigan Conflo IV gas handling device, and a Thermo Finnigan Delta V analyzer. The quality of the sample was evaluated by the percent crude gelatin yield, \%C, \%N, and C:N ratios before AMS C\textsuperscript{14} dating (Hoggarth, et al., 2014; McClure, et al., 2010a).
Following Hoggarth et al. (2014), AMS C^{14} samples (~2.5 mg) were combusted for three hrs. at 900°C in vacuum sealed quartz tubes with CuO wire and Ag wire. The sample of CO\textsubscript{2} was reduced to graphite at 550°C using H\textsubscript{2} and Fe catalyst, with reaction water drawn off with Mg (ClO\textsubscript{4})\textsubscript{2}, completed at the University of California, Irvine Keck AMS facility (Santos et al. 2004). Graphite samples were pressed into targets in Al boats and loaded on the target wheel for AMS analysis. C^{14} ages were corrected for mass-dependent fractionation with measured δ^{13}C values (Stuiver and Polach, 1977) and compared with samples of Pleistocene whale bone (background >48 \textsuperscript{14}C kyr BP), late Holocene bison bone (~1850 \textsuperscript{14}C BP), late AD 1800s cow bone, and OX – 1 oxalic acid standard for calibration. (Hoggarth, et al., 2014; McClure, et al., 2010a).

The stable isotope results consist of five different readings: \(\delta^{13}C\) VPDB (amount of \(^{13}C\) isotope versus \(^{12}C\) with respect to VPDB standard); \(\delta^{15}N\) (amount of \(^{15}N\) versus \(^{14}N\) with respect to the Atm. N\textsubscript{2} standard); \%C (amount of carbon in sample); \%N (amount of nitrogen in sample), C:N (carbon versus nitrogen ratio in sample). The term ‘VPDB’ stands for “Vienna Pee Dee Belemnite”, referring to the original sample of an extinct fossilized shell of the belemnite organism, which is used as a comparison to normalize the values to that standard (Kendall, 2006).
Chapter 5

Results

There were five children sampled for AMS radiocarbon dating (Table 5). Three individuals dated to the Late Neolithic, ranging from 3,624 – 2,972 BC. There were no sex estimations for the children, but there were age estimations. For these remains dating to the Late Neolithic, the ranges are from 3 – 5 years old for two of the individuals and 8 – 10 years old for one child. There was one individual dating to the Bell Beaker period, ranging from 2,456 – 2,205 BC and was 3 – 5 years old. One child dated to the Bronze Age, ranging from 2,140 – 1,972 BC, was 3 – 5 years old.

For the isotopic analysis of the children remains, the δ\(^{13}\)C ranges were between -20.0 and -19.5 and the δ\(^{15}\)N ranges were between 7.9 and 9.5 (Table 6). The fauna remains δ\(^{13}\)C ranges were between -20.6 and -19.6 and the δ\(^{15}\)N ranges were between 3.7 and 7.9 (Table 7). In order to make sure that the samples were not contaminated, we observed the readings for the C:N ratios. The ranges expected for the C:N ratio range from 3.2 to 3.4. The children and fauna remains are within, or very close to, the recommended limits (see Table 7).
Comparing these isotopic results to the adults shows that their C:N range (3.22 – 3.34) was within the recommended limit as well. Figure 4 compares the children and fauna isotopic data to the published data on the adults sampled from Cova de la Pastora. The $^{15}$N in the human remains are on average 3 – 5 ‰ higher than the fauna remains, providing support for the “trophic level effect”. The $^{13}$C of the human remains are about a 1‰ increase (-20.0 to -19.0) compared to the fauna remains at -20.6 to -19.6 (McClure, et al., 2010b). Even though there are more positive values for the $^{13}$C results for the humans, there is still a great deal of overlap with the fauna remains. This overlaps suggests the fauna (sheep/goats) and human were consuming similar types of plant protein.

Comparing the new AMS radiocarbon dates of the children and published adult values, we see that Cova de la Pastora was used as a burial site for almost 2,000 years (Figure 5). In total, there were nine remains dating to the Late Neolithic, including six adults and three children ranging from 3,712 –
2,972 BC (McClure, et al., 2010a). The adult age estimations ranged from 20 – 40 years old, and two were male, one female, and three that were most likely males (McClure, et al., 2010b). For the Chalcolithic, there were three sets of adult remains dating to this time period, ranging from 3,011 – 2,635 BC. The age ranges for this time period are from 20 – 40 years old and all three are indeterminate in sex except one, most likely to be male. There was one adult and one child dating to the Bell Beaker period, ranging from 2,461 – 2,205 BC (McClure, et al., 2010a). The age range for the adult is from 25 – 35 years old and is male (McClure, et al., 2010a). Lastly, there were three sets of remains dating from 2,140 – 1,752 BC, dating to the Bronze Age (McClure, et al., 2010a). Two sets of remains are adult females and range in age from 25 – 35 (McClure, et al., 2010a). The 17 human remains that were dated are spread out over 2,000 years (3,800 – 1,800 BC) and show no preference for sex, age, or time period.
Chapter 6

Other Burial Caves of the Alicante Region

Cova de la Pastora was one of several influential burial sites during the Late Neolithic to the Bronze Age. It is important to examine published data from other sites in the region to determine if Cova de la Pastora is illustrative of the time periods in question. Four of these other burial caves in the Alicante region include Cova de Sant Martí, Cova de la Sarsa, Cova de la Barcella, and Cova d’En Pardo. These sites have AMS dates of children, adults, and fauna remains. This information from these neighboring sites allows for comparisons and contrasts between the sites.

La Cova de Sant Martí

La Cova de Sant Martí is a site about 35 km from the coast of the western Mediterranean (Pérez Fernández & Soler Mayor, 2010). The site was occupied from 12,000 - 5,000 BP and the remains of 26 individuals were found (Pérez Fernández & Soler Mayor, 2010). There were three main excavations at the site (2001, 2002, 2003) (Torregrosa Giménez & López Seguí, 2004) and researchers unearthed several children identified by their dental growth. In addition to the human remains, many material goods were found including ceramics, lithics, worked bones, mollusks, animal bones, and charcoal (Torregrosa Giménez & López Seguí, 2004).

The children consisted of one 3 - 6 year old, one 7 - 8 year old, one 10 - 12 year old, and one about 15 years old (Giménez, et al., 2004). When the researchers AMS radiocarbon dated individuals from six different levels, the results varied from 5,260 - 4,600 BC (Torregrosa Giménez & López Seguí, 2004). The animal remains included domesticated and wild animals.
Some of the domesticated animals were sheep, pigs, cows, and dogs, whereas wild animals included horses, aurochs, deer, roe deer, wild goats, wild boars, wolves, foxes, lynxes, wild cats, hares, turtles, amphibians, reptiles, birds, and fish (Torregrosa Giménez & López Seguí, 2004).

The occlusal surfaces of the human teeth were studied to obtain the diet (Giménez, et al., 2004). They suggest the diets of the people at Sant Martí consisted mostly of agricultural products and they noted an increase in the consumption of meat from carnivores, but not a high consumption of marine resources (Giménez, et al., 2004). They also noticed signs of enamel hypoplasia in two of the children’s skeletons, suggesting their diets were rich in carbohydrates (Giménez, et al., 2004).

**La Cova de Sarsa**

La Cova de Sarsa was excavated on numerous occasions during the twentieth century: in 1928 by Ponsell, then again in 1931-1932, 1935, and 1939 (Pérez Botí), and finally in 1971-1974 by Mª Dolores Asquerino (Pérez Botí). Throughout the excavations a variety of material goods, faunal and human remains were found.

Some of the materials goods included Early Neolithic Cardial style cups, spoons made of bone, fragments of rings, shell pendants, and pottery with decorated reliefs (Aparisi, 1950; Botí G. P.). In addition, a variety of faunal remains such as goat, sheep, cattle, wild boar, rabbits, domesticated dogs, wild cats, and birds were unearthed (Asquerino, et al., 1998). There were also 10 human burials identified, three of them children (one having a trepanated skull) (Pérez Botí, 1999). The individuals themselves consisted of several cranial and post-cranial bone fragments including frontal, occipital, teeth, humerus, radius, ulna, phalanges, and pelvis (Pérez Botí,
When the researchers dated the human and several faunal remains, five samples dated to the Late Neolithic (5,531 – 5,222 BC), one to the Chalcolithic (2,839 – 2,487 BC), one to the Bronze Age, and one to the Moorish period (1,162 – 1,031 BC) (Borja, et al., 2012).

**La Cova de la Barcella**

Cova de la Barcella was first excavated in 1928 by D. José Belda Domínguez and had a second campaign in 1929 (Borrego, et al., 1992). Domínguez discovered two caves; the Superior cave was a natural cave oriented north to south and contained 14 burials (individuals 1 – 14), while the Lower cave contained 7 burials (individuals 15 – 21) (Borrego, et al., 1992). Many of the humans were buried in groups of two facing each other or in groups of three (Borrego, et al., 1992). These burials were characterized by the presence of metals, axes or stone tools, but missing the typical flint and with only few ceramics and arrow points (Borrego, et al., 1992).

Artifacts were found in both Superior and Inferior caves and included grave goods mention above along with polished stones, bone tools, and many decorative and adornment items (Borrego, et al., 1992). Unfortunately, there are no AMS radiocarbon dates or isotopic data from this site. The site was dated based of the material goods discovered mentioned above, dating to the Neolithic and Chalcolithic (Borrego, et al., 1992; Pérez Fernández & Solar Mayor, 2010).

**La Cova d’En Pardo**

Cova d’En Pardo was first excavated by Vicente Pascual 1965, and again from 1993-2007 by Mª P. Fumanal and M. Dupré (Soler Díaz, 2012). There were several types of graves
goods uncovered including arrowheads, flint, ceramic fragments, beaded necklaces and pendants, and wide flat bars (Soler Díaz, 2012).

A total of 27 radiocarbon dates were generated from sediments, faunal, and human remains (Soler Díaz, 2000). Of those dates, seven burials dated ranging from 4,760 – 1,003 BC, spanning the Neolithic to the Bronze Age (Soler Díaz, 2000). There were several dates for sheep/goat bones, ranging from 5,512 – 3,811 BC, spanning the Early Neolithic to Middle Neolithic (Soler Díaz, 2000). Other species were noted, similar to the other caves in the region including sheep, goats, Spanish ibex, red deer, rabbit, wild boar, and wildcat (Soler Díaz, et al., 2013).

A total of 15 humans were recovered including 11 adults, 1 teenager, and 3 children (3 year old, 5 - 9 years old, 10 - 14 year old) (Pérez Fernández & Solar Mayor, 2010; Soler Díaz, 2012). There were several pathologies that were discovered, occurring equally in males and females, including caries, occlusal wear, tooth loss, cribra orbitalia, and periodontitis (Soler Díaz, 2012). There is also evidence of trepanation in an adult, aged 20 – 25, and dated to 3,214 – 2,922 BC (Soler Díaz, 2012). One very interesting discovery was a burial of two women, aged 16 – 20, that showed evidence of bites from carnivores and signs of disarticulation, some possibly caused by a metal instrument (Soler Díaz, 2012). The remains were dated to the Bronze Age (1,357 – 920 BC) (Soler Díaz, 2012). Furthermore, two adult crania from Cova d’En Pardo were particularly interesting. The individuals were 30 to 40 years old, and had traumatic lesions localized to the frontal bone (Rodes, et al., 2006). In both cases, the crania had evidence of caries and periodontal disease.
Chapter 7
Discussion

Cova de la Pastora is a complex burial site with a great deal of history and archaeology. Through modern excavations and analyses, we have been able to classify Cova de la Pastora as a burial cave due to the large amounts of grave goods, including jewelry, carved bone, precious stones, early metallurgy, and the 70+ human remains buried at the site (Figure 6). The people buried at Cova de la Pastora likely lived in surrounding open air villages permanently (Figure 7).

The stable isotope results established several trends. Before processing the samples, we were expecting the children’s $^{15}$N levels to be slightly elevated compared to the adults, which would have occurred if, in fact, the children were breast feeding, or consuming more nitrogen than the adults in some manner. We did not see that in our results, however, one fauna sample’s $^{15}$N level was elevated more than expected (see Figure 4). This could be the result of a young sheep/goat still nursing, consuming the extra nitrogen from its mother’s breast milk.

Figure 85. Grave goods excavated at Cova de la Pastora (photo credit: Museum of Prehistory, Valencia).

Figure 86. Open air sites (circles) and burial sites (purple squares) in the Alicante region; Chalcolithic (in black), Bell Beaker (in red) (photo credit: Oreto Garcia).

Figure 87. Grave goods excavated at Cova de la Pastora (photo credit: Museum of Prehistory, Valencia).

Figure 88. Open air sites (circles) and burial sites (purple squares) in the Alicante region; Chalcolithic (in black), Bell Beaker (in red) (photo credit: Oreto Garcia).

Figure 89. Chronology and comparison of the time of use for each cave (Botí G. P., 1999; Giménez, et al., 2004; McClure, et al., 2010b; Soler Díaz, 2000).

Figure 90. Open air sites (circles) and burial sites (purple squares) in the Alicante region; Chalcolithic (in black), Bell Beaker (in red) (photo credit: Oreto Garcia).

Figure 91. Grave goods excavated at Cova de la Pastora (photo credit: Museum of Prehistory, Valencia).

Figure 92. Open air sites (circles) and burial sites (purple squares) in the Alicante region; Chalcolithic (in black), Bell Beaker (in red) (photo credit: Oreto Garcia).

Figure 93. Chronology and comparison of the time of use for each cave (Botí G. P., 1999; Giménez, et al., 2004; McClure, et al., 2010b; Soler Díaz, 2000).
This analysis has shown that children had similar diets to the adults interred at Cova de la Pastora, in terms of animal and plant protein consumption. This is supported by the overlapping $^{13}$C ranges: -20.0 - -19.6 (children) and -19.6 - -19.0 (adults), and $^{15}$N ranges: 7.9 – 9.5 (children) and 7.5 – 10.6 (adults) (McClure, et al., 2010b). The children’s diets did not seem to have extreme changes from the Late Neolithic to the Bronze Age. The $^{13}$C started at -19.8 for our earliest date (3,624 – 3,372 BC), decreased by .3 by the Bell Beaker period, and increased to -20.0 by the latest date in the Bronze Age (2,140 – 1,972 BC). We see a similar pattern for the $^{15}$N ranges, starting at 8.8 for the earliest date, increasing by 0.7 for the Bell Beaker period, and decreasing to 7.9 for the latest date in the Bronze Age. Comparing the human’s and herbivore’s plant protein intake, there is evidence of continuity. The adults’ and children’s’ $^{13}$C ranges were about 1 ‰ more positive than the fauna remains, signifying both humans and fauna (sheep and goats) had similar plant proteins, focused on C3 plants, such as peas, lentils, and wheat (McClure, et al., 2010b). Furthermore, the human’s remains had evidence supporting the idea that their diet was comprised of 60 – 80 % animal meat (Hedges & Reynard, 2007). The 3 – 5 ‰ increase in $^{15}$N between the sheep/goats and the humans indicates the humans were consuming meat, putting them at higher trophic level.

The AMS dates of the children demonstrate they were interred at Cova de la Pastora from the Late Neolithic to the Bronze Age. These results overlap with the dates previously published on the adults from Cova de la Pastora (see Figure 5). There does not appear to be a preference for age or sex for interring individuals at Cova de la Pastora since about an equal number of adult males and females are represented in the mortuary assemblage along with children and adults throughout the entire 2,000 years.
The AMS dates from the other burial caves show similarities in the time periods that were being utilized. By examining the chronology of four of the burial caves (Cova de la Barcella does not have direct AMS dates), we can tell that the caves were in use in overlapping time periods. Most of the overlap occurs from the Late Neolithic to the Bronze Age (3,800 – 1,800 BC), but several burials sites have evidence of use in the Early Neolithic and later use in the Moorish period (Figure 8). Cova de Sant Martí was used as a burial cave earlier than Cova de la Pastora, starting in the early Neolithic around 5,260 BC (Giménez, et al., 2004). The time utilized as a burial site is shorter than that of Cova de la Pastora’s, ending around 4,600 BC, where Cova de la Pastora continued to be in use until ca. 1,800 BC (Giménez, et al., 2004). Cova de la Sarsa dates are more similar to Cova de la Pastora. Cova de la Sarsa has dates starting slightly earlier, around 5,531 BC, but continues to show use in the Chalcolithic and Bronze Age, then extends into the Moorish period with a latest date around 1,162 BC (Pérez Botí, 1999). Cova d’En Pardo has the most in common to Cova de la Pastora in terms of chronology since it was in use from 4,760 – 1,003 BC (Soler Díaz, 2000). Both sites also had similar cases of trepanations as well. At Cova d’En Pardo, the trepanated skull dated to 3,214 – 2,922 BC and at Cova de la Pastora, the two skulls dated to 3,717 – 3,529 BC and 3,011 – 2,704 BC (McClure, et
al., 2010b; Soler Díaz, 2000). Interestingly, two of the crania trepanated were male (one undetermined), aging from 20 – 40 years old (McClure, et al., 2010b; Soler Díaz, 2012). A possible explanation for these trepanations was that it was ceremonial in nature, and that this was the most likely age to survive this invasive procedure (McClure, et al., 2010b).

Along with sharing similar times periods of use, these five burial caves have several other characteristics in common. These similarities include having grave goods (e.g. jewelry, stone and metal tools, carved bone, flint), children and adult burials, and skeletons with pathologies (e.g. cribra orbitalia, trepanations) (Botí G. P., 1999; Giménez, et al., 2004; McClure, et al., 2010b; Soler Díaz, 2000). In total, there were 12 children interred in all five caves (Botí G. P., 1999; Giménez, et al., 2004; McClure, et al., 2010b; Soler Díaz, 2000). Of these 12 children, six dated to the Neolithic, four dated to the Chalcolithic, one dated to the Bell Beaker, and one dated to the Bronze Age (Figure 9) (Botí G. P., 1999; Giménez, et al., 2004; McClure, et al., 2010b; Soler Díaz, 2000). It is difficult to interpret the differences among the five caves for several reasons. First, the level of preservation could vary from site to site, in which over time, materials and artifacts can either preserve very well, degrade completely, or fall somewhere in between. Secondly, one site could have had a smaller (or larger) population size
using the burial cave, influencing the number of people interred there. Thirdly, one of these
groups could have had a smaller (or larger) number of children dying, influencing the number of
children interred at their burial site.

Table 8. shows the various age categories of children at the burial caves in Alicante: 0-1, 2-4, 5-9, and 10-14 (Table 8). Of these 12 children, only two were found to have pathologies; one from Cova de la Pastora (trepanation and cribra orbitalia), one from Cova de la Sarsa (trepanation) (Table 9) (Botí G. P., 1999; McClure, et al., 2010b). It does not appear that the pathologies that leave markers on the skeleton were prominent among the majority of the children. There is most likely another factor for cause of death that cannot be seen in the archaeological record. As for their overall health, it is difficult to say if these pathologies played a role in every child’s life. For what we can see in the archaeology, there were only two children’s crania that had these pathological markers, suggesting the children were living with the disease (or cause for the trepanations) for a long period of time (Wood, et al., 1992). As mentioned earlier, trepanations are a very invasive surgery to perform, and may have not be done unless it was the last option or as part of a ritual (McClure, et al., 2010b). If there was a ritualistic or ceremonial tie to the trepanations, it is
suggested in McClure et al. (2010) that the mark left on the skull after would help make an individual stand out amongst their population (McClure, et al., 2010b). As for the other 10 children, we can say with certainty that they did not have these pathological markers, but they still may have suffered from a disease or elements that lead to the bone pathology (Wood, et al., 1992). Since children are vulnerable, especially to diseases and becoming ill, they may have experienced these illnesses and were unable to fight them off, passing away before they lived with them long enough to leave markers on the bones (Wood, et al., 1992). It is unclear which children experienced these illnesses, except for the two remains we have markers on, to determine their wellbeing. Another method to address the wellbeing of children without the pathological markers at the other sites would be to do isotopic analyses to see if any deficiencies in their diet could be detected.
Chapter 8  
Conclusions

Before this study, it was unclear how children’s diets compared to the adult’s from the same burial site and how their wellbeing compared to children of other burials sites. From these analyses, we know children were consuming similar plant protein as the adult’s and sheep/goats within the region inferred by the overlapping ranges of $^{13}$C (McClure, et al., 2010b).

Furthermore, children and adults were most likely consuming some amount of animal protein due to $3–5\%$ increase in $^{15}$N levels compared to the sheep/goat remains (McClure, et al., 2010b). The overall wellbeing of the children from Cove de la Pastora was similar to four other burial caves in the region, based on the low percentage of pathologies that left markers on their skeletons.

These trends appear to be constant throughout the Late Neolithic to the Bronze Age. Despite the major economic and social changes that the Alicante regions underwent throughout this 2,000-year time period, this study suggests there is a level of equality, in regards to food sources, among all members of the population that was utilizing Cova de la Pastora for their burials. The estimations of sex, age, and time period for the 12 adults and five children sampled, along with the numerous grave goods, indicate that Cova de la Pastora was a burial cave in use from the Late Neolithic to the Bronze Age with all sexes and ages represented (men, women, and children). Cova de la Pastora does not appear to have the characteristics of a population that exhibits social inequality.

There are still several questions unanswered about the lives of the population interring their dead at Cova de la Pastora. We were able to study the pathologies that left markers on the skeleton of the children to give indications of wellbeing, but not every child had these markers.
How do we understand how those children without pathological markers died? For the children without markers, we cannot assume they were not experiencing the illnesses or malnutrition that lead to pathologies. Rather, they may not have survived long enough for them to leave markers on the skeleton.

Another question to be examined is the burial rites associated with the children. Unfortunately, the children were found out of their primary context. If they had been excavated in their original context, we could have noted their body position and have associated grave goods. This information could have been compared to interments of children from other burial sites, adults from other sites, and adults from Cova de la Pastora. Across the Alicante region, we could have observed trends of change or continuity in the burial rites between children and adults. With all of the social and economic changes that were taking place in this time period, this information would help clarify if the populations using Cova de la Pastora, and burial caves like it, had social stratification, when it started, and how intense it was.

We know that Cova de la Pastora was used as a burial site for a 2,000-year time period, but are unsure why it continued to stay in use for such a long time. Did the people interred at Cova de la Pastora over the years have a relationship to each other? With ancient DNA testing, we have the potential to understand if the individuals were related to one another and if they represent a distinct lineage from other burial sites in the region. With further study, I believe these questions have the potential to be answered.

During the Late Neolithic to the Bronze Age there were many social and economic changes occurring in the Alicante region. The burials at Cova de la Pastora do not appear to show preference for men, women, or children. Furthermore, the AMS radiocarbon dates and isotopic analyses indicates the diets for the adults and children were similar and remained
constant for both groups during this 2,000-year time period. The evidence suggests that the population utilizing Cova de la Pastora was not experiencing social inequality, despite the shifts occurring socially and economically. In conclusion, the relative wellbeing of children remained constant within the context of increasing social complexity and economic change at Cova de la Pastora.
BIBLIOGRAPHY


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   Lynch, P., McClure, S. B., García, O. – In Prep
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