"A BIOARCHAEOLOGICAL APPROACH TO PREHISTORIC CEMETERY POPULATIONS FROM WESTERN AND CENTRAL GREEK MACEDONIA"

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

DEPARTMENT OF ARCHAEOLOGY AND PREHISTORY

UNIVERSITY OF SHEFFIELD

November 1999

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ABSTRACT

The osteological material under study consists of 510 skeletal remains dating from the Early Neolithic (6000 BC) to the Early Iron Age (1100-700 BC). It comes from nine different cemeteries and burial locations extending from the coastal to the inland areas of the study region.

The current thesis attempts to explore two major issues: 1) the reconstruction of aspects of life history and 2) the treatment and manipulation of the deceased as revealed by the human skeletal remains.

With regard to the former, the investigation of demographic parameters, patterns of health and oral status as well as diet have been considered. In short, local conditions defined by environmental and social constraints probably affected the general quality of life reconstructed for the study populations. There is an overall tendency however, towards declining levels of health and oral status in the Late Bronze and Early Iron Age populations, while certain assemblages provide high levels of infant and child mortality, possibly associated with a type of anaemia. There is also a substantial involvement of the upper skeleton in work patterns, possibly related to activities such as food acquisition, processing and preparation. Meanwhile, the evidence for dietary patterns from the Neolithic/Early Bronze Ages to the Late Bronze/Early Iron Ages is consistent with an overall shift from a high reliance on meat consumption to a diet based on carbohydrate foodstuffs.

The evaluation of the manipulation of the deceased, alongside the evidence for mortuary differentiation through time, reveals a striking transformation from the practice of single inhumations in the Early Bronze Age to multiple/secondary burials in the Late Bronze and Early Iron Age assemblages, suggesting a shift in emphasis from individual to lineage-group identity.

Furthermore, the integration of biological inferences with the evidence of mortuary behaviour provides further insights into sex roles and the position of subadults, otherwise invisible, in the living community.

ACKNOWLEDGEMENTS

Although the responsibility for the completion of a doctoral dissertation falls to one person only, the production of it requires fruitful collaboration between a large number of people. The current work would have been impossible without the crucial contribution of the field archaeologists who excavated, retrieved and curated the study skeletal material. I am particularly indebted to Manthos Bessios, Areti Hondroyianni-Metoki, Georgia Karametrou-Mentesidi, Maria Pappa, Efi Poulaki-Pantermali and Christina Ziota who very kindly entrusted me with their material and facilitated the procedures for obtaining the permissions necessary for study and sampling and field work. Dr Ken Wardle, who is in charge of the Neolithic site of Nea Nikomedeia, offered me easy access and permits to re-study the human bones. I am especially grateful to Manthos Bessios, Maria Pappa and Christina Ziota, responsible for most of the cemetery populations analysed here, who offered me ideal conditions for collaboration, as well as contextual information and unpublished reports. Despite their tight schedules and bureaucratic obligations to the Archaeological Service, they were always willing to answer to my questions and discuss with me aspects of burial practices from the study area.

My supervisors in Sheffield offered me a great deal of invaluable help and numerous useful comments. Dr Andrew Chamberlain as primary supervisor gave crucial advice, especially on technical matters regarding human bone analysis, modern methodology and standards of physical anthropology. Dr Paul Halstead as secondary supervisor managed to extrapolate my deep thoughts and ideas and made me convert what was originally a dry, technical osteological text into a more comprehensive study which integrates archaeological and scientific knowledge. Paul went far beyond his obligations; he helped me significantly with editing and working on the text to make it readable and comprehensible. I owe special thanks to him. Dr Stelios Andreou as joint supervisor provided his expertise and valuable knowledge on archaeological issues from Northern Greece and, despite the long distance, he responded quickly by reading and making challenging comments on the archaeological chapters. He also encouraged me in critical moments when my energy was running out. Dr Gert van Klinken conducted the stable isotope analysis in the Oxford Laboratory, and helped me enormously by explaining the use and complex details of the analysis. Gert helped me to pose the archaeological questions for the project, and thus to match the scientific information directly to the aims of this thesis. His contribution to the interpretation of the final results was invaluable, since chemistry was until recently a field relatively new to me.

In addition to the obvious people involved in the shape of this thesis, I should also mention a number of friends who offered their help and advice in moments of total chaos. Mike Charles, Amy Bogard and Ingrid Mainland gave me their invaluable help on complex statistical questions. Beth Rega, in addition to teaching me how to handle bones during the years of my MSc studies at Sheffield, entrusted me with her unpublished thesis and data and provided enormous help with suggestions based on her own investigation of the Early Bronze Age populations at Mokrin, in Hungary. Rob Craigie and Rockie Hyacinth helped with scanning the photographs and printing out the thesis, while Arturo Vargas took some superb pictures of human bones from EIA Makrigialos. Yiannis Karliabas gave me a copy of his Master dissertation before he had even submitted it and discussed with me significant aspects of the mortuary behaviour he explored at the Early Iron Age Makrigialos cemetery. Mike Parker Pearson pointed out to me useful references regarding the interpretation of disarticulated human skeletal remains. Rosalia Christidou drew my attention to animal bone assemblages from prehistoric sites in Greek Macedonia which yielded scattered human bones in the settlement deposits. Vangelio Kiriatzi helped me enormously in occasional discussions we had on issues of material culture in Northern Greece, especially during the early years of the project. Nancy Krahtopoulou checked the environmental sections of the thesis and enriched them with references unknown to me and with unpublished information from her own work. Katerina Skourtopoulou also offered helpful comments and information from Neolithic Makrigialos.

Writing a doctoral dissertation is a formidable test of ones own resources, both intellectual and personal, requiring not only a huge investment of academic knowledge and research, but also continuous moments of solitude and self-consciousness. Nancy Krahtopoulou, Vangelio Kiriatzi and Eva Panagiotakopoulou gave me enormous energy to keep strong in extremely difficult times in England when I was very close to collapse. The Fishers, my English family in Sheffield, put me up and put up, with my stormy Greek character through all the years of my studies since the time of my Master's degree. Greg Anderson helped me with the editing and final polishing of large sections of this thesis, but mainly he supported me through this particular period of my life with his entertaining company, steady character and patience.

This thesis could never have been completed without the funding support of several institutions and foundations. The University of Sheffield provided me for three years with substantial funding support as a Research Student in the Department of Archaeology and Prehistory. The American School of Classical Studies at Athens, and the Wiener Laboratory in particular, where a large component of the study material was processed and analysed, gave me the impetus to start such a task by awarding me the J. L. Angel Fellowship and a Research Associateship, and provided me with generous financial support to cope with the expenses of field work. The British School at Athens approved a three-month Bursary for my initiation into the use of stable isotope analysis. The Institute of Aegean Prehistory, through the large-scale Neolithic Makrigialos project, covered the expenses for dating the Early Bronze Age assemblage. The BFWG Women's Foundation helped significantly during the last year of writing up when I was almost financially exhausted.

Lastly, I want to thank the Greek Ministry of Culture, the Ephoreia of Speleology and Palaeoanthropology, the IΘ Ephoreia of Thessaloniki and IΣT Ephoreia of Pella which facilitated the procedures for obtaining permissions for the study, sampling and transfer part of the material to the Wiener Laboratory in Athens. I also owe special thanks to people at Makrigialos, particularly Panagiotis, the guards of the Kozani Archaeological Museum and the Museums in Dion, Veroia and Aeani. They kindly offered me their help with cleaning, washing, boxing and transferring bones, which is not such a pleasant activity for the uninitiated and also did their best in providing me with excellent working conditions, including work space, food, drinks and a lot of gossip. I do hope that this work will find its ultimate approval in Panagiotis' summer club in Makrigialos, just behind the bar bench of Bora-Bora.

I dedicate this thesis to my family, Ritsa, Dimitris and Anna who tolerated my lunatic habits and mood swings, I hope temporary, during the years of completion. Without their support and relief in times of absolute madness, the idea of this thesis would not even have been conceived.

Although a great number of people have helped with this thesis, I take all responsibility for the good points, if any, and unfortunately, for all the bad as well.

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ABBREVIATIONS

AMS:	Accelerator Mass Spectrometry
EBA:	Early Bronze Age
EIA:	Early Iron Age
EN:	Early Neolithic
ENE:	East-north-east
IndAdult:	Indeterminate adult
LBA:	Late Bronze Age
LN:	Late Neolithic
Madult/MA:	Mature adult
masl:	meters above sea level
MN:	Middle Neolithic
MNI:	Minimum Number of Individuals
Mt:	Mount
NIA:	Number of Individuals Affected
NIO:	Number of Individuals Observed
N-S Infection:	Non-Specific Infection
Oadult/OA:	Old adult
P/SC:	Pit covered with schist
P/W:	Pit with wooden cover
Padult/PA:	Prime adult
Yadult/YA:	Young adult

CHAPTER 1: INTRODUCTION

1.1. DEFINITION AND AIMS OF THE THESIS

A large number of works on prehistoric Greek mortuary behaviour have focused on grave assemblages from the southern mainland, Crete and the Cyclades (Persson 1931; Mylonas 1966; Blackburn 1970; Pelon 1976; Doumas 1977; Protonotariou-Deilaki 1980; Nordquist 1987; Branigan 1993; Cavanagh and Mee 1998). This thesis will reverse this geographical bias by exploring the evidence of human skeletal remains from Central and Western Greek Macedonia. In contrast to the studies relating to the southern Greek mainland, which have produced exhaustive discussions of mortuary behaviour and burial practices, the current work will draw attention to the occupants of the grave assemblages, that is to the human skeletal remains buried, disposed of or treated as secondary products.

Most research to date on prehistoric burial assemblages in the study area has been strictly limited to preliminary excavation reports briefly describing aspects of burial practices and evidence of material culture such as ceramics, jewellery and weaponry. As regards human skeletal material, the preliminary report on Early Neolithic Nea Nikomedeia (Angel 1973a) treats the human skeletal material out of archaeological context and there is no thorough study at a population level which considers a large series of human remains from a broad geographical area diachronically. The current thesis examines human skeletal remains from the study area, spanning the period from the Neolithic to the Early Iron Age, with two aims:

- first, *the reconstruction of aspects of life history*
- secondly, *analysis of the treatment and manipulation of the deceased* and their role in social mobility and social transformations.

The analysis will thus focus on the investigation of demographic parameters, patterns of health and oral status, as well as on diet in the study cemetery populations. Apart from overall comparisons at the population level, these parameters will be explored for population subgroups such as those defined by age and/or sex. It must be emphasised that these parameters will not be considered as strictly biologically determined. Rather, demography, health status and dietary patterns will be seen in a historical, regional and chronological context, while the archaeological background of

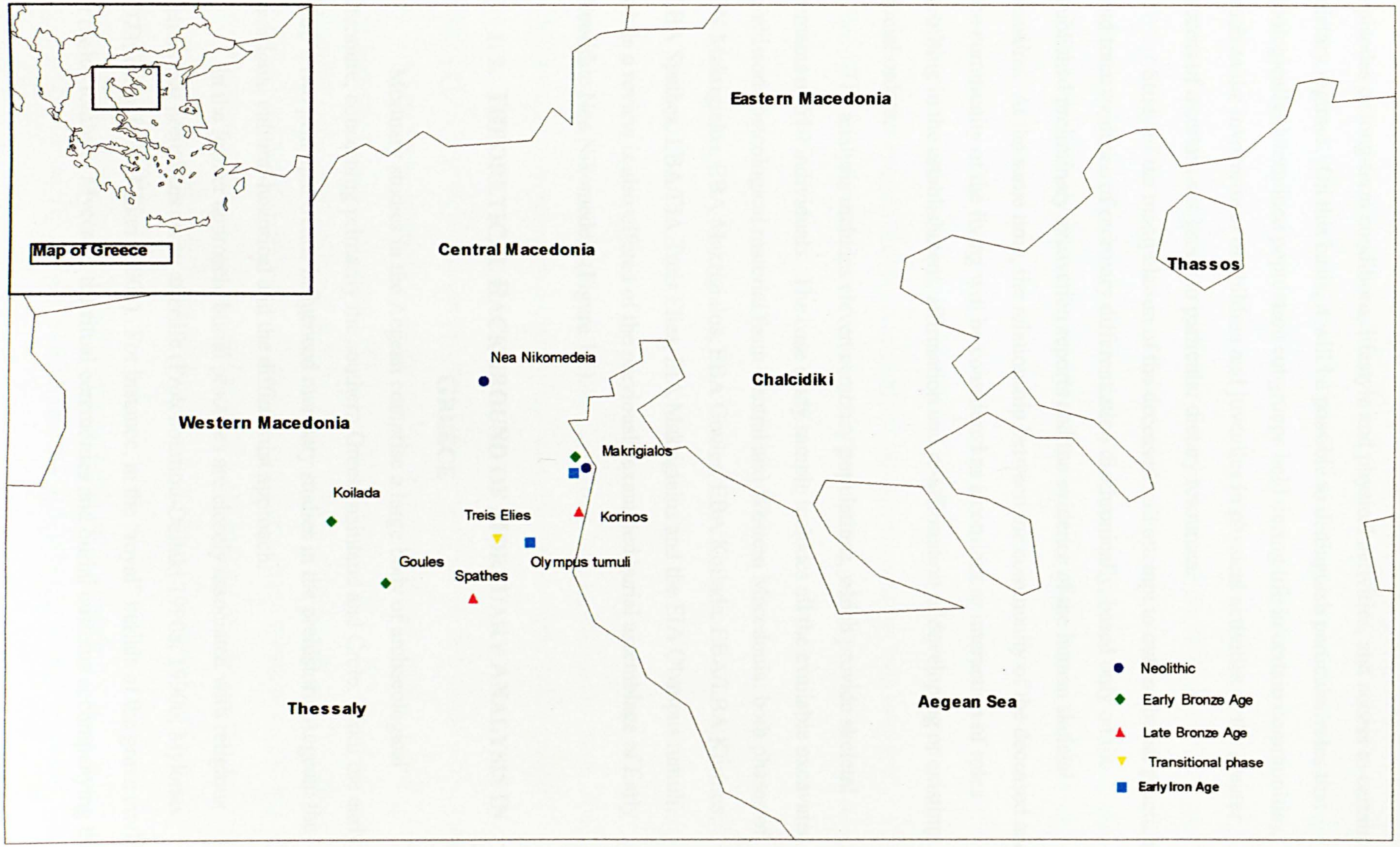

Figure 1.1: Map of the study area indicating the case study populations

the cemetery populations will be also taken into account. The aim of this thesis will be to define the effect on the different age and/or sex groups of quality of life, stress episodes or long-term conditions, lifestyle and physical activities, and access to certain dietary regimes. On this basis, it will be possible to distinguish particular roles that biologically-determined population subgroups held during life in certain communities, such as the involvement of children and juveniles in physical activities or the greater access of a certain sex group to particular dietary resources.

Study of the manipulation of the deceased will attempt to outline burial practices and trace evidence of mortuary differentiation diachronically, based only on the published preliminary excavation reports and the evidence of the human skeletal remains. At the same time, the relationship between the community of the deceased and the community of the living will be considered as a continuous interaction of roles resulting in the establishment, affirmation and re-affirmation of developing or existing social orders.

The analysis includes eleven cemetery populations, which provide skeletal remains of 510 individuals. The case study sample includes all the available excavated prehistoric osteological material from Central and Western Macedonia: both phases of LN Makrigialos, EBA Makrigialos, EBA Goules, EBA Koilada, EBA/LBA Korinos, LBA Spathes, LBA/EIA Treis Elies, EIA Makrigialos and the EIA Olympus tumuli, while a review is also offered of the previously examined burial assemblage of Early Neolithic Nea Nikomedeia (Figure 1.1).

1. 2. THEORETICAL BACKGROUND OF MORTUARY ANALYSIS IN GREECE

Mortuary studies in the Aegean comprise a large body of archaeological literature, concerning primarily the southern Greek mainland and Crete. Until the early 1980's two principal trends influenced mortuary studies in the prehistoric Aegean: the traditional cultural-historical and the diffusionist approach.

In the former approach, burial practices are closely associated with religious beliefs and prejudices on an afterlife (Protonotariou-Deilaki 1990a; 1990b; Mylonas 1973; Hägg 1990; Kilian 1990b). For instance, in the "royal" burials of the grave circles or tholos tombs at Mycenae, the ritual ceremonies and burial customs accompanying the funeral have been interpreted in terms of the celebrations of the living for the dead who were recognised as mediators to the afterlife.

The diffusionist approach treats burial practices as products of cultural influences, thus paying attention to the different elements represented in the mortuary arena. In this case, in order to trace cultural groups affecting burial practices, "otherness" is interpreted as the product of foreign influences originating from an outside world (Evans 1929; Persson 1931; Mylonas 1966; 1973; Marinatos 1974). For example, the occurrence of "tumuli" in the Early /Middle Bronze Age particularly in the southern Greek mainland, has been interpreted as a foreign element imported from the northern "Kurgan" tradition (Hammond 1967; Müller 1989; for a discussion see Forsèn 1992).

The crucial problem with both approaches is that the constituent principles which structure mortuary behaviour as a whole are usually ignored. Instead, there is a clear tendency towards the profound study of isolated phenomena, such as grave offerings and tomb architecture (Pelon 1976), which represent only a very limited aspect of mortuary behaviour.

This gap was partly bridged in the 1980's under the influence of New Archaeology (Saxe 1973; Binford 1972; Brown 1971; Goldstein 1976; 1981; Tainter 1978, O'Shea 1981). According to this theoretical perspective, the form of the burial ritual is defined in part by the social persona of the individual, that is, by the social statuses or social identities that the individual possessed during life and by the numbers of people who participated in the burial and recognised responsibilities toward the deceased. Thus, the "new wave" in Aegean mortuary studies tends to share a concern with extrapolating social phenomena from funerary contexts. In fact, much of this work has given particular emphasis to the association of burial practices with social and political structure (e.g. Cavanagh 1987; Mee and Cavanagh 1984; 1990; Cavanagh and Mee 1998; Wright 1987; Graziadio 1991; Alden 1981; Nordquist 1987; 1990). These studies, often supported by statistical analyses and thorough consideration of the social, cultural and economic background of the burial assemblages examined, have contributed significantly to the transformation of the static, traditional ideas which had dominated the field.

Nevertheless, the straightforward relationship between burial practices and social organisation has been the subject of a debate, largely influenced by the norms of social anthropology, arguing that what burial practices are reflecting may be an idealised picture of social relations (Hodder 1982). Furthermore, the social role of the living and their interaction with the deceased has been particularly emphasised by viewing mortuary practices as an active arena where the living, acting with the deceased, attempt to reaffirm or redefine their roles in social practices (Parker Pearson 1982; 1993). Voutsaki has introduced a similar perspective in the Aegean mortuary context by trying to trace the symbolic and cultural significance of mortuary forms and practices and so to interpret their use in the developing social strategies of the Late Bronze Age in the southern Greek mainland (Voutsaki 1998).

In Northern Greece, there is a remarkable lack of any thorough work on mortuary behaviour based on prehistoric burial assemblages. One problem is the limited amount of material, and another is the total absence of publications of excavated prehistoric cemeteries, except for Early Iron Age Vergina in Central Macedonia (Andronikos 1969) and Kastri on Thassos (Koukouli-Chrysanthaki 1992) (Figure 1.1). Moreover, the views expressed in preliminary reports on Late Bronze and Early Iron Age cemeteries, such as LBA Spathes and Rymnio, LBA/EIA Treis Elies and EIA Makrigialos have been largely influenced by the diffusionist approach. The occurrence of new "Mycenaeanised" elements, such as large cists recalling the Mycenaean shaft graves and chamber tombs known from the southern Greek mainland, together with the adoption of new burial practices, such as secondary and multiple burials, have been seen as evidence for the direct import of ideas and/or products from the South (Karametrou-Mentesidi 1993; Poulaki-Pantermali 1993; Bessios 1997b).

1.3. THE STUDY OF ANCIENT HUMAN REMAINS IN GREECE

Despite the excavation of a great number of cemeteries in Greece, and thus the availability of large series of skeletal remains, the study of human remains has advanced relatively little. Until very recently, the study of ancient human bone was a branch of physical anthropology and the biological sciences (for an analytical review of the history of physical anthropology in Greece together with current perspectives and a rich bibliography, see Roberts et al. in press, and Agelarakis 1995). The majority of the scholars involved, from the foundation of the Anthropological Museum in Athens (1886) onwards, come exclusively from biological and medical backgrounds without any essential knowledge of history and archaeology. Academic study of physical anthropology and palaeoanthropology has been established only in departments of Biology and Palaeontology, at the same time being conspicuously absent in departments of Archaeology and History.

The development of physical anthropology in Greece, at the end of the 19^{th}/beginning of the 20^{th} century, followed similar ideological trends to those which influenced Greek archaeology. Thus, the primary aim of researchers in the field was to investigate issues of ethnogenesis associated with the origins of the Greeks and their close links with their ancient ancestors. This interest resulted in the collection, study and thorough analysis almost exclusively of human crania (Musgrave 1980b; 1985; Xirotiris 1981; 1986; Manolis 1991; Panagiaris 1992; Panagiaris et al. 1994; Panagiaris et al. 1997). In particular, there was a constant attention to the study of morphological similarities in different populations or ethnic groups based on large series of metric data. Obviously, such analytical work, when considered systematically and free from political motives, can contribute greatly to the interest of physical anthropology and archaeology in population movements, immigration, population affiliations, population inter-breeding and family relations.

Additionally, physical and biological anthropology in Greek contexts has tended towards the study of isolated individuals rather than of large series of cemetery populations and, in general has focused on famous or notorious discoveries (Musgrave 1985; 1990; Prag 1990; Musgrave et al. 1994; Musgrave et al. 1995; Prag and Neave 1997), thus neglecting the evidence as a whole provided by archaeological and historical sources.

Therefore, study of ancient human remains in Greece to date can be summarised in terms of three characteristics: 1) the selective consideration of the human *skull* as opposed to the postcranial skeleton; 2) the investigation of disease lesions or skeletal abnormalities in *single* skeletons as opposed to the epidemiology of series of skeletal populations; and 3) particular interest in *"famous" individuals*, considered to be members of "royal families" and "elites", as opposed to the study of complete cemetery populations from a comparative regional and diachronic perspective.

The ignorance of the majority of archaeologists of the procedures for the collection, conservation and analysis of human remains has also limited biological anthropology in Greek contexts, and has led to the discarding of large well preserved skeletal populations which could have provided valuable information with regard to palaeodemography, epidemiology, diet, occupational and health status, and the history of medicine. Appropriate standards of dealing with human bones have not been widely adopted and only a few cemetery excavations have involved the participation of a human bone specialist.

Finally, particularly with regard to Northern Greece, there is a notable lack of studies of ancient human remains, in contrast with the larger number of reports and publications concerning populations of the Southern Greek mainland (Angel 1959; 1971a; 1973b; 1973c; 1975; 1982; Musgrave 1980a; Musgrave and Popham 1991), Crete (Musgrave 1976a; 1976b; 1996; McGeorge 1983; 1988; 1989; Hallager and McGeorge 1992; Bourbou 1998), and the islands (Angel 1977a). The limited work in biological anthropology in Greek Macedonia is consistent with the low level of prehistoric research in general in this area. Osteological analyses from Northern Greece include: 1) work by A. Agelarakis in Eastern Macedonia and Thrace (Agelarakis 1996; Agelarakis and Agelarakis 1989; Agelarakis and Efstratiou 1996); 2) the preliminary results on Neolithic Nea Nikomedeia and Classical Olynthus by J. L. Angel (Angel 1942; 1973b); 3) and the few isolated cases of historical date from Central Macedonia investigated by J.H. Musgrave (1985; 1990).

1.4. STRUCTURE AND SIGNIFICANCE OF THIS THESIS

This thesis will attempt to bridge the gap between the two disciplines of archaeology and biological anthropology by thoroughly analysing Northern Greek osteological material. Thus, Chapter 2 is an introduction to the historical, geographical, environmental, chronological and archaeological background of the study area. The history of prehistoric research is briefly discussed, and an outline of the geography of the region and the present-day environment is also presented. The archaeological periods are defined in terms of the existing regional chronology. Finally, the archaeological background to the study is discussed with regard to such relevant aspects as settlement patterns, subsistence and social organisation.

Chapter 3 presents the information available in preliminary reports on cemetery excavations and burial assemblages. The study cemetery populations are defined in geographical, environmental and chronological terms. Neolithic to Early Iron Age burial practices are then discussed on the basis of the published excavation evidence.

Chapter 4 analyses demographic parameters, that is mortality and survivorship, together with the distribution of the sex groups from the study cemetery populations. There is an extensive section on preservational factors, including excavation and retrieval, which have affected the condition and size of the samples studied. This chapter partly sets the framework for the following chapters by addressing specific questions as regards, first, the manipulation of the deceased and, secondly, the effect of overall health status on the demographic representation of the populations.

Chapter 5 considers the manipulation of the deceased in the light of the minimum number of individuals held in a single burial assemblage, ranging from the Neolithic ditches and disarticulated skeletal remains of Makrigialos to the single burials of the Bronze Age and the multiple and secondary burials of the Late Bronze and Early Iron Ages grave assemblages. Issues of burial treatment are cautiously discussed in terms of changes in the household unit and the character of relationships between the community of the deceased and the community of the living through time.

Chapter 6 assesses patterns of health status in the cemetery populations by focusing on two major parameters: 1) heavy workload as evidenced by arthritic changes, trauma and vertebral abnormalities; and 2) the overall pathogen load as shown by the distribution of non-specific infections, anaemia and enamel hypoplasia. The former enables inferences about the lifestyle and physical activities of the study populations, while the latter can shed light on stress episodes or long-term conditions which may have affected the study populations and thus provide evidence on the biological adaptability of certain age and/or sex groups to their physical and social environment.

Chapter 7 discusses aspects, first, of dietary patterns and secondly, of oral health status. In particular, the prevalence of certain dental conditions is evaluated in relation to age and sex groups, showing that certain population subgroups had greater access to particular dietary regimes. In addition to the results of macroscopic investigation, this chapter discusses the results of a stable isotope analysis, which characterises human skeletal remains in terms of broad dietary categories.

The significance of the current thesis may be summarised as follows:

A. It is the first study of a large series of skeletal remains from Greek Macedonia, ranging chronologically from the Neolithic to the Early Iron Age and geographically from the coast to the lowlands of Central Macedonia and the uplands of Western Macedonia.

B. It approaches the human skeletal remains in their burial context, trying to explore evidence of burial treatment as indicated by the human remains alone and by preliminary excavation reports. Issues of mortuary treatment are considered for the first time in this area in the light of recent theoretical approaches, treating mortuary behaviour as an arena of social interaction between the community of the deceased and the community of the living where social roles are continuously affirmed and re-affirmed in new or existing social orders.

C. It focuses, according to modern standards of physical anthropological methodology, on the reconstruction of aspects of life from human remains. Demographic parameters, patterns of health, oral status and diet are considered within the historical context of the study cemetery populations in order to explore the response of different populations and population subgroups to biological or environmental effects such as stress episodes, long-term conditions, physical activities and particular dietary patterns; the differential response of population subgroups to the above conditions can shed further light on the roles they held in their prehistoric communities.

Difficulties encountered include the poor condition of the human skeletal remains, the rescue character of the excavations, the notable lack of absolute chronological series and the lack of published comparative studies.

CHAPTER 2: HISTORICAL, CHRONOLOGICAL, ENVIRONMENTAL AND ARCHAEOLOGICAL BACKGROUND TO THE STUDY REGION

2.1. HISTORICAL CONTEXT: HISTORY OF PREHISTORIC RESEARCH IN THE STUDY AREA

During and after World War I, the allied armies carried out surveys and small-scale excavations in Macedonia, especially while digging military trenches near visible prehistoric mounds. The results of these early explorations were reported in the journals of the British and French Archaeological Schools in Athens (Rey 1916; Casson 1919-1920; 1924; 1968; for a good review and discussion, see Fotiadis, in preparation) and included inventories of the sites and crude pottery descriptions (Rey 1917-1919). Rey invented a first typology of prehistoric settlements, distinguishing three types of mounds (toumba, table and toumba-on-table), while Casson conducted at *Tsaousitsa*, in Central Macedonia, what he regarded as the "first scientific" excavation (Casson 1919-1920; 1924). Tsaousitsa is located in the Axios valley and Casson's work was inspired by his belief in the strong relationships of Macedonia to the Balkans and Central Europe and his desire to search for firm evidence of these.

The first major synthesis of prehistoric research in Central and Western Macedonia was in Heurtley's *Prehistoric Macedonia* (1939). Heurtley catalogued all then known prehistoric sites, together with a discussion of location, architectural remains, small finds and pottery styles and manufacture.

After a hiatus of some thirty years, excavation began again in 1961 with the joint Cambridge-Harvard expedition to *Nea Nikomedeia* (Figure 2.1), the earliest farming settlement then known in Europe (Rodden 1962). The location of the site in the southern Balkans was of particular interest regarding the presumed spread of the Neolithic and of farming to Europe from Anatolia. The excavation achieved the first systematic retrieval of post-built structures in Greece, and included a team of specialists with well-defined goals: first, to trace any material evidence for the adoption of farming and neolithisation of Europe and for the possible links of "advanced" Anatolia to "barbarian" Europe; and, secondly, to explore aspects of social organisation and the potential for adaptation of the community to its physical environment. Thus, issues of geomorphology, economy, society, ideology and material culture were explored by the experts who participated in the team.

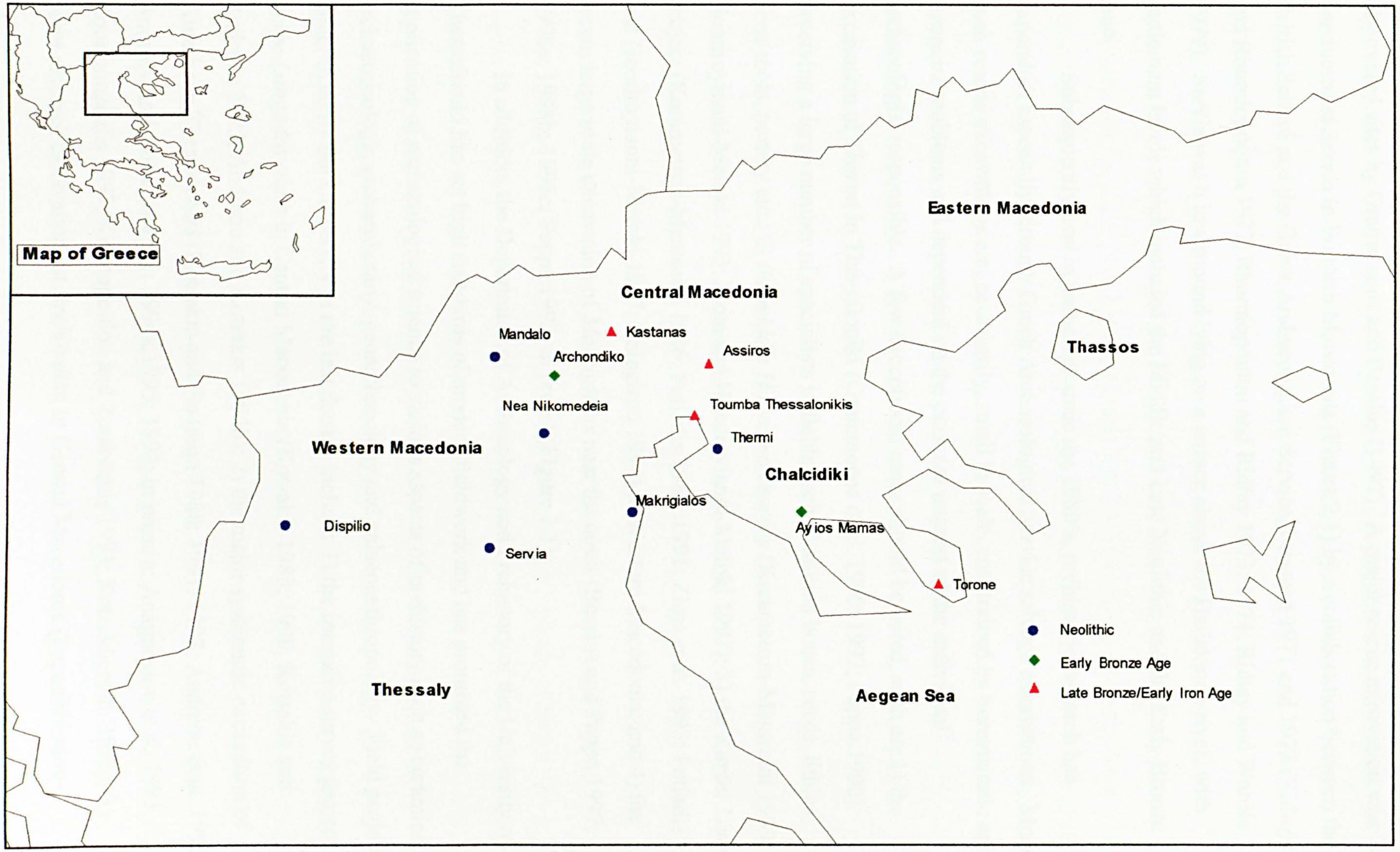

Figure 2.1: Map of the excavated prehistoric sites in the case study region

In the late 1960's, a systematic reconnaissance of prehistoric sites in Central Macedonia was produced by D. H. French (1967), recently updated with newly discovered sites by Grammenos and Bessios (1997). A major rescue excavation was conducted at *Servia* in Western Macedonia (Figure 2.1) by a collaboration between the British School and the Greek Archaeological Service, between 1971 and 1973 (Ridley and Rhomiopoulou 1972; Rhomiopoulou and Ridley 1973; 1974; Ridley and Wardle 1979). Servia was a low mound lying on a terrace above the Haliakmon river, with settlement levels which included the Middle and Late Neolithic and the Early Bronze Age.

Subsequently, and in particular since the 1980's, prehistoric research has expanded, especially through Greek Archaeological Service salvage excavations. Most such rescue excavations are, necessarily, small in scale, constrained by bureaucratic and financial problems and dependent on the personal interest of the individual archaeologist responsible. A few exceptional cases should be noted, such as: 1) the excavation of *Thermi* in Thessaloniki (Grammenos et al. 1990; 1992; Pappa 1990) involving a large number of specialists in fields such as animal bones, seeds, lithics, bone tools, pottery etc.; 2) *the middle Haliakmon survey* (Karametrou-Mentesidi 1989; Hondroyianni-Metoki 1993; Ziota and Hondroyianni-Metoki 1997); 3) *the Kitrini Limni* project (Karametrou-Mentesidi 1986; Fotiadis 1988; 1991; Ziota et al. 1993; Fotiadis and Hondroyianni-Metoki 1997; Kalogirou 1994) in Western Macedonia; and 4) the recent large scale excavation of *Makrigialos* near the coast (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press) (Figure 2.1).

In addition, the Department of Archaeology and Prehistory of the University of Thessaloniki has set high standards of modern fieldwork and has promoted the application of archaeological science to various aspects of prehistory such as ceramics, archaeozoology, archaeobotany, geoarchaeology and palaeoanthropology. Field projects undertaken by the University in the last decade include: 1) the intensive survey project in *the Langadas plain* in Central Macedonia (Kotsakis 1989; 1990; Kotsakis and Andreou 1995; Andreou and Kotsakis 1994b); 2) the major systematic excavation of *Toumba* in Thessaloniki (Kotsakis and Andreou 1988; 1991; 1997; Andreou et al. 1990, Andreou and Kotsakis 1991; 1994a;1995; 1997; in press a; Anagnostou et al. 1993, Hourmouziadis 1993; Krahtopoulou and Touloumis 1993; Kotsakis et al. 1995); 3) other research excavations at *Archondiko* in Central Macedonia (Papaefthimiou-

Papanthimou and Pilali-Papasteriou 1991; 1995; 1997; 1998), *Mandalo* in Western Macedonia (Pilali-Papasteriou et al. 1986; Kotsakis et al. 1989; Pilali-Papasteriou and Papaefthimiou-Papanthimou 1989; Papaefthimiou-Papanthimou and Pilali-Papasteriou 1988; 1989; 1990; 1991; 1993; in press) and the settlement of *Dispilio* on the shore of the lake of Kastoria, in Western Macedonia (Hourmouziadis 1997; Anagnostou et al. 1997; 1998) (Figure 2.1).

Finally, prehistoric research has also been conducted in the last decades in Central and Western Macedonia by foreign Archaeological Schools and Institutes: excavations at *Kastanas* (Kroll 1983; Aslanis 1985; Becker 1986; 1998; Hochstetter 1984; 1987; Hänsel 1989), *Torone* (Cambitoglou and Papadopoulos 1981; 1984; 1988; 1990; 1991; 1992), *Assiros* (Wardle 1980; 1983; 1987; 1988; 1989), and *Ayios Mamas* (Hänsel 1997; 1998); and *the Grevena survey* project (Wilkie 1993) (Figure 2.1). These projects have enjoyed relatively generous funding, technical support and the participation of specialists, resulting in systematic fieldwork and the publication of detailed preliminary or final reports.

The development of research in Macedonia has evidently been affected by its wider political and historical context and, particularly by two concerns: first, by attempts to demonstrate the antiquity of Greek culture in this area; and secondly, by perceptions of this area as a marginal or transitional province between great centres of civilisation in southern Greece and in Central Europe and the Balkans (for a fruitful discussion, see Kotsakis 1991; Andreou et al. 1996; Wardle 1997b and Fotiadis in preparation).

Archaeological remains relevant to the first of these concerns attracted the attention of scholars: monumental architecture, public buildings and palaces, elite tombs and luxurious finds, which emphasised the prosperity of the area in the 4^{th} century BC. "There was indeed very little chance of including in this strict ideological model anything that would not establish a direct continuity with the Classical Greek past, since anything else was either disregarded or seen as an unnecessary complication" (Kotsakis 1991: 67). Time periods preceding the late $5^{th}/4^{th}$ century BC have been constantly neglected.

Moreover, the perception of this region as marginal has led to the particular character of its culture being interpreted in terms of southern or northern parallels. Only recently, has it been treated as an autonomous entity shaped by local political, social and historical processes within a broad world system which gives a special emphasis to the "interaction among centres, peripheries and margins" (Andreou et al. 1996). Thus, most prehistoric remains recovered in Macedonia have been dealt with in terms of similarities with Neolithic Thessaly, with Late Bronze Age Mycenae or, in the most open-minded cases, with the neighbouring Balkans. This has resulted in an emphasis on "foreign" cultural influences, represented by either imported products or local imitations thereof, and in a rejection of the indigenous dimensions of the cultural background of Macedonia. Macedonia's "otherness" in relation to southern parallels is often expressed in terms of its distance from the prosperous monumental civilisations of the southern mainland, and from the islands and the barbaric wilderness of the North (Andreou et al. 1996; Fotiadis in preparation). Besides, Macedonia represented "the land which lay on the route from one important area of civilisation to another. Its own importance for prehistory was precisely that condition: being a passage, or a highway" (Fotiadis, in preparation). A typical example of the latter approach is the association of the region with the passage of the Dorians from north to south en route to the violent destruction of Mycenaean civilisation. It is not accidental that this attitude is mirrored in academic overviews of Greek prehistory such as the recent *The Aegean Bronze Age* by O. Dickinson (1994) which avoids extended reference to the prehistory of Macedonia.

It is encouraging that in the last twenty years members of both the University of Thessaloniki and the Greek Archaeological Service have begun to apply modern methods and theoretical models to the investigation of the prehistory of Macedonia.

2.2. Chronological Context of the Study

The prevalent relative chronological framework in Northern Greece is largely based on similarities of pottery styles with the south, namely the Greek mainland and Thessaly, and with the neighbouring Balkans, for which there are a large number of absolute chronologies (Warren and Hankey 1989; Manning and Weniger 1992; Manning 1995; for an extensive discussion, see Grammenos 1991: 85-98 for Central and Eastern Macedonia and Kalogirou 1994: 30-38 for Western Macedonia). The assumption underpinning this relative chronology, that similar artefacts necessarily represent the same chronological periods over a broad geographical area, is very dubious, however, and inconsistencies in ceramic typology between different regions also pose problems (Halstead 1994: 195).

Considering the relatively limited scale of fieldwork conducted in Macedonia, there are a fairly large number of radiocarbon dates. There are securely dated chronological series from Central and Western Macedonian settlement deposits for the middle and late phases of the Neolithic (5800/5600 cal BC- 5400/5300 and 5400/5300-4700/4500 cal BC respectively) and the early and late phases of the Bronze Age (3300/3100 cal BC-2300/2200 cal BC and 1700/1500-1100 cal BC respectively).

Some periods have not been accurately defined, however, in terms of either relative or absolute chronology: the "Middle Bronze Age" can be identified only in Thessaly and parts of Macedonia (Andreou et al. 1996); and the transition from the "Late Bronze Age" to the "Early Iron Age" has very broad time limits, extending from the 11th to the 8th century BC.

Moreover, prehistoric cemeteries in Macedonia are particularly poorly dated. This study adopts the absolute chronological scheme (in calibrated years BC) described in the most recent review of northern Greek prehistory (Andreou et al. 1996):

Early Neolithic	6700/6500-5800/5600 BC
Middle Neolithic	5800/5600-5400/5300 BC
Late Neolithic	5400/5300-4700/4500 BC
Final Neolithic	4700/4500-3300/3100 BC
Early Bronze Age	3300/3100-2300/2200 BC
(Middle Bronze Age)	2300/2200-1700/1500 BC
Late Bronze Age	1700/1500-1100 BC
Early Iron Age	1100-700 BC

Because the "Middle Bronze Age" has not been recognised in a large part of the study region, Andreou et al. suggest the broader term "later Bronze Age" to cover the time period from 2300/2200 to 1100 BC. (Andreou et al. 1996: 539).

2.3. GEOGRAPHICAL LOCATION AND PRESENT-DAY NATURAL ENVIRONMENT

The cemeteries examined in this thesis are located in the modern regions of Central and Western Macedonia. The area presents a broad range of physical settings,

Figure 2.2: Map of the case study area (Wardle 1997: Figure 1)

from the coastline of the Thermaic gulf to the lowlands and uplands of the interior (Figure 2.2). Three main features define the physical environment of the region: 1) the mountain ranges including Mt Olympus; 2) the large lowland plains (e.g. that of Giannitsa in Central Macedonia) and upland basins (e.g. that of Kitrini Limni in West Macedonia); and 3) the rivers, of which the Haliakmon and Axios (Vardar) are the largest.

The main mountainous area is in the region of Western Macedonia and consists of high ranges on three sides: the Kamvounia (1675 masl), Pieria mountains (2190 masl) and Mount Olympus (2917 masl) (Borza 1990).

The great plain of Central Macedonia is defined by the Pierian Mountains to the south, the long ridges of Mt Vermion to the west, Mt Paikon to the north and the lower Axios valley to the east. Additionally, the study area includes the upland basin of Kitrini Limni in Western Macedonia located between 650 and 680 masl on the ENE lower slopes of Mt Vermion.

Finally, four great rivers, the Haliakmon, Axios, Loudias and Gallikos run through the area and flow into the upper Thermaic Gulf. In particular, the Haliakmon forms the Middle Haliakmon valley in a major part of Western Macedonia and then enters the great plain of Central Macedonia at its south-western corner through a gap between Mt. Vermion and the Pieria range.

Two distinct climate zones are represented in the study area: 1) the interior experiences a "continental" climate, marked by cold winters and hot summers and, while the range of mean monthly temperature is wide, the annual range of mean monthly rainfall is relatively narrow; 2) the coastal area experiences a generally warmer and more moderate "mediterranean" climate, characterised by much greater variation in mean monthly rainfall (that is by very distinct rainy and dry seasons) and by a much narrower annual range of mean monthly temperature (Balafoutis 1977).

The lowlands and upland basins of Macedonia provide some of the richest arable land in Greece and, until very recently, the region also supported large numbers of transhumant stock, alternating pasturage between the highlands in summer and the lowlands in winter. Also, the great rivers provide ample water for the irrigation of the basins during the summer (Hammond 1972; Borza 1990).

2.4. THE PREHISTORIC NATURAL ENVIRONMENT

Recent research has revealed that the prehistoric environment of Macedonia differed significantly from that of the present day:

- The major part of the great plain of Central Macedonia formed from the 2nd and 1st century BC onwards, as a result of alluvial depositions in the gulf of Thessaloniki (Struck 1908; Bintliff 1976; Schulz 1989; for further discussion see Georgas and Perissoratis 1992).
- The coastline of Central Macedonia has changed substantially, particularly where the great rivers flow into the gulf of Thessaloniki, as a result of the combined effects of alluviation, deltaic progradation and sea level change. The central section of coast between Makrigialos and Kitros has been highly affected by erosion of the shoreline, while the narrow coastal strip to the south has been formed by alluviation during the Holocene (Georgas and Perissoratis 1992, Krahtopoulou in preparation).
- Large-scale anthropogenic effects of the last decades have drastically changed the natural environment of Western Macedonia, particularly in the upland basin of Kitrini Limni and the Middle Haliakmon valley.

Most of the work on environmental changes has been based on palynological analysis and so has focused on the vegetation history of the area rather than on geomorphological transformations (Bottema 1974; 1982; 1994; Bottema and Woldring 1990; for further bibliography see Andreou et. al. 1996). After the late glacial steppe, trees recolonised the landscape and a deciduous oak forest dominated the lowlands by the Early Neolithic. Between the seventh and third millennium BC, the forest changed in composition, with an expansion of conifers in the uplands and the extension of the forest to the lowlands (Bottema 1974). Possible causes of such changes in vegetation include the impact of climate (Bottema 1974) and the migration of species from glacial refugia (Bennet et al. 1991; Willis 1994).

Only in the second millennium BC is there clear evidence of anthropogenic impact upon the vegetation, including: 1) the appearance of *fruit-bearing trees* exploited by humans (Bottema 1974: 162-163), -the walnut and sweet chestnut in the uplands and the olive tree in the lowlands; 2) a suggested decrease in forest cover due to *clearance for grazing* in the uplands (Bottema 1974; Willis 1994). Extensive deforestation resulted in severe soil erosion and deposition of large quantities of sediment in the plains (Willis 1994). The episode may have initiated a cycle of slope erosion and deposition of coarse sediments along the peripheries of the valleys. As a further result, surface outlets in some basins may have been blocked, and marshes may thus have formed and expanded, for example, in Kitrini Limni (Andreou et al. 1996).

Finally, changes in climate can only be inferred indirectly from the palynological record of changing vegetation. During the Early Holocene, temperatures must have risen quite markedly and, by the fifth millennium BC, summers in the uplands may have been warmer than today by up to 4° C (Huntley and Prentice 1988). Cooler, more humid conditions, approximating to those of the present, became progressively prevalent in the last two millennia of prehistory, especially after 2500 BC (Andreou et.al. 1996: 562).

2.5. ARCHAEOLOGICAL BACKGROUND TO THE STUDY AREA

This section briefly reviews three aspects of the Neolithic to Early Iron Age archaeological record from the study area which are particularly relevant to the bio-archaeological evidence investigated in this thesis: settlement patterns, subsistence and social organisation.

2.5.1. SETTLEMENT PATTERNS

Settlement patterns in the study area are known primarily from excavations, briefly summarised at the beginning of this chapter, and secondarily from systematic, intensive survey projects, both on a large-scale in the Langadas basin (Kotsakis 1989; 1990; Kotsakis and Andreou 1995; Andreou and Kotsakis 1994b) and Grevena area (Wilkie 1993) and on a small-scale in the Haliakmon valley (Hondroyianni-Metoki 1993; Ziota and Hondroyianni-Metoki 1997) and Kitrini Limni basin (Karametrou-Mentesidi 1986; Fotiadis 1988; 1991; Ziota et al. 1993; Fotiadis and Hondroyianni-Metoki 1997).

A detailed analysis of settlement patterns is beyond the scope of the current work. Here, two points are briefly considered: 1) *the distribution* of prehistoric settlements in the "natural" environment and 2) *the character* of prehistoric settlements in each chronological period.

(1) During the early phases of the Neolithic, the majority of sites were located in the lowlands, preferably near water sources (Andreou et al. 1996: 575). This is the case

particularly in Western Macedonia (except perhaps Grevena), since in Central Macedonia the early phases of the Neolithic are poorly represented. By the end of the sixth millennium, that is the Late Neolithic, settlements seem to expand to a variety of locations, for example, to elevated dry terraces north of the Haliakmon (Andreou et al. 1996: 575).

During the Bronze Age, however, and especially the later phases of that period, "high places" affording wide views tended to be preferred (Andreou et al. 1996: 575). While Early Bronze Age sites seem to occupy previous Neolithic settlements, the Late Bronze Age habitation expansion may suggest a preference for more strategic locations for territorial surveillance, and thus better control and prominence in the broader region (Andreou et al. 1996), or the exploitation of new environmental zones including isolated hills which were previously considered "marginal" (Grammenos et al. 1997: 91). With regard to the Early Iron Age settlements, some continued occupation of settlements of the Late Bronze Age (e.g. Toumba Thessalonikis, Assiros) and others are new sites established on hill tops or upland locations (Andreou and Kotsakis in press b; Koukouli-Chrysanthaki and Vokotopoulou 1993: 129; Grammenos et al. 1997: 91).

(2) The character of settlements in each period has implications for palaeodemography, but the archaeological evidence is very sparse. Parameters needing to be considered in palaeodemographic analysis include: 1) number of sites, 2) overall size of site, 3) longevity of site, 4) typology and habitation density within the settlement (Hassan 1981). Additionally, factors related to soil deposition or erosion and other geomorphological changes can obviously affect the recovery rates of sites and thus the overall population estimations. It is clear, therefore, that any attempt to estimate population sizes from settlement pattern analysis would require much intensive and systematic survey work which for the study area is only sporadically available.

In the *later Neolithic phases*, an increase of population, particularly in Western Macedonia, can possibly be suggested, in line with the overall picture of "Neolithic dispersal" claimed elsewhere (Demoule and Perlès 1993: 399; Halstead 1994: 200; Andreou et al. 1996: 575). In Kitrini Limni, for example, there is a remarkable increase in settlement numbers noted from the Middle Neolithic (5400/5300 BC) onwards (Fotiadis and Hondroyianni-Metoki 1997), while the size of some Late Neolithic sites can be identified as "massive even by Aegean standards" (Andreou et al. 1996: 575).

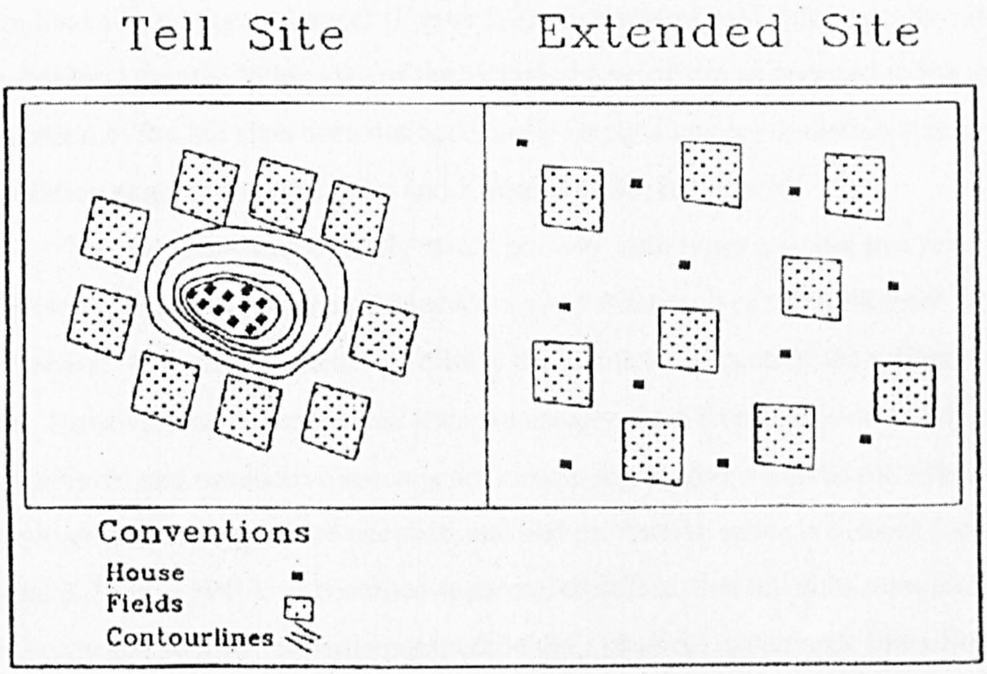

Figure 2.3: Drawing of tell and extended sites (Kotsakis and Andreou 1994: Figure 6)

In Central Macedonia, the evidence of Neolithic habitation is particularly problematic. This area, however, reveals during the late phases of the period, the co-existence of two settlement types which are both well known from the Balkans (McPherron and Srejovic 1988; Chapman 1988; Tringham and Krstic 1990): 1) flat, extended settlements and 2) tells (Andreou and Kotsakis 1986; 1994b; in press b). The former often extended over several hectares and perhaps indicate restricted, widely-spaced habitation closely attached to agricultural land. The latter, by contrast, occupy a restricted area, often less than 1 hectare, and suggest densely nucleated habitation with farm land around the settlement (Figure 2.3). In terms of palaeodemography, it is worth emphasising that the larger size of the extended type of site as opposed to the nucleated habitation of the tell sites does not necessarily imply a larger population size or population aggregation (Andreou and Kotsakis 1986; in press b).

The questions immediately raised are why both types co-exist in a relatively restricted region such as Central Macedonia and what each of the settlement types represents? It is difficult to define clearly the character of each of the settlement types here. However, the flat, extended sites are usually short-lived settlements where occupational and productive space is not clearly segregated, whereas the tell sites are long-lived settlements where occupational and productive space is distinct (Andreou and Kotsakis 1986; 1994b). It becomes apparent, therefore, that tell sites represent continuity and stability of settlement, while their physical appearance identifies them as prominent landmarks in the prehistoric landscape (Chapman 1988; Andreou et al. 1996). It has been suggested that *economic parameters*, particularly the intensification of production implied by the clear distinction between farm land and habitation, together with an *ideological and symbolic content* implied by the prominent appearance of tells, played a major role in the formation of the two settlement types in the restricted area of Central Macedonia (Andreou et al. 1996). As yet, there is no indication of a hierarchical relationship between the two settlement types, with tells predominant in the local regional territory.

The internal organisation of Neolithic settlements is not very clear, but the few excavated sites suggest that overall there is no marked sign of spatial differentiation within settlements which lasted probably until the late phases of the Bronze Age (Andreou et al. 1996). Individual, free-standing buildings, possibly occupied by one nuclear family, seem to have been the basic residential unit in the Neolithic and the early phases of the Bronze Age (Halstead 1994; Andreou et al. 1996), although the recent evidence of megaroid structures in phase II of Makrigialos would suggest the emergence of possible extended families in the Late Neolithic (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press).

With regard to the *Bronze Age*, in Western Macedonia, although sites are numerous through the Late Neolithic and Early Bronze Age, the Late Bronze Age gives evidence of a decrease in site numbers (Kokkinidou and Trandalidou 1991). The Kitrini Limni project, however, together with the Middle Haliakmon valley survey, suggests a decrease in the number of settlements before the Early Bronze Age which cannot yet be interpreted (Fotiadis and Hondroyianni-Metoki 1997; Ziota and Hondroyianni-Metoki 1997). The Middle Haliakmon valley survey, in particular, has provided evidence of an overall decrease of sites in the Early Bronze Age followed by an increase in the later Bronze Age (Ziota and Hondroyianni-Metoki 1997: 34).

In Central Macedonia, there is an overall increase in the number of sites, particularly in the Late Bronze Age, although this is not as marked as in southern Greece and also does not seem to be the case in all subregions (Grammenos et al. 1997; Wardle 1997b). The Langadas basin survey, for example, provides evidence of a dramatic decrease in the mean size of settlements in the Bronze Age without any significant changes in the number of sites (Andreou and Kotsakis in press b).

The prevalent type of settlement is the long-lived, tell site, known from the preceding period and emphasising the nucleated character of habitation. The occupation of tell sites during the Bronze Age may again have been related to the adoption of an intensive agricultural regime. This intensification in agriculture, implied by the existence of distinct, ample farm land in close proximity to settlement, offered more security and perhaps better prospects for further intensification of production (Andreou and Kotsakis in press b). It is worth pointing out again that the nucleated character of tell sites does not suggest any population aggregation. In particular, the Langadas basin survey underlines the total absence of any Bronze Age finds outside the immediate area of the tells, indicating the restricted character of habitation and land use (Andreou and Kotsakis in press b).

In this respect, however, the tell sites of the Late Bronze Age provide evidence suggesting the development of possible hierarchies at the inter-site level (Halstead 1994; Andreou et. al. 1996; Andreou and Kotsakis in press b). Such evidence includes the scale of public works, extent and size of occupation, capacity and centralisation of agricultural storage and internal arrangement of houses, which suggest either primary or secondary positions in a regional hierarchy for certain sites (Andreou and Kotsakis 1986, Halstead 1994; Andreou et al. 1996).

The Late Bronze Age habitation levels of Kastanas (Figures 2.4, 2.5 and 2.6) (Hänsel 1989: 193-336), Assiros (Figures 2.7 and 2.8) (Wardle 1987: 387; 1989: 457-458, 462) and Toumba Thessalonikis (Figure 2.9) (Andreou and Kotsakis 1994a: 218; 1991: 192) give clear evidence of domestic storage and private cooking facilities together with free-standing buildings or complexes of buildings, crossed by a system of streets. Conversely, excavation at Assiros (Figure 2.10) has established the existence during building horizons 9 and 8 of storage facilities covering 75% of the total excavated settlement space, and it has been suggested that this storage was probably communal. Their size and the quantity of produce stored in them far exceed the needs of the presumed inhabitants of the site. A similar complex with extensive storerooms has been uncovered in Toumba Thessalonikis (Figure 2.9) occupying more than half of the excavated area at the top of the mound (Andreou and Kotsakis 1995). It can be assumed that the significance of these storage rooms covers a wider region than the sites themselves. If this assumption is correct, then the sites of Assiros and Toumba Thessalonikis respectively could have been the focal point of a regional settlement network with a hierarchical structure. Besides, in Toumba Thessalonikis and Assiros the construction of massive terraces on the side of the mound, creating a stepped form of settlement, indicates a large-scale communal effort which may point to a centralised social structure. Conversely, the architectural layout of the site of Kastanas, in the Axios valley, with the remarkable absence of both the communal storerooms and the system of terraces found at Assiros and Toumba Thessalonikis, suggests that this site is not the centre of the local regional polity (Andreou et al. 1996: 581). Thus, there is evidence from Late Bronze Age Macedonia, that localised hierarchies had developed at the inter-site level.

There are also indications, albeit scarce, of a possible shift in household size in the Late Bronze Age. The previous assumption of one nuclear family comprising the basic residential unit in the Neolithic and the early phases of the Bronze Age (Figure 2.11) thus tends to give way in the Late Bronze Age to expanded residential units comprising more than one household. Examples of this latter pattern come from the

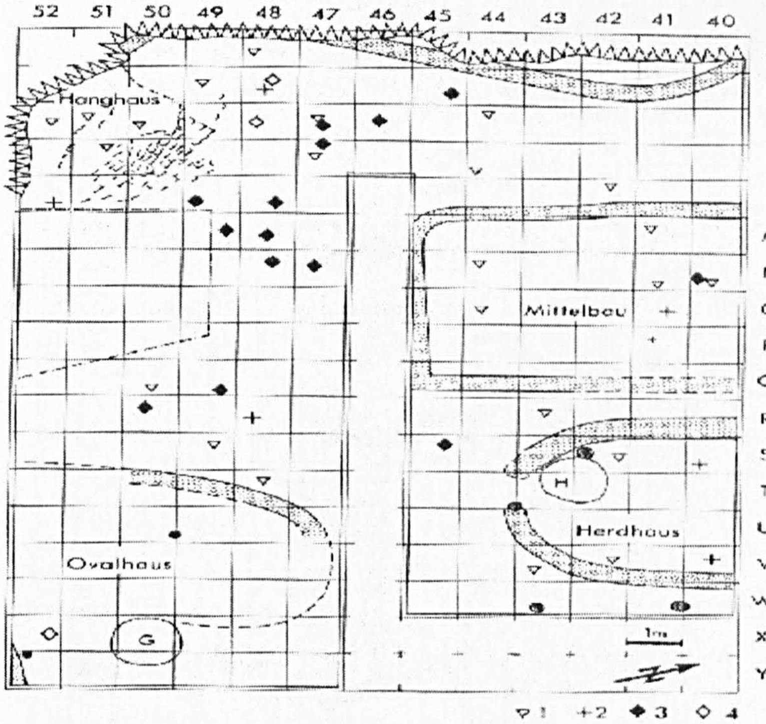

Figure 2.4: Plan of Kastanas phase 17 (LH IIIA) indicating single-room houses (Hansel 1989: Figure 24)

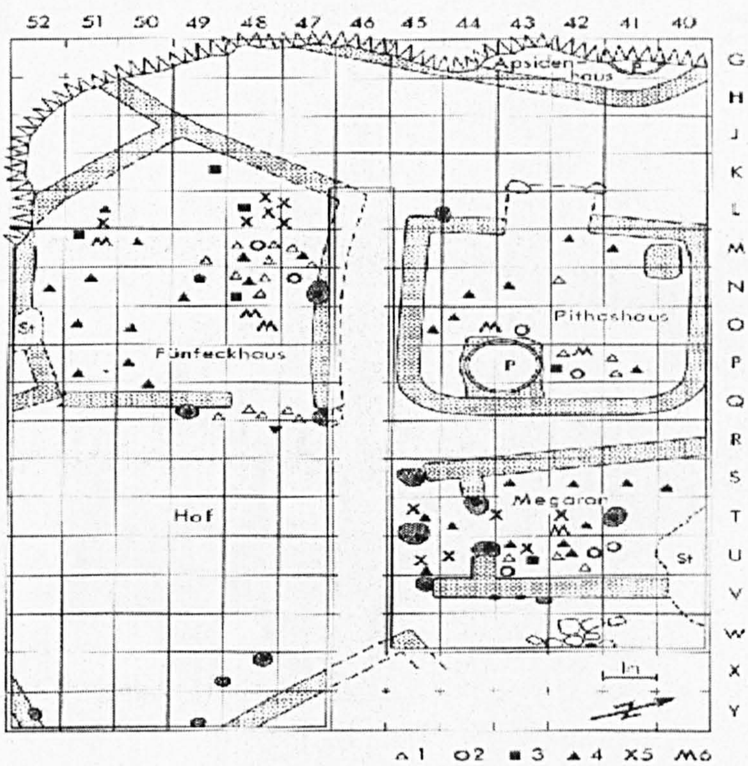

Figure 2.5: Plan of Kastanas phase 16 (LH IIIB) indicating single- and multiple-room houses (Hänsel 1989: Figure 31)

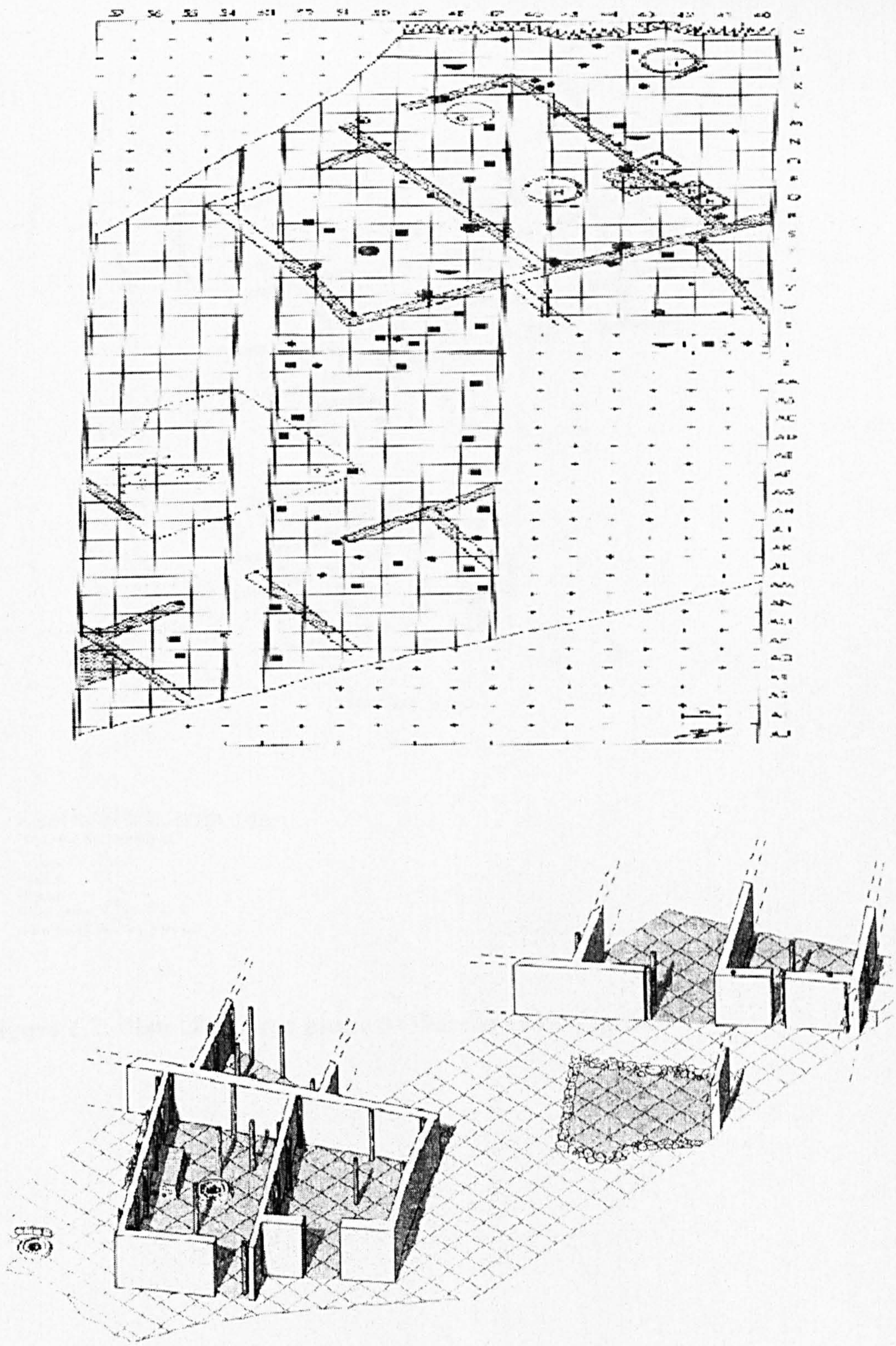

Figure 2.6: (Above) Plan of Kastanas phase 12 (LH IIIC) indicating multiple-room houses (Hänsel 1989: Figure 71).
(Below) Reconstruction of the same phase (Hänsel 1989: Figure 74)

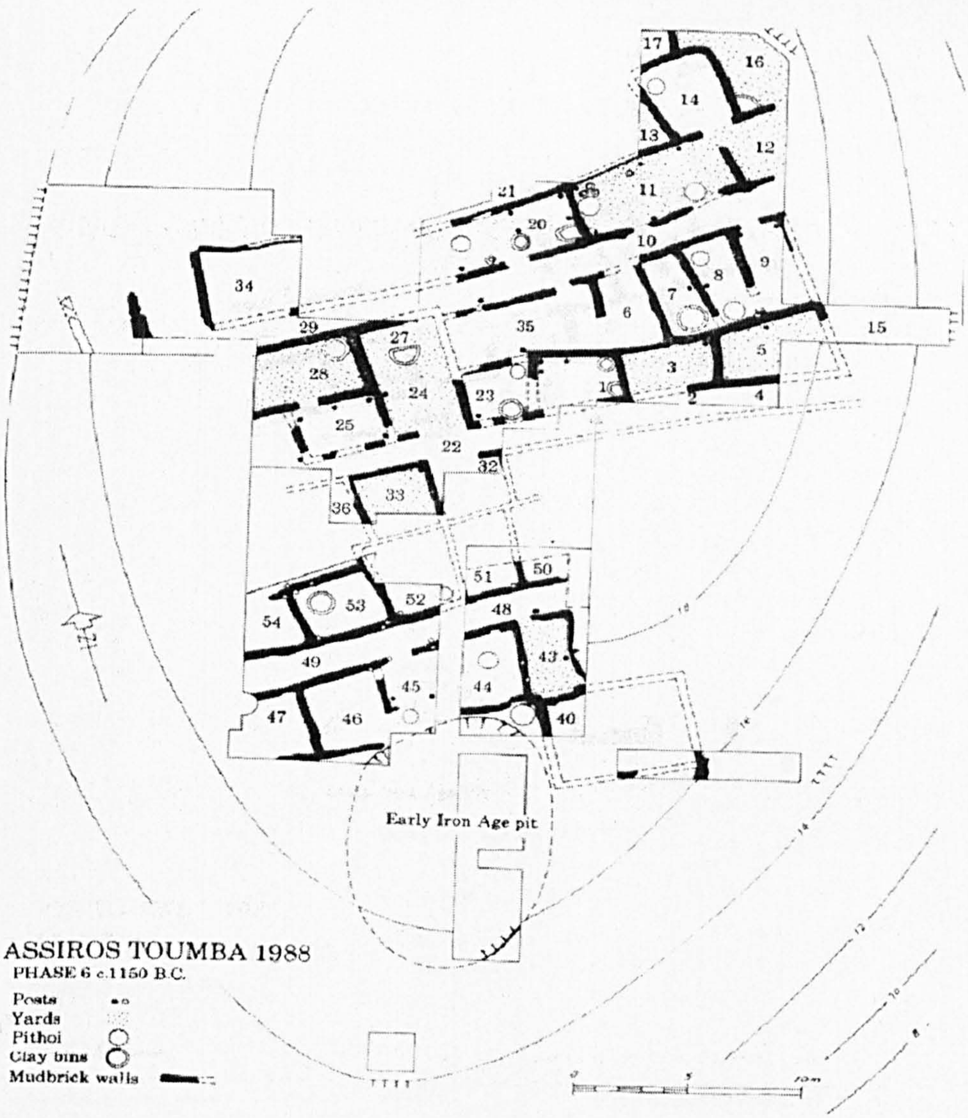

Figure 2.7: Plan of Assiros phase 6 (Wardle 1989: Figure 2)

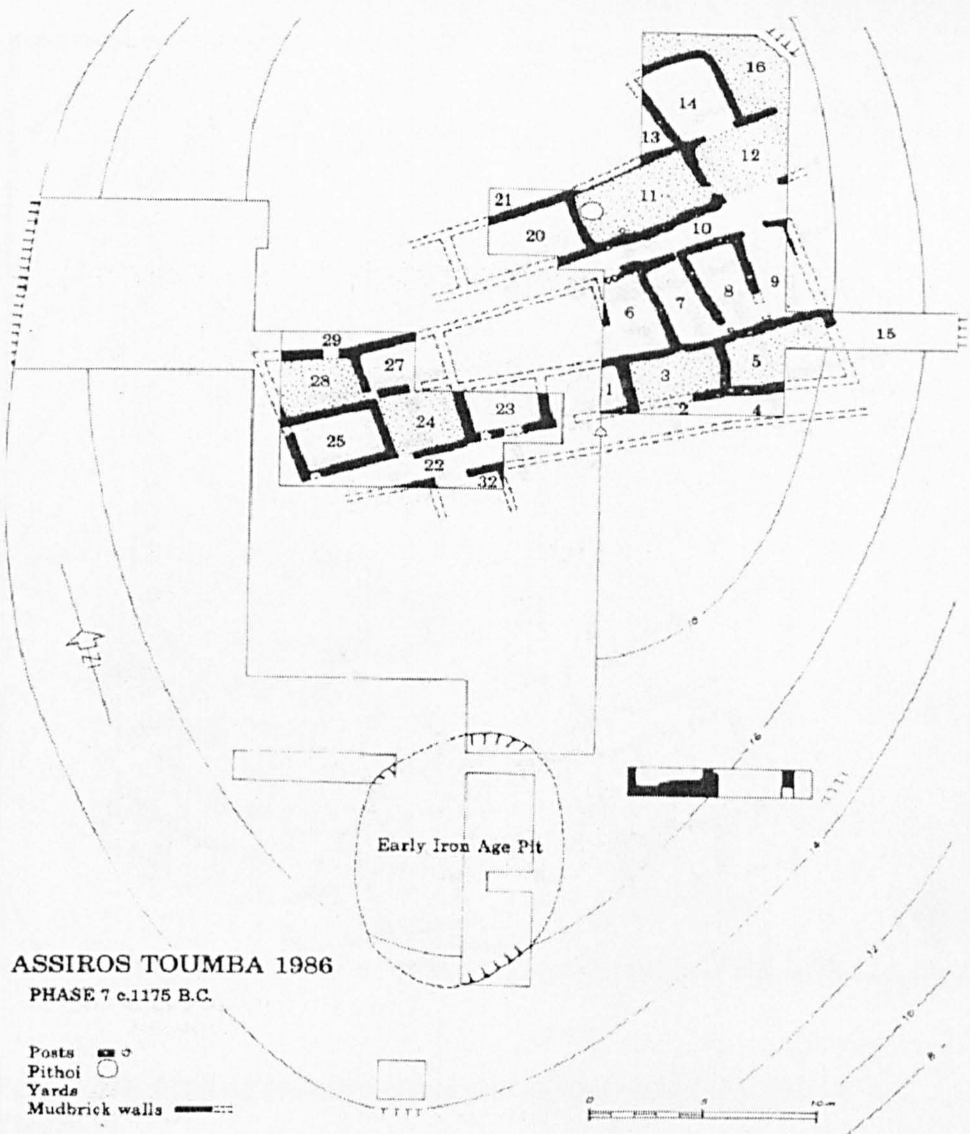

Figure 2.8: Plan of Assiros phase 7 (Wardle 1987: Figure 5)

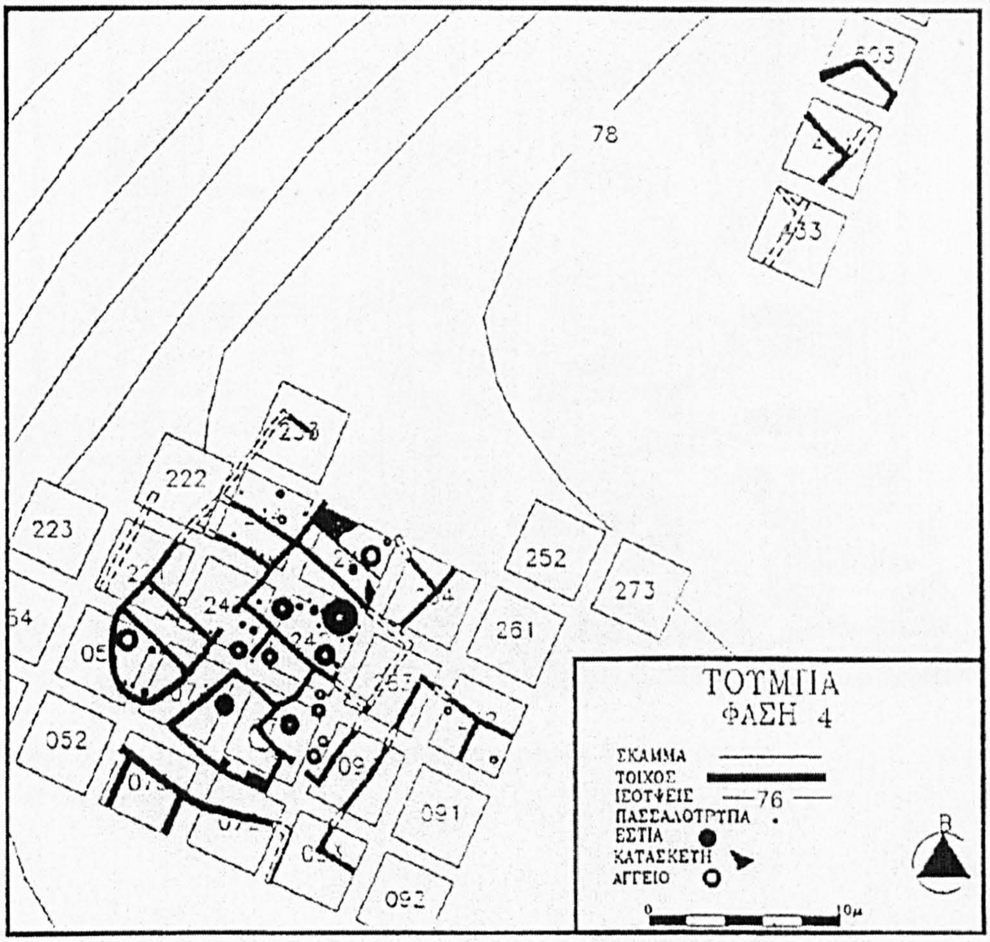

Figure 2.9: Plan of Toumba phase 4 (Andreou and Kotsakis 1994: Figure 7)

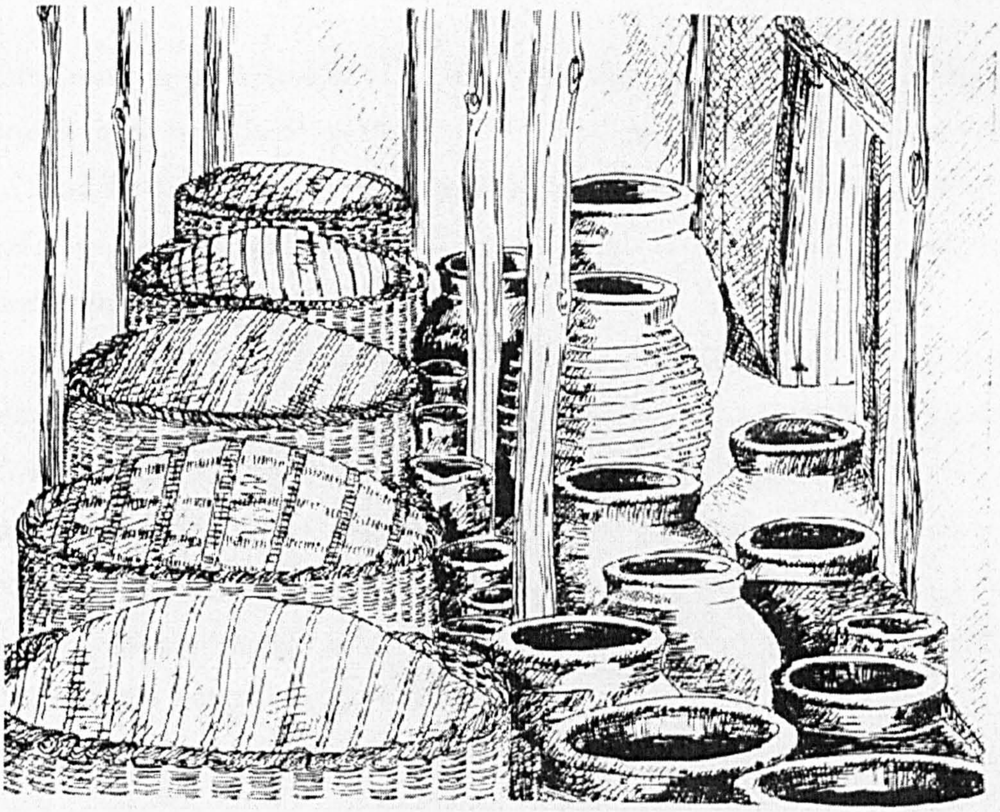

Figure 2.10: Reconstruction of Assiros phase 9 storeroom (Wardle 1986: Figure 8b)

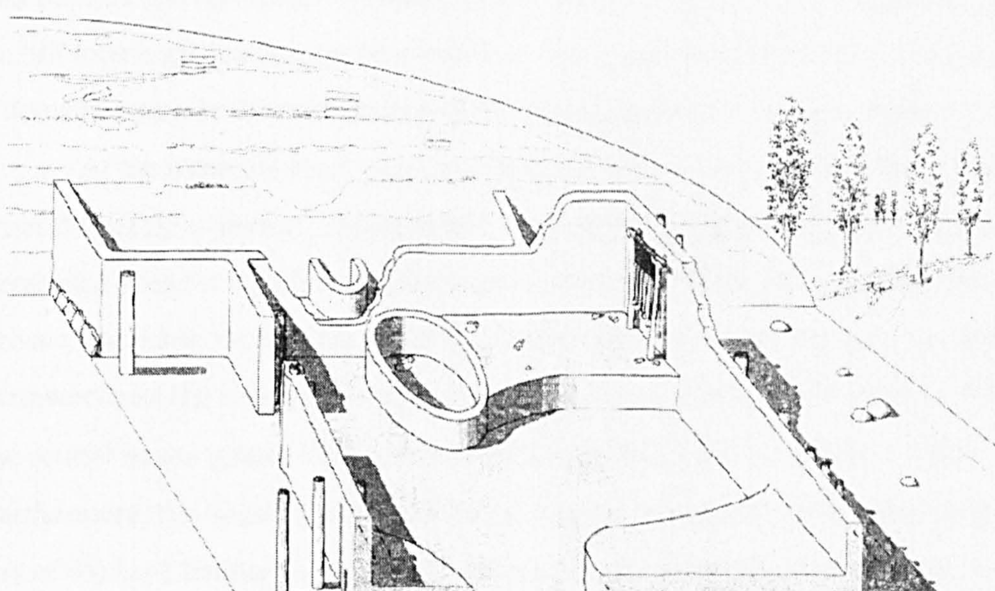

Figure 2.11: Recontruction of Kastanas House A (EBA) (Aslanis 1985: Figure 24)

Late Bronze Age settlements of Kastanas, especially the transitional phase from the Late Bronze to the Early Iron Ages (phases 13, 12) (Figure 2.6), Assiros (phases 7-5) (Figure 2.7) and Toumba Thessalonikis (phase 4) (Figure 2.9), where large complexes of buildings were equipped with multiple cooking and storage facilities possibly serving a large number of occupants.

Finally, the evidence of *Early Iron Age* settlement patterns is extremely poor and comes only from Central Macedonia. There is an overall increase in site numbers (Grammenos et al. 1997: 91; Andreou and Kotsakis in press b) which, in the Langadas basin, is consistent with a significant demographic rise. It is interesting to note that, although there is an increase in site numbers, the mean size of settlement is under 1 hectare, which again does not constitute a strong indication of population aggregation (Andreou and Kotsakis in press b).

Furthermore, a new type of settlement emerges in Early Iron Age, the "table" which is often associated with a previous Late Bronze Age tell site. These "tables" develop at the base of the Late Bronze Age tells, e.g. at Axiochori and Toumba Thessalonikis, suggesting that the area available on top of the Bronze Age settlement had become too restricted (Wardle 1997b). Besides, new sites also appear as small tells on hill tops implying the use of previously "marginal" environmental zones and possibly a diversification in the exploitation of the landscape (Andreou and Kotsakis in press b).

At the intra-site level, the Early Iron Age does not reveal dramatic differences from the previous period. Nevertheless, there is some slight evidence from the excavated sites for a shift from previously "communal buildings" to structures of a private character, such as the house founded on the earlier Late Bronze Age public earthworks on the slopes of Toumba Thessalonikis (Andreou and Kotsakis 1991) and the central house (phase 10) on the top of the Kastanas tell site (Hänsel 1989). Furthermore, the large storage facilities in Assiros decreased in size significantly by the end of the Late Bronze Age onwards so that the characteristics of a regional local centre were replaced by those of individual households (Wardle 1989).

2.5.2. SUBSISTENCE

The systematic collection of archaeobotanical and archaeozoological data, requiring the use of flotation and sieving, has developed only in the last fifteen years. Therefore, the scarce evidence for the dietary components and subsistence of the prehistoric inhabitants of Central and Western Macedonia has been provided primarily by individual site reports (Halstead and Jones 1980; Kroll 1983; 1984; Becker 1986; Jones et al. 1986) or synthetic studies of agriculture and stock rearing in Greece (Halstead 1981; 1987; 1989a; 1990a; 1992; Hansen 1988; Jones 1987; 1992; Payne 1985).

Thus, for the *Neolithic*, the archaeobotanical data of the study region show a predominance of domestic seed crops and, it is suggested, "dependence for the bulk of dietary energy requirements on arable farming" (Halstead 1994: 200). Neolithic grain crops included einkorn (EN Nea Nikomedeia, MN Servia), emmer (EN Nea Nikomedeia), hulled and naked barley (EN Nea Nikomedeia, LN Olynthos), common millet (LN Olynthos), lentil (EN Nea Nikomedeia, MN Servia), grass pea (MN Servia) and bitter vetch (MN Servia), while spelt (LBA Assiros) may not have been cultivated until the Bronze Age (Halstead 1994: table 7.1). The relatively balanced combination of cereals and pulses indicates a marked diversification as opposed to the highly specialised production in present-day Greece (Halstead 1992).

The archaeozoological evidence for the same period indicates a predominance of sheep, although goat, cow and pig were all present from the beginning of settled village life in the Early Neolithic. It has been proposed that the high prevalence of sheep rather than of cattle, goats, or pigs meant that little use was made of the extensive woodland and so perhaps suggests that stock were few in number, largely restricted to the agricultural land (Halstead 1987: 74, 81). In later Neolithic assemblages, however, a more balanced mixture of sheep, goats, cattle and pigs is evidenced. The latter may reflect the expansion of stock rearing beyond the arable sector by farmers "colonising parts of the landscape more marginal for annual crops" (Halstead 1994: 202), as already suggested in an earlier section of this chapter.

Wild species such as deer, boar, aurochs, fox, hare, beaver, birds and fish occur in Late Neolithic sites but are always rare (Demoule and Perlès 1993: 361). It is of particular importance that Neolithic assemblages from extensive Late Neolithic sites such as Vasilika C and Thermi in Central Macedonia are also dominated by domesticates (Grammenos 1991; Yannouli 1990; 1994). Furthermore, it has been argued as much on ecological as on archaeozoological grounds that fishing was only moderately exploited even at coastal sites (Gallant 1985; Garnsey 1999 cf. Bintliff 1977).

During the *Bronze Age*, evidence from Kastanas, offering the best example of published bioarchaeological analysis, suggests a highly diversified subsistence system during the Early Bronze Age which was succeeded in the Late Bronze Age by a more specialised and extensive system of agriculture and stock-raising. The end of the Bronze Age was marked by the adoption of a more balanced regime, namely, intensive small-scale cultivation of a wide variety of crops and a new interest in gathering, and especially hunting (Becker 1986: 291; Andreou et al. 1996: 580). Fallow, red and roe deer are well represented in Neolithic and Bronze Age Macedonia and their more frequent occurrence in Bronze Age assemblages has variously been attributed to progressive woodland clearance, to the introduction of the horse (making the capture and transport of game easier) and to the growth of hunting as an aristocratic sport (Halstead 1987: 74).

Further diversity with regard to plant products consumed was provided by the introduction of fruits (fig, pear, strawberry, olive and grape) and nuts (walnut, chestnut, shelled acorn). Palynological evidence from Western Macedonia, already described above, indicates the occurrence of the walnut and chestnut in Northern Greece as cultivated trees from the second millennium BC (Bottema 1982). Besides, grape pips both from Late Bronze Age Kastanas (Kroll 1983: 67) and Toumba Thessalonikis (Andreou and Kotsakis 1997: 374) may represent wine-pressing waste. Also, by the end of the period, it is of particular interest that millet was an important dietary element for inhabitants of Assiros and Kastanas (Halstead and Jones 1980; Kroll 1983; Jones et al. 1986).

The analysis of the archaeobotanical data from Late Bronze Age Assiros in Central Macedonia has shed light on *the scale of cultivation.* The annual crops recovered were associated with weed species characteristic of modern gardens as well as modern fields (Jones 1992). Comparative data are not available either from neighbouring sites or from prehistoric Greece as a whole but such a mixture of field-and garden-weeds is paralleled in Neolithic central Europe and has been seen as indicating small-scale, intensive crop husbandry. Moreover, Assiros provides evidence for local redistribution of staple grains (Halstead 1994: 209). The range of grain crops stored is impressive, but there is a distinct concentration on cereals, with a special emphasis on einkorn, which combines low risk of failure in the field with a relatively long storage life (Halstead 1992). Storage at Assiros, therefore, may not represent a centrally collected surplus in order to serve a large aggregation of craft specialists or elite retainers as in the southern Greek palaces. Instead, it seems possible that the Assiros stores were a secure reservoir against unpredictable bad years and contained the surplus "banked" by numerous small-scale producers (Halstead 1992; 1994).

At the same time, cut marks on bones show that most animals, domestic and wild were eaten, while high levels of mortality between six months and three years of age suggest that management of livestock follow a "meat production model", although this does not exclude the use of animals for their secondary products (milk, wool, etc.) (Halstead 1987: 77). Moreover, during the Bronze Age, possible increased costs of animal husbandry and a suggested shift from small-scale herding by individual households to the collective herding of large flocks may be consistent with the nucleated type of settlements represented by the tell sites (Halstead 1987: 82).

The *Early Iron Age* evidence comes primarily from the site of Kastanas. Agricultural products include domestic seed crops such as hulled barley, emmer, einkorn, bitter vetch, lentil, grass pea, bean and pea, with an emphasis on millet, while cultivated grapes and figs are supplemented by fruits gathered in the fields and the woods (Kroll 1983). Wild animals, on the other hand, make up a high proportion of the animal bone assemblage, particularly during the transitional period from the Late Bronze to Early Iron Age. Apart from fallow, red deer and wild boar, large predatory animals like bear, lynx, lion and wolf occur. The mortality curves associate pig inevitably with "meat consumption" while sheep were also kept for their wool (Becker 1986).

2.5.3. SOCIAL ORGANISATION

Evidence for social organisation in the study region is very limited and, for the Neolithic and Early Bronze Ages, is almost non-existent. Moreover, because in no case has a settlement been excavated together with its associated burial ground, it is not possible to explore social issues in the sphere of both the living and the deceased.

For both the *Neolithic* and *Early Bronze Ages* in Central and Western Macedonia, it is widely assumed that society was essentially egalitarian with the basic unit of production and consumption being the family household based on the nuclear family, as suggested by the scarce architectural remains of individual free-standing houses. On the other hand, there are indications, particularly from the Late Neolithic onwards, of the mobilisation of materials and ideas at a broader level beyond the confines of the local community.

Thus, at the inter-site level, the occurrence of Melian obsidian at Megalo Nisi Galanis in Kitrini Limni, Makrigialos and Servia and of Carpathian obsidian at Mandalo (Kilikoglou et al. 1996; Pilali-Papasteriou and Papaefthimiou-Papanthimou 1997), the widespread exchange of fine, painted pottery including Classical Dimini types (e.g. Servia, Makrigialos, Megalo Nisi Galanis in Kitrini Limni), the implications for craft specialisation of certain pottery shapes and types (Kalogirou 1994), and the introduction of metal work (e.g. Makrigialos, Mandalo) involving use of copper, lead and sporadically gold (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press), are all consistent with the development of long-distance exchange networks extending beyond Central and Western Macedonia to Thessaly, the Aegean islands and the Balkans.

At the intra-site level, however, the indications of such a shift are less obvious. The emergence of buildings with multiple rooms possibly holding an extended family, such as megaroid structures in the "classical Dimini" phase of Makrigialos (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press), the occurrence of collective large-scale works, such as the ditches surrounding both phases of Makrigialos and the stone wall partly ringing Mandalo (Pilali-Papasteriou et al. 1986; Papaefthimiou-Papanthimou and Pilali-Papasteriou 1988; 1989; 1990; 1991; 1993; Pilali-Papasteriou and Papaefthimiou-Papanthimou 1989), emphasise community solidarity, while the organisation of distinct burial grounds (e.g. EBA Makrigialos, EBA Ayios Mamas and EBA Goules and Koilada in Central and Western Macedonia) perhaps implies the development at the end of the Neolithic and in the Early Bronze Age of more complex rules to determine social integrity.

By the end of the *Bronze Age*, the organisation of society becomes clearer, at least for Central Macedonia. Developing regional hierarchies and the possible shift in the household unit from nuclear families to larger groups have already been mentioned. These changes may have been accompanied by a tendency to specialisation and extensification in the exploitation of agricultural and animal products.

Additionally, it is worth emphasising the expansion of exchange networks with the southern Greek mainland, as seen particularly in the use of southern styles of pottery. Thus, "Mycenaean pottery" appeared in the settlement deposits of Toumba

Thessalonikis (phases 5-3), Assiros (phases 9-6), Kastanas (phases 18-13), the broader area of the Middle Haliakmon valley (Ziota and Hondroyianni-Metoki 1997) and in the grave deposits of the mount Olympus cemeteries (e.g. Spathes and Treis Elies), Korinos and Aiani. It may not be accidental that a notable proportion of the sites yielding Mycenaean pottery, including those of Aiani, the Middle Haliakmon valley and Mt Olympus, are located on major routes to Thessaly (Ziota and Hondroyianni-Metoki 1997; Andreou et al. 1996). It is also important to note that the earliest evidence of southern contacts through pottery comes from two coastal sites in the Chalkidiki peninsula, namely Torone (Cambitoglou and Papadopoulos 1993) and Ayios Mamas (Hänsel 1997; 1998). The "Mycenaean" type features recovered in the study region also include other artefacts, such as weaponry and jewellery, often found within grave contexts (e.g. the mount Olympus prehistoric cemeteries and Aiani).

Moreover, in the Late Bronze Age/Early Iron Age, the "Macedonian" style of hand-made, matt-painted pottery gradually spread in Western and Central Macedonia, for example in the grave deposits of Aiani and the settlement deposits of Toumba Thessalonikis (phases 7-4), Kastanas (phases 19-13) and Assiros (phases 9-6) (Wardle 1993; 1997a). Finally, during the same period, very strong links with the broader area of the Balkans and Central Europe are suggested by metal finds, such as bronze and copper ornaments and weaponry recovered in Early Iron Age grave deposits (Wardle 1997b).

The occurrence of "Mycenaean" evidence in the Late Bronze Age plays a key role in a broader discussion of the social transformations at this time in the study region. In particular, sites with evidence of "Mycenaean" influence have often been perceived as "Mycenaean colonies" rather than "indigenous foci" of local social transformation (for discussion see Kilian 1990a; Wardle 1993; Andreou and Kotsakis in press a; Halstead 1994). Thus, the coastal settlements of Ayios Mamas and Torone have been regarded as the primary nuclei for expansive diffusion. The term "community colony" has been suggested for this type of settlement which maintained continuous contact with the central zones (Kilian 1990a: 455). It remains an open question, however, whether these settlements were "Mycenaean colonies" or Macedonian settlements with abundant local production as well as imports (Wardle 1993: 120).

The restricted character of "Mycenaean" items in the Late Bronze Age deposits may suggest that they held special roles in the local community or among the people who owned or used them (Andreou and Kotsakis in press a; Halstead 1994). For example, "Mycenean pottery" in Toumba Thessalonikis is associated almost exclusively with eating and drinking (Kiriatzi et. al. 1997). It has been proposed, therefore, that the production, acquisition and consumption of "Mycenaean" pottery in Toumba Thessalonikis was associated with social roles such as gender and kin relationships. Thus "Mycenaean pottery" appears to have played a key role in the organisation and re-negotiation of social boundaries and identities" (Kiriatzi et al. 1997).

During the Late Bronze Age, therefore, there is a broad range of evidence, such as the local hierarchies at the inter-site level, the shift in residential units to include more than one household, exchange networks with the southern mainland and neighbouring areas, which suggests a perceptible change in social organisation. The emerging stability of the preceding periods seems to be replaced by a fluidity in the definition of new social roles, identities and perhaps a "new order" in the Late Bronze Age communities. It is a matter of further archaeological research and systematic survey work to specify the character and the extent of this "new order", and also to link it with the aggregated population centres which emerged in the following period, the Early Iron Age.

CHAPTER 3: HISTORICAL, CHRONOLOGICAL, ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXT OF THE STUDY CEMETERIES

3.1. HISTORICAL CONTEXT

As described in Chapter 2, most of the projects undertaken in the study area focus on settlement sites. Recording of prehistoric cemeteries or isolated prehistoric burials is very limited, and the evidence is particularly scarce for the Neolithic and Early Bronze Ages. Published evidence of prehistoric burial activity in the study area was largely restricted until the beginning of the 1980's to Early Neolithic Nea Nikomedeia and the Early Iron Age Vergina tumuli (Table 3.1, Figure 3.1).

During the mid/late 1980's, a great increase took place in the recovery of prehistoric burials in the study area. The majority of the newly found cemeteries or isolated burials come from rescue excavations conducted by the Archaeological Service, so that the recording of the former results from the expansion of the latter. Systematic surveys, particularly in Western Macedonia, have also contributed to the discovery of prehistoric burial grounds. Nevertheless, it is worth emphasising that most of the newly recovered cases date from the Late Bronze and Early Iron Ages, so that, until very recently, the evidence for Neolithic and Early Bronze Age burial activities was either very poor or non-existent. It is only in the last five years that the latter periods have produced some burial assemblages, such as those from LN Makrigialos in Central Macedonia (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press), EBA Ayios Mamas (Pappa 1992; Triantaphyllou pers. investigation) and Sykia (Assouchidou et al. in press) in Chalkidiki, EBA Goules (Ziota and Hondroyianni-Metoki 1997) and Koilada in Western Macedonia (Ziota 1996a; 1996b; 1998a; 1998b; in press).

With regard to prehistoric burial grounds in the study area, four points should be noted:

1. Except for EBA Koilada, in Western Macedonia, none of the cemeteries reported in Table 3.1 has been totally excavated. Moreover, the excavation of EBA Koilada has only recently been completed (October 1998), so that the final results have not been included in the current study.
2. The rescue character of the excavations creates certain problems and limitations for the study of the prehistoric cemeteries. Due to partial excavation, it is not known what part of the original cemetery is represented and as a result, it is not possible to

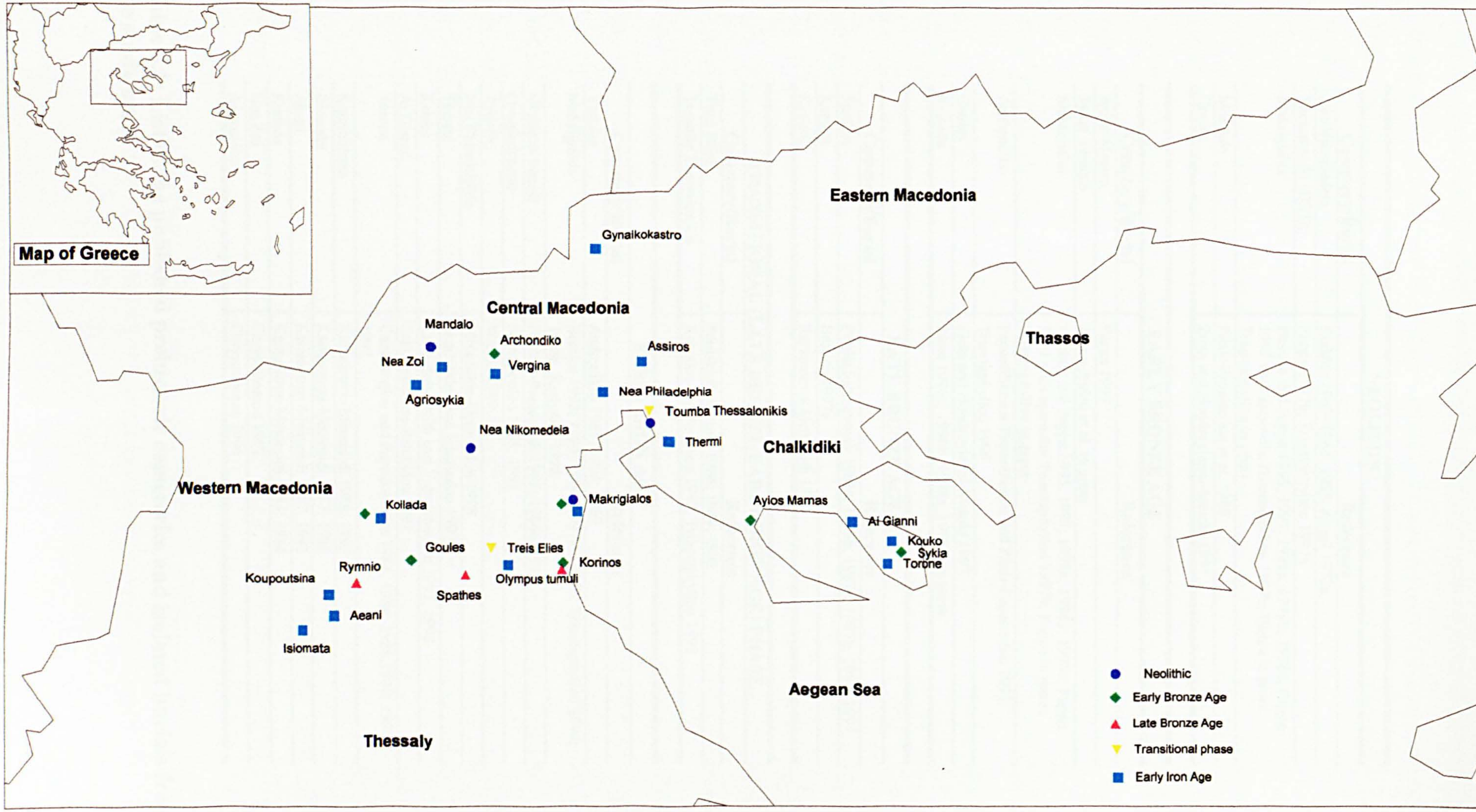

Figure 3.1 Map of the published and excavated prehistoric cemeteries in the case study area

NEOLITHIC

Cemetery/Burial	Reference
Nea Nikomedeia	Rodden 1962; 1964; 1965; Angel 1973a
Thessaloniki (DETh)	Pappa 1997b; Triantaphyllou 1997a
Makrigialos	Bessios and Pappa 1995; 1997; 1998a; 1998b; 1998c; Pappa 1997 with appendix Triantaphyllou 1997b; Pappa in press; Triantaphyllou in press
Mandalo	Pilali-Papasteriou et al. 1986
Goules	Ziota and Hondroyianni-Metoki 1997

EARLY BRONZE AGE

Cemetery/Burial	Reference
Ayios Mamas	Pappa 1995
Sykia tumulus	Assouchidou et al. in press
Makrigialos	Bessios and Pappa 1995; 1997; 1998a; 1998b; 1998c; Pappa 1997 with appendix Triantaphyllou 1997b; Pappa in press; Triantaphyllou in press
Archondiko	Papaefthimiou-Papanthimou and Pilali-Papasteriou 1997; Triantaphyllou 1996
Goules	Ziota and Hondroyianni-Metoki 1997
Koilada	Ziota 1996a; 1996b; 1998a; 1998b; in press

LATE BRONZE AGE

Cemetery/Burial	Reference
Spathes	Poulaki-Pantermali 1986a; 1986b; 1987a; 1987b; 1990; 1991
Korinos	Bessios 1997a
Rymnio	Karametrou-Mentesidi 1990

TRANSITIONAL (LATE BRONZE/EARLY IRON AGE) PHASE

Cemetery/Burial	Reference
Treis Elies	Poulaki-Panternali 1988; 1989; 1992
Toumba Thessalonikis	Kotsakis and Andreou 1997; Triantaphyllou 1993

EARLY IRON AGE

Cemetery/Burial	Reference
Vergina	Andronikos 1961; 1964; 1969
Makrigialos	Bessios 1992; 1993; 1994; 1997a; 1997b; Triantaphyllou 1994; 1998b, Karliabas 1998
Olympus tumuli	Poulaki-Pantermali 1985; 1986a; 1990
Gynaikokastro	Savvopoulou 1988; 1991
Assiros	Wardle 1989
Nea Philadelphia	Misailidou-Despotidou 1998
Thermi	Skarlatidou and Ignatiadou 1997
Kouko	Carington-Smith and Vokotopoulou 1991; 1992
Ai Gianni	Trakasopoulou-Salakidou 1991
Torone	Cambitoglou and Papadopoulos 1981; 1984; 1988;1990; 1991; 1992
Koupoutsina	Karametrou-Mentesidi 1988; 1992
Isiomata	Karametrou-Mentesidi 1987; 1988
Aeani	Karametrou-Mentesidi 1987; 1992
Koilada	Karametrou-Mentesidi 1983; 1984
Nea Zoi	Chrysostomou 1997
Agriosykia	Chrysostomou 1994

Table 3.1: List of the published prehistoric cemeteries and isolated burials from the study area

estimate the population size initially disposed of in a particular burial ground.

3. With the exception of the Neolithic assemblages, no cemetery is associated with a settlement site. Thus, no further analysis can be conducted of any potential relationships between habitation and mortuary areas.
4. Whereas Neolithic and Bronze Age assemblages are always confined to burial grounds used only in prehistory, most of the Early Iron Age cemeteries form part of larger cemeteries which continued in use into historical times. The latter suggests the use and re-use of the space throughout antiquity and especially from the Early Iron Age onwards.

3.2. Chronological Definition of the Study Cemeteries

The chronological phases to which the study cemeteries are attributed refer only to relative chronology. Thus, the typology of artefacts and, in particular, of the associated ceramics has primarily contributed to the archaeological chronology of, for example, the Late Bronze and Early Iron Age cemetery populations. In some cases, however, such as the Neolithic and Early Bronze Age assemblages, there is not enough secure evidence from associated grave goods for chronological definition. In these circumstances, other factors such as stratigraphy and the association of the recovered burials with securely dated archaeological contexts have been used by the excavators to define provisional dates, such as at LN Makrigialos, EBA Goules and EBA Koilada.

With regard to LN Makrigialos in particular, three human bone samples from the organised cemetery in close proximity to the site have been dated in the Arizona Laboratory by Accelerator Mass Spectrometry (Gillespie 1986; Hedges and van Klinken 1992). This burial assemblage, which post-dates the phase I Ditch A was initially considered to be associated with the phase II habitation area on the indirect evidence of its close proximity to the phase II rubbish pit of sector Ξ (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997 with appendix Triantaphyllou 1997a; Pappa in press; Triantaphyllou in press). The AMS dates (Table 3.2), however, assign it to the early/middle Early Bronze Age.

The lack of absolute dating of the case study cemeteries and burials is a serious obstacle to further analysis of both mortuary behaviour and bioarchaeological issues:

1. There is not a single case where the *time limits for the use of a cemetery* have been defined in terms more narrow than attribution to a particular archaeological period. Consequently, it is not possible to establish demographic features such as the total size of the living population or the number of generations, possible family or kin groups, according to the total number of the recovered individuals drawn from certain skeletal assemblages.

Lab no	Excavation no	Radiocarbon age (BP)
AA 32676	28	4,205 ± 70
AA 32677	30	4,275 ± 75
AA 32678	33	4,115 ± 70

Table 3.2: AMS dates from the Early Bronze Age cemetery of Makrigialos

2. It is uncertain whether variations observed at the intra-cemetery level are due to *different mortuary behaviour or chronological variation.* Thus, variability in burial practices and manipulation of the deceased within the study cemeteries may reflect the use of a particular burial ground through different chronological subphases.

3.3. Environmental Background of the Case Study Cemeteries

As has already been emphasised in Chapter 2, the prehistoric environment of the case study cemeteries has undergone radical transformations. Divergence of the prehistoric landscape from the present-day situation may be noted for three regions:

1. The shoreline of the gulf of Thessaloniki, because of alluviation and fluctuations in sea level, has changed significantly (Figure 3.2). This change has clearly affected the proximity of certain sites, such as EN Nea Nikomedeia, EBA/LBA Korinos and LN and EIA Makrigialos, to the coastline. It is possible that, with the exception of EIA Makrigialos, the rest of the sites were closer to the coast than their present-day location (Struck 1908; Bintliff 1976; Schulz 1989; Georgas and Perissoratis 1992). EN Nea Nikomedeia, in particular, was grounded on a marshy area located either on

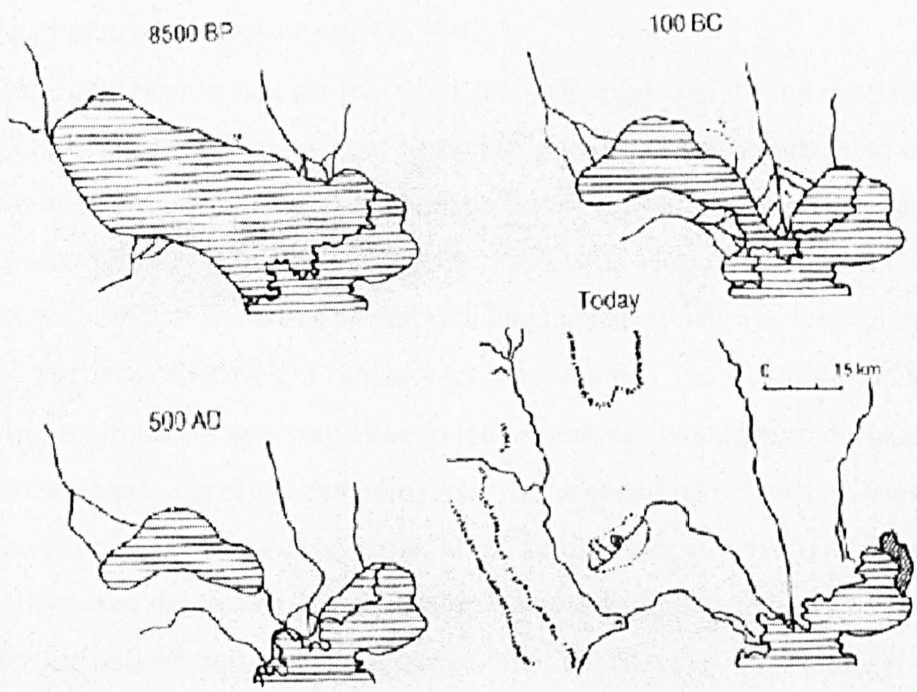

Figure 3.2: Map indicating changes of the shoreline of the gulf of Thessaloniki from 8500 BP to today (Georgas and Perissoratis 1992: Figure 13.4)

or near to the coast (Rodden 1964; Bintliff 1976). Conversely, the Early Iron Age settlement of Makrigialos, which probably corresponds to the cemetery of the same name, was on the coast and has been eroded by the sea (Figure 3.3) (Bessios 1997b).

2. The Early Bronze Age cemetery of Goules in the middle Haliakmon valley is currently under water (Hondroyianni-Metoki 1993; Ziota and Hondroyianni-Metoki 1997). The landscape along the middle Haliakmon has changed dramatically since the 1970's with the damming of the river and the construction of the large artificial lake of Polyfitos (Figure 3.4). The Goules cemetery was only recovered after the level of this lake was lowered in 1993.
3. The Early Bronze Age cemetery of Koilada is located in the upland basin of Kitrini Limni, near the modern city of Kozani (Figure 3.5). The broader area of Kitrini Limni has been the focus of systematic survey, including preliminary work on geomorphology (Fotiadis 1988; 1991; Ziota et al. 1993; Fotiadis and Hondroyianni-Metoki 1997). The area was part of a large marsh which was drained in the 1950's by the Greek Electricity Company for strip mining. The Neolithic and Early Bronze Age environment was very close to the present-day picture with the exception of the dense forest of conifers extending over the surrounding uplands. In about 1200 BC, there was increasing deforestation of the surrounding mountains and thus "soil erosion and deposition of large quantities of sediments together with a blockage of surface outlets" resulted in the formation of the lake of Kitrini Limni (Fotiadis 1988; Ziota et al. 1993; Andreou et al. 1996). The formation of the lake, however, was preceded by the gradual development of a marshy area. The chronology of this episode, its extent and its causes cannot be precisely defined. It is not possible, therefore, to define whether the area currently occupied by the EBA settlement associated with the cemetery was on dry or marshy land. It is highly probable, however, that the EBA settlement was in close proximity to the marshy area extending towards the lowest level of the basin.

In terms of environmental setting, therefore, the case study cemeteries can be assigned to four broad units: (1) *the coastal zone* including LN and EIA Makrigialos, EBA/LBA Korinos and probably EN Nea Nikomedeia, (2) *the lowlands* represented solely by the EIA Olympus tumuli, (3) *the high mountainous zone*, including LBA Spathes and LBA/EIA Treis Elies and (4) *the uplands* represented by the EBA

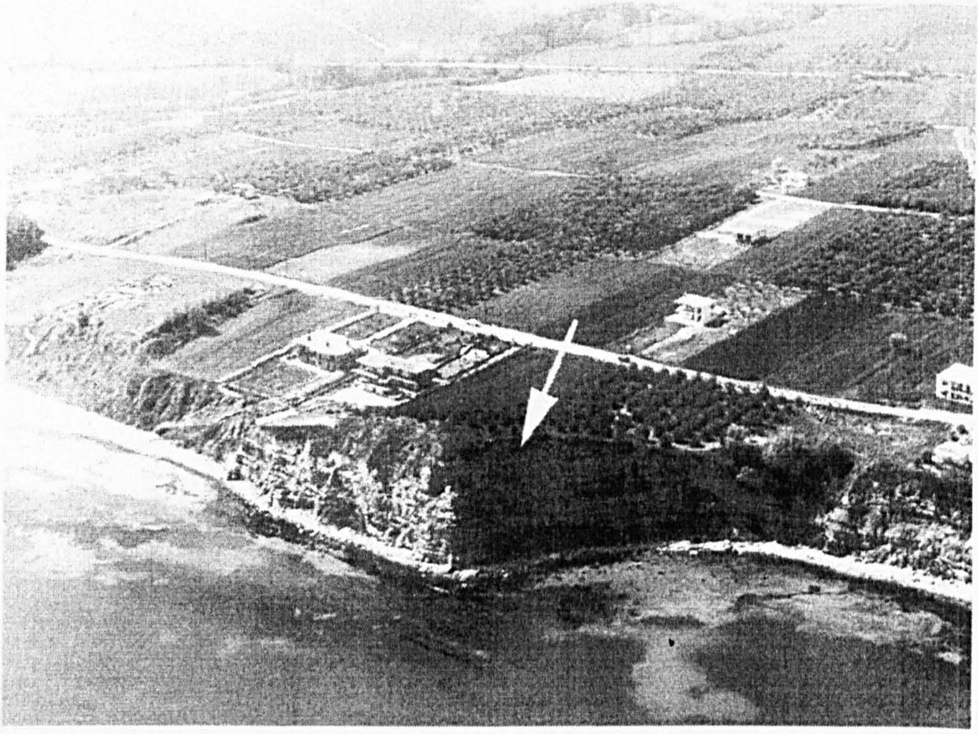

Figure 3.3: The Early Iron Age Makrigialos settlement indicating erosion activity (Bessios and Pappa 1995: Figure 7)

Figure 3.4: The artificial lake of Polyfitos (Hondroyianni-Metoki archives)

Figure 3.5: The Early Bronze Age Koilada cemetery showing in the background the modern factory of the Greek Electricity Company

cemeteries of Goules and Koilada, located in the middle Haliakmon valley and the upland basin of Kitrini Limni respectively.

3.4. ARCHAEOLOGICAL BACKGROUND

The overall scarcity of prehistoric cemetery populations from the study region has already been underlined. Evidence from the Neolithic and Early Bronze Ages, in particular, is very scanty, while that from the Late Bronze and, especially, Early Iron Ages increases markedly.

3.4.1. NEOLITHIC ASSEMBLAGES

The evidence from the Neolithic indicates a diversity in the manipulation of the deceased (Table 3.3) (Triantaphyllou 1997b; in press). Two types of mortuary treatment can be distinguished:

1) *Burials within the settlement* are most common. This category includes all the excavated Neolithic burials from the study region (*Nea Nikomedeia*: Rodden 1962; 1964; 1965; Angel 1973a, *Mandalo*: Pilali-Papasteriou et al. 1986, *Thessaloniki*: Pappa 1997b; Triantaphyllou 1997a, *Makrigialos*: Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997 with appendix Triantaphyllou 1997b; Pappa in press; Triantaphyllou in press). The deceased were usually inhumed in a contracted position in simple pit-graves with minimal grave goods, consisting of the occasional single handmade pot. They are all single burials with the sole exception of a double burial from Nea Nikomedeia, popularly known as the "mother with the child" (Rodden 1962; Gallis 1996). In a few cases, however, such as Thessaloniki and Makrigialos, the deceased were disposed of as primary burials in refuse pits without any particular care.
2) *Disarticulated bones* within the settlement deposits (*Nea Nikomedeia*: Angel 1973a and *Makrigialos*: Triantaphyllou 1997b; in press, *Vasilika, Thermi and E. Macedonia*: Yannouli 1994). This category is complex and has not attracted much attention from researchers. It is notable that the occurrence of disarticulated bones, often showing cut marks, is common in the deposits of many prehistoric sites in Greece, from the Neolithic and other prehistoric periods (Yiannouli 1994; Christidou pers. comm.). The majority of these remains are small e.g. hand and foot bones and

long bones (Yannouli 1994). It is an open question whether the “scattered bones” noted in preliminary reports originated from *intentionally disposed primary or secondary burials*, which were subsequently disturbed by later use of the disposal area, or were simply *refuse* coincidentally deposited among other discarded materials.

1) Location:

Chronological Period	Within- settlement burials	Disarticulated bones	Cemeteries
Neolithic	+	+	
Early Bronze Age	+		+
Late Bronze Age			+
Transitional Phase			+
Early Iron Age			+

2) Type of disposal:

Chronological Period	Inhumation	Cremation	Single	Multiple/secondary
Neolithic	+	+	+	+
Early Bronze Age	+	+	+	
Late Bronze Age	+		+	+
Transitional Phase	+		+	
Early Iron Age	+	+	+	+

3) Treatment of the deceased (external features [1]):

Chronological Period	Grave type diversity	Grave type homogeneity	Visibility	Clustering
Neolithic		+		
Early Bronze Age	+		+	+
Late Bronze Age		+		+
Transitional Phase	+		+	
Early Iron Age	+		+	+

4) Treatment of the deceased (internal features [2]):

Chronological Period	Special care	Standardisation	Variability	Age/Sex group differentiation	“Valuable” grave goods
Neolithic					
Early Bronze Age	+	+		+	+
Late Bronze Age	+	+		+	+
Transitional Phase	+		+	+	+
Early Iron Age	+	+		+	+

Table 3.3: Features of mortuary behaviour in the different archaeological periods

Overall, the dead were not accorded any particular treatment, such as the construction of associated monumental structures or additional furnishing. According to Demoule and Perlès (Demoule and Perlès 1993: 385), the burial was rather a matter of

[1] Grave type and additional elements furnishing the grave, such as covering and floor.
[2] Characteristics of the disposal of the deceased, such as burial position, grave goods etc.

one social unit and so occurred in the boundaries of *the nuclear family*, as the burials within the settlement suggest. In general, there seems to be no emphasis on the visibility of the dead, little indication of elaborate rituals, and no indication of social inequality (Demoule and Perlès 1993: 385), although the evidence of LN Makrigialos, as discussed in Chapter 5, suggests the opposite. Inhumations appear to have been the commonest type of disposal, while cremations have also been occasionally recorded, such as in LN Makrigialos phase II (Bessios and Pappa 1998a; 1998b; 1998c) and Neolithic Goules, in the Middle Haliakmon valley (Ziota and Hondroyianni-Metoki 1997: 36). In all primary burials, the bodies were placed in a contracted position without any additional furnishing of the grave such as a floor or covering. Finally, the grave goods accompanying the deceased were very few and comprised mostly of everyday items, such as bone and stone tools or pottery.

3.4.2. EARLY BRONZE AGE ASSEMBLAGES

The Early Bronze Age picture differs significantly from that for the Neolithic (Table 3.3). The prevalent burial practice continued to be inhumation, although cremations increase in frequency (Ayios Mamas, Goules, Koilada and lately Sykia). Cremations are usually associated with infant burials but, in the Early Bronze Age, adults also appear occasionally to have been disposed of in this way (Koilada, Sykia).

In terms of burial location, two types may be distinguished:

1) *Burials within the settlement* such as the two burials from Archondiko (Papaefthimiou-Papanthimou and Pilali-Papasteriou 1997; Triantaphyllou 1996) and a few burials from Korinos (Bessios 1997a); the former were placed in pithoid jars laid in pits while the latter were casually thrown into the rubbish pits of the Early Bronze Age settlement.
2) *Organised cemeteries* such as at Ayios Mamas (Pappa 1995; Triantaphyllou pers. investigation) and Sykia (Assouchidou et al. in press) in Chalkidiki, at Makrigialos in Central Macedonia (Bessios and Pappa 1998a; 1998b; 1998c; Triantaphyllou 1997b; in press) and at Goules (Figure 3.6) (Ziota and Hondroyianni-Metoki 1997) and Koilada (Figure 3.7) in Western Macedonia (Ziota 1996a; 1996b; 1998a; 1998b; in press; Triantaphyllou 1998a); these appeared at the end of the period, except for Makrigialos which is dated to the early/middle Early Bronze Age.

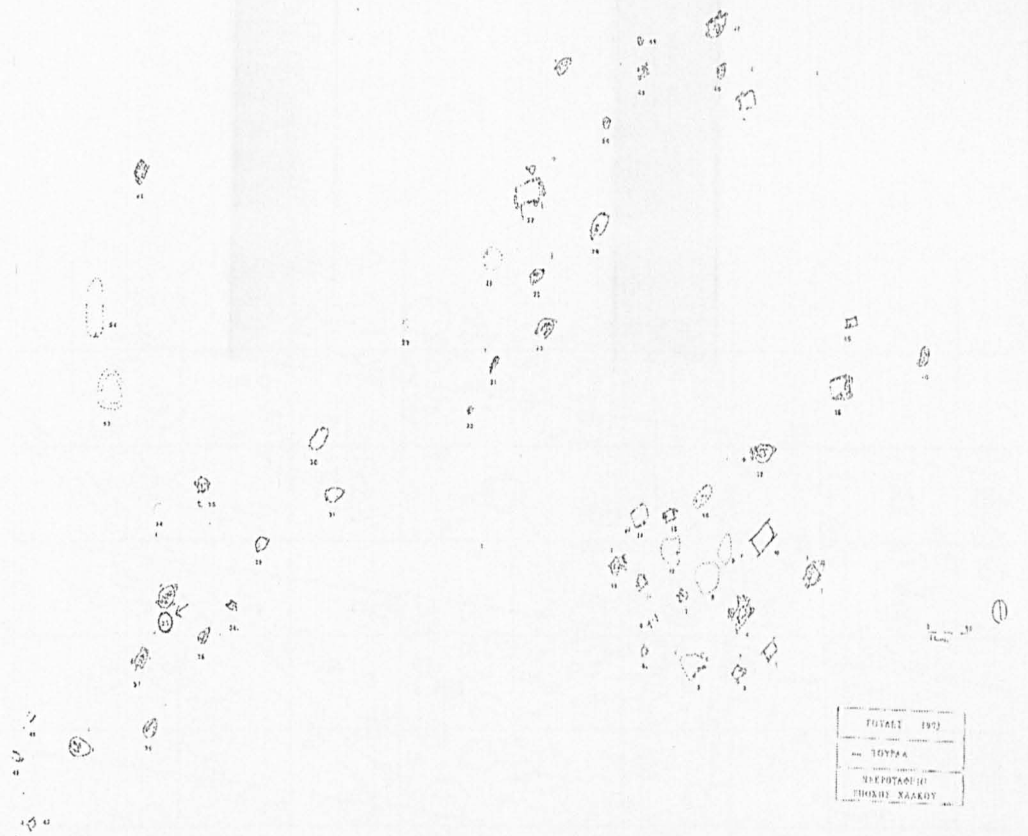

Figure 3.6: Plan of the Early Bronze Age Goules cemetery (Hondroyianni-Metoki archives)

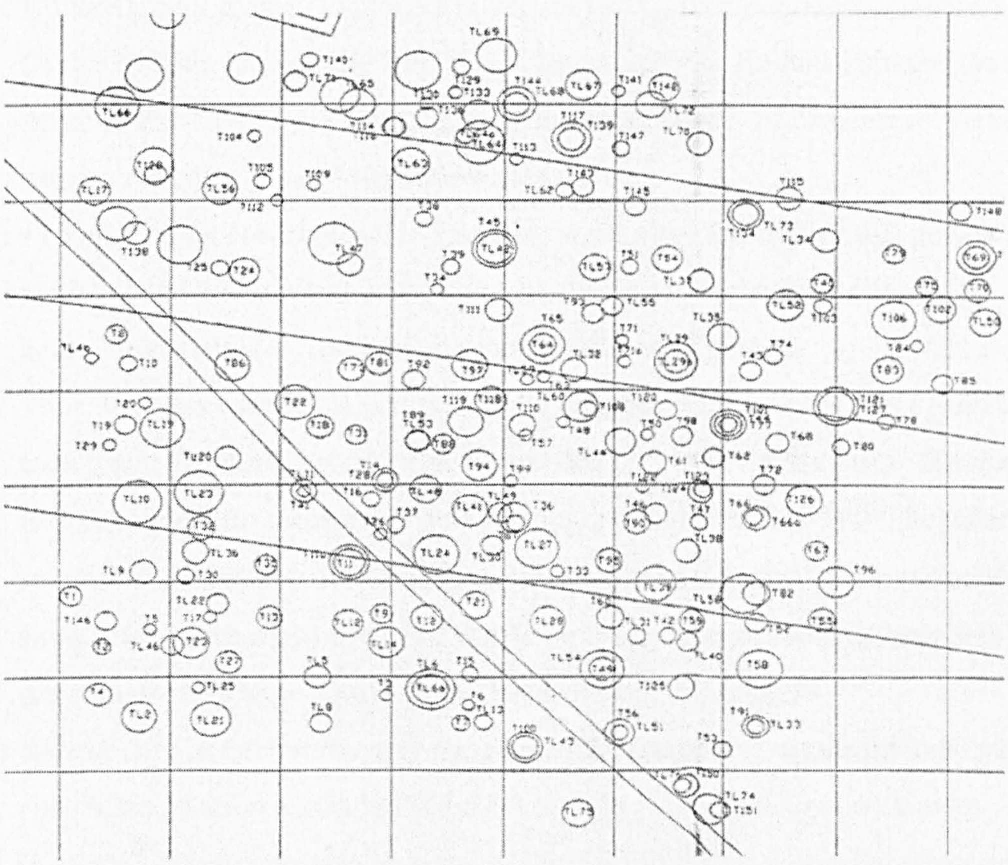

Figure 3.7: Plan of the Early Bronze Age Koilada cemetery (Ziota archives)

The mortuary evidence for the Early Bronze Age based on the five organised cemeteries, may be summarised as follows:

1) *Emerging diversity in grave types.* In contrast to the simple pit graves which prevailed in the Neolithic, the Early Bronze Age displayed a relatively large variety of grave types, including pits (Makrigialos, Ayios Mamas, Koilada), cists (Goules, Koilada), built graves (Figure 3.8) (Koilada) and pithos/pot burials (Figure 3.9) (Ayios Mamas, Goules and Koilada). The cemetery of Koilada contains the full range of grave types, elaborated into an immense variety of "structural" versions using a variety of locally available materials.
2) *Visibility of the burial ground.* There are some clear indications that graves were visible to the living community, although modern disturbance, primarily by agricultural activities, has limited secure evidence of possible "grave markers". Thus, in Ayios Mamas, in addition to the possible occurrence of stone piles on top of each grave, the burials were often surrounded by low rows of stones. Similar features have been recorded in both Goules and Koilada. The latter, in particular, has revealed the repetitive occurrence, on top of each of a large number of burials, of stone piles which may have been visible on the ground and so may have served as grave markers (Figure 3.10) (Ziota 1998a; 1998b; in press).
3) *Special care in the treatment of the deceased.* The bodies continued to be placed in a contracted position on the left (Goules) or right (Makrigialos) or both sides (Koilada). There may also be some additional furnishing within the grave, such as floor bedding and covering of the burial. With regard to the former, burials in Ayios Mamas were laid on a pebble floor, which also appears in a few cases at Goules and Koilada. Otherwise, burials in the latter cemeteries were commonly laid out on the natural bedrock. At the same time there is a tremendous variety in the covering of each grave, ranging from the simple accumulation of soil to one slab, or a pile of rough stones or scattered sherds or even intentionally broken pots. Finally, grave goods, consisting primarily of pottery, possibly used during life, begin to accompany the majority of burials. A limited number of burials were equipped additionally with stone and occasionally faience, copper/bronze and gold ornaments and tools. There are also a couple of cases, one each in Goules and Koilada, with a copper dagger. The rare occurrence of items of metal and faience, raw materials of valuable and

Figure 3.8: Picture of a built grave from the EBA Koilada cemetery (Ziota archives)

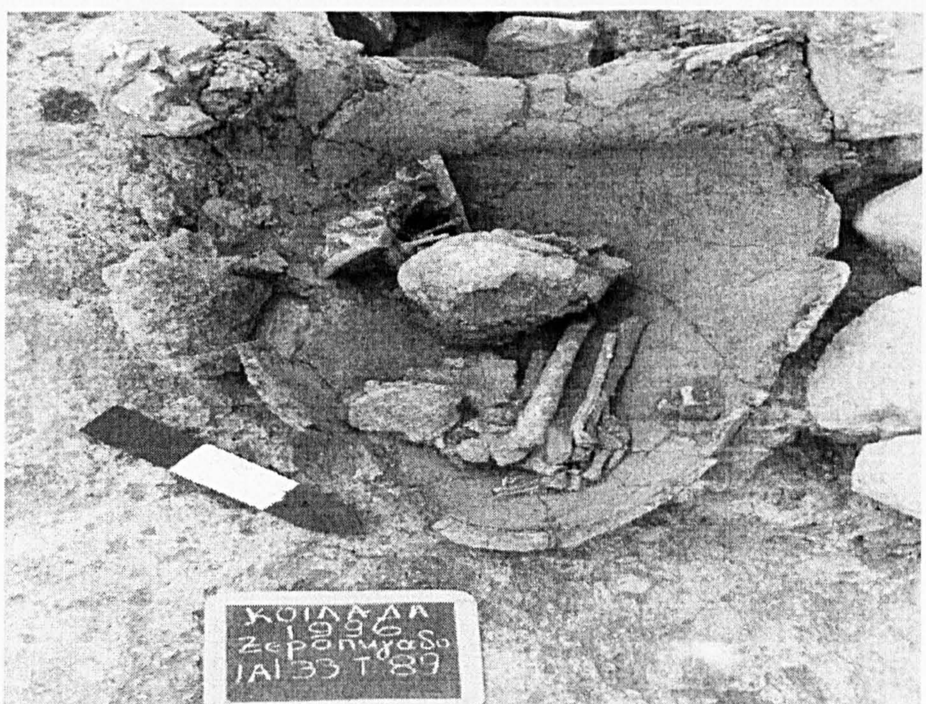

Figure 3.9: Picture of a pithos burial from the EBA Koilada cemetery (Ziota archives)

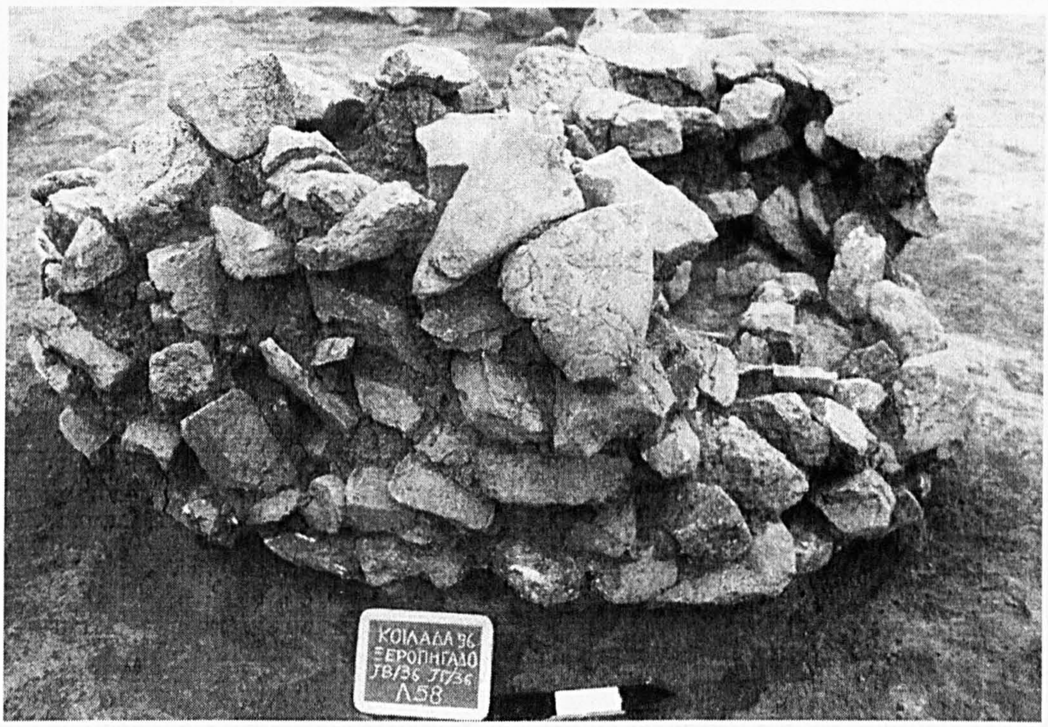

Figure 3.10: Picture of a stone pile from the EBA Koilada cemetery (Ziota 1998: Figure 1)

"exotic" character, perhaps indicated the special significance of their associated burials.

4) *A tendency towards standardisation at the intra-cemetery level.* The common method of disposal in most cemeteries continued to be *single inhumations placed in a contracted position.* There are only a few exceptions: two double burials in Koilada and a secondary burial in Goules. Furthermore, there is a tendency at the intra-cemetery level for burials to follow *common orientations*: East/West in Goules, South/North in Koilada and West/East in Makrigialos. Also, burials placed in pithoi or pots tend to have *the head of the body* towards the opening of the vessel. Burials in Goules and Koilada were also accompanied by *a standard set of grave goods,* consisting of one or two *particular types* of handmade pots usually placed in *certain positions*, by the head (Goules), or by the head and feet (Koilada). Finally, there are some indications of *possible differential treatment by age/sex* within the cemeteries. First, with regard to age groups: (1) pot-burials are associated with infant and child burials in both Goules and Koilada, while pithos burials are associated with adults in Goules; (2) cists in Koilada were found to accommodate only subadults; and (3) some of the "richest" burial assemblages are associated with infant and child burials in the cemeteries of Ayios Mamas, Goules and Koilada. Secondly, as regards differential treatment by sex group, it is important to note that all the evidence has been provided by the cemetery of Koilada: (1) although all burials appear to have been placed in a contracted position, women were clearly laid on their left and men on their right side; and (2) a significant proportion of female burials were disposed of in pit graves, while male burials were predominately placed in built graves.

5) *Possible indications of clustering in the Koilada cemetery.* It must be emphasised that the evidence from the Early Bronze Age as a whole does not indicate the development of clustering within cemeteries. In the Koilada cemetery, however, ca. 10 burials out of 153 were placed on top of existing burials and covered by stone piles which were probably visible on the ground. It is quite possible that the existence of the earlier burials was known to the relatives of the new occupants since the new burials did not disturb the earlier ones. Thus, it is tempting to consider the latter as possible indications of family or descent links with the preceding burials. Also, the latest findings from the Sykia tumulus in Chalkidiki (summer 1998) are consistent with the clustering of burials within the cemetery.

3.4.3. Late Bronze Age Assemblages

Although a few Late Bronze Age settlements are extensively excavated (Kastanas, Assiros and Toumba Thessalonikis), the burial data are very scanty and come essentially from three sites: Spathes on Mount Olympus, Korinos in Central Macedonia, and Rymnio, near Aiani, in Western Macedonia. Although the Late Bronze Age mortuary evidence is extremely limited, it displays significant changes from earlier mortuary behaviour (Table 3.3) (Triantaphyllou 1998a: 152-154). Three main features of Late Bronze Age mortuary practice may be noted: (1) the exclusive use of *organised cemeteries* outside the settlements; (2) the occurrence of *multiple and/or secondary burials* swept aside for the primary burial, and thus the inclusion in the same grave of more than one individual; and (3) a tendency towards *greater standardisation in the treatment of the deceased.*

All three of the organised cemeteries have been only partially excavated so that it is not possible to determine their total layout. Besides, it is not possible to define what portion of the overall burial ground is represented by the existing excavation, with the result that it is not really possible to analyse aspects of spatial organisation such as the distribution and frequency of graves in the burial ground and possible clustering at the intra-cemetery level. With regard to the latter, however, there are some clear indications from both Korinos (Bessios 1997a: 202) and Rymnio (Karametrou-Mentesidi 1990: 355), which are consistent with the occurrence of tumuli covering clusters of graves. Furthermore, in the case of Rymnio, some of the graves are reported to have been placed in a radial pattern in relation to the centre of the tumulus.

Moreover, the tendency towards clustering at the intra-cemetery level can possibly be associated with the occurrence of multiple and/or secondary burials within the same grave. In Spathes, for instance, the graves hold between two and five individuals, implying an emphasis on small kin groups (Triantaphyllou 1998a: 153). The inclusion of more than one individual in the same grave, however, does not occur often in any of the three cases. Thus, while in Spathes this is the rule for all burials (Figure 3.11), in Korinos, only one double burial has been recorded, out of ca. 30 securely dated to the Late Bronze Age and in Rymnio out of the total of ca. 15 burials, three have provided evidence of more than one individual.

It appears, therefore, that the occurrence of multiple and/or secondary burials was not a generalised practice. In fact, *the emergence of clusters* in the cemetery layout,

Figure 3.11: Picture of Grave 8 in LBA Spathes indicating secondary burials (Bessios archives)

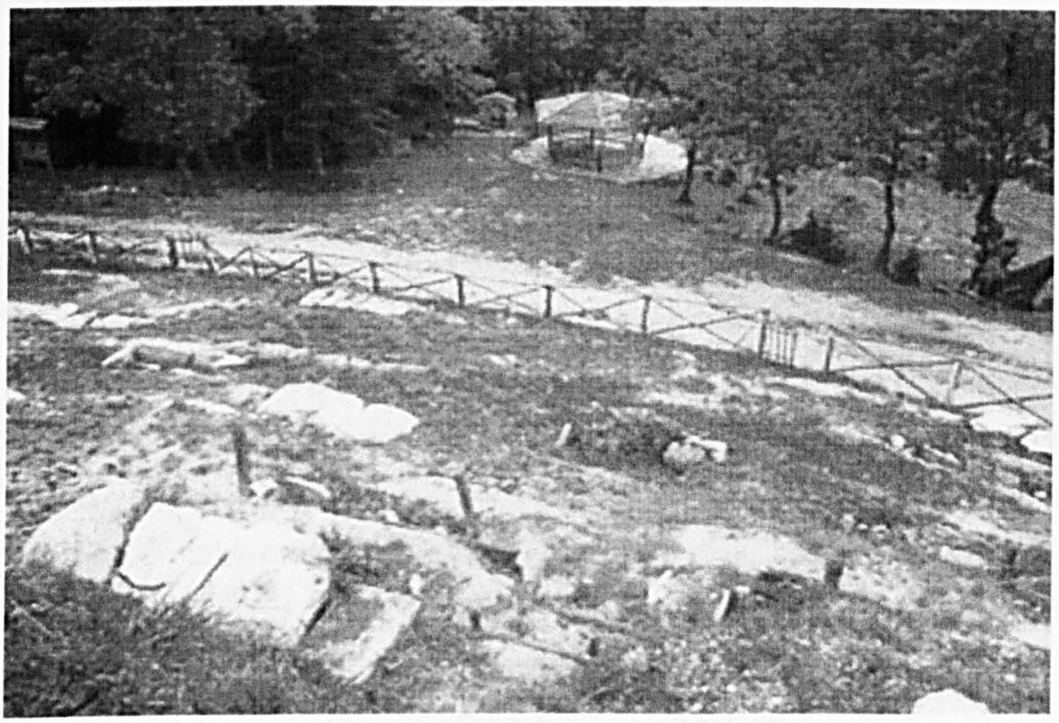

Figure 3.12: Overview of the Late Bronze Age Spathes cemetery

together with *multiple and/or secondary burials* in the same grave, probably reflects a similar tendency towards alteration of the basic social unit participating in social, productive and economic activities of the community from the *nuclear family* to larger *descent groups*. The latter process apparently did not develop in the same way, however, in all Late Bronze Age societies. This is to say that the emphasis on descent groups in Late Bronze Age mortuary practices may reflect particular social transformations regarding the household unit. It was suggested earlier in Chapter 2 that the shift towards the formation of larger descent groups as basic social units can be seen on a limited scale in the spatial organisation of some Late Bronze Age settlements (Triantaphyllou 1998a: 153); this aspect will be developed in detail in Chapter 5.

Finally, standardisation with regard to the treatment of the deceased is apparent in:

1) *The adoption of certain grave types* at the intra-cemetery level. Cists are found at Spathes (Figure 3.12) and Rymnio, and pit graves at Korinos. There is no diversity in grave types within the same cemetery as observed in earlier periods.
2) *The adoption of inhumation* as the only kind of disposal of the deceased. Conversely, throughout the earlier periods, cremation, though rare, is also evident, especially in neonates and infants.
3) *The contracted burial position* in all cases, following the tradition established during the Neolithic and Early Bronze Ages.
4) *The occurrence of standard types of grave goods*. Standard types of grave goods, such as ceramics, including local painted and Mycenaean pottery, tools, jewellery and occasionally weaponry, accompany the deceased. In particular, jewellery of metal, bone or stone usually accompanies the female burials, while weapons or tools of metal and stone mostly accompany the male burials. In fact, the latter distinction was already becoming evident in the Early Bronze Age, though not as regularly.
5) *The accumulation of distinct artefacts as evidence for social identity*. In the Late Bronze Age, there are burial assemblages, such as the majority of grave contents in Spathes and Rymnio, with an accumulation of personal items such as sealstones, clothing equipment, jewellery of "exotic" material, such as amber and glass paste, stone or clay "buttons", bronze weapons recalling Mycenaean types, and Mycenaean or "Mycenaeanising" pottery. We can clearly see in these deposits an attempt to

display social identity, reflected in the possession and destruction after death of personal items. This which will be discussed further in Chapter 5.

3.4.4. TRANSITIONAL (LATE BRONZE/EARLY IRON AGE) ASSEMBLAGES

The only evidence for this phase comes from the Mount Olympus cemetery of Treis Elies and the burial found in the phase 3 settlement of Toumba Thessalonikis. Thus, the sample is certainly not sufficient for a general view of transitional assemblages. The picture presented, however, includes some interesting novelties (Table 3.3), primarily introduced in the course of the Early Iron Age, as well as features reminiscent of the Bronze Age cemeteries. In general four distinctive features may be noted:

1) *Visibility of the burial ground.* There are clear indications of a grave circle surrounding the burial ground of Treis Elies.
2) *Relative variability in grave types and burial positions.* In contrast to the preceding period, there is a relative variability in grave types and burial positions at the intra-cemetery level, with cists and a type of built grave constituting the primary burial containers. With regard to burial positions, there is a clear variability ranging from strongly to slightly contracted bodies, reminiscent of the Late Bronze Age tradition.
3) *Adoption of single burials.* The majority of the graves consist of single burials, with a few exceptions only, in contrast to the Late Bronze Age tradition of secondary/multiple use of the grave. Single burials tend to become the rule in the Early Iron Age.
4) *A remarkable decrease in "Mycenaean" or "Mycenaeanising" items.* The latter comprise probably the strongest associations with the Late Bronze Age tradition. At the same time, those burial assemblages which do include some pottery and other items of a "Mycenaeanising" type recall, to a limited degree, the repertoires of the preceding period (Triantaphyllou 1998a).

3.4.5. EARLY IRON AGE ASSEMBLAGES

Finally, the Early Iron Age witnessed an increased number of cemeteries (ca. 13) in locations which would continue to be used down into historical times. The use of organised cemeteries was already established from the Early Bronze Age. Nevertheless, it is remarkable that, in the large settlement sites of Kastanas, Assiros and Toumba Thessalonikis, the evidence for Early Iron Age mortuary activity is limited to only one burial from Assiros, disposed of in the settlement deposits without any special treatment or care. Burial practices are not dramatically different from those of the Late Bronze Age. Nevertheless, while there is a distinct standardisation in the overall treatment of the deceased, there is remarkable heterogeneity in burial assemblages at the level of the cemetery, a feature which is not so obvious in previous periods (Table 3.3). Seven features deserve mention:

1) *The tendency to mark burial grounds or single graves.* Most excavated cemeteries provide evidence of distinct marking of either clusters of graves or single graves. In the majority of the cemeteries, *tumuli* were the commonest type of grave marker (Figure 3.13). The number of graves included in a tumulus varied between two and twenty-five (Vergina). The tumuli usually consist of a pile of soil, sometimes brought from a distance (such as the clayey soil in the Olympus tumuli, Vergina and the Makrigialos chamber tombs), on a stone foundation variously constructed (Olympus, Vergina, Thermi, Agriosykia?). In addition, graves were sometimes covered by *stone piles* (lithosoroi) (Gynaikokastro) which can be classified under the general term of tumuli. Finally, there are also two possible *grave circles* at the Kouko cemetery in Sykia (Chalkidiki), and at Gynaikokastro; these surrounded a cluster of graves and a pot containing cremations respectively. A "grave circle" has also been recorded in the transitional Late Bronze-Early Iron Age cemetery of Treis Elies (Mount Olympus), but at Kouko and Treis Elies the grave circle enclosed the whole burial ground, not just the clusters of graves. With regard to single graves, there is evidence for an overlying *stone pile* or *tumulus* (Isiomata in Western Macedonia; Olympus; Makrigialos in Central Macedonia) or low *stone enclosure* (Ai Gianni, Nikitis in Chalkidiki; Nea Zoi, in Central Macedonia), or even a *grave marker* indicating the location of the burial (Olympus; Makrigialos?). In Early Iron Age Makrigialos, in particular, the latter is suggested by the fact that few graves were disturbed during the later use of the burial ground throughout historical times (Bessios 1992).
2) *Strong evidence for clustering at the intra-cemetery level.* The broad adoption of *tumuli* in the Early Iron Age marks a strong tendency towards the development of

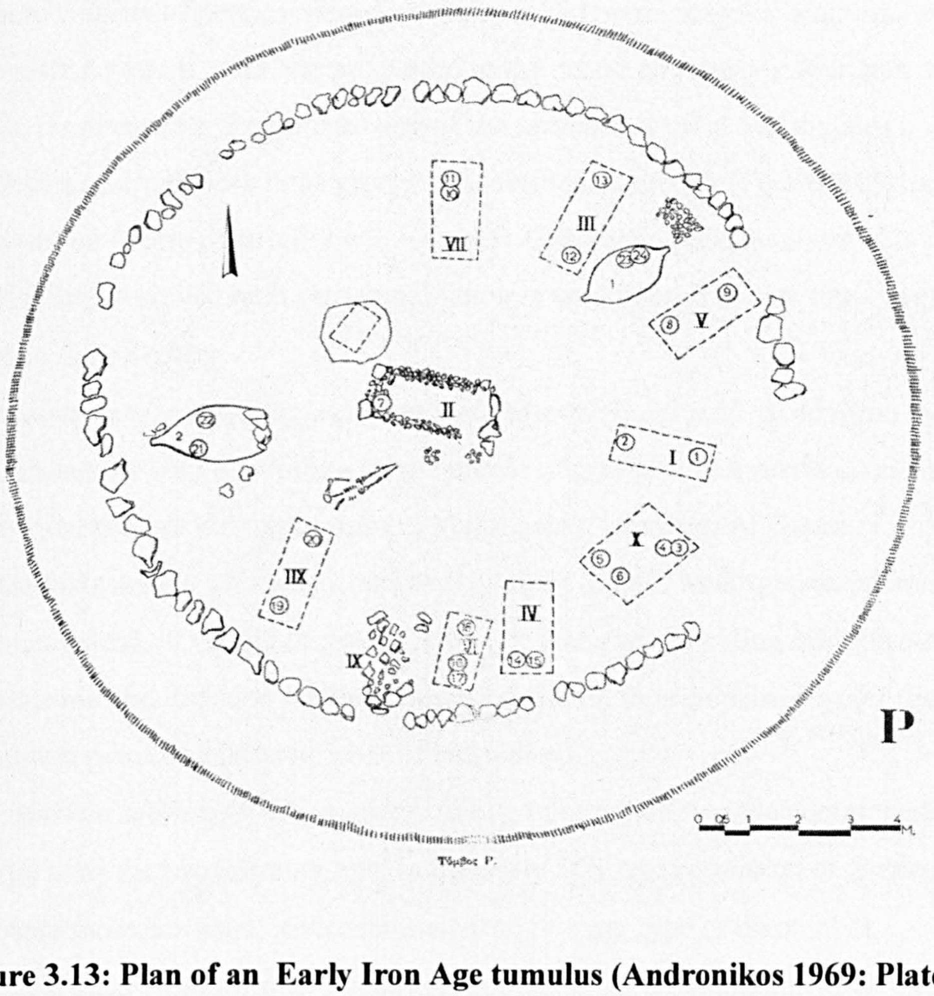

Figure 3.13: Plan of an Early Iron Age tumulus (Andronikos 1969: Plate H)

clusters within the cemetery. In two cases, there is evidence for *clusters of tumuli* (Olympus tumuli and Vergina) and, in cases where clustering is not clearly displayed by tumuli, there are possible *clusters of graves* within a cemetery, distinguished by common structural features (Makrigialos, in Central Macedonia; Koupoutsina in Western Macedonia): either clusters of graves set around a particular chamber tomb (Figure 3.14) or clusters of graves constructed in a similar way possibly representing descent groups (Karliabas 1998). There is a remarkable case at Gynaikokastro, where clusters of pots contained cremations laid on rectangular *platforms* in a consistent pattern, with one pot placed in the centre and another four pots on each side. Furthermore, the introduction of the *chamber tomb* at Makrigialos could also reflect a desire to bury large groups of individuals together (Figure 3.15), and further discussion of this possibility will follow in Chapter 5. Also noteworthy is the variability observed in the structural features used in each case to express clustering within the cemetery.

3) *The co-occurrence of single and multiple/secondary burials.* In addition to the occurrence of single burials, a large number of graves hold more than one individual, either in *multiple* (Olympus tumuli, Makrigialos, Isiomata, Ai Gianni, Kouko, Gynaikokastro) or *secondary* burials (Olympus tumuli, Makrigialos, Isiomata?, Koupoutsina). It should be noted, however, that graves holding multiple/secondary burials may be included within a cluster of graves, thus emphasising the disposal in a common place of a large number of individuals.

4) *Cremations alongside inhumations.* While inhumation was the commonest type of burial until the Late Bronze Age, in the Early Iron Age cremation of the deceased became more common. Cremation was the primary type of disposal at Gynaikokastro and Torone, it was more common than inhumation at Kouko and occurred occasionally at Makrigialos and, to a lesser extent, at Vergina, although inhumation remained the rule at both of these sites. In some cemeteries with cremations, special areas have been identified where the actual burning took place before the bodies were placed in their final position as secondary products of cremation.

5) *A large diversity in grave types.* There is a great range of grave types, with variants of each structural type depending to a great extent on local raw materials. The primary types distinguished include *pit graves* (Vergina, Makrigialos, Olympus

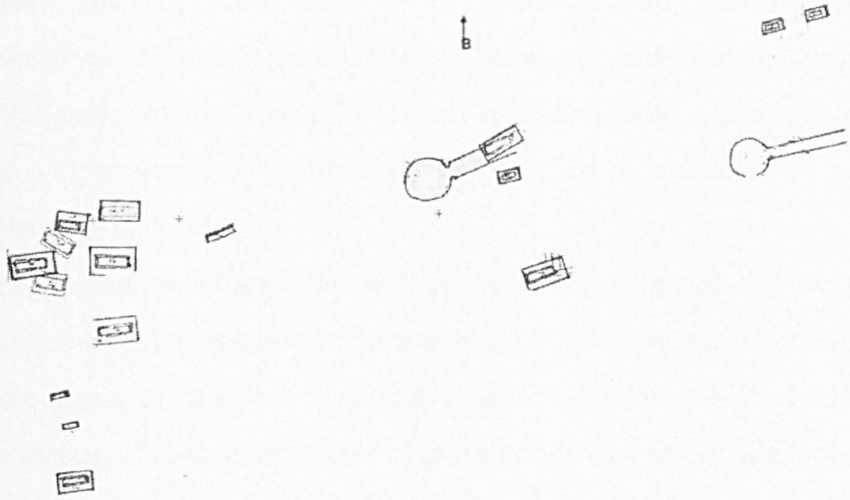

Figure 3.14: Plan of a section from the EIA Makrigialos cemetery indicating grave clusters around chamber tombs 4 and 11 (Bessios archives)

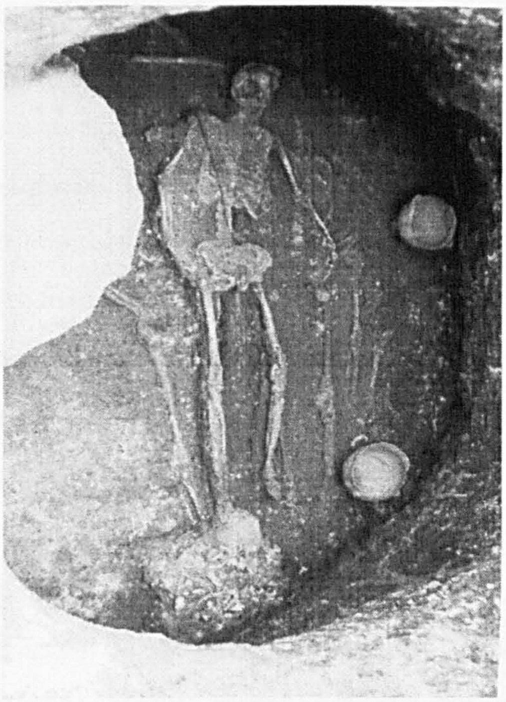

Figure 3.15: Picture of chamber tomb 11 from the EIA Makrigialos cemetery (Bessios archives)

tumuli, Nea Zoi), *cists* (Figure 3.16) (Vergina, Makrigialos, Isiomata, Koupoutsina, Kouko, Thermi), *built graves* (only in Olympus tumuli), *pot/pithos burials* (Vergina, Makrigialos, Olympus tumuli, Kouko, Torone, Gynaikokastro, Agriosykia, Nea Zoi) and *chamber tombs* (Figure 3.17) (only in Makrigialos). As already mentioned the above types were usually furnished with a variety of additional elements, especially covering and flooring.

6) *Standardisation in the treatment of the deceased*, as regards (1) burial position and orientation, (2) orientation of the grave, (3) the occurrence of certain categories of grave goods, often placed in specific positions in relation to the body, and (4) the association of certain categories of grave goods with sex or age groups. The *burial position* prevalent in the Early Iron Age is the extended placement of the body with arms and hands usually folded in the abdomen region. With regard to *the orientation of the grave*, graves in tumuli were usually placed in a radial pattern around the centre of the tumulus (Vergina, Agriosykia). A recent analysis of the Makrigialos assemblages (Karliabas 1998) has shown that the majority of the graves were oriented East/West (Bessios 1992; 1993; 1994; Karliabas 1998), while there was a tendency for male burials to be laid with the head to the west and female burials with the head to the east (Karliabas 1998: 96). The possible association of burial orientation with biological sex is of particular importance, since it clearly suggests differential treatment of the body according to *sex distinction*. The latter can also be broadly seen in the categories of associated grave goods, with jewellery in a variety of materials occurring in female burials and weaponry in male burials; certain types of metal fibulae and exotic craft products, such as faience beads, were also frequently associated with female burials. Finally, analysis has also suggested a possible *age distinction* in one particular category of grave goods: bronze bracelets were usually placed with infant and child burials, while various types of fibulae were usually associated with adult burials only (Karliabas 1998). Also possibly indicative of differential treatment by age group is the apparent exclusion of infant and child burials from chamber tombs. Pottery is a common category of grave good, represented by a variety of shapes and types mostly associated with food consumption; no sex distinction has yet been identified, although detailed analysis has yet to be applied. Finally, with regard to grave goods in the Makrigialos cemetery, *the standardisation in the placement of certain categories within the grave*

Figure 3.16: Picture of a cist grave from the EIA Makrigialos cemetery (Bessios archives)

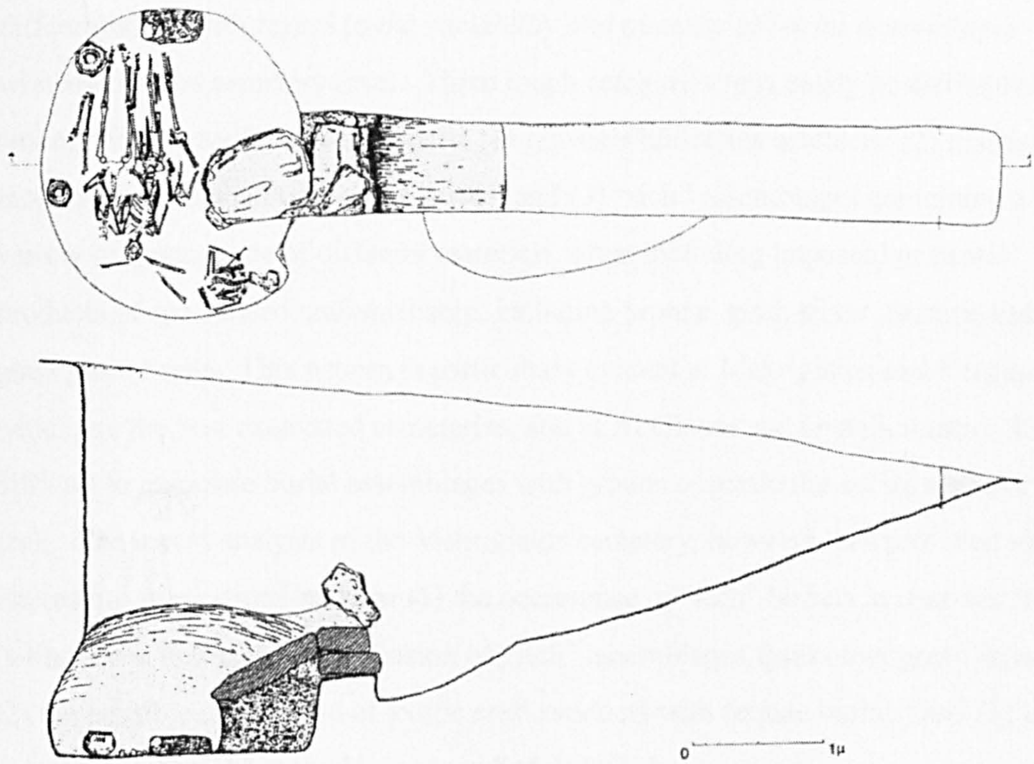

Figure 3.17: Plan of chamber tomb 11 from the EIA Makrigialos cemetery (Bessios archives)

should be emphasised: in the majority of single burials, a pot was placed by the lower limbs of the deceased, while in multiple burials, a pot was usually laid by the head of the deceased (Karliabas 1998: 104). Similarly, in Vergina, burials contained two pots, one for liquids placed by the head and the one for food placed by the lower limbs (Andronikos 1969: 165). Also, where male burials were furnished with a sword, this was usually placed to the right of the body (Karliabas 1998: 106).

7) *Differentiation of burial assemblages*. Despite the standardisation in some categories of grave goods and in their placement in relation to the body, there is evident differentiation with regard to *the variability and quantity of burial assemblages* witnessed at the cemetery level. Three rough categories may easily be distinguished among the few well excavated cases: (1) graves without any artefacts; (2) graves moderately furnished with grave goods; and (3) "rich" assemblages containing a large variety of items made of different materials, often including imported or exotic products of specialised craftsmanship, including bronze, gold, silver, faience and glass paste beads. This pattern is particularly evident at Makrigialos and Vergina, which are the best excavated cemeteries, and at Ai Gianni and Gynaikokastro. It is difficult to associate burial assemblages with groups of particular social status or rank. The recent analysis of the Makrigialos cemetery, however, has provided some interesting suggestions such as: (1) the occurrence of "rich" burials in chamber tombs (which need not mean the exclusion of "rich" assemblages from other grave types); (2) the possible association of exotic craft products with female burials; and (3) the occurrence of "rich" assemblages in subadult burials.

CHAPTER 4: PALAEODEMOGRAPHY

4.1. INTRODUCTION: AIMS OF THE ANALYSIS

The primary aim of palaeodemography is to reconstruct demographic parameters, such as the size, structure and dynamics of once living archaeological populations (Chamberlain in press). The study of palaeodemography enhances understanding of a range of aspects of the subsistence, health status and adaptation of past human populations to their environment. Additionally, the cultural, historical, economic and social background of the case study populations must be taken into account to interpret their palaeodemography.

The aim of this chapter is to outline the demographic properties of the case study cemetery populations. Thus, mortality profiles and survivorship curves are analysed in two ways:

- first, the above parameters will be viewed within each cemetery population;
- secondly, variations through time and geographical setting will be explored through inter-cemetery comparisons.

Furthermore, this review will attempt to investigate issues of differential mortality in the two sex groups with a special emphasis on their distribution in the various age categories.

There is already a substantial literature on the impact of agriculture, settled way of life and nucleation of population on demographic parameters. One prevailing idea proposes an overall decline in health status after the development of high degrees of sedentism, population density, and reliance on intensive agriculture, followed at the same time by an increase in mortality rates and declining life expectancy (Larsen 1982; 1995; Goodman et al. 1984; Cohen and Armelagos 1984; Cohen 1989). With reference to the current analysis in Northern Greece, the transition from the small-scale societies of the Neolithic and Early Bronze Age to the slightly more complex Late Bronze and Early Iron Age societies was associated with a tendency towards the development of nucleated habitation possibly in the Early Iron Age, the emergence of hierarchies at the inter- and possibly the intra-site level, the development of extensive exchange networks with the south and the possible expansion of residential units to more than one household. All of these might be expected to have had an impact on the demographic structure of the case study populations. Lower mortality rates and higher survivorship would presumably be expected for the populations of the Neolithic and Early Bronze Age, as opposed to higher mortality rates and lower survivorship for the populations of the Late Bronze and Early Iron Age.

Before we proceed to the investigation of the results of the palaeodemographic analysis, it will be worth considering first the factors which have affected the nature of the sample and preservation of the skeletal material and have consequently placed certain limitations on the current case study.

4.2. LIMITATIONS AND PROBLEMS: What's left?

Palaeodemographic analysis can be biased by extrinsic factors, that is *the nature of the sample*, preservation and retention of the skeletal material, and also by intrinsic factors, namely the *methodology and techniques* utilised for sexing and ageing individuals along with *the nature of bone itself*, chemistry, shape, size, density and age of the bone material (Boddington 1987a; 1987b; Henderson 1987; Waldron, 1994). Overall, three objective limitations can be distinguished in the analysis of past population dynamics which need to be taken into account: 1) the component of the original population that is buried at the site, 2) the component lost due to poor preservation, later disturbance or even extraordinary burial practices, and 3) the proportion of those finally excavated and recovered for anthropological study.

The case study burial assemblages provide minimal evidence regarding the original population whose remains were interred at the site. Only exceptional catastrophic assemblages comprising deaths from an acute event such as a large massacre, an earthquake or an epidemic disease can provide a representative sample of the living population. Moreover, in the current case study, *the lack of systematic survey work* in the area and *the rescue character of the excavation* do not allow the case study cemeteries to be directly correlated with settlement sites, with the single exception of the Early Neolithic skeletal assemblage recovered within the settlement deposits of Nea Nikomedeia. At EBA Goules, EBA Koilada and EIA Makrigialos, there are settlements in close proximity, which have been assumed to relate to the respective cemeteries, while for the rest of the populations no associated habitation site has been suggested. Furthermore, it is not clear whether these burial assemblages constituted the primary disposal area of one or more settlement sites. *The rescue character of the cemetery excavations* made it difficult to estimate the proportion of the burial ground that was excavated. Furthermore, the duration of use of each burial ground is poorly known, making it impossible to estimate living population size from the number of individuals in the cemetery. Besides, *differential burial treatment*, where certain age and/or sex groups may not be included in the case study cemetery area, can distort the demographic picture of the initial population and lead to false suggestions with regard to gender or age distinctions at the intra-population level. The latter is common in the early age groups, with neonates in particular sometimes intentionally excluded from burial assemblages (see further discussion in the results of this chapter). Finally, it has to be emphasised that demography usually needs to consider past populations as stable and/or stationary units, whereas the extent and diversity of *migration*, that is, movement of individuals to and out of their originally residential place, especially in prehistoric populations, is difficult to evaluate (Bocquet-Appel and Masset 1982; Wood et al. 1992).

Of particularly great significance is the proportion of the population preserved, excavated and finally recorded. Factors which can affect preservation and later disturbance include *cultural*, *environmental* and *excavation techniques and methodology*.

Cultural bias refers to burial customs, that is treatment and manipulation of the deceased practised from the Neolithic to the Early Iron Age which have led to differential preservation. Furthermore, different grave types and additional furnishing have also affected the general preservation and degree of completeness of the skeletal material. Thus, skeletons disposed of in cist or built graves e.g. in LBA Spathes, LBA/EIA Treis Elies and EIA Makrigialos are characterised overall by a greater degree of completeness than those in EBA Makrigialos and EBA/LBA Korinos disposed of in pit graves where the soil had direct contact with and thus pressure on the remains (Table 4.1). Besides, the additional occurrence of large stones covering parts or all of the body, such as in EBA Koilada, contributed to crushing of the bones with a special emphasis on fragile spongy elements such as the thorax, vertebral column and the pubic symphysis - the latter being a particularly valuable age indicator - and also most of the cranial (e.g. facial) bones.

In terms of the manipulation of the deceased, three main forms of deposition can be distinguished as major contributing factors in poor preservation: 1) *the disarticulated bone assemblages* of Late Neolithic Makrigialos, 2) *the multiple/secondary* burials of

Late Bronze and Early Iron Age cemeteries (Spathes, Treis Elies, Makrigialos, Olympus tumuli), together with 3) the practice of *cremation and secondary burial* of skeletal remains observed particularly in the Early Iron Age assemblages and more rarely in earlier populations (e.g. EBA Koilada). The two former practices have been mainly associated with later disturbance of the skeletal material due to re-use of the same burial ground, while the latter has led to loss of information for a proportion of the affected populations due to distortion and secondary treatment of the skeletal remains (Boddington 1987b; Henderson 1987).

Environmental biases include a range of extrinsic factors related to the taphonomic environment and processes following the burial of the deceased and are highly affected by the type of soil, water, temperature and air (Gordon and Buikstra 1981; Henderson 1987). In the case study populations, the disastrous effects of the environmental processes can be seen clearly in EBA Goules where the largest proportion of the cemetery area used to be lying underwater on the bed of the artificial lake of the river Haliakmon in Western Macedonia, resulting in the extremely poor and fragmentary preservation of the skeletal material. Also, local fauna and flora, including micro- and macro-organisms, may play a major role in bone preservation. It is worth mentioning the bad condition of the skeletons in Spathes and Treis Elies which have been largely eroded by plant roots and also weathered due to post-mortem exposure of some of the bones to erosional agencies (sun, rain) for quite long periods. Damage affecting particularly the spongy parts of the skeleton (e.g. articular joints) can also cause marks on the bone material which can be easily mistaken as osteolytic or other abnormal lesions in palaeopathological investigation. Similarly, insects and mammals (e.g. rodents etc.) can cause serious damage and disturb the body after burial. for example by removing small bones and teeth. The interference of rodents, in particular, has been recognised in the majority of the case study cemeteries.

Finally, the *excavation techniques and methodology* have substantially contributed to both the degree of preservation and completeness of the skeletal remains. Bearing in mind the salvage character of the case study excavations, it is becoming apparent that the condition of the material could not possibly remain unaffected. *Excavation interference* tends to occur in two ways: 1) selective collection of skeletons or even skeletal parts and 2) relative negligence of guidelines concerning excavation, collection and curation of human bone material. With regard to the former, in some instances, a preference for cranial over postcranial elements and minimal care in handling the thorax, vertebral column and ribs, and small hand and foot bones have been noted.

Collection and retention, involving boxing, labelling and storing of the skeletal material, is in some cases particularly poor. Of course, difficult excavation conditions, time pressure and minimal funding have led to poor excavation techniques and methods, but a combination of poor labelling and inadequate conditions of curation has had an adverse effect on the recording and preservation of the skeletal remains recovered. Also, the long-term storage of some skeletal remains in damp, inappropriate storerooms, disturbed additionally by insects and rodents, has obviously resulted in damage to a proportion of the recovered populations.

In addition to the extrinsic factors described above, intrinsic variables, that is *ageing and sexing methods* and *the nature of human bone* have an impact on the demographic picture of the case study populations (Ruff 1981; Jackes 1992; Chamberlain in press). Age, sex and pathological conditions of the individual (Henderson 1987) can affect the decomposition of human bone. In particular, postmenopausal females, immature individuals (i.e. infants and children) and elderly adults (perhaps due to poorly calcified bones) are more affected by decomposition (Weiss 1972; Walker et al. 1988; Walker 1995; Saunders 1992), although this is not always the case (Farwell and Molleson 1993). Finally, current techniques of ageing and sexing are often highly biased. Most of the methods utilised have been developed and tested on American collections of known age and sex and applied directly to past human populations. The ageing methods are especially unreliable for the old adult age groups, resulting in significant under-representation of individuals aged above 25 years old. The latter obviously distorts the palaeodemographic picture since the majority of adult individuals appear to fall into the young adult age groups so that the inferred average age at death is usually lower than the true value (Jackes 1992). Moreover, with regard to sexing techniques, alteration of cranial anatomical features in elderly women which tend to approach average male characteristics may lead to misrepresentation of the true proportion of the two sex groups (Ruff 1981; Walker 1995).

To estimate the degree of completeness of the skeletal remains in the case study cemeteries, the numbers of identifiable elements have been expressed as a percentage of expected values. The expected values have been computed by the multiplication of the

MNI recorded in each burial assemblage by 37 (the number of identifiable skeletal elements selected to be tested for presence or absence in the skeletal material (Table 4.1). The skeletal elements considered here include both sides of the postcranial and

Population	Expected value (37x MNI [1])	Observed	%
EN Nea Nikomedeia	1258	610	48
LN Makrigialos I	2664	469	18
LN Makrigialos II [2]	444	50	11 ↓
EBA Makrigialos	370	163	44
EBA Goules	1369	377	26
EBA Koilada	6290	2738	44
EBA/LBA Korinos	888	199	22
LBA Spathes	999	502	50
LBA/EIA Treis Elies	1295	542	42
EIA Makrigialos	1998	1066	53 ↑
EIA Olympus tumuli	1295	577	45

Table 4.1: Overall frequencies of completeness of the skeletal remains [3] (expected/observed and percentage rate) in the case study cemetery populations

cranial skeleton, while some anatomical regions have been counted as overall units such as the hand, foot, ribs, pelvis, cervical, thoracic, lumbar and sacral vertebrae (Table 4.2). The same test has also been applied by age and sex groups in order to assess completeness of the skeletons according to the above variables. These calculations show that LN Makrigialos I and II human remains have the least complete skeletal material (18% and 11%), as expected, due to cultural biases already described, while EIA Makrigialos (53%) has provided the most complete burial assemblage. Overall, four groups can be distinguished with regard to skeletal completeness:

1) *Extremely poor preservation*- below 20%, such as LN Makrigialos I and II (due to continuous re-use of the ditch and settlement deposits),
2) *Very poor preservation*- between 20% and 40%, such as EBA Goules (due to river-water conditions) and EBA/LBA Korinos (due to acid soil),

[1] MNI: Minimum Number of Individuals.

[2] LN Makrigialos II has not been considered in the osteological analysis regarding each cemetery separately due to the extremely fragmentary condition of the human remains and the resulting insufficiency of anatomical parts for reliable ageing and sexing. It has been considered, however, in the geographical and chronological groups discussed at the end of each chapter.

[3] Teeth have been excluded from estimates of the completeness of the skeletal remains.

3) *Poor preservation*- between 40% and 50%, such as EN Nea Nikomedeia, EBA Makrigialos, EBA Koilada, LBA/EIA Treis Elies and EIA Olympus tumuli (due to excavation and retention bias) and

4) *Good preservation*- above 50%, such as LBA Spathes and EIA Makrigialos.

Skeletal element/Bone part			
Skull	**Upper skeleton**	**Lower skeleton**	**Thorax**
Orbit [4]	Scapula [4]	Os coxa [4]	Cervical vertebrae
Frontal	Clavicle [4]	Femur [4]	Thoracic vertebrae
Parietal [4]	Humerus [4]	Tibia [4]	Lumbar vertebrae
Temporal [4]	Radius [4]	Fibula [4]	Sacrum
Occipital	Ulna [4]	Foot [4]	Ribs
Sphenoid [4]	Hand [4]		

Table 4.2: Skeletal elements and bone parts selected to be tested for bone representation in the case study skeletal populations

Similarly, with regard to the completeness of the skeletal material in different age groups (Table 4.3), it is striking that, contrary to the literature described above, half of the case study populations are represented by relatively complete adult skeletons, including prime, mature and old adult individuals. On the other hand, the less complete skeletal material has been provided by the subadult age categories which is consistent with the general expectation of an overall under-representation of subadults in cemetery collections due to preservation factors (Saunders 1992). For neonate, infant and child age categories, the exceptionally good representation in EN Nea Nikomedeia contrasts with their poor state at LN Makrigialos I, EBA Goules, EBA Koilada, LBA Spathes and EIA Makrigialos.

Finally, analysis by sex group (Table 4.4) reveals a better representation of male skeletal material in all cemetery populations with the exception of LN Makrigialos I, EBA Makrigialos and LBA Spathes where female individuals have a higher degree of completeness. The pattern of male skeletons having higher representation is consistent with systematic bias in skeletal sexing in favour of males (Weiss 1972).

[4] Both sides

	EN Nea Nikomedeia		LN Makrigialos I	
Age group	**Expected/Observed**	**%**	**Expected/Observed**	**%**
Neonate	296/112	38	0/0	0
Infant	296/118	40	185/18	10
Child	74/33	45	222/15	**7↓**
Juvenile	111/27	24	185/27	15
YA	74/46	62	222/73	**33↑**
PA	296/210	71	37/7	19
MA	74/59	**80↑**	0/0	0
OA	35/5	**14↓**	0/0	0
Indeterminate adult	0/0	0	1813/329	18

	LN Makrigialos II		EBA Makrigialos	
Age group	**Expected/Observed**	**%**	**Expected/Observed**	**%**
Neonate	74/4	**5↓**	37/11	**30↓**
Infant	37/0	0	37/21	**57↑**
Child	0/0	0	37/9	24
Juvenile	74/4	**5↓**	0/0	0
YA	0/0	0	74/34	46
PA	0/0	0	0/0	0
MA	0/0	0	0/0	0
OA	0/0	0	0/0	0
Indeterminate adult	222/42	**19↑**	185/88	48

	EBA Goules		EBA Koilada	
Age group	**Expected/Observed**	**%**	**Expected/Observed**	**%**
Neonate	0/0	0	370/39	**9↓**
Infant	0/0	0	1554/424	27
Child	111/8	**7↓**	518/240	46
Juvenile	111/50	45	370/254	69
YA	222/96	**43↑**	777/505	65
PA	222/75	34	962/679	**71↑**
MA	148/42	28	481/344	36
OA	0/0	0	74/49	66
Indeterminate adult	555/106	19	592/144	24

	EBA/LBA Korinos		LBA Spathes	
Age group	**Expected/Observed**	**%**	**Expected/Observed**	**%**
Neonate	0/0	0	0/0	0
Infant	0/0	0	74/19	26
Child	148/52	35	74/8	**11↓**
Juvenile	0/0	0	74/27	36
YA	259/44	17	333/238	71
PA	74/13	18	148/94	64
MA	0/0	0	37/37	**100↑**
OA	37/33	**89↑**	37/33	89
Indeterminate adult	370/57	**15↓**	222/46	21

Table 4.3: Overall frequencies of completeness of the skeletal remains (expected/observed and percentage rate) by age group

	LBA/EIA Treis Elies		EIA Makrigialos	
Age group	**Expected/Observed**	**%**	**Expected/Observed**	**%**
Neonate	0/0	0	0/0	0
Infant	0/0	0	148/46	**31 ↓**
Child	74/21	28	74/46	62
Juvenile	37/17	46	185/103	56
YA	518/271	52	740/408	55
PA	0/0	0	407/232	57
MA	222/132	**59 ↑**	111/87	78
OA	0/0	0	37/33	**89↑**
Indeterminate adult	444/101	**23 ↓**	222/105	47

	EIA Olympus tumuli	
Age group	**Expected/Observed**	**%**
Neonate	0/0	0
Infant	0/0	0
Child	74/25	34
Juvenile	37/29	**78 ↑**
YA	444/205	46
PA	296/176	59
MA	111/41	37
OA	0/0	0
Indeterminate adult	333/101	**30 ↓**

Table 4.3 (continued): Overall frequencies of completeness of the skeletal remains (expected/observed and percentage rate) by age group

	EN Nea Nikomedeia		LN Makrigialos I	
Sex group [5]	Expected/Observed	%	Expected/Observed	%
Male	148/112	76	333/40	12
Female	333/208	62	888/137	15

	LN Makrigialos II		EBA Makrigialos	
Sex group	Expected/Observed	%	Expected/Observed	%
Male	37/2	5	185/94	51
Female	0/0	0	37/24	65

	EBA Goules		EBA Koilada	
Sex group	Expected/Observed	%	Expected/Observed	%
Male	111/87	78	1258/907	63
Female	333/232	70	1443/768	53

	EBA/LBA Korinos		LBA Spathes	
Sex group	Expected/Observed	%	Expected/Observed	%
Male	222/77	35	222/88	40
Female	518/70	14	555/350	63

	LBA/EIA Treis Elies		EIA Makrigialos	
Sex group	Expected/Observed	%	Expected/Observed	%
Male	555/304	55	333/212	64
Female	629/200	32	1184/653	55

	EIA Olympus tumuli	
Sex group	Expected/Observed	%
Male	555/281	51
Female	629/242	38

Table 4.4: Overall frequencies of completeness of the skeletal remains (expected/observed and percentage rate) by sex group

Overall, the case study skeletal material is in a poor and fragmentary state of preservation, due to various types of cultural, environmental and excavation/retention biases. These factors obviously place constraints on the demographic analysis and make it difficult to standardise the eleven different population groups used in the case study. Finally, as already noted, the burial assemblages investigated represent a large range of differential preservation and completeness reflected mainly in the disproportionate representation of age and sex groups. Having considered the specific limitations of the nature of the sample, the methodology and results of the palaeodemographic analysis will be described next.

4.3. METHODOLOGY

Methods of sex determination have been applied only to adults (above 18 years old). The sex estimation of adults was based on the available pelvic and cranial morphology and long bone measurements. Specifically, morphology of the os coxa has been considered as the most reliable sex indicator (Phenice 1969; Kelley 1978; 1979; Krogman and Isçan 1986; Mac Laughlin and Bruce 1986; Lovell 1989; Sutherland and Suchey 1991). When the pelvis was not well preserved, less reliable sex indicators were used, such as cranial morphology and skeletal robusticity, as represented by long bone measurements (Berrizbeitia 1989; Holland 1991; Holman and Bennett 1991). Finally, if none of the above skeletal elements was available, an undetermined sex category was assigned, demonstrating the ineffectiveness of current macroscopic sexing techniques in fragmentary, poorly preserved skeletal assemblages.

Estimation of age at death was based primarily on the teeth, due to their relatively good preservation, and secondarily on other anatomical points where available. Thus, subadults were aged on the bases of dental development (Moorees et al. 1963a; 1963b) and epiphyseal closure (Steele and Bramblett 1988; Ubelaker 1978). In addition, where no teeth were available, long bone length measurements were considered (Hoppa 1991; 1992). Adult skeletons were aged on a combination of methods, depending on which anatomical points were best preserved. In descending order of reliability, the techniques utilised included: pubic symphyseal morphology, according to Suchey and Brooks' system for age determination from the os pubis (Katz and Suchey 1986; Brooks and Suchey 1989); dental attrition, primarily after Miles (Miles 1963a; 1963b) and secondarily after the scheme of Bouts and Pot (1989); epiphyseal completion (Brothwell 1981; Ubelaker 1978; Steele and Bramblett 1988); changes to the auricular surface of the ilium, following Lovejoy and co-workers (Lovejoy et al. 1985); and the ectocranial suture closure method (Meindl and Lovejoy 1985).

In order to minimise estimation error in ageing, eight broad age categories were defined, based on criteria related to dental development and epiphyseal completion of long bones for subadults and degenerative processes and degradation for adults: 1) *neonate*: birth to one year, 2) *infant*: 1 year to 6 years, 3) *child*: 6 to 12 years, 4) *juvenile*:

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[5] Only sexed individuals have been counted.

12 to 18 years, 5) *young adult*: 18 to 30 years, 6) *prime adult*: 30 to 40 years, 7) *mature adult*: 40 to 50 years and 8) *old adult*: 50+ years. It is notable that the age intervals of the proposed groups expand with increasing age while the accuracy of ageing techniques decreases.

Values such as mortality rates (d_x), survivorship (l_x) and probability of death (q_x), which usually appear in life tables, have been adopted in the current analysis in order to compare the prehistoric populations with expectations derived from model life tables. The Coale and Demeny (1969) West series, with a life expectancy at birth of thirty, has been used as a baseline human demographic pattern with which to compare the overall shape of the distribution. It is important to note controversy regarding the use of life tables in palaeodemography on two points: 1) the perception of the samples as stable populations and 2) the assumption that excavated cemetery populations represent once complete living populations (Moore et al. 1975; Bocquet-Appel and Masset 1982; Buikstra and Konigsberg 1985; Buikstra and Mielke 1985; van Gerven and Armelagos 1983; Wood et al. 1992; Chamberlain in press). The current assessment of the case study prehistoric populations should not be seen, therefore, as a true representation of past population dynamics as a whole. Rather, it has been used as a tool for comparing different populations with each other and with modern standard tables - that is, for comparing otherwise incomparable samples.

In the life tables produced for the case study populations, four values have been tabulated, which effectively express the same data in different ways. First, D_x is the absolute number of individuals calculated to have died within each of the age intervals defined above. Many individuals could only be assigned to the very broad age categories of subadult and adult (Table 4.5). These individuals of the "unknown" age categories have been distributed proportionately across the subadult and adult age intervals represented in each cemetery population in order to be utilised in the case study life tables (Chamberlain 1994). Secondly, *mortality rates* have been estimated by d_x, which is the percentage of the total sample dying within the defined age category and is computed as $100 \times D_x/\Sigma D_x$. Thirdly, *survivorship*, that is l_x, reflects the percentage of an initial population cohort remaining alive at the end of the defined age intervals, namely $l_x = l_{x-1} - d_{x-1}$. Thus, survivorship decreases at each successive age interval, from a maximum value at birth of 100 to zero at the age at which the last survivor dies (Hassan 1981; Buikstra and Mielke 1985; Chamberlain in press). Fourthly, the *probability of dying* within each age interval, q_x is computed as d_x/l_x. In addition, in order to compare age-specific probability of death in each cemetery population to the model life table values, probability of death has been "corrected" for the life years represented by each age interval (t), by computing q_x/t, where t = the length of the age interval.

Regarding the distribution of sex groups in the case study cemetery populations, two principal problems have significantly reduced the size of the samples: 1) the application of sexing methods only to adult individuals and 2) the relatively large number of indeterminate individuals recorded, whose sex was impossible to define.

	SUBADULT AGE GROUP				
Population	**Neonate**	**Infant**	**Child**	**Juvenile**	**Indeterminate subadult**
EN Nea Nikomedeia	8	8	2	3	0
LN Makrigialos I	0	4	5	4	3
LN Makrigialos II	2	1	0	2	0
EBA Makrigialos	1	1	1	0	0
EBA Goules	0	0	3	3	0
EBA Koilada	10	42	14	10	16
EBA/LBA Korinos	0	0	4	0	0
LBA Spathes	0	2	2	2	0
LBA Treis Elies	0	0	2	1	0
EIA Makrigialos	0	4	2	5	2
EIA Olympus tumuli	0	0	2	1	0

	ADULT AGE GROUP				
Population	**YA**	**PA**	**MA**	**OA**	**Indeterminate adult**
EN Nea Nikomedeia	2	8	2	1	0
LN Makrigialos I	6	1	0	0	49
LN Makrigialos II	0	0	0	0	7
EBA Makrigialos	2	0	0	0	5
EBA Goules	6	6	4	0	15
EBA Koilada	21	26	13	2	16
EBA/LBA Korinos	7	2	0	1	10
LBA Spathes	9	4	1	1	6
LBA Treis Elies	14	0	6	0	12
EIA Makrigialos	20	11	3	1	6
EIA Olympus tumuli	12	8	3	0	9

Table 4.5: Number of individuals by age group before proportionate redistribution

Therefore, demographic analysis concerning sex groups has been limited to the representation of mortality rates within each burial assemblage and to the distribution of the sexes by age group. The shape of mortality curves for each sex group has also been compared with expected estimations derived from model life tables (Coale and Demeny 1969).

Chronology/ Region	Early populations	Late populations
Coastal	n= 65 Nea Nikomedeia, LN and EBA Makrigialos	n= 78 Korinos, EIA Makrigialos
Inland	n= 207 Koilada, Goules	n= 97 Spathes, Treis Elies, Olympus tumuli

Table 4.6: Grouping of the case study populations according to geographical and chronological variables

The analysis of the demographic parameters has been conducted at two levels: 1) between the case study populations and 2) within geographical and chronological groups. To this end, the study populations have been grouped chronologically, as early or late, and geographically, as inland or coastal (Table 4.6).

4.4.1. INTER-CEMETERY ANALYSIS: Is everybody here?

Table 4.7 summarises the values of the demographic parameters based on the developing demographic dynamics by *age group* in the case study burial assemblages. Only mortality profiles and survivorship curves will be considered in detail as these suffice to draw attention to the demographic properties of the assemblages. The shaded areas in Table 4.7 indicate age groups for which no individuals have been recorded.

It is worth noting four points which are immediately apparent in Table 4.7:

A. Only two out of ten burial assemblages, EN Nea Nikomedeia and EBA Koilada, have provided deaths *within all age categories*.

B. In eight out of ten cemetery populations, the largest number of deaths falls in the *young adult* category.

C. *The age groups systematically missing* from the cemetery populations (see shaded areas in Table 4.7) are early (neonates and/or infants) and/or old age categories (mature and/or old adults). Factors contributing to this pattern, which include preservational, funerary and methodological effects, are discussed below when the case study mortality profiles and survivorship curves are compared with the model life tables.

D. Two burial assemblages, EBA/LBA Korinos and LBA/EIA Treis Elies, have an uneven distribution of adult age categories, with a lack of the *intermediate age groups of mature and prime adults respectively* (see shaded areas in the respective

Early Neolithic Nea Nikomedeia (n=34)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	8	23.52	100.00	0.2352	0.2352
Infant	8	23.52	76.48	0.3075	0.0615
Child	2	5.88	52.96	0.1110	0.0185
Juvenile	3	8.82	47.08	0.1873	0.0312
YA	2	5.88	38.26	0.1536	0.0128
PA	8	23.52	32.38	0.7263	0.0726
MA	2	5.88	8.86	0.6636	0.0663
OA	1	2.94	2.98	0.9865	0.0394

Makrigialos I (n=72) [6]					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	5	6.94	100.00	0.0694	0.0138
Child	6	8.33	93.06	0.0895	0.0149
Juvenile	5	6.94	84.73	0.0819	0.0136
YA	48	66.66	77.79	0.9982	0.0682
PA	8	11.11	11.13	0.9972	0.0997
MA	0				
OA	0				

EBA Makrigialos (n=10)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	1	10.00	100.00	0.1	0.1
Infant	1	10.00	90.00	0.11	0.022
Child	1	10.00	80.00	0.125	0.020
Juvenile	0	0.00	70.00	0.00	0.00
YA	7	70.00	70.00	1.00	0.083
PA	0				
MA	0				
OA	0				

Early Bronze Age Goules (n=37)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	0				
Child	3	8.10	100.00	0.081	0.0135
Juvenile	3	8.10	91.90	0.0881	0.0146
YA	12	32.43	83.80	0.3869	0.0322
PA	12	32.43	51.37	0.6313	0.0631
MA	7	18.91	18.94	0.9984	0.0998
OA	0				

Early Bronze Age Koilada (n=170)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	12	7.05	100.00	0.0705	0.0705
Infant	51	30.00	92.95	0.3227	0.0645
Child	17	10.00	62.95	0.1588	0.0264
Juvenile	12	7.05	52.95	0.1331	0.0221
YA	26	15.29	45.90	0.3331	0.0277
PA	33	19.41	30.61	0.6341	0.0634
MA	16	9.41	11.20	0.8401	0.0840
OA	3	1.76	1.79	0.9832	0.0393

Early/Late Bronze Age Korinos (n=24)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	0				
Child	4	16.66	100.00	0.1666	0.0277
Juvenile	0				
YA	14	58.33	83.34	0.6999	0.0583
PA	4	16.66	25.01	0.6661	0.0666
MA	0				
OA	2	8.33	8.35	0.9976	0.0399

Late Bronze Age Spathes (n=27)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	2	7.40	100.00	0.074	0.0148
Child	2	7.40	92.60	0.0799	0.0133
Juvenile	2	7.40	85.20	0.0868	0.0144
YA	13	48.14	77.80	0.6187	0.0515
PA	6	22.22	29.66	0.7491	0.0749
MA	1	3.70	7.44	0.4973	0.0497
OA	1	3.70	3.74	0.9893	0.0395

Late Bronze/Early Iron Age Treis Elies (n=35)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	0				
Child	2	5.71	100.00	0.0571	0.0095
Juvenile	1	2.85	94.29	0.0302	0.0050
YA	22	62.85	91.44	0.6873	0.0057
PA	0				
MA	10	28.57	28.59	0.9993	0.0999
OA	0				

Early Iron Age Makrigialos (n=54)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	5	9.25	100.00	0.0925	0.0185
Child	2	3.70	90.75	0.0407	0.0067
Juvenile	6	11.11	87.05	0.1276	0.0212
YA	23	42.59	75.94	0.5608	0.0467
PA	13	24.07	33.35	0.7217	0.0721
MA	4	7.40	9.28	0.7974	0.0794
OA	1	1.85	1.88	0.9840	0.0393

Early Iron Age Olympus tumuli (n=35)					
Age (x)	D_x	d_x	l_x	q_x	q_x/t
Neonate	0				
Infant	0				
Child	2	5.71	100.00	0.0571	0.0095
Juvenile	1	2.85	94.29	0.0302	0.0050
YA	17	48.57	91.44	0.5311	0.0442
PA	11	31.42	42.87	0.7329	0.0732
MA	4	11.42	11.45	0.9973	0.0997
OA	0				

Table 4.7: Number of individuals (D_x), mortality (d_x), survivorship (l_x) and probability of dying (q_x) in the case study populations

6 The Minimum Number of Individuals estimated from the phase I disarticulated bones has been redistributed proportionately according to the distribution of the age categories in the articulated skeletons.

Figure 4.1: Mortality profiles (d_x) in the Neolithic and Early Bronze Age case study populations

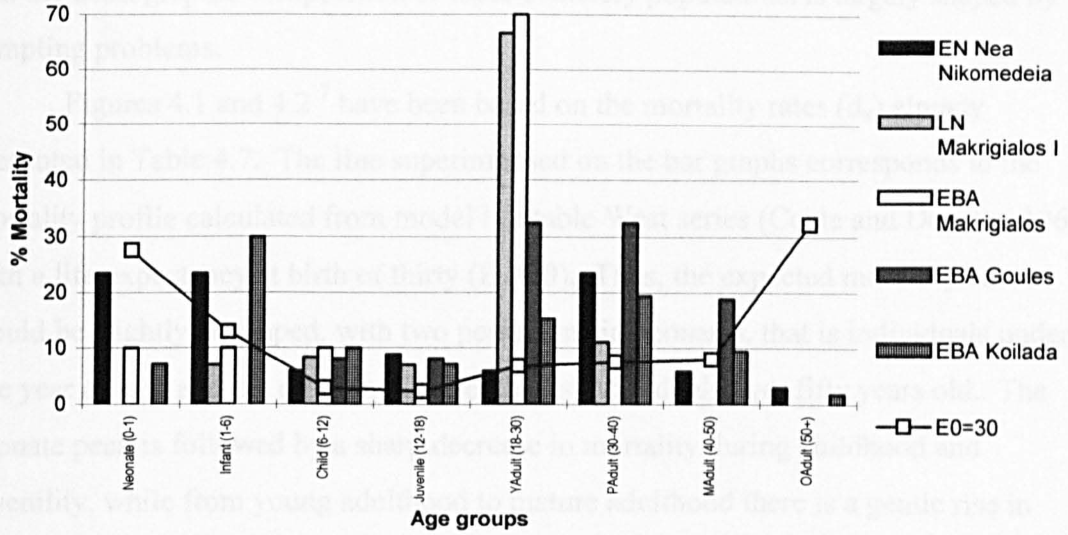
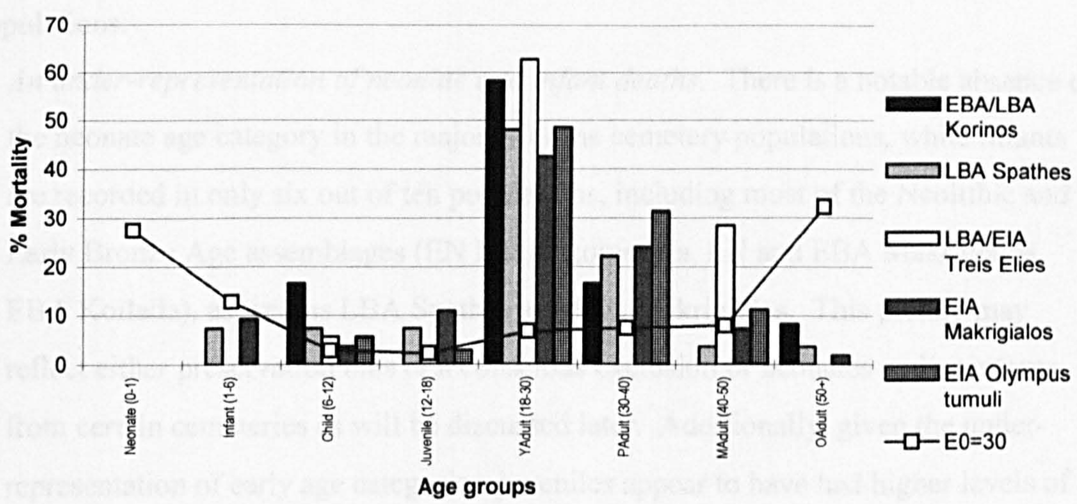


Figure 4.2: Mortality profiles in the Late Bronze and Early Iron Age case study populations



cemeteries of Table 4.7). In addition, EBA Makrigialos and EBA/LBA Korinos have no evidence of juvenile individuals. The absence of intermediate age groups may indicate that the demographic composition of these cemetery populations is largely shaped by sampling problems.

Figures 4.1 and 4.2 [7] have been based on the mortality rates (d_x) already presented in Table 4.7. The line superimposed on the bar graphs corresponds to the mortality profile calculated from model life table West series (Coale and Demeny 1969) with a life expectancy at birth of thirty (E_0=30). Thus, the expected mortality curve would be slightly U-shaped, with two peaks: one in neonates, that is individuals under one year of age, and the other in old age, that is individuals over fifty years old. The neonate peak is followed by a sharp decrease in mortality during childhood and juvenility, while from young adulthood to mature adulthood there is a gentle rise in mortality, followed by a sharp increase in the old age category.

The survivorship curves of the case study burial assemblages (Figures 4.3 and 4.4) provide an additional visual aid to comparing several assemblages with the model life table. According to the E_{30} life table model, survivorship should decline sharply in the first two age categories, neonates and infants, followed by a slight decrease from childhood to prime adulthood, and then a renewed sharp decline in old age.

Figures 4.1- 4.4 reveal two overall characteristics of the archaeological cemetery populations:

A. *An under-representation of neonate and infant deaths.* There is a notable absence of the neonate age category in the majority of the cemetery populations, while infants are recorded in only six out of ten populations, including most of the Neolithic and Early Bronze Age assemblages (EN Nea Nikomedeia, LN and EBA Makrigialos, EBA Koilada), as well as LBA Spathes and EIA Makrigialos. This picture may reflect either preservation bias or a conscious exclusion of neonates and/or infants from certain cemeteries as will be discussed later. Additionally, given the under-representation of early age categories, juveniles appear to have had higher levels of mortality than children in EN Nea Nikomedeia, LN Makrigialos I and EIA Makrigialos which is opposite to the expected mortality trend.

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[7] Due to the large number of cemetery populations included in the study, the demographic parameters analysed in detail, mortality profiles and survivorship curves, have been drawn in separate graphs for the Neolithic-Early Bronze Age and the Late Bronze-Early Iron Age burial assemblages respectively.

Figure 4.3: Survivorship (l_x) in the Neolithic and Early Bronze Age case study populations

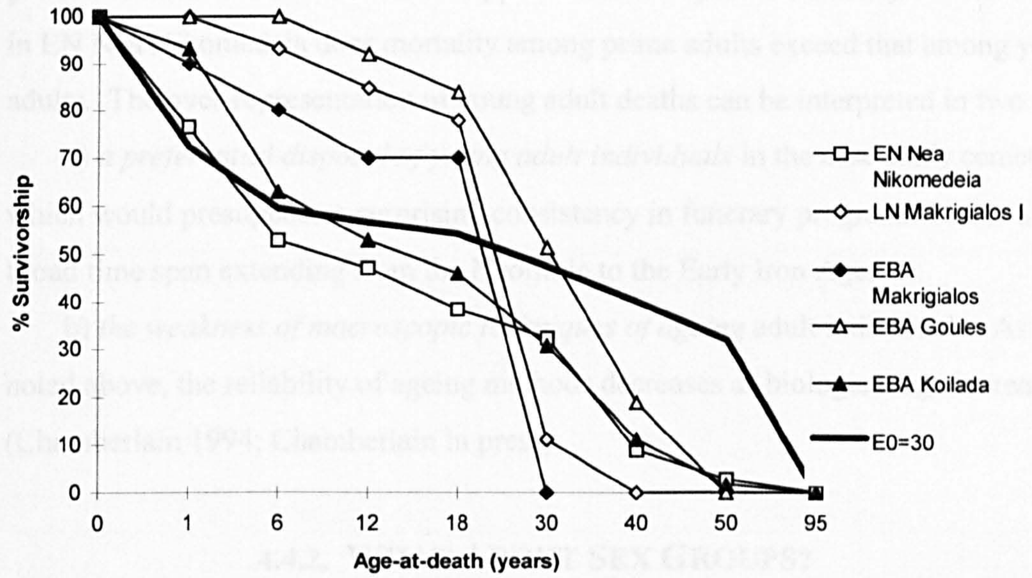
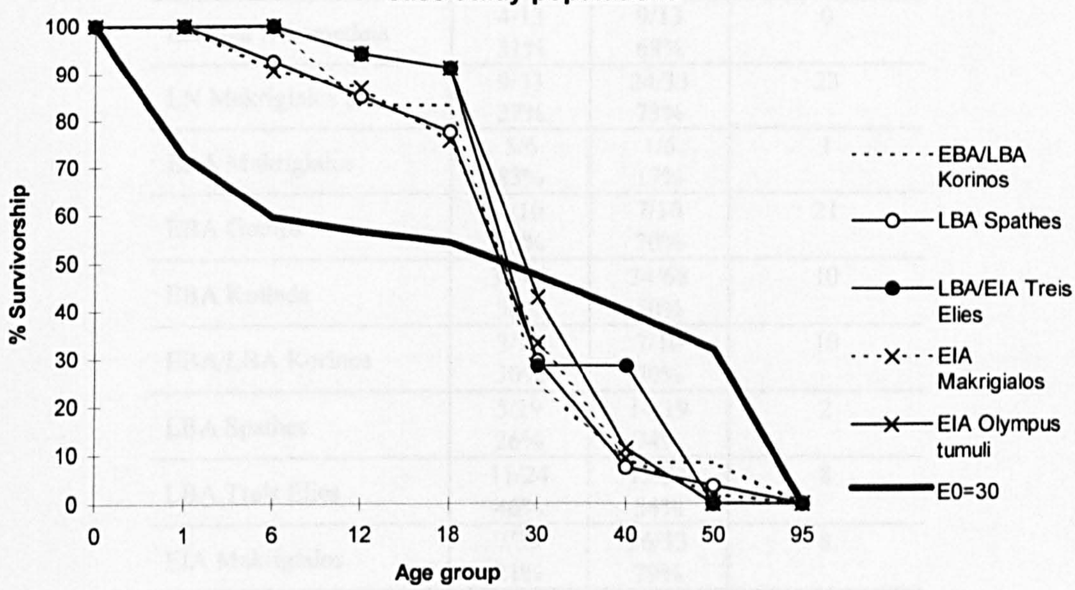


Figure 4.4: Survivorship (l_x) in the Late Bronze and Early Iron Age case study populations



B. *An over-representation of young adult deaths.* Young adults are the most abundant age category in the majority of the skeletal assemblages with much lower numbers of prime and older adults which is the opposite of the expected mortality curve. Only in EN Nea Nikomedeia does mortality among prime adults exceed that among young adults. The over-representation of young adult deaths can be interpreted in two ways:

a) *a preferential disposal of young adult individuals* in the case study cemeteries, which would presuppose a surprising consistency in funerary programme over a broad time span extending from the Neolithic to the Early Iron Age,

b) *the weakness of macroscopic techniques of ageing* adult individuals. As noted above, the reliability of ageing methods decreases as biological age increases (Chamberlain 1994; Chamberlain in press).

4.4.2. WHAT ABOUT SEX GROUPS?

Table 4.8 represents the distribution of the sex groups in the case study populations. As has been emphasised above in the discussion of methodology, sample sizes have been reduced here by the exclusion of the subadult segment of the

Population	Male	Female	Indeterminate
EN Nea Nikomedeia	4/13 31%	9/13 69%	0
LN Makrigialos I	9/33 27%	24/33 73%	23
EBA Makrigialos	5/6 83%	1/6 17%	1
EBA Goules	3/10 30%	7/10 70%	21
EBA Koilada	34/68 50%	34/68 50%	10
EBA/LBA Korinos	3/10 30%	7/10 70%	10
LBA Spathes	5/19 26%	14/19 74%	2
LBA Treis Elies	11/24 46%	13/24 54%	8
EIA Makrigialos	7/33 21%	26/33 79%	8
EIA Olympus tumuli	12/28 43%	16/28 57%	4

Table 4.8: Distribution of the case study populations by sex group (adults only)

populations and by the large number of indeterminate individuals (see Table 4.8). In investigating the relationship between sex and age at death, the samples are further reduced by the exclusion of individuals of indeterminate age (Table 4.9).

In addition, Table 4.8 reveals a striking prevalence of *female individuals* in the cemetery populations, except for EBA Makrigialos, where the sample is exceptionally small, and EBA Koilada, where both sex groups are equally represented. The sex

	EN Nea Nikomedeia				LN Makrigialos I			
Sex	YA	PA	MA	OA	YA	PA	MA	OA
Male	1/4 25%	2/4 50%	1/4 25%	0/4	1/2 50%	1/2 50%	*Undefined*	*Undefined*
Female	1/9 11%	6/9 67%	1/9 11%	1/9 11%	4/4 100%	*Undefined*	*Undefined*	*Undefined*

	EBA Makrigialos				EBA Goules			
Sex	YA	PA	MA	OA	YA	PA	MA	OA
Male	2/2 100%	*Undefined*	*Undefined*	*Undefined*	2/3 67%	1/3 33%	0/3	*Undefined*
Female	0/1	*Undefined*	*Undefined*	*Undefined*	1/9 11%	4/9 44%	1/9 11%	*Undefined*

	EBA Koilada				EBA/LBA Korinos			
Sex	YA	PA	MA	OA	YA	PA	MA	OA
Male	11/34 32%	13/34 38%	7/34 21%	1/34 3%	1/3 33%	0/3	*Undefined*	1/3 33%
Female	9/34 26%	13/34 38%	6/34 18%	1/34 3%	3/7 43%	2/7 29%	*Undefined*	0/7

	LBA Spathes				LBA/EIA Treis Elies			
Sex	YA	PA	MA	OA	YA	PA	MA	OA
Male	0/5	3/5 60%	0/5	0/5	7/11 64%	*Undefined*	2/11 18%	*Undefined*
Female	9/13 69%	1/13 8%	1/13 8%	1/13 8%	5/13 38%	*Undefined*	4/13 31%	*Undefined*

	EIA Makrigialos				EIA Olympus tumuli			
Sex	YA	PA	MA	OA	YA	PA	MA	OA
Male	2/7 29%	3/7 43%	1/7 14%	1/7 14%	5/12 42%	5/12 42%	1/12 8%	*Undefined*
Female	14/26 54%	6/26 23%	2/26 8%	0/26	5/14 36%	3/14 21%	1/14 7%	*Undefined*

Table 4.9: Distribution of the sexes by age group in the case study populations (excluding adults of indeterminate age)

groups are also fairly evenly represented in LBA Treis Elies and the EIA Olympus tumuli, but overall the difference between the two sex groups is statistically significant (chi square test: $x^2=18.733> p=16.919$, at the 0.05 level of significance).

Table 4.9 represents the distribution of males and females among the adult age categories. The age distributions of the two sexes are significantly different only in LBA Spathes (chi square test: $x^2=10.912> p=9.348$, at the 0.025 level of significance). High mortality rates are expected among young adult women, due to the stress of pregnancy and childbirth (Larsen 1997). In Table 4.9, three cemetery populations, LBA Spathes (differences statistically significant), EIA Makrigialos and the EIA Olympus tumuli match the expected high mortality rates for young adult women, while no male assemblage has a similar distribution. The high prevalence of young adult women should be viewed with extreme caution, bearing in mind the weakness of the macroscopic ageing methods used to distinguish adult age categories.

Two interpretations can be proposed for the prevalence of female adults in the case study burial assemblages:

A. *Sample bias.* In some assemblages, there is a large number of individuals of indeterminate sex (see Table 4.8). In LN Makrigialos I, EBA Goules and EBA/LBA Korinos, the sex-indeterminate skeletons equal or exceed those of known sex, so that the contrasting mortality rates of the two sex groups might be regarded as unreliable. On the other hand, the analysis of skeletal preservation by sex group (Table 4.4) revealed a greater completeness of male than female skeletons in the study assemblages overall. This suggests that a majority of the unsexed skeletons may in fact be female and that the prevalence of female burials may actually be under-estimated by the available data.

B. *Preferential inclusion of female individuals.* This interpretation is particularly plausible for the assemblages from EN Nea Nikomedeia, LBA Spathes, EIA Makrigialos and the EIA Olympus tumuli, for which the number of indeterminate individuals is relatively modest. It is possible that some males died elsewhere, e.g. in warfare, but there is no evidence (in the form of a high incidence of wounds) to favour such an interpretation (below Chapter 6). In LBA Spathes, all males recovered belong to the prime adult age group (Table 4.9), suggesting a possible preferential inclusion of adult males of a particular age in this burial ground. On the other hand, in EN Nea Nikomedeia and EIA Makrigialos, males are represented in all adult age categories similarly to the females. It is even conceivable that males were preferentially subject to infanticide, perhaps because women were highly valued in both reproduction and agricultural production, as discussed later.

4.4.3. Analysis of Geographical and Chronological Groupings

Table 4.10 presents the values of mortality (d_x), survivorship (l_x) and probability of dying (q_x) computed for the chronological/geographical population groups defined previously.

Early populations (Neolithic and Early Bronze Age)										
	Coastal (n=128)					*Inland (n=207)*				
Age (x)	D_x	d_x	l_x	q_x	q_x/t	D_x	d_x	l_x	q_x	q_x/t
Neonate	11	8.59	100.00	0.0859	0.0859	12	5.79	100.00	0.0579	0.0579
Infant	15	11.71	91.41	0.1281	0.0256	51	24.63	94.21	0.2614	0.0522
Child	9	7.03	79.70	0.0882	0.0147	20	9.66	69.58	0.1388	0.0231
Juvenile	10	0.78	72.67	0.1074	0.0179	15	7.24	59.92	0.1208	0.0201
YA	64	50.00	64.87	0.7707	0.0642	38	18.35	52.68	0.3483	0.0290
PA	16	12.50	14.87	0.8406	0.0840	45	21.73	34.44	0.6309	0.0630
MA	2	1.56	2.37	0.6582	0.0658	23	11.11	12.60	0.8817	0.0881
OA	1	0.78	0.81	0.9629	0.0385	3	1.44	1.49	0.9664	0.0386

Late populations (Late Bronze and Early Iron Age)										
	Coastal (n=78)					*Inland (n=97)*				
Age (x)	D_x	d_x	l_x	q_x	q_x/t	D_x	d_x	l_x	q_x	q_x/t
Neonate	0	0.00				0	0.00			
Infant	5	6.41	100.00	0.0641	0.0128	2	2.06	100.00	0.0206	0.0041
Child	6	7.69	93.59	0.0821	0.0136	6	6.18	97.94	0.0630	0.0105
Juvenile	6	7.69	85.90	0.0895	0.0149	4	4.12	91.76	0.0448	0.0074
YA	37	47.43	78.21	0.6064	0.0505	52	53.60	87.64	0.6115	0.0509
PA	17	21.79	30.78	0.7079	0.0707	17	17.52	34.04	0.5146	0.0514
MA	4	5.12	8.99	0.5695	0.0569	15	15.46	16.52	0.9358	0.0935
OA	3	3.84	3.87	0.9922	0.0396	1	1.03	1.06	0.9716	0.0388

Table 4.10: Number of individuals (D_x), mortality (d_x), survivorship (l_x) and probability of dying (q_x) in the case study cemeteries

Figures 4.5 and 4.6 present the mortality rates and survivorship respectively, for the same groups. In each case, the prehistoric assemblages are compared with the model values for life expectancy at birth of thirty. Three points are worth considering:

A. *There is a lack of neonates in the late populations*, both coastal and inland (Figure 4.5). In the early populations, neonates are fewer than expected, perhaps due to preservational factors. In the late populations, however, the total lack of neonates is unlikely to result from preservational biases alone and may instead reflect funerary behaviour, that is the disposal of this age category outside the excavated cemeteries.

B. *Mortality rates in the subadult categories (infants, children and juveniles) are higher in the early than the late populations* with a particular emphasis on infant deaths. This picture may be explained by the inclusion in the early populations of EN Nea Nikomedeia and EBA Koilada which present high levels of infant mortality, apparently associated with a high prevalence of anaemia in the same age category (Chapter 6). The difference in the distribution of the cumulative frequencies of mortality rates between early and late populations is statistically significant (Kolmogorov-Smirnov test: $D_{maxobs} = 0.260 > D_{max0.05} = 0.126$). In particular, infant mortality represents high levels especially in the early inland populations (Figure 4.5). The difference in the distribution of the cumulative frequencies of age

Figure 4.5: Mortality profiles (d_x) in the case study populations

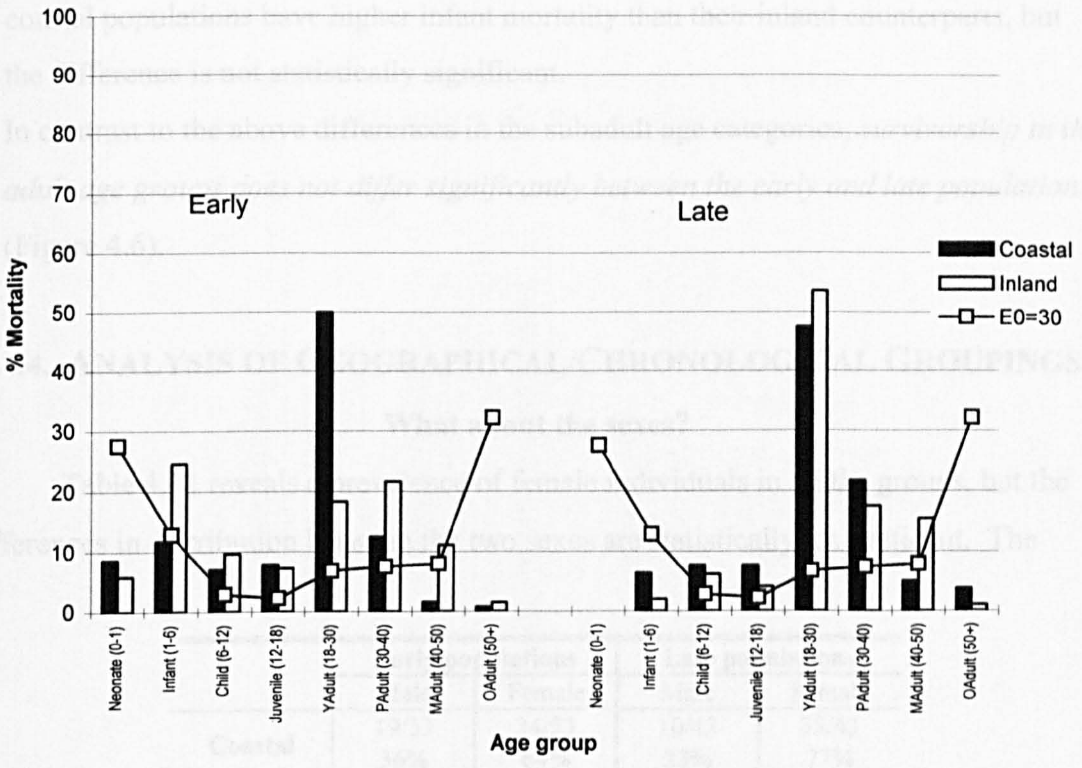
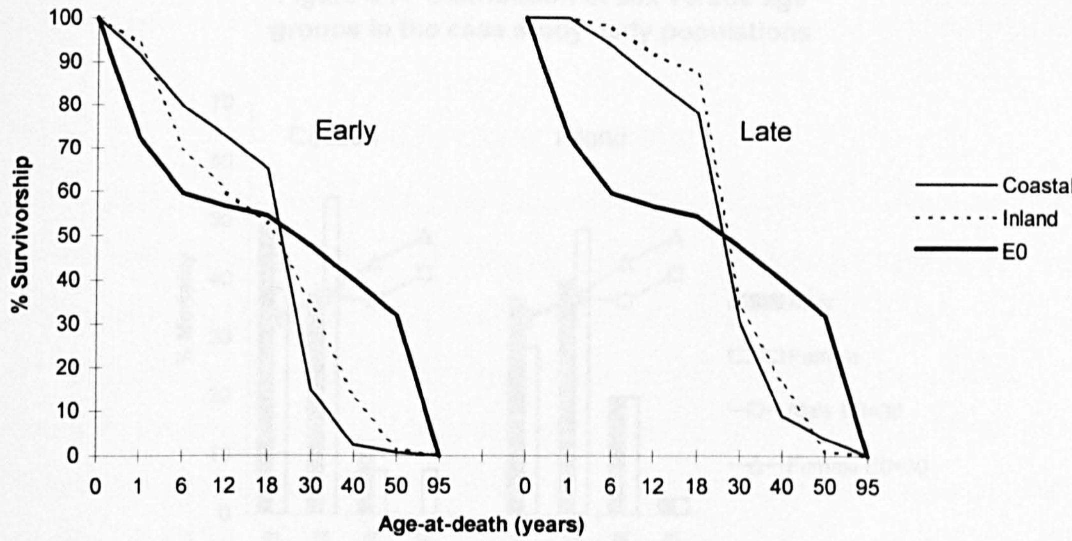


Figure 4.6: Survivorship (l_x) in the case study populations



categories between the early inland and coastal populations is statistically significant (Kolmogorov-Smirnov test: $D_{maxobs} = 0.196 > D_{max0.05} = 0.152$). In the late periods, coastal populations have higher infant mortality than their inland counterparts, but the difference is not statistically significant.

C. In contrast to the above differences in the subadult age categories, *survivorship in the adult age groups does not differ significantly between the early and late populations* (Figure 4.6).

4.4.4. Analysis of Geographical/Chronological Groupings: What about the sexes?

Table 4.11 reveals a prevalence of female individuals in all the groups, but the differences in distribution between the two sexes are statistically insignificant. The

	Early populations		Late populations	
	Male	Female	Male	Female
Coastal	19/53 36%	34/53 64%	10/43 23%	33/43 77%
Inland	37/78 47%	41/78 53%	28/71 39%	43/71 61%

Table 4.11: Distribution of the sexes in the geographical/chronological groupings

Figure 4.7: Distribution of sex versus age groups in the case study early populations

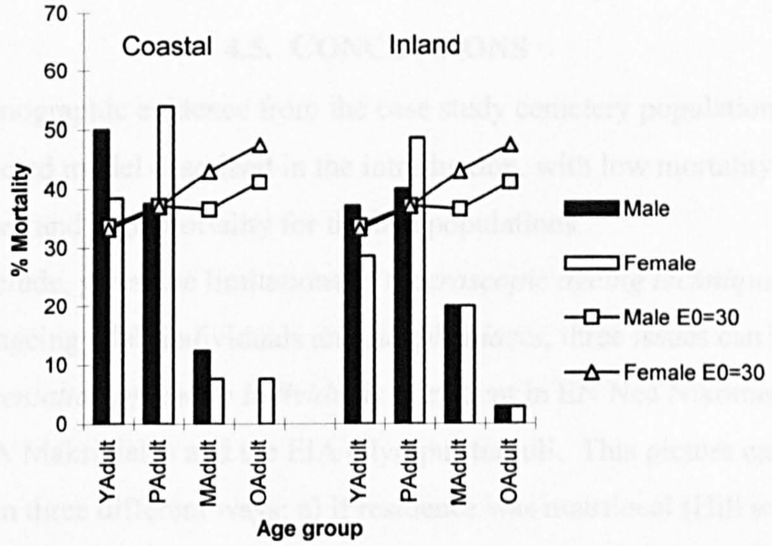
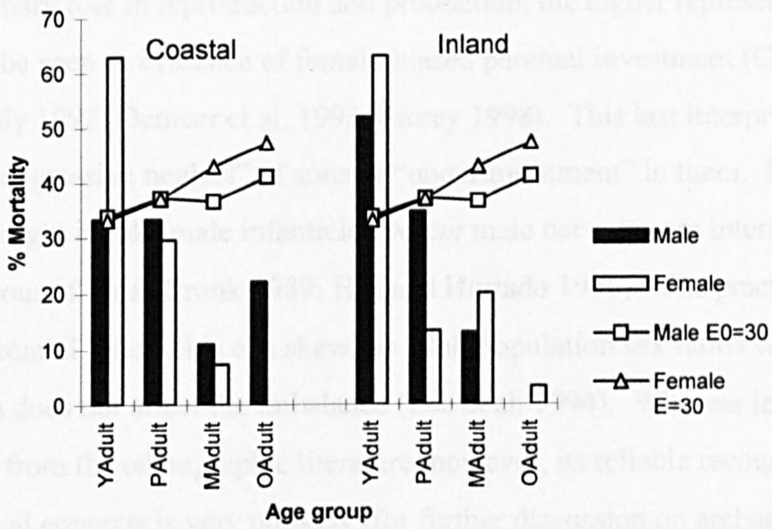


Figure 4.8: Distribution of sex versus age groups in the case study late populations



investigation of the occurrence of the two sex groups in the early and late case study populations will focus on the overall shape of mortality profiles in the different age categories and not on the absolute frequency of mortality in individual age categories.

Figures 4.7 and 4.8 represent the distribution of sex versus age groups in the defined geographical/chronological population subgroups. In early populations, men died earlier than women while in late populations, the reverse occurred. Thus, there is a hint of a greater susceptibility of females to stress factors in the late populations. In both early and late populations, this trend is clearer for the coastal than inland region.

4.5. CONCLUSIONS

The demographic evidence from the case study cemetery populations does not match the expected model described in the introduction, with low mortality rates for the early populations and high mortality for the late populations.

To conclude, given the limitations of *macroscopic ageing techniques* used particularly in ageing adult individuals and *sample biases*, three issues can be stressed:

A. *Over-representation of female individuals* is evident in EN Nea Nikomedeia, LBA Spathes, EIA Makrigialos and the EIA Olympus tumuli. This picture can be interpreted in three different ways: a) if residence was matrilocal (Hill and Hurtado 1996: 234), women may have revealed strong links to their place of residence by being buried in the cemetery of the community where they belonged; b) men may have been involved in a range of activities such as trade or warfare requiring long absences from home and resulting in their burial off-site; c) if women were valued for their primary role in reproduction and production, the higher representation of women can be seen as evidence of female-biased parental investment (Cronk 1989; Li 1991; Hrdy 1992; Demeer et al. 1993; Storey 1998). This last interpretation implies an "aggressive neglect" of sons or "underinvestment" in them. In extreme forms, this might invoke male infanticide where male neonates are intentionally killed in favour of girls (Cronk 1989; Hill and Hurtado 1996). The practice of sex-biased differential infanticide can skew the adult population sex ratios where immigration does not affect the imbalance (Lee et al. 1994). Whereas infanticide is well known from the ethnographic literature, however, its reliable recognition in archaeological contexts is very unlikely (for further discussion on archaeological cases see Rega 1997). Differential infanticide is more common in female children and occurs in cultures where males are valued more than females. Only a few cases of female-biased parental favouritism are documented ethnographically. According to the Trivers and Willard model (1973), in hierarchical societies, parents at the higher end of the hierarchy will invest more in sons than in daughters while parents at the lower end will favour daughters.

B. In some populations there is clearly an *exclusion of certain age categories* from the formal disposal area. For example, neonates and possibly infants are missing or under-represented in the LBA and EIA cemetery populations. Additionally, among male adults in LBA Spathes, it appears that only prime adults have been included in the burial ground. It is likely that the exclusion of certain age categories from the above burial assemblages may be the result of the funerary programme adopted by particular societies.

C. Some population subgroups reveal *high mortality rates*, possibly due to biological susceptibility in terms of overall health status and physiological stress. These population subgroups are, first, subadult age categories, particularly infants and juveniles, in early populations, and, secondly, certain sex groups - men in the early populations and women in the late burial assemblages.

Overall, however, the case study cemetery populations do not reveal very clear geographical or chronological patterning in demographic patterns. Local variables associated with health, nutritional status and the social environment reflected in the funerary programme of each cemetery have equally contributed to the demographic structure of the case study burial assemblages. These issues will be investigated in the next three chapters.

CHAPTER 5: MANIPULATION OF THE DECEASED

5.1. DEFINITION AND AIMS OF THE ANALYSIS

Mortuary behaviour is not an event taking place at the moment of funeral or immediately before and after. It is rather "a continuous flow of relationships developing between the living and the deceased" (Parker Pearson 1993). In these terms, four types of analysis are appropriate to explore the above inter-relationship: 1) the spatial location of the disposal area and its relationship with the habitation area of the living, 2) the intra-site organisation of the disposal area and of the habitation area of the living, 3) the distribution of artefacts in funerary and residential assemblages and 4) bioarchaeological residues represented in funerary and residential assemblages.

Given the total absence of published material, the current work will focus on *the manipulation of the deceased* in the case study cemetery populations. Only information provided by the investigation of the human bones will be utilised here. Particular attention is paid to the Neolithic Makrigialos skeletal assemblage because of the accessibility of contextual information and archaeological records, although at a preliminary level.

The manipulation of the deceased will be considered in relation to two axes:

1) *the minimum number of individuals* included in each burial assemblage, that is, the disarticulated versus articulated skeletal material of LN Makrigialos and single versus secondary and multiple burials of the late populations, and
2) *the distribution of sex and age groups* in each burial assemblage in order to distinguish factors which determined accessibility of the disposal area to certain population subgroups.

The manipulation of the deceased will be examined in relation to the living and their social roles as recognised in the arena of mortuary behaviour. The ultimate goal of this study will be to trace the role of burial practices and, in particular, of the manipulation of the deceased in *the transformation of social organisation* through time.

5.2. THE CASE OF NEOLITHIC MAKRIGIALOS

Two chronological components have been distinguished by the excavators at Makrigialos, both dated to the Late Neolithic (Figure 5.1). The phase I component includes two parallel ditches enclosing the settlement area (Ditch A and B) and a third

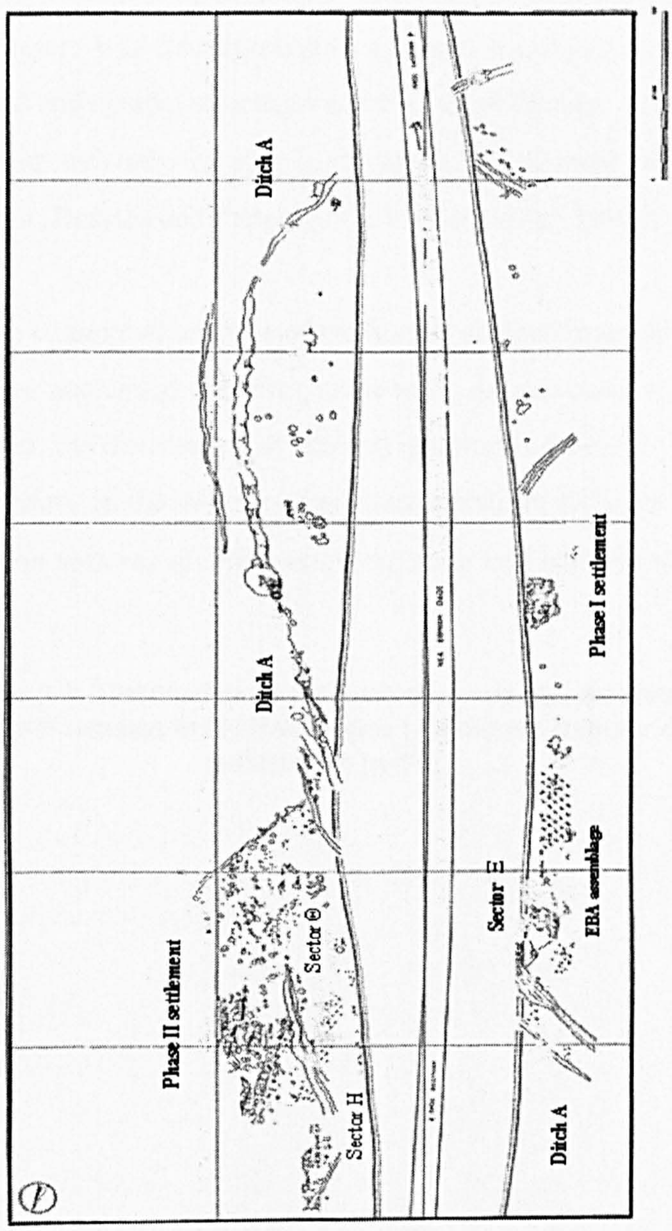
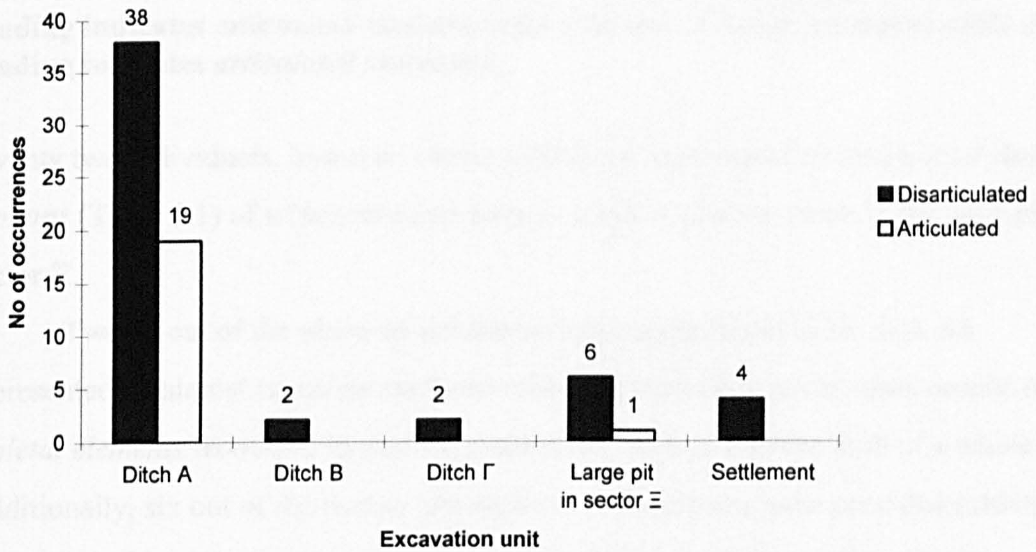


Figure 5.1: Plan of Neolithic Makrigialos (Bessios and Pappa 1998a: Figure 4)

smaller ditch (Ditch Γ) which possibly subdivided the settlement area. The deposits of ditch A contained large quantities of pottery and animal bones, as well as some human bones and small finds. The habitation remains consisted of pits, often representing houses separated by extensive open spaces. The phase II settlement developed next to its phase I predecessor. It is characterised by a greater density of architectural units, consisting of round and apsidal structures and two small ditches. It is believed that the excavated area comprises only the edge of the phase II settlement, which probably extended to the east (Bessios and Pappa 1997; 1998a; 1998b; 1998c; Pappa 1997; in press).

A thorough contextual analysis of the human skeletal material is not possible, because study of the associated ceramics, stone tools, animal bone, etc., is still in progress. Moreover, the distribution of skeletal material is limited by lack of information, at present, on the volume of earth excavated in different contexts. Thus, this study focuses on *patterns of differential treatment and manipulation of the*

Figure 5.2: Distribution of articulated versus disarticulated skeletal remains in LN Makrigialos I (Minimum Number of Individuals) (n=72)



deceased.

The majority of phase I skeletal material has been recovered as *disarticulated skeletal remains* from all three ditches (A, B and Γ), from a large pit in excavation sector Ξ and from the settlement deposits (Figure 5.1). Out of the phase I total of

Excavation No	Context	Sex	Age	Skeletal condition	Evidence of burial treatment
Ξ 0444006	Ditch A	?	Child	Skeleton	+
Ξ 0444006	Ditch A	?	Adult	Skeleton	+
Ξ 0541020	Ditch A	M?	YAdult	Skeletal elements	None
Ξ 0691002 (36)	Large pit in sector Ξ	F?	Adult	Skeleton	None
I 0504001	Ditch A	M?	Adult	Skeleton	None
I 0504006	Ditch A	M?	PAdult	Skeleton	None
K 0353001	Ditch A	?	Child	Skeleton	+
K 0353002	Ditch A	?	Infant	Skeleton	+
K 0353002	Ditch A	?	YAdult	Skeletal elements	None
Λ 0124027	Ditch A	?	Juvenile	Skeletal elements	None
Λ 0124027	Ditch A	F?	Adult	Skeletal elements	None
Λ 0131013	Ditch A	F?	YAdult	Skeleton	None
Λ 0133012	Ditch A	F?	Adult	Skeletal elements	None
Λ 0152015	Ditch A	F?	YAdult	Skeleton	None
Λ 0152019	Ditch A	F	YAdult	Skeleton	None
Λ 0124027	Ditch A	F	YAdult	Skeleton	None
Λ 0203010	Ditch A	F?	Adult	Skeleton	+
Φ 0262032	Ditch A	F?	Adult	Skeletal elements	None
Φ 0262032	Ditch A	?	Infant	Skeleton	+
Φ 0262032	Ditch A	F?	Adult	Skeletal elements	None

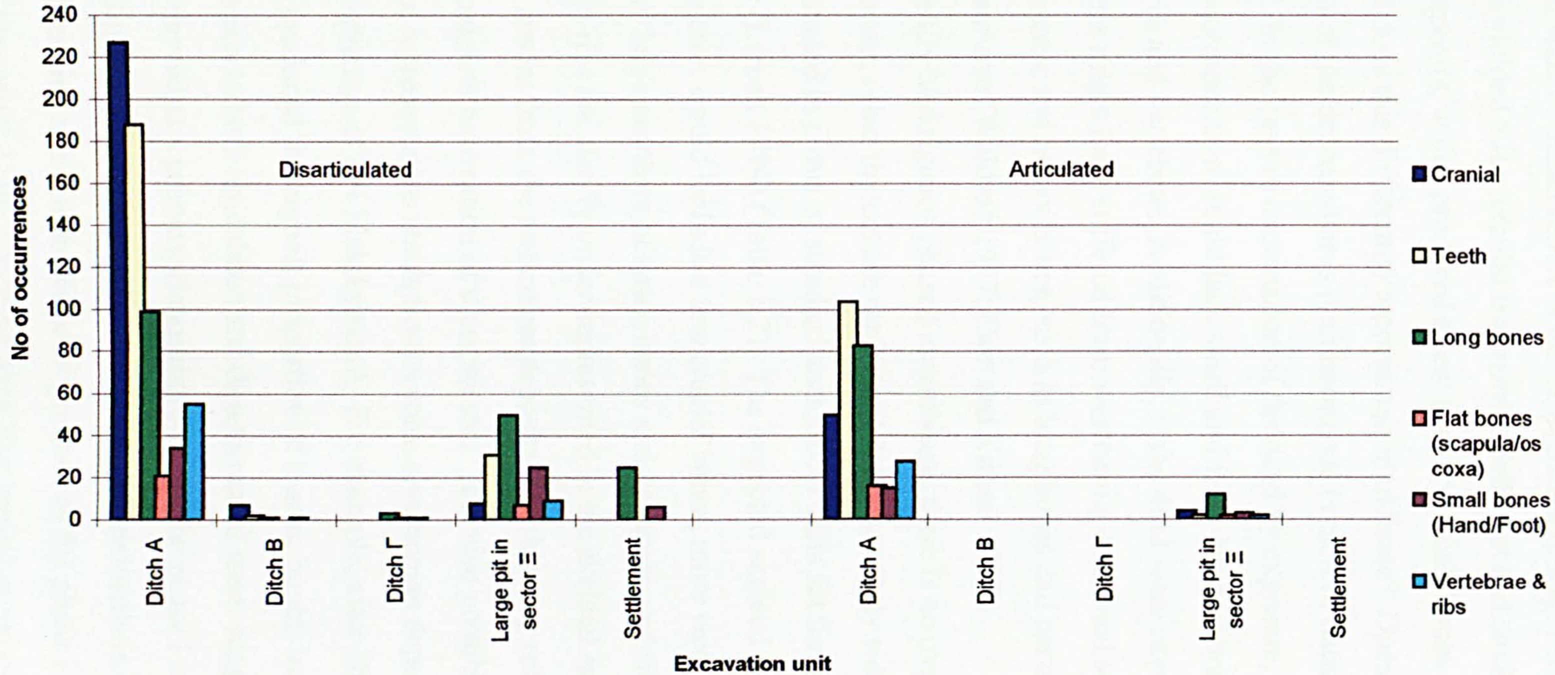
Table 5.1: The articulated skeletal remains of Neolithic Makrigialos I (light shading indicates *articulated skeletons with evidence of burial treatment* while dark shading indicates *articulated skeletons*)

seventy two individuals, however, twenty (28%) are represented by *articulated skeletal remains* (Table 5.1) of which nineteen were in Ditch A and one more in the large pit of sector Ξ.

Twelve out of the nineteen articulated individuals found in Ditch A are represented by almost *complete skeletons* while the remaining seven cases consist of *skeletal elements* recovered in skeletal association, such as a lower limb or a whole arm. Additionally, six out of the twelve almost complete skeletons have provided evidence of some kind of *burial treatment*, such as a simple pit grave, burial position, burial orientation, a substantial covering or, occasionally, associated artefacts.

The recovery of the largest proportion of both disarticulated skeletal elements and articulated skeletal remains from Ditch A suggests that this was perhaps the main

Figure 5.3: Bone representation in disarticulated versus articulated skeletal elements of LN Makrigialos I



disposal area of phase I. This possibility can be explored by investigating the distribution of disarticulated and articulated skeletal elements in different phase I contexts (Figure 5.3). In fact, only Ditch A and the large pit of sector Ξ include all skeletal elements in both disarticulated and articulated state, in contrast with the disarticulated state of preservation of the skeletal assemblages recovered from Ditches B and Γ, which yielded a few cranial fragments, teeth, flat and small bones, and the settlement deposits, which produced a few long and small bones.

What does this differential representation indicate? Does it imply a differential manipulation of the deceased or is it an unintended result of natural or human disturbance? In the case of excarnation of the dead by exposure, the expected picture of anatomical representation would lack small and flesh-bearing bones such as ribs and scapulae, teeth and vertebrae. Additionally, if the dead were exposed for a period of time, the bones might have suffered from weathering or animal scavenging. Conversely, dense and heavy bones, such as long bones and parts of the skull, might be expected to survive (Waldron 1987; Carr and Knüsel 1997).

In the LN Makrigialos phase I assemblage, there is no overall lack of the above skeletal elements, other than in the settlement deposits. Only sided skeletal elements have been counted in terms of standard anatomical units set for disarticulated skeletal assemblages (Lyman 1994) (Table 5.2). The expected skeletal representation of a complete skeleton would include a few cranial bones, more teeth and long bones, a few flat bones and large numbers of small bones and vertebrae and ribs (Figure 5.4). Teeth, flat bones and ribs are clearly under-represented in the skeletal assemblages of Ditches B and Γ and absent from the settlement deposits, but this may reflect the small sample size and incomplete excavation of these sectors. It is also possible, however, that these differences in representation result from a conscious human deposition reflecting the mortuary programme of LN Makrigialos I. For example, after Ditch A, the large pit in sector Ξ has produced the highest proportion of human bones, including all types of skeletal elements in both articulated and disarticulated state, suggesting that the latter also perhaps served as a primary disposal ground of the phase I community.

The high frequency of disarticulated skeletal elements in these two areas, tentatively identified as the main disposal grounds of the phase I settlement, can be explained in two ways: 1) the deceased were first buried or exposed elsewhere and their skeletal remains then re-buried in Ditch A or the large pit of sector Ξ as a secondary treatment; or 2) the deceased were originally placed in Ditch A or the large pit of sector

Cranial (12) [1]	**Long bones (36)** [2]	**Flat bones (16)** [1]	**Small bones (50)** [1]	**Vertebrae & ribs (53)**
Frontal (2)	**Upper skeleton (18)**	**Scapula (8)**	**Hand bones (26)**	Cervical (7)
Occipital (2)	Humerus (6)	Acromion (2)	Capitate (2)	Thoracic (12)
Parietal (2)	Radius (6)	Coracoid (2)	Trapezoid (2)	Lumbar (5)
Temporal (2)	Ulna (6)	Glenoid cavity (2)	Hamate (2)	Sacrum (5)
Mandible (2)	**Lower skeleton (18)**	Scapula blade (2)	Pisiform (2)	Ribs (24) [1]
Maxilla (2)	Femur (6)	**Os coxa (8)**	Lunate (2)	
Permanent Teeth (32) [3]	Tibia (6)	Acetabulum (2)	Triquetral (2)	
M3 (4)	Fibula (6)	Ilium (2)	Scaphoid (2)	
M2 (4)		Pubis (2)	Trapezium (2)	
M1 (4)		Ischium (2)	Metacarpal (10)	
PM2 (4)			**Foot bones (24)**	
PM1 (4)			Talus (2)	
C (4)			Calcaneus (2)	
I2 (4)			1st cuneiform (2)	
I1 (4)			2nd cuneiform (2)	
Deciduous Teeth (20) [3]			3rd cuneiform (2)	
m2 (4)			Navicular (2)	
m1 (4)			Cuboid (2)	
c (4)			Metatarsal (10)	
i2 (4)				
i1 (4)				

Table 5.2: List of the skeletal elements counted in the analysis of the disarticulated assemblages based on Lyman (1994) (number in parenthesis indicates the expected number of each anatomical unit in a complete adult skeleton)

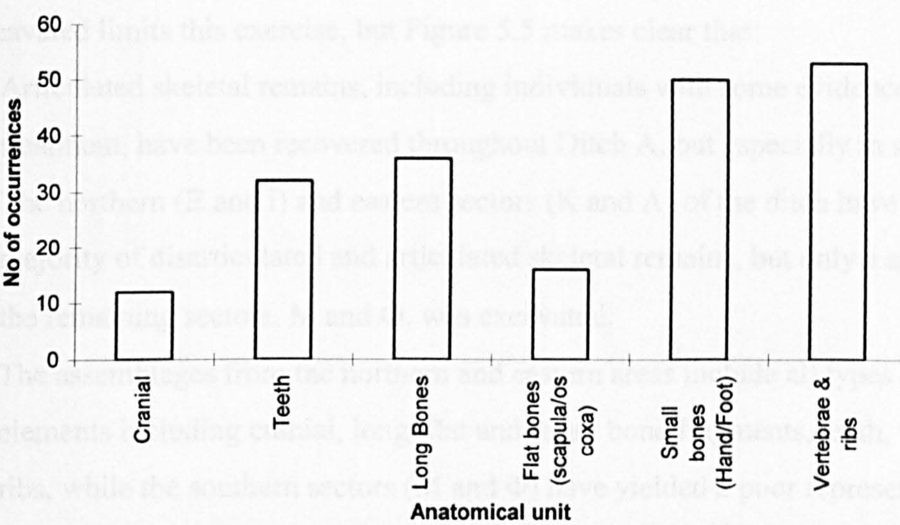
Ξ and their remains later disturbed, possibly unintentionally, by repeated re-digging of these features. The principal difference between the two interpretations is that, in the former case, there is an emphasis on *the secondary treatment* of the human remains, while, in the latter, *the primary character* of the burials is emphasised.

Osteological examination of the skeletal material from Ditch A has not yielded any evidence of factors such as weathering, gnawing, breakage from trampling etc. Furthermore, there is no lack of the more vulnerable and fragile bones, that is of small

[1] Both sides have been counted.
[2] Proximal, mid and distal thirds of both sides.
[3] Maxillary and mandibular teeth of both sides.

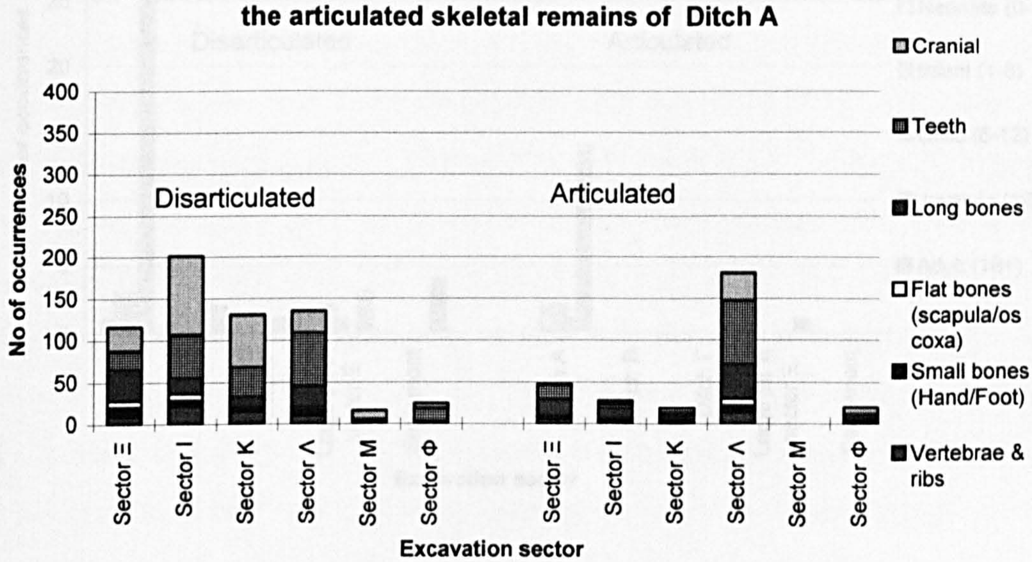
and flat bones or teeth, vertebrae and ribs. The only evidence possibly consistent with the initial exposure of the deceased outside Ditch A is the occurrence of half-articulated

Figure 5.4: Expected skeletal representation in a complete adult skeleton



skeletons (Table 5.1), which might have resulted from secondary burial in Ditch A before total decomposition. Excavation records however, emphasise the continuous digging and re-digging of Ditch A, which could well have given rise to disturbed and half-articulated skeletal remains originally placed there.

Figure 5.5: Bone part representation in the disarticulated versus the articulated skeletal remains of Ditch A



Finally, the possibility that certain areas of Ditch A were used as primary disposal areas more frequently than others has also been investigated by looking at the distribution of disarticulated and articulated skeletal remains in the different excavation sectors of Ditch A (Figure 5.5). Again, lack of information on the volume of earth excavated limits this exercise, but Figure 5.5 makes clear that:

A. Articulated skeletal remains, including individuals with some evidence of burial treatment, have been recovered throughout Ditch A, but especially in sector Λ.

B. The northern (Ξ and I) and eastern sectors (K and Λ) of the ditch have produced the majority of disarticulated and articulated skeletal remains, but only a small area of the remaining sectors, M and Φ, was excavated.

C. The assemblages from the northern and eastern areas include all types of skeletal elements including cranial, long, flat and small bone fragments, teeth, vertebrae and ribs, while the southern sectors (M and Φ) have yielded a poor representation of cranial and small bones and teeth only. This, however, may be result of the small sample size.

Figure 5.6: Distribution of disarticulated versus articulated skeletal remains in LN Makrigialos I by age group (n=72)

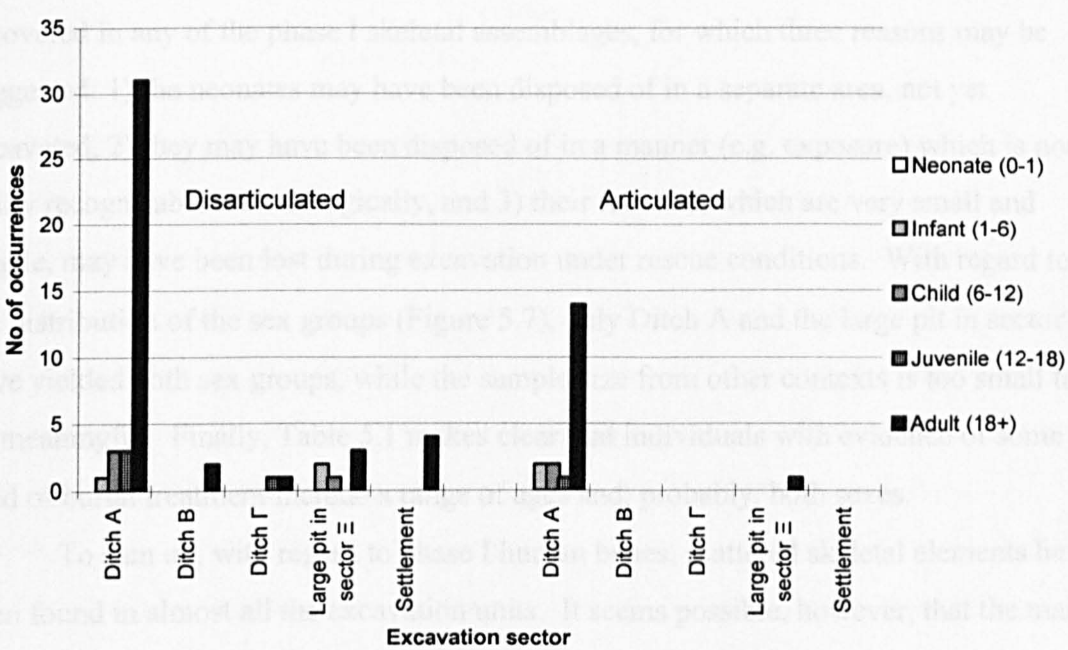
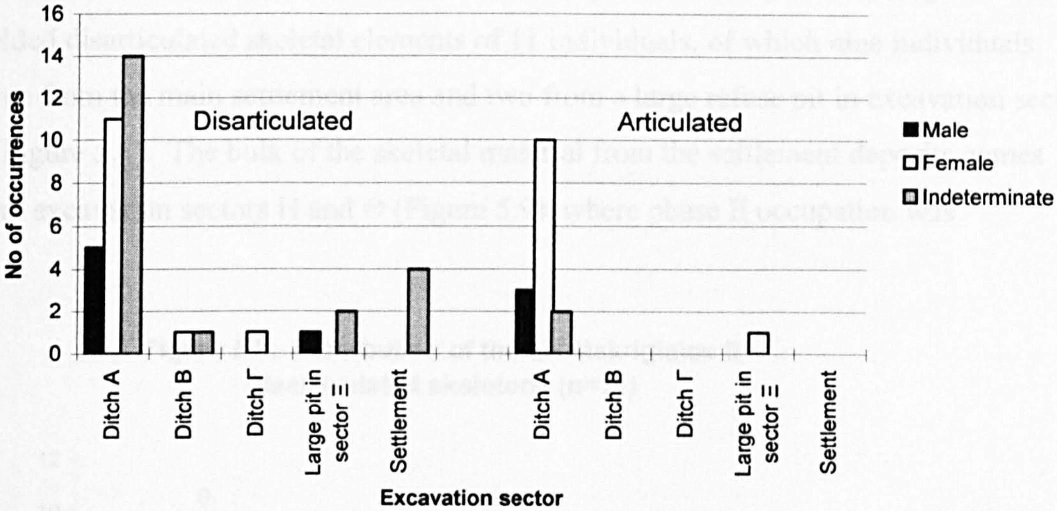


Figure 5.7: Distribution of disarticulated versus articulated skeletal remains in LN Makrigialos I by sex group (n=56)

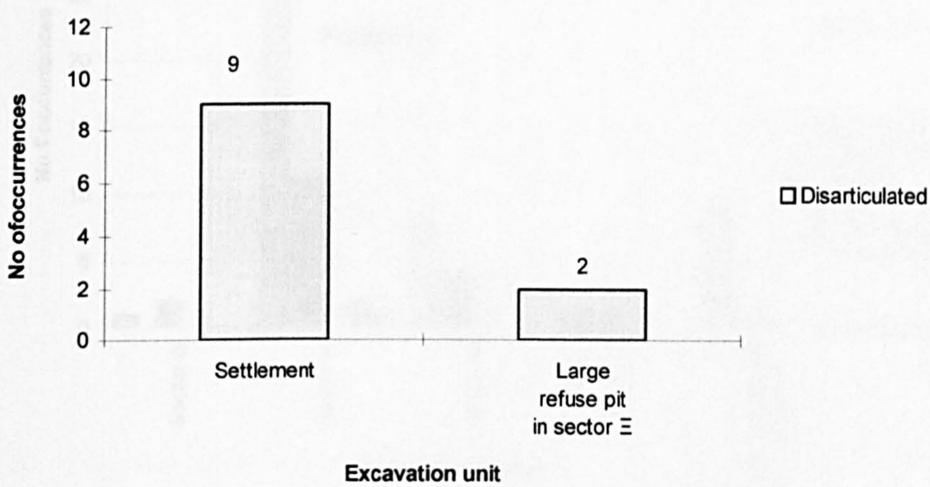


Figures 5.6 and 5.7 represent the distribution of disarticulated versus articulated skeletal elements by age and sex groups respectively. Figure 5.6 reveals that almost all age groups are distributed evenly between disarticulated and articulated skeletal remains in Ditch A. The sample sizes from other contexts are too small for such analysis, although the large pit in sector Ξ has produced a range of ages. No neonates have been recovered in any of the phase I skeletal assemblages, for which three reasons may be suggested: 1) the neonates may have been disposed of in a separate area, not yet excavated, 2) they may have been disposed of in a manner (e.g. exposure) which is not easily recognisable archaeologically, and 3) their remains, which are very small and fragile, may have been lost during excavation under rescue conditions. With regard to the distribution of the sex groups (Figure 5.7), only Ditch A and the large pit in sector Ξ have yielded both sex groups, while the sample size from other contexts is too small to be meaningful. Finally, Table 5.1 makes clear that individuals with evidence of some kind of burial treatment include a range of ages and, probably, both sexes.

To sum up, with regard to phase I human bones, scattered skeletal elements have been found in almost all the excavation units. It seems possible, however, that the main disposal area of phase I was, primarily, Ditch A, and secondarily, the large pit of sector Ξ, due to: a) *the skeletal elements represented*, including all parts of the human skeleton, b) *the occurrence of articulated individuals*, some of them providing evidence of burial treatment too and c) *the representation of all age and sex groups*. Secondary treatment of the phase I skeletal remains is not indicated by anatomical representation, since there is no lack of teeth, small/flat bones, vertebrae and ribs.

The second phase of occupation at Makrigialos (Makrigialos II) (Figure 5.1) has yielded disarticulated skeletal elements of 11 individuals, of which nine individuals come from the main settlement area and two from a large refuse pit in excavation sector Ξ (Figure 5.8). The bulk of the skeletal material from the settlement deposits comes from excavation sectors H and Θ (Figure 5.9), where phase II occupation was

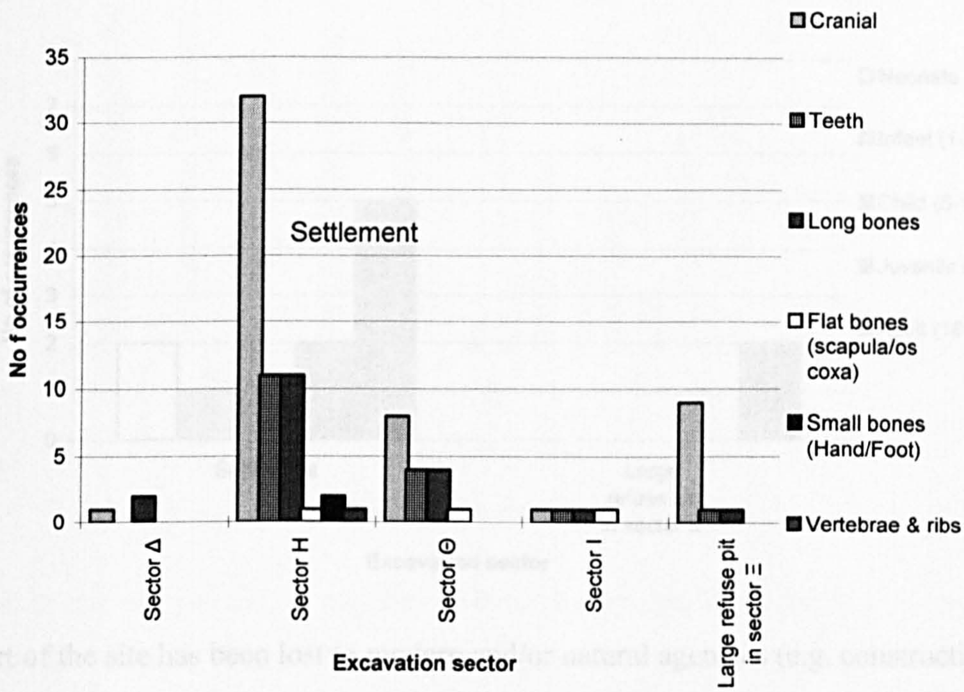
Figure 5.8: Distribution of the LN Makrigialos II disarticulated skeletons (n=11)



concentrated. In addition, one neonate/infant cremation has been recovered from excavation sector Θ. Among the phase II disarticulated skeletal remains, skull fragments, teeth and long bones are best represented, while flat, small bones and vertebrae are significantly under-represented, although not totally absent. Additionally, there is a total lack of ribs (Figure 5.9). It should be noted, however, that the phase II human bone is much more fragmentary than the disarticulated skeletal remains of phase I. Part of sector H, where the largest proportion of disarticulated human bones was recovered, has been described by the excavation reports as "an area of large-scale earth removals from the habitation levels of phase II" (Bessios and Pappa 1998b; 1998c; Pappa in press). Such reworking of deposits may account for the fragmentary state of the disarticulated human bones from phase II.

To sum up, the phase II skeletal assemblage reveals three depositional patterns: 1) the occurrence of *scattered human bones* in the settlement deposits and the large refuse pit in sector Ξ, 2) the occurrence of one *cremation* within the area of the settlement and, 3) the high proportion of disarticulated human bones recovered in sector H, part of which represents *large-scale earth removals* from the habitation area. The bone representation from all assemblages does not suggest any intentional secondary

Figure 5.9: Distribution of the LN Makrigialos II disarticulated skeletal elements

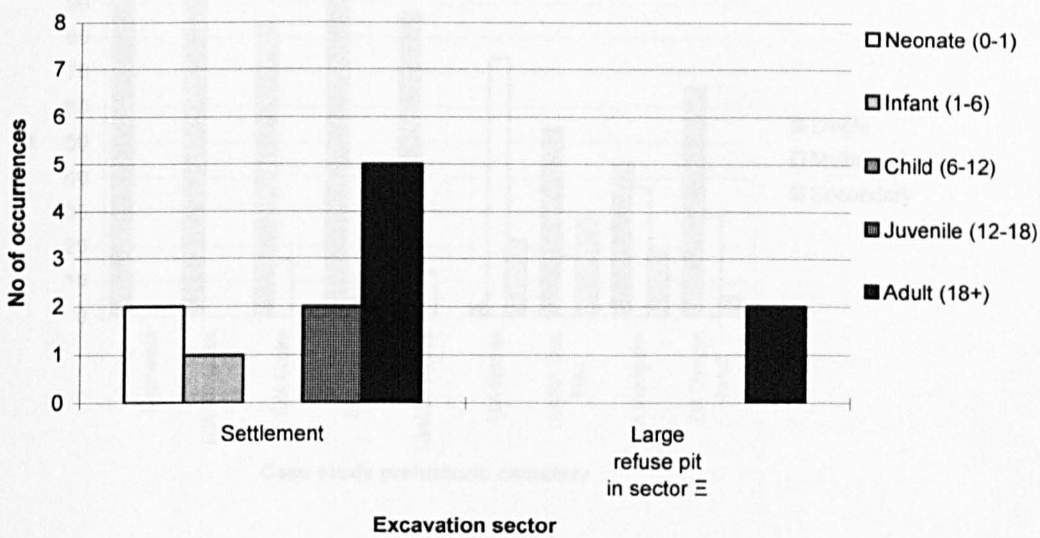


treatment of the phase II skeletal remains. Two alternatives can thus be proposed. The disarticulated skeletal remains may be the result of either 1) previously articulated skeletons placed originally within the settlement deposits and the large refuse pit of sector Ξ and disturbed later by human and/or natural factors or 2) unintentional removal from a location, outside the excavated area, used as the main burial ground of phase II which has not been recovered. At present, there is no strong evidence to support either suggestion.

Figure 5.10 represents the distribution of the phase II skeletal assemblages by age group. It is striking that the settlement deposits appear to have held individuals of all age categories, including neonates which were totally absent from the significantly larger skeletal assemblage of phase I. Conversely, the large refuse pit of sector Ξ gives evidence solely of adult individuals, but the sample is small. Overall, the fragmented state of the assemblage has limited information on age and, especially, sex. Out of five adult individuals, only one male from the settlement has been identified.

Finally, it is necessary to reiterate that the picture of mortuary behaviour in both phases of Neolithic Makrigialos is based solely on the recently excavated area; a large

Figure 5.10: Distribution of the age groups in LN Makrigialos II (n=12)



part of the site has been lost to modern and/or natural agencies (e.g. construction of the National motorway, erosion) (Bessios and Pappa 1995; 1997; 1998a;1998b; 1998c).

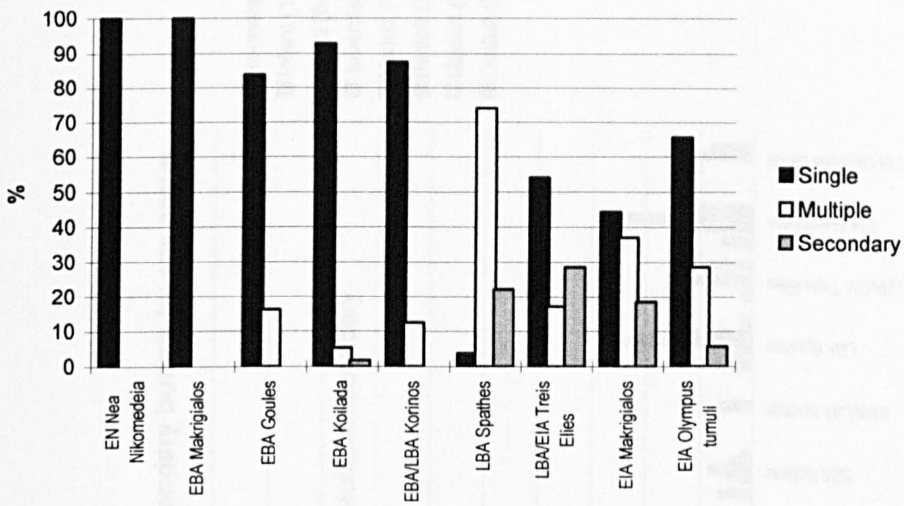
5.3. Single versus Secondary and Multiple Burials

This section compares the single burials, which were the normal practice in the Neolithic and Early Bronze Age, with the multiple and secondary burials, common in the Late Bronze and Early Iron Age. It must be remembered that none of the case study cemeteries has been totally excavated and that it is impossible to estimate what proportion of the original cemetery is included in the current analysis.

Figure 5.11 represents the distribution of single, multiple and secondary burials in the case study cemeteries. Cases with more than one burial in articulated state in one grave assemblage are categorised as *multiple*, while disarticulated skeletal remains swept aside are counted as *secondary* burials. In the latter case, where there is a primary burial placed in the grave after sweeping away the former burial, the primary burial has been considered *multiple*, since it was the last one placed in the grave assemblage.

Single burials predominate in all the case study populations, except for LBA Spathes. The high frequencies of *single burials* in the Neolithic and Early Bronze Age suggest that this was the common burial practice. In contrast, in the Late Bronze Age

Figure 5.11: Distribution of burial type in the case study cemeteries



assemblage of Spathes, the majority of individuals was disposed of in *multiple and secondary* burials. The practice of single burial re-appears in the transitional phase and Early Iron Age assemblages, although at the same time multiple and secondary burials continued to be frequent. Furthermore, although EIA Olympus includes a high proportion of single burials, these were placed within tumuli, thus emphasising their collective character.

To interpret the variation in burial types, it will be interesting to investigate, first, whether the differential disposal of individuals reflects age and/or sex distinctions (Figure 5.12 and 5.13). Secondly, the minimum number of individuals disposed of in multiple and secondary burials will be assessed in order to clarify the character of the units held in each grave assemblage (Figure 5.14).

The distribution of the age groups by burial type (Figure 5.12 and Table 5.3) does not suggest any preferential selection of certain age categories for either single or multiple/secondary burial in the early populations. In the late populations, however,

Figure 5.12: Distribution of single versus multiple/secondary burials by age group.

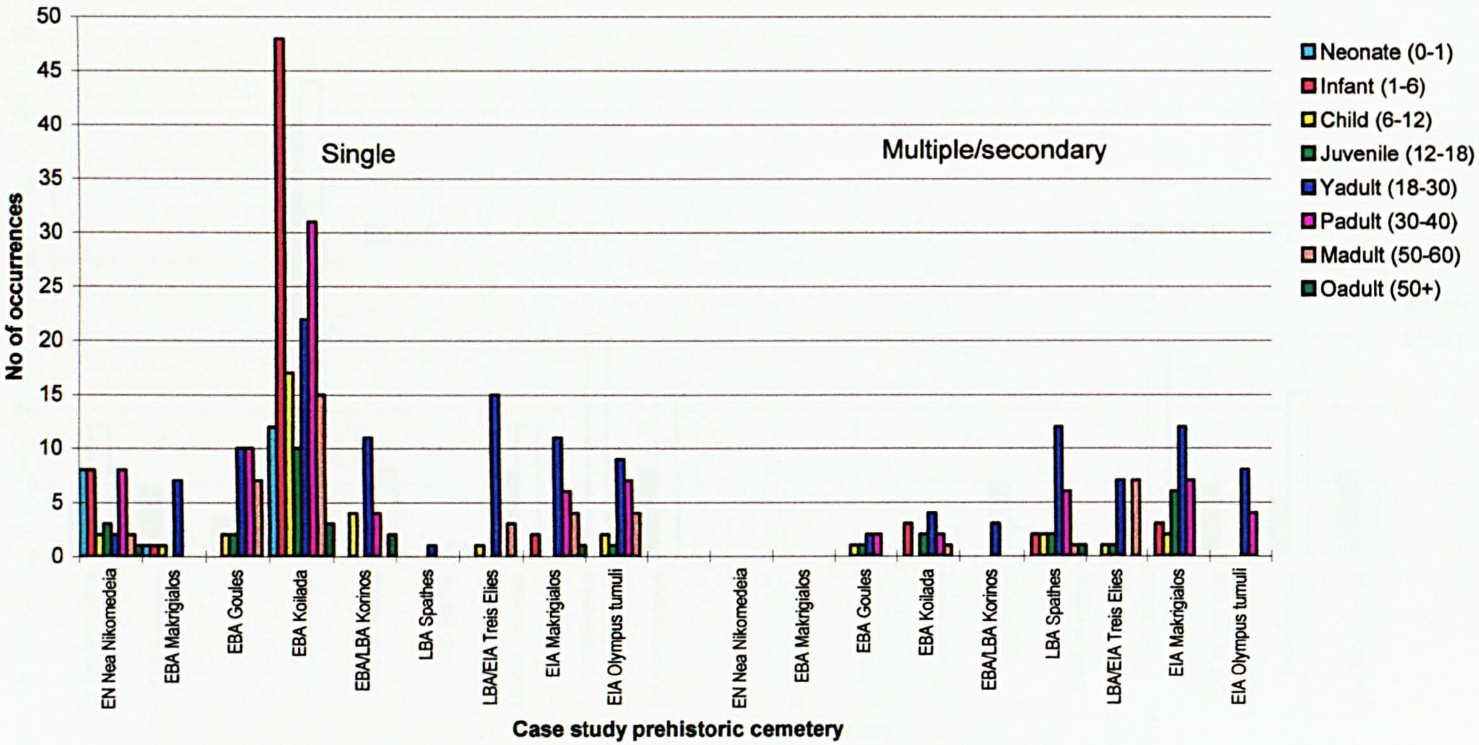
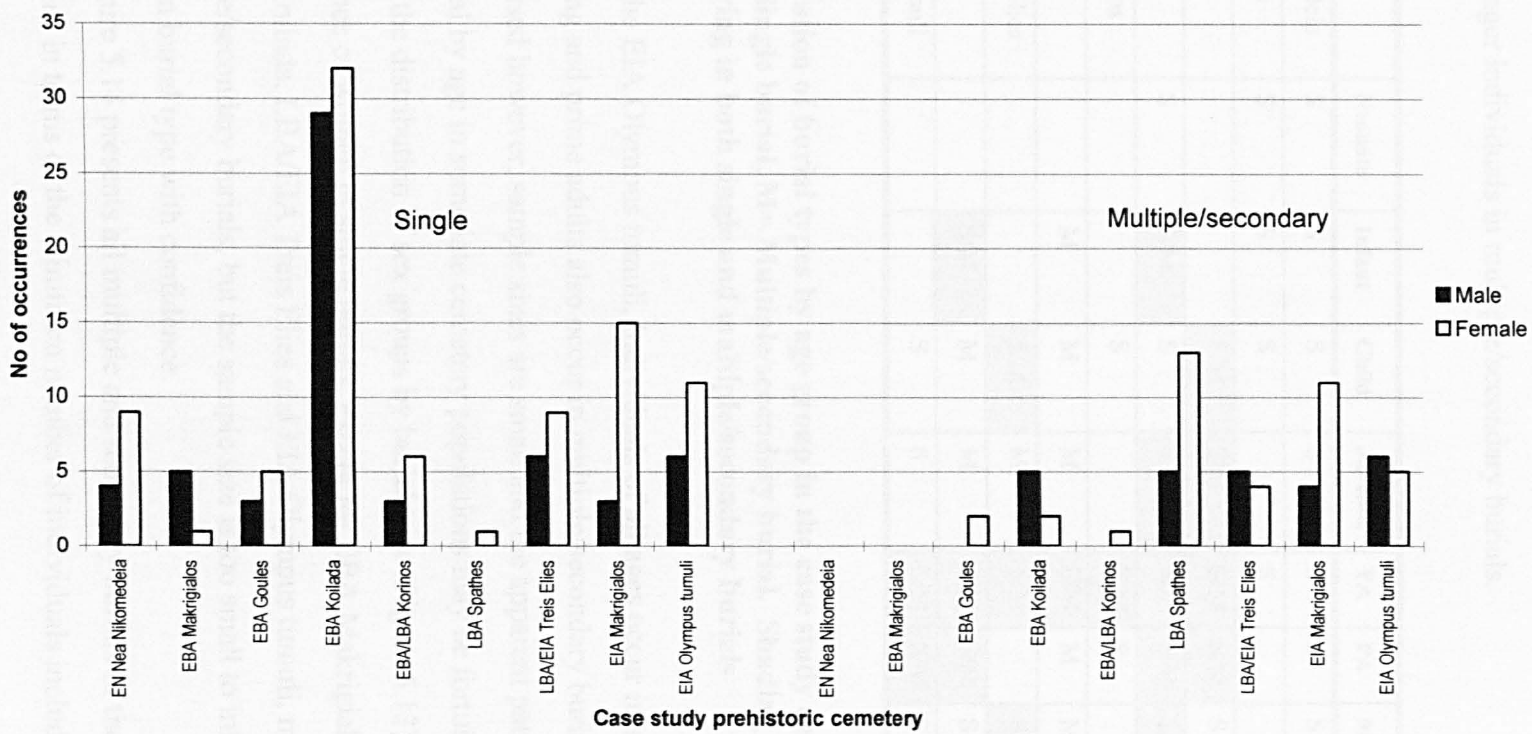


Figure 5.13: Distribution of single versus multiple/secondary burials by sex group.



except for LBA/EIA Treis Elies, there is some evidence of *differential burial in relation to age*:

1. Only young adults occur in multiple/secondary and single burials in EBA/LBA Korinos and LBA Spathes, respectively.
2. In EIA Makrigialos, there is a slight tendency for adults to be disposed of in single burials and younger individuals in multiple/secondary burials.

Cemetery	Neonate	Infant	Child	Juvenile	YA	PA	MA	OA
EN Nea Nikomedeia	S	S	S	S	S	S	S	S
EBA Makrigialos	S	S	S		S			
EBA Goules			S/M	S/M	S/M	S/M	S	
EBA Koilada	S	S/M	S	S/M	S/M	S/M	S/M	S
EBA/LBA Korinos			S		S/M	S		S
LBA Spathes		M	M	M	S/M	M	M	M
LBA/EIA Treis Elies			S/M	M	S/M		S/M	
EIA Makrigialos		S/M	M	M	S/M	S/M	S	S
EIA Olympus tumuli			S	S	S/M	S/M	S	

Table 5.3: Distribution of burial types by age group in the case study cemetery populations. S= Single burial, M= Multiple/secondary burial. Shading indicates age groups occurring in both single and multiple/secondary burials

3. Conversely, in the EIA Olympus tumuli, individuals of all ages occur in single burials, but young and prime adults also occur in multiple/secondary burials. As already emphasised however, sample sizes are small and the apparent patterning of differential burial by age in some late cemetery populations may be fortuitous.

In terms of the distribution of sex groups by burial type (Figure 5.13), there is an overall predominance of women in single burials, except for EBA Makrigialos. In contrast, in EBA Koilada, LBA/EIA Treis Elies and EIA Olympus tumuli, men are more frequent in multiple/secondary burials, but the sample size is too small to infer any sex-related patterning in burial type with confidence.

Finally, Figure 5.14 presents all multiple and secondary burials of the case study cemetery populations in terms of the minimum number of individuals included in each assemblage:

Figure 5.14:

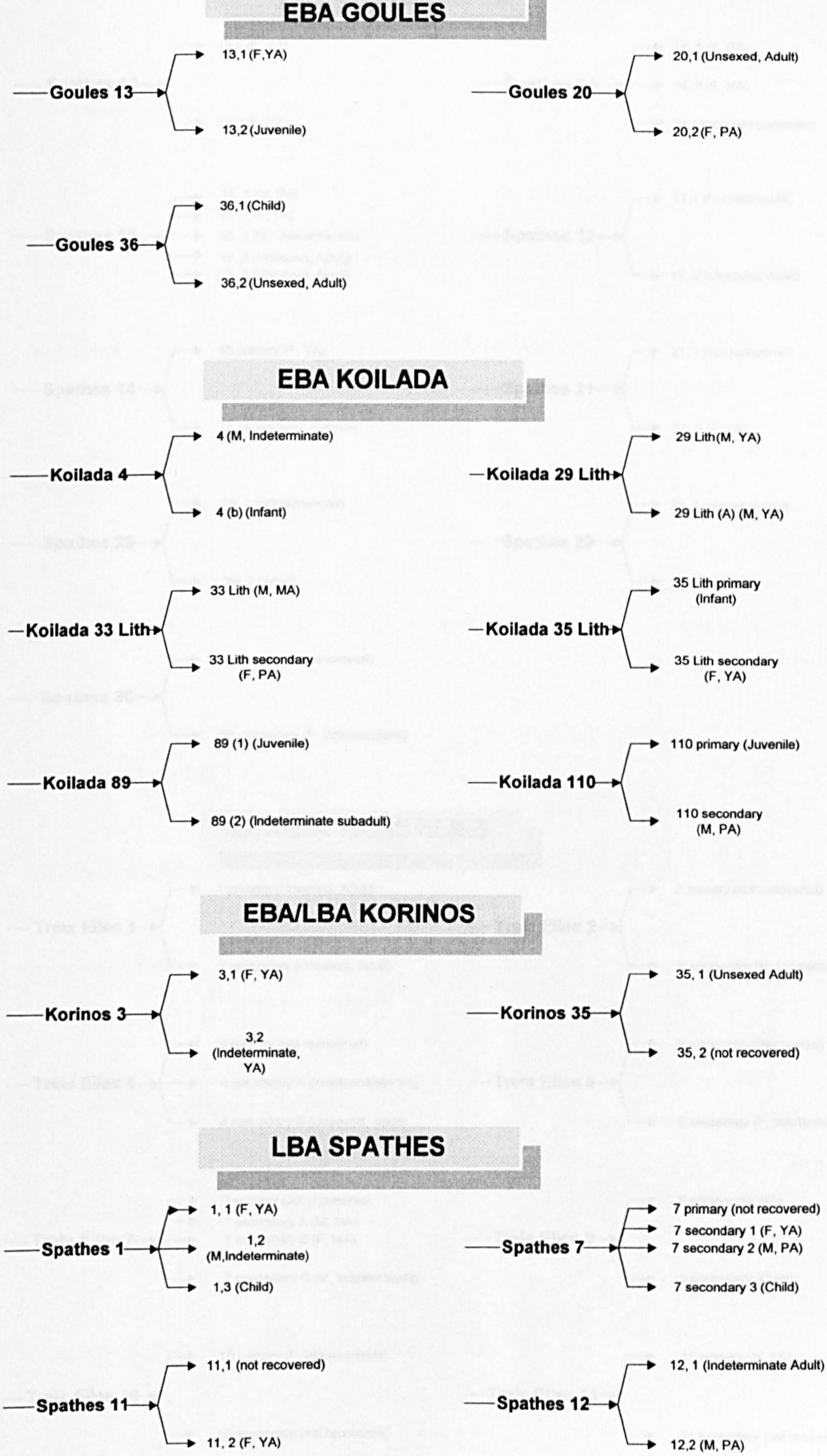

EBA GOULES
Goules 13
13,1 (F,YA)
13,2 (Juvenile)
Goules 20
20,1 (Unsexed, Adult)
20,2 (F, PA)
Goules 36
36,1 (Child)
36,2 (Unsexed, Adult)
EBA KOILADA
Koilada 4
4 (M, Indeterminate)
4 (b) (Infant)
Koilada 29 Lith
29 Lith(M, YA)
29 Lith (A) (M, YA)
Koilada 33 Lith
33 Lith (M, MA)
33 Lith secondary (F, PA)
Koilada 35 Lith
35 Lith primary (Infant)
35 Lith secondary (F, YA)
Koilada 89
89 (1) (Juvenile)
89 (2) (Indeterminate subadult)
Koilada 110
110 primary (Juvenile)
110 secondary (M, PA)
EBA/LBA KORINOS
Korinos 3
3,1 (F, YA)
3,2 (Indeterminate, YA)
Korinos 35
35, 1 (Unsexed Adult)
35, 2 (not recovered)
LBA SPATHES
Spathes 1
1, 1 (F, YA)
1,2 (M,Indeterminate)
1,3 (Child)
Spathes 7
7 primary (not recovered)
7 secondary 1 (F, YA)
7 secondary 2 (M, PA)
7 secondary 3 (Child)
Spathes 11
11,1 (not recovered)
11, 2 (F, YA)
Spathes 12
12, 1 (Indeterminate Adult)
12,2 (M, PA)

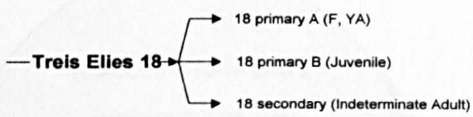
Figure 5.14 continued: LBA SPATHES

- Spathes 13
  - 13,1 (F, YA)
  - 13,2 (F, YA)
- Spathes 14
  - 14, 1 (F, OA)
  - 14, 2 (F, MA)
  - 14 secondary (Juvenile)
- Spathes 15
  - 15, 1 (M, PA)
  - 15, 2 (F, YA)
  - 15, 3 (M, Indeterminate)
  - 15, 4 (Unsexed, Adult)
  - 15, 5 (Unsexed, Adult)
- Spathes 17
  - 17,1 (not recovered)
  - 17, 2 (Unsexed, Adult)
- Spathes 18
  - 18 primary (F, YA)
  - 18 secondary (Juvenile)
- Spathes 21
  - 21, 1 (not recovered)
  - 21, 2 (F, YA)
- Spathes 28
  - 28, 1 (not recovered)
  - 28, 2 (Infant)
- Spathes 29
  - 29, 1 (not recovered)
  - 29, 2 (F, YA)
- Spathes 30
  - 30 primary (not recovered)
  - 30 secondary (F, Indeterminate)

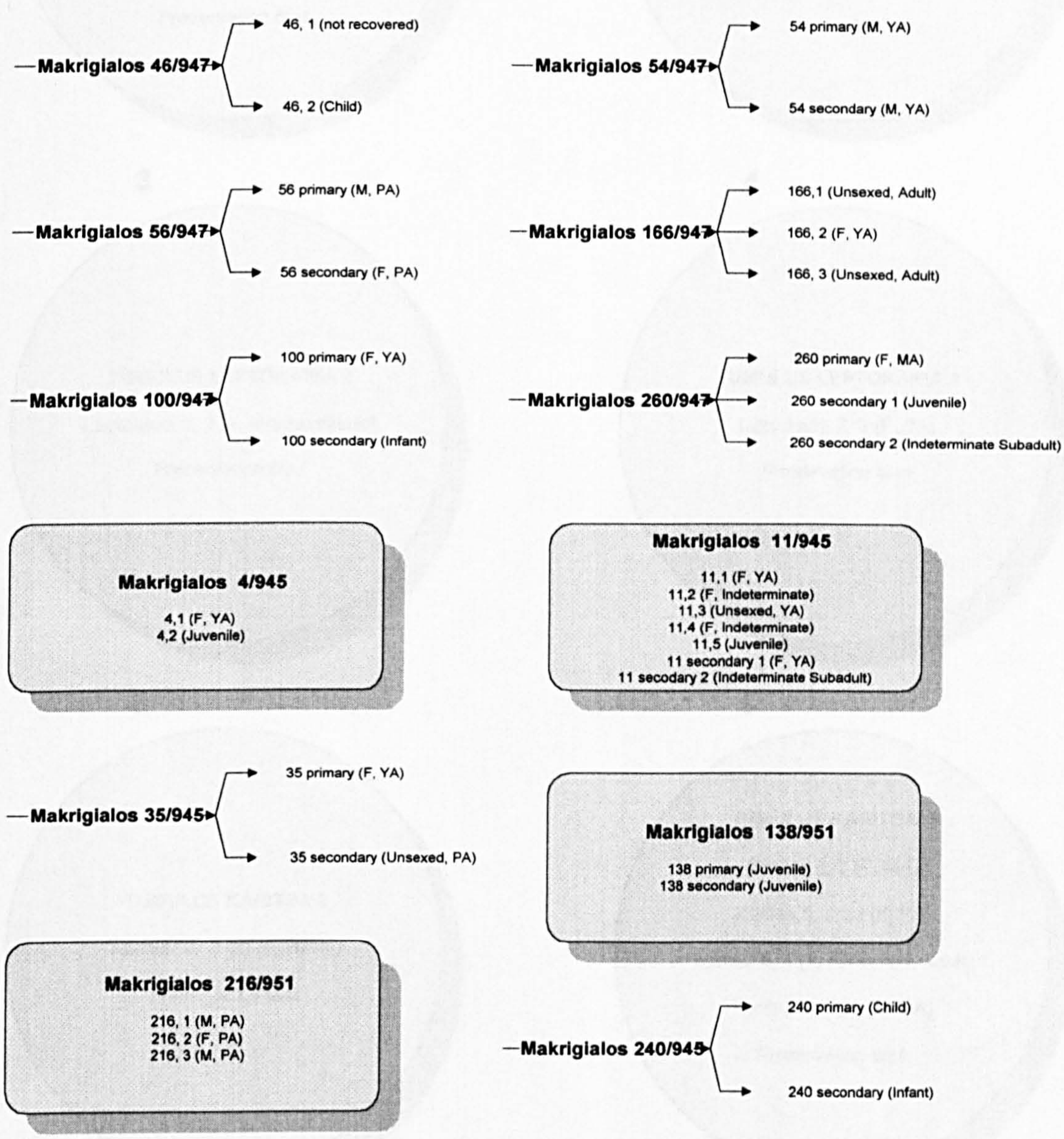
LBA/EIA TREIS ELIES

- Treis Elies 1
  - 1 primary (Unsexed, Adult)
  - 1 secondary (Unsexed, Adult)
- Treis Elies 2
  - 2 primary (not recovered)
  - 2 secondary (M, Indeterminate)
- Treis Elies 4
  - 4 primary (not recovered)
  - 4 secondary A (Indeterminate YA)
  - 4 secondary B (Unsexed, Adult)
- Treis Elies 6
  - 6 primary (not recovered)
  - 6 secondary (F, Indeterminate)
- Treis Elies 7
  - 7 primary (not recovered)
  - 7 secondary A (M, MA)
  - 7 secondary B (F, MA)
  - 7 secondary C (M, Indeterminate)
- Treis Elies 9
  - 9 primary (M, MA)
  - 9 secondary (Child)
- Treis Elies 10
  - 10 primary (F, Indeterminate)
  - 10 secondary (not recovered)
- Treis Elies 11
  - 11 primary (M, YA)
  - 11 secondary (not recovered)

Figure 5.14 continued: LBA/EIA TREIS ELIES

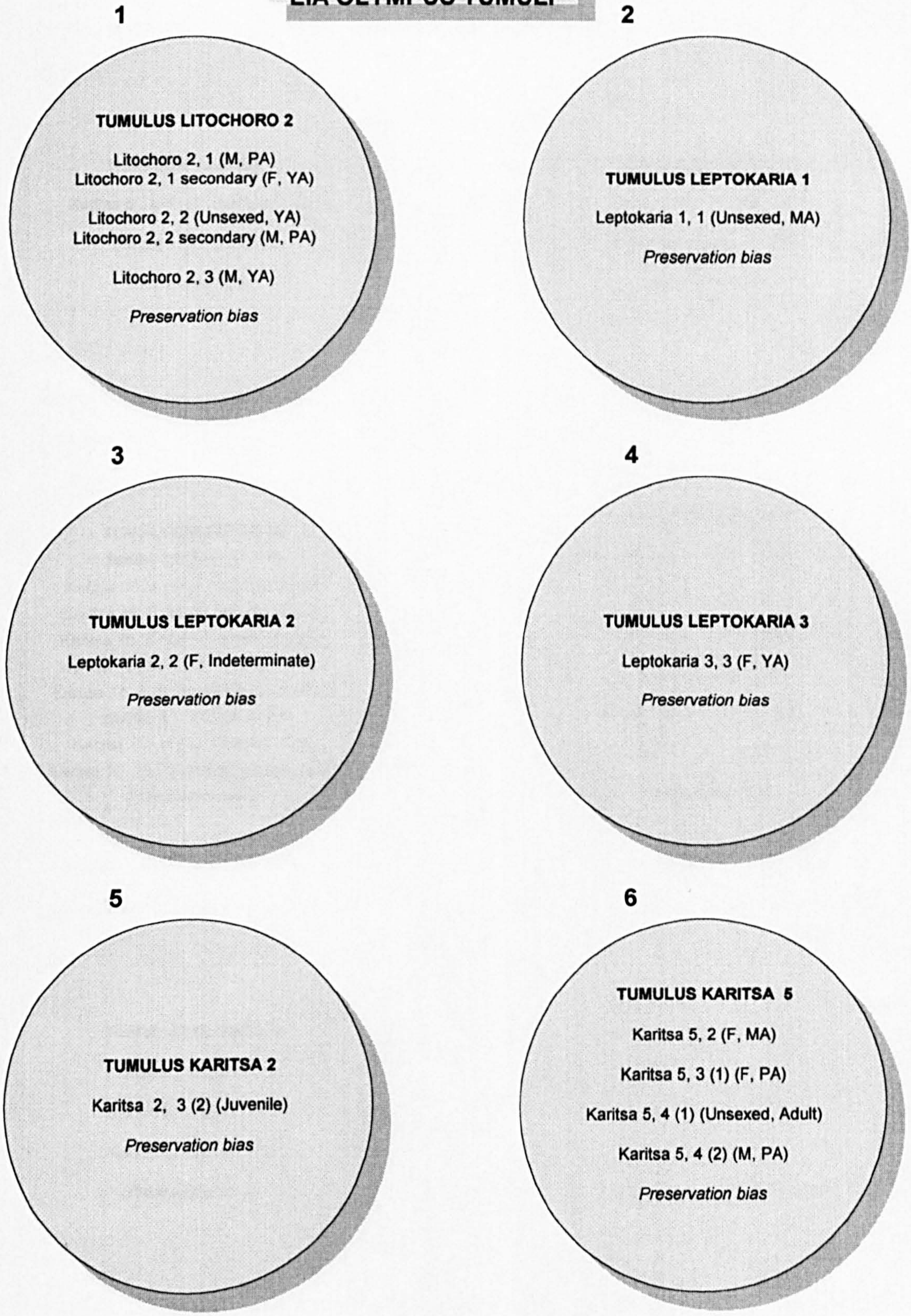


EIA MAKRIGIALOS



The rectangular shapes indicate chamber tombs.

Figure 5.14 continued:
EIA OLYMPUS TUMULI



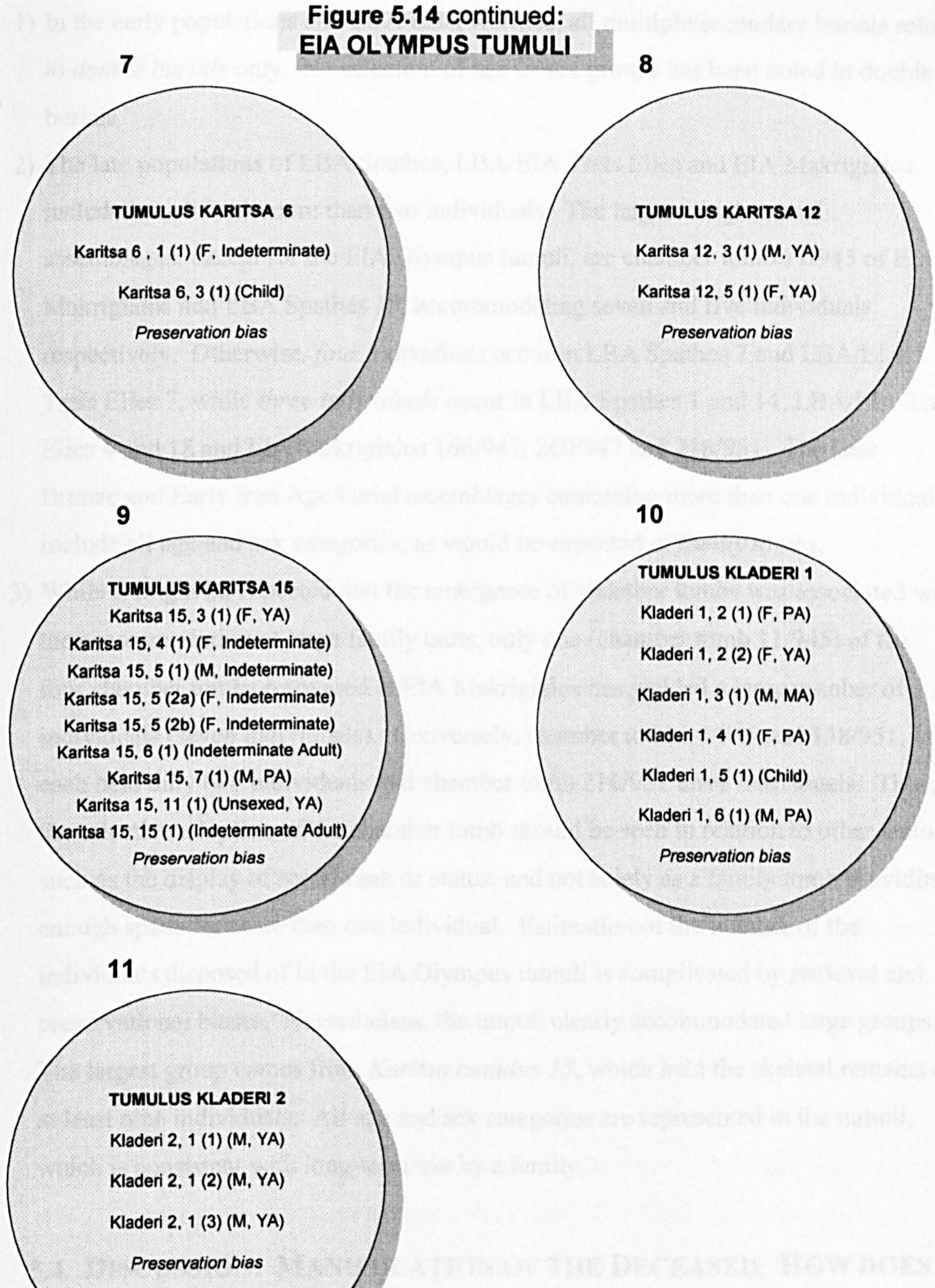


Figure 5.14: Distribution of the individuals disposed of in multiple and secondary burials in each grave assemblage of the case study cemeteries

1) In the early populations and EBA/LBA Korinos, all multiple/secondary burials refer to *double burials* only. No selection of age or sex groups has been noted in double burials.
2) The late populations of LBA Spathes, LBA/EIA Treis Elies and EIA Makrigialos include burials with more than two individuals. The largest single burial assemblages, except for the EIA Olympus tumuli, are chamber tomb 11/945 of EIA Makrigialos and LBA Spathes 15, accommodating seven and five individuals respectively. Otherwise, *four individuals* occur in LBA Spathes 7 and LBA/EIA Treis Elies 7, while *three individuals* occur in LBA Spathes 1 and 14, LBA/EIA Treis Elies 4 and 18 and EIA Makrigialos 166/947, 260/947 and 216/951. The Late Bronze and Early Iron Age burial assemblages containing more than one individual include all age and sex categories, as would be expected of *family tombs*.
3) While it might be expected that the emergence of chamber tombs was associated with the accommodation of large family units, only one (chamber tomb 11/945) of the four chamber tombs recovered at EIA Makrigialos has yielded a large number of individuals (seven individuals). Conversely, chamber tombs 4/945 and 138/951, each held only two individuals and chamber tomb 216/951 three individuals. Thus, the selective adoption of the chamber tomb should be seen in relation to other factors such as the display of social rank or status, and not solely as a family tomb providing enough space for more than one individual. Estimation of the number of the individuals disposed of in the EIA Olympus tumuli is complicated by retrieval and preservational biases. Nevertheless, the tumuli clearly accommodated large groups. The largest group comes from *Karitsa tumulus 15*, which held the skeletal remains of at least nine individuals. All age and sex categories are represented in the tumuli, which is consistent with long-term use by a family.

5.4. DISCUSSION: MANIPULATION OF THE DECEASED. HOW DOES IT CHANGE?

The minimum number of individuals in each burial assemblage has already been discussed, as has *the type of burial* (articulated or disarticulated at Neolithic Makrigialos; single and/or multiple/secondary in the remaining cemeteries). This information is now combined with that from published reports in order to clarify the transformations taking place in burial practices through time. It is possible to distinguish two crucial axes in the continuous interaction between the communities of the living and the deceased:

- *the perception of the mortuary arena as a site of social interaction* where various events took place in order to define and re-define the social roles of participants belonging to the sphere either of the deceased or of the living. Thus, the disposal in one burial assemblage of more than one individual suggesting a continuous opening and re-opening of the grave can be seen as a social statement of the relationship between the deceased and those participating in the funeral, linking them together as members of the same family, lineage or kin group. Also, the existence of distinct disposal areas or tombs as visible landmarks etc. can be interpreted in terms of social roles assigned to both the deceased and the living,
- *the perception of the mortuary arena as a site of memorable action for the community of the living* reflecting the use of the ancestors (deceased) in the establishment and social definition of the descendants (living).

It is worth considering next how the changing manipulation of the deceased in the case study cemeteries emphasised the active role of the deceased in the social construction of the living community:

- A. *Burials in Makrigialos Ditch A*. As discussed above, the main disposal area of Neolithic Makrigialos phase I was Ditch A, and secondarily, the large pit in sector Ξ. The following section will focus on the burials of Ditch A which represent the highest proportion of the phase I skeletal assemblage. Ditch A, being a visible landmark, which marked the boundary of the phase I settlement, can be seen primarily as a continuous, permanent monument to the community of living. "The building of the monuments prevented the ritual and mythological significance of particular places being lost and forgotten" (Tilley 1994: 204). "Seen as mnemonic markers in the landscape, they stabilised both cultural memory of place and connections between places" (Holtorf 1997: 50). Although Ditch A did not comprise such an obvious monument, its massive appearance in the Neolithic landscape, in close proximity to the habitation area may have continually emphasised its symbolic significance to the living. Ditch A signifies a will by the living to make it visible, "to be seen and remembered" (Tilley 1994: 204). The latter may have been underlined by the possible use of Ditch A as the main disposal area of the phase I inhabitants of

Neolithic Makrigialos. It is interesting that burial disposition was not the sole use of the ditch. It apparently served a variety of other purposes especially as a line of demarcation between the phase I habitation area and the outside world. The continuous filling and re-filling of this area, together with the evidence of small finds, animal bones and pottery recovered in settlement deposits, suggest open access to the ditch and the continual use of the area by the living community. The lasting character of the ditch may derive from its reference to the past "as a source of legitimate authority and its role as a medium through which later generations can express their links with tradition" (Hobsbawm 1983; also Bradley 1984; Barrett 1988). Thus, if Ditch A was openly accessible, the disposal of the dead in the ditch deposits can be considered as "a *public event* which consequently incorporates the whole group of people in a common ceremony" (Chapman 1993: 81). Public event should not be considered in this context as a large-scale ritual ceremony, since there is no evidence to support this, but as an open gathering of the members of the living displaying their association with the deceased during the funeral. As has been argued in a different context, "if a link is made between the ditch and the social units involved both in its construction and its later use as a disposal area, it is possible that social alliances were continually being realigned and renegotiated through continuous and multifarious uses of the ditch" (Hodder 1992: 232).

Furthermore, the *individual identity* of the dead begins to disappear after disposal in the communal area of Ditch A and is gradually transformed into the *group identity* represented by the memorable past/ancestors. The community of ancestors representing the memorable past may have played a series of roles in reproducing relations amongst the community of the living. While the collective character of the deposits may have masked certain asymmetries of power, the presence of the ancestors as mediators with the memorable past "would have reinforced the ties between lineages - or the whole community - and the land they worked" (Edmonds 1993: 114). The loss of individual identity can be inferred also from the lack in most cases of any special mortuary treatment, resulting in a mass of disarticulated skeletal elements where the initial shape of the dead had totally disappeared (Fleming 1973; Shanks and Tilley 1982). For Shanks and Tilley, this is "an assertion of the collective, a denial of the individual and of differences between individuals - an expression of equality" (Shanks and Tilley 1982: 150).

The decision by the community of the living to dispose of their deceased, in an area that was continuously used and thus disturbed by everyday activities, suggests an intention to incorporate the dead in a *communal monument*, a contemporaneous memorial. The funeral can be considered as the intermediary stage where the descendants (living) pay their respects to the community of the ancestors (deceased). After that, the occurrence of the ditch as a monument continuously visible and accessible to the living motivates the recollection and remembrance of the deceased/ancestors (Parker Pearson 1984; 1993; Barrett 1988; Chapman 1988; 1991; 1993). It can be seen ultimately as "an attempt to re-establish the unity of society through an explicit link with the traditions of the past" (Bradley 1984: 65).

- B. *Intramural burials in the Neolithic.* Intramural burials occur in EN Nea Nikomedeia and possibly LN Makrigialos II, although the evidence for the latter is not strong. Individuals interred intramurally received specific burial treatment, seen in the construction of simple pit graves and placement in a contracted position, but, the mortuary programme was strictly confined to the boundaries of the household unit, suggesting limited access to the funeral by close relatives (Chapman 1983; 1991; 1993). Burial was a private affair of the household unit, in contrast to the communal character of burial in phase I, and in particular in Ditch A, where the ditch itself played the role of a lasting monument in close proximity to the habitation area. Significantly, the deceased in intramural burials kept intact their individual identity since they do not appear to be associated with the group identity of the "community of the deceased", as in Ditch A burials.
- C. *Extramural cemeteries in the Bronze and Early Iron Age.* Extramural cemeteries became common during the Bronze and Early Iron Age. In the Late Bronze and Early Iron Age, all age and sex categories were buried in extramural cemeteries, except for neonates (Chapter 4). It is unlikely that neonates were disposed of within settlement deposits, since the few excavated Late Bronze and Early Iron Age settlements have provided no evidence of neonatal skeletal remains. Thus, a type of disposal other than inhumation was probably practised for new-born individuals, although there is no positive evidence to support this. Wherever neonates were disposed of, it is of interest that, in the Late Bronze and Early Iron Age, this age category was not considered appropriate for inclusion in the common disposal area of

the community and, thus, for incorporation into the community of the deceased and possibly of the living.

The extramural communal cemeteries of the Bronze and Early Iron Ages suggest a clear separation between the communities of the living and of the deceased. "The use of formal cemeteries distances and circumscribes the realm of the dead and emphasises its separation from the realm of the living" (Wells 1990: 128; also Voutsaki 1998: 45).

Furthermore, the Bronze and Early Iron Age extramural cemeteries exhibit *growing mortuary variability* (Chapter 3), in terms of grave structure, visibility of graves, and mortuary treatment (burial position, burial orientation, additional furnishing, associated grave goods). This developing mortuary variability can be seen as a potential platform for competition between groups in the community of the living. The character and consistency of these groups is not clear-cut, nor is it homogeneous in all periods. For instance, there is a tendency, in particular in Early Iron Age populations, for individuals of the same sex to display a standardised type of mortuary treatment, so that mortuary variability partly coincides with *sex distinction*. On the other hand, especially in the Late Bronze Age, the deposition in individual grave assemblages of considerable wealth, including imported items suggests *the emergence of competition* in social ranking or individual status. "Items placed with or destroyed alongside the deceased can be seen as the wasteful economic consumption of materials which have held some other socially valued capacity and might have served to build up obligations between people" (Parker Pearson 1982; 1984). In this context, the mortuary behaviour displayed by the living becomes a powerful means of advertising their social status within the local community (Triantaphyllou 1998: 154). The community of the living, therefore, defined sex and status roles in the mortuary arena.

☐ D. *Single versus multiple and secondary burials*. There is a substantial difference between single and multiple/secondary burials in the *ritual sequence* involved in each of the three types. The archaeological record suggests that, in *single burials*, the ritual ceremony took place primarily at the moment of the funeral, although the evidence of grave markers raises the possibility that repeated acts of commemoration were occasionally performed outside the grave in respect of the deceased. Also, it is possible that the recollection of the deceased did not require the physical presence of the living in the original disposal area, but could also have taken place elsewhere, such as at a relative's house.

The multiple/secondary burials clearly suggest at least a two-part sequence, including the funeral/burial of the deceased and later re-arrangement or re-burial of the remains of the deceased. Again, the second part of the ritual performance will have been a social gathering of people who desired to display their close ties to the deceased by participating in the re-opening of the grave and re-arrangement of the skeletal remains (Hertz 1960; van Gennep 1960; Metcalf and Huntington 1991). By this elaborate ritual sequence, which seems to have been limited to some members of the living community, "death becomes part of a predictable, cyclical scheme of continuity and renewal" (Voutsaki 1998: 45). At the same time, through the social gathering, the participants re-assert continuity and unity with the community of the deceased/ancestors.

Multiple and secondary burials both involved the action of *re-opening of the grave*. The deceased, once buried in a communal grave, shared his/her individual identity with the existing occupants of that particular grave. That is, the individual's identity was partly transformed and blended with the identity of the deceased/ancestors. There is however, a substantial difference between multiple and secondary burials. *Multiple burials* were primary burials, where the bones of individuals buried earlier were not disturbed; skeletons remained in an articulated state with grave goods remaining in their original position. Thus, the original arrangement established during the funeral was preserved. *Secondary burials* involved the complete disturbance and disarticulation of the skeleton and thus the total loss of the individual's physical shape and appearance; all accompanying grave goods were similarly disturbed or removed from their original position. Thus, in *multiple burials*, the individual re-established ties with the family deceased/ancestors without losing his/her basic physical shape and identity while, in *secondary burials*, despite a clear emphasis on family ties, the individual's identity was obviously disregarded during the secondary ritual of the manipulation of the bones by the participant members of the living community.

In conclusion, how the disposal of the deceased changed through time, from the Neolithic to the Early Iron Age, may be outlined, as follows:

I. *In Neolithic Makrigialos I*, many or most of the deceased were buried in a *communal area* such as Ditch A, to which all members of the living community had easy access and where there were no particular features to emphasise the deceased's individuality. This implies the loss of the individuals' identity and their incorporation into a *group identity* represented by the community of the deceased. Nevertheless, the occurrence of a limited number of burials in Ditch A and the large pit of sector Ξ, with evidence of formal mortuary treatment in grave structure, articulated burial position and occasionally associated grave goods, does suggest emerging differential manipulation of the deceased in phase I at Neolithic Makrigialos. There is no clear spatial segregation, however, of these burials displaying some kind of mortuary treatment from the remaining burials in the ditch deposits.

II. *In the Early Bronze Age*, there is a clear spatial segregation between the community of the living and the community of the deceased indicated by the broad adoption of the extramural cemetery, a formal disposal area outside the settlement. Furthermore, there is evident diversity in grave types, though with a clear tendency towards standardisation of mortuary treatment. It is also important that indications of formality and standardisation in funerary programme can be associated with *sex and/or age distinction* expressed through burial position, associated artefacts and to a lesser extent grave type. As for burial types, the majority of individuals were disposed of in single burials, thus keeping their *individual identity* along with any furnishing, clothing or grave goods which served to reinforce it (Triantaphyllou 1998: 153). Interestingly, however, there is some evidence in a limited number of cases for a tendency to emphasise *lineage-group identity*, through multiple/secondary burials and grave clustering.

III. *In the Late Bronze Age*, multiple burial was commonly adopted in the case study assemblages, especially at LBA Spathes, where more than one individual was placed in the grave in a perfectly articulated state while secondary burials also took place. Furthermore, there is evidence for a standard funerary programme in all aspects of mortuary behaviour such as grave type, additional furnishing equipment, burial type, position and orientation, and associated artefacts (Triantaphyllou 1998: 153). This homogeneity of funerary programme is cross-cut by the variable deposition of wealth within the cemetery, including carved sealstones, jewellery, pots and bronze weapons, which often recall Mycenaean or "Mycenaeanising" types, together with artefacts of exotic material. The combination of multiple, and thus articulated, burials and of artefacts closely associated with the identity of the deceased, such as the sealstones, strongly suggests an emphasis on individual identity, albeit within the overall descent group context. Moreover, in the variable accumulation of wealth, it is tempting to see an intentional display of social identity by a limited number of living participants in the ceremony. The latter evidently emphasised their close ties to the deceased and also witnessed the destruction of valuable and prestigious artefacts. Mortuary variability thus may be consistent with a growing tendency towards the development of competition between small kin groups to negotiate and define their social roles such as social status or rank over the living community.

IV. Finally, in the *Early Iron Age* burial assemblages, there is a tendency towards standardisation of the funerary programme alongside diversity in grave, burial and disposal types. Single burials and multiple/secondary burials occur in similar frequencies, while two new ways of accommodating more than one individual developed, *the chamber tomb* and *the tumulus*. Although the chamber tombs appear to have been designed to hold large groups of individuals, it is notable that this grave type at EIA Makrigialos did not contain many more individuals than the cist graves of LBA Spathes. Nevertheless, "the structure of the chamber tomb and its division into three substantial, totally innovative components, namely dromos, entrance and chamber, seem to reflect the tripartite scheme of mortuary behaviour developed by Hertz (1960), that is the rites of separation, transition rites and rites of incorporation" (Voutsaki 1998). It is the first time, therefore, that the tripartite form of mortuary ritual can be clearly visualised in the structure of a grave type, emphasising the close relations between the living and the deceased. The chamber tombs probably held members of the same family, but it is notable that subadults under twelve years old were excluded. Chamber tombs may represent a new developing social order, in which the living sought to establish themselves by emphasising their respect for the past and their ancestors. Tumuli, on the other hand, appear to have accommodated large groups of individuals possibly representing family lineages. The overall picture of burial practices in the Early Iron Age, thus serves to reinforce *lineage identity* alongside *the emergence of more visible differences* in social display and social ranking by particular groups which evidently use their past and tradition in processes related to the establishment and legitimisation of their social power and identity.

CHAPTER 6: PATTERNS OF HEALTH STATUS

6.1. INTRODUCTION

A number of recent bioarchaeological studies worldwide has focused on the assessment of health status together with the distribution of health patterns at the individual and population level. Health as a composite of nutrition, disease and other aspects of life contributes to the reconstruction of "patterns of community health, nutritional status, and well-being in earlier human populations" (Larsen 1987).

In order to reveal aspects of health status, bioarchaeological studies attempt to trace the manifestations of chronic or acute disease and developmental, functional or mechanical stress observed on dry bones, the latter being known as stress indicators. "Stress" is defined as the physiological disruption resulting from "any extrinsic variable or combination of variables which causes the organism to react" (Buikstra and Cook 1980; Goodman et al. 1980; Huss-Ashmore et al. 1982). A model described by Goodman and co-workers (Huss-Ashmore et al. 1982) represents stress as the interaction of three main factors including environmental constraints, cultural systems and host resistance. The latter model emphasises the biological adaptation and response to the cultural and biological environment developed by earlier populations. Biological features include age, sex and genetic background of the case study populations while the cultural environment represents settlement patterns, social organisation, subsistence and living conditions. Consequently, skeletal stress indicators and health patterns appear to represent a dynamic relationship between individuals and populations and the environment.

Sedentism, dense housing, and aggregation of population in larger centres, along with changes in diet quality, food processing and cooking, appear to have resulted in a decline in health status of earlier populations (Cassidy 1984; Cohen and Armelagos 1984; Cohen 1989; Cook 1984; Goodman et al. 1984; Lallo and Rose 1979; Larsen 1982; 1987). According to the above model, exposure to infectious pathogens, due to interaction with dense housing, immigration or trade, would result in a high prevalence of infectious disease; malnutrition and poor diet would result in high frequencies of enamel hypoplasia and anaemia; and occupational activities and conditions demanding a heavy mechanical workload would give rise to a high prevalence of degenerative joint changes and traumatic lesions.

Stress indicators are no longer thought to provide a straightforward measurement of the health status of prehistoric populations (Bocquet-Appel and Masset 1982; van Gerven and Armelagos 1983; Buikstra and Konigsberg 1985; Wood et al. 1992). Assessment of pathological conditions affecting living populations from skeletal material is complex, especially bearing in mind the methodological and taphonomic limitations on palaeodemographic studies, outlined above (Chapter 4).

The aims of this chapter are, first, to record and evaluate the pathological and abnormal conditions manifested in the skeletal populations and, secondly, to explore their association with population subgroups defined by age and sex. The ultimate goal of the analysis will be to explore the biological adaptability and response of the prehistoric populations to their physical and cultural environment.

With regard to the overall health status of the case study archaeological populations, two subgroups of pathological conditions will be analysed: first, skeletal manifestations largely associated with *physical mechanical load* experienced throughout life and varying according to type of occupation; secondly, pathological lesions closely related to the overall *pathogen load* of the populations affected. The former includes evidence of degenerative joint disease, vertebral pathologies and trauma, while the latter primarily involves non-specific infectious lesions, anaemia and enamel hypoplasia lines. Aspects of oral health status, together with dietary implications, are considered separately in Chapter 7.

The distinction between the two types of pathological conditions has been adopted in this chapter solely for methodological reasons. It is not feasible to draw a strict line between the two categories since the term "pathogen load" refers to the overall health status of the individuals affected and so includes conditions classified under "physical mechanical load". Also, degenerative joint lesions, being an age progressive disease, do not solely refer to physical mechanical load, but are also a normal occurrence in old individuals.

Due to the overall poor preservation of the human remains studied here, very little attention has been paid to bioarchaeological work based on the comparative prevalence of pathological conditions in the study area. The current analysis has been shaped by the nature of the material and, in particular, by three limitations:

1. the relatively small samples of individuals comprising the overall population cohort in each cemetery,

2. the lack of sexed and/or aged individuals from some cemetery populations, such as LN Makrigialos, EBA Makrigialos, EBA Goules and EBA/LBA Korinos, and
3. the common occurrence of incomplete skeletons.

The methodology adopted, which is described below, has attempted to set general standards in the assessment of health status patterns in order to allow comparison between the case study cemetery populations.

6.2. METHODOLOGY

The methodology adopted has had to take account of two substantial constraints in the nature of the osteological material:

1. The differential preservation of the skeletons both within and between cemetery populations.
2. The differential demographic structure of the case study populations, that is the variation in the proportions of age and sex groups comprising each population.

In order to control the former problem, the evaluation of the overall prevalence of pathological conditions has been based primarily on the *skeletal element count*. Thus, the occurrence of the recorded pathological lesions has been measured out of the total number of the skeletal elements represented in each osteological assemblage. A substantial problem of this method is that single skeletal elements have been treated as separate, independent units and thus the effect of a disease on the whole skeleton has been under-estimated. Furthermore, when a disease, such as a type of anaemia, can be detected solely in a specific part of the skeleton, such as the orbits and the cranial vault, the overall prevalence of the disease will not be reliably reflected if these parts are under-represented in the assemblage. With the exception of degenerative joint disease, most of the diseases studied here affect single bones rather than whole skeletons.

The effect of the differential demographic structure of the skeletal assemblages has been eliminated by *standardising* the crude prevalences of the pathological conditions, particularly those highly affected by age and/or sex. Standardisation is a statistical technique applied commonly in epidemiology that weights the average values of crude rates to allow comparisons between populations with different demographic structure (Coggon et al. 1993; Waldron 1994). The crude rates of the prevalence of the diseases have been weighted with reference to a standard population. The standard population of the current analysis has been defined by the overall total of the skeletal elements observed for each pathological condition from all the case study cemetery populations classified by age and/or sex groups separately. Therefore, the age and/or sex specific rates of the test population have been multiplied by the number of skeletal elements in each age and/or sex category in the standard population. The standardised rate of prevalence consists of the total rates of the test population divided by the total size of the standard population, that is: $\Sigma (R_{x,t} . P_{x,s})/P_s$, where $R_{x,t}$ is the age specific rate in the test population, $P_{x,s}$ is the size of the age and/or sex cohort x in the standard population and P_s is the total size of the standard population. It is worth emphasising that P_s varies between populations since not all age and/or sex groups are represented in all the case study cemetery populations. Standardised rates are entirely artificial and do not imply anything about the true rates in the original populations except their relationship to one another (Waldron 1994).

Finally, the macroscopic and, where necessary, radiographic identification of pathological lesions has been based on standards of recording and scoring set by modern anthropological work (Ortner and Putschar 1981; Buikstra and Ubelaker 1994; Aufderheide and Rodriguez-Martin 1998).

6.3. DEGENERATIVE JOINT DISEASE

6.3.1. INTRODUCTION

Degenerative joint disease describes the pathology of articular joints of the human skeleton. It can also be called osteoarthritis, which, however, defines a specific type of degenerative joint disease. Two types of articular joints are involved in palaeopathological analyses: *amphiarthrodial*, such as the intervertebral bodies of the vertebral column, and *diarthrodial* (synovial), which include the joints between the ends of long bones such as the knee or the elbow (Ortner and Putschar 1981; Jurmain 1977; 1980; Rogers et al. 1987; Larsen 1997; Aufderheide and Rodriguez-Martin 1998).

Degenerative changes can be recorded and scored in human skeletal remains either as erosive or proliferative lesions although commonly both lesions may occur together at the same articular joint. *Erosive* lesions are the result of loss of bone substance, while new bone formation occurs in proliferative changes. The former category involves the destruction of articular cartilage recognised as pitting, porous

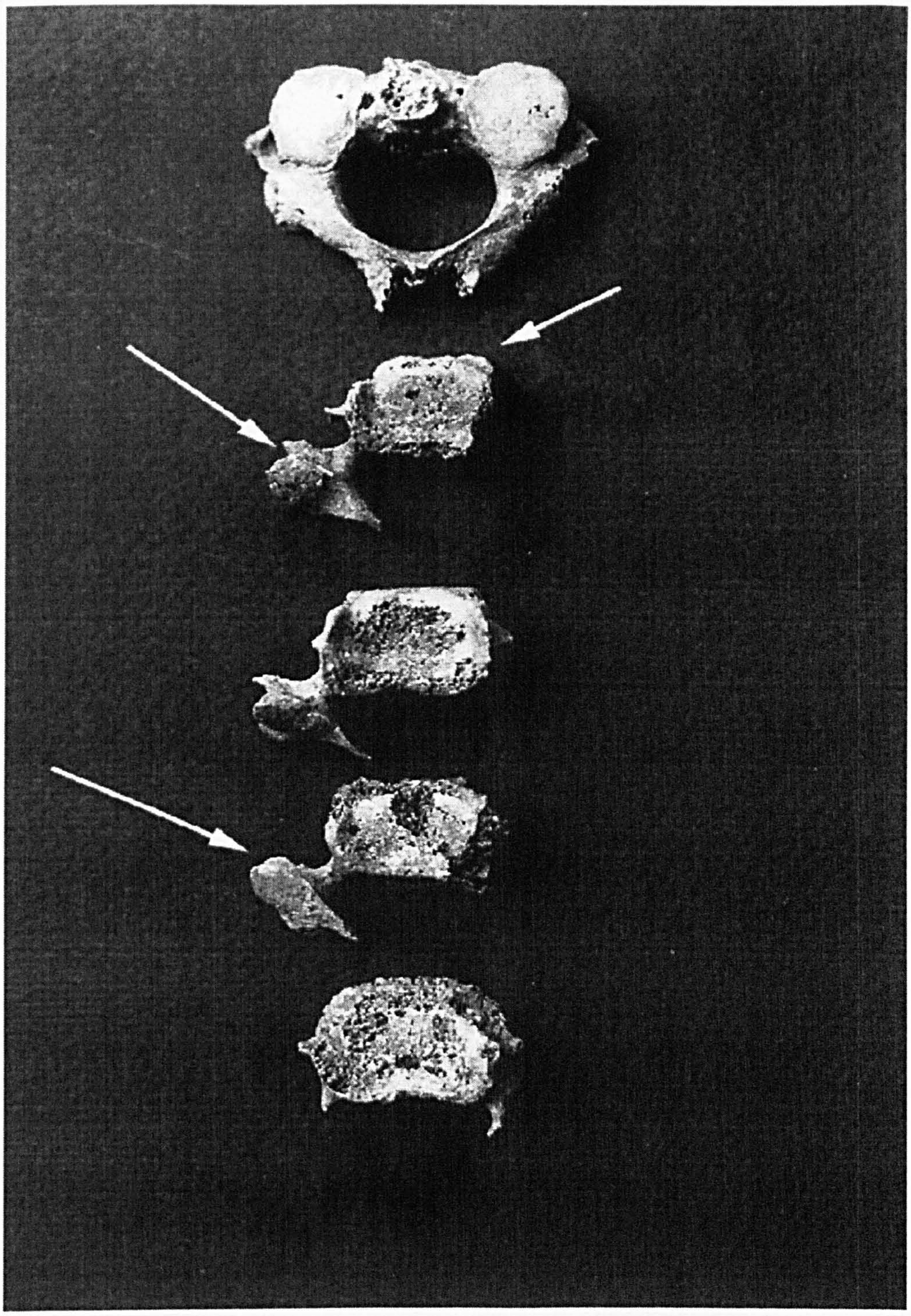


Figure 6.1: Degenerative joint disease on cervical vertebrae (Koilada Lith34)

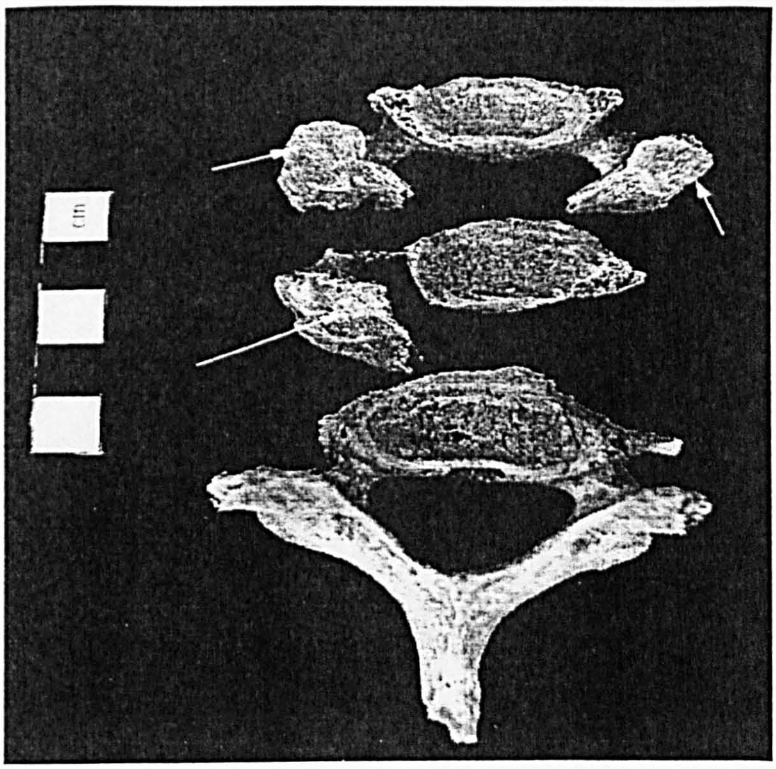


Figure 6.2: Evidence of eburnation on C5 and C7 (Spathes 1)

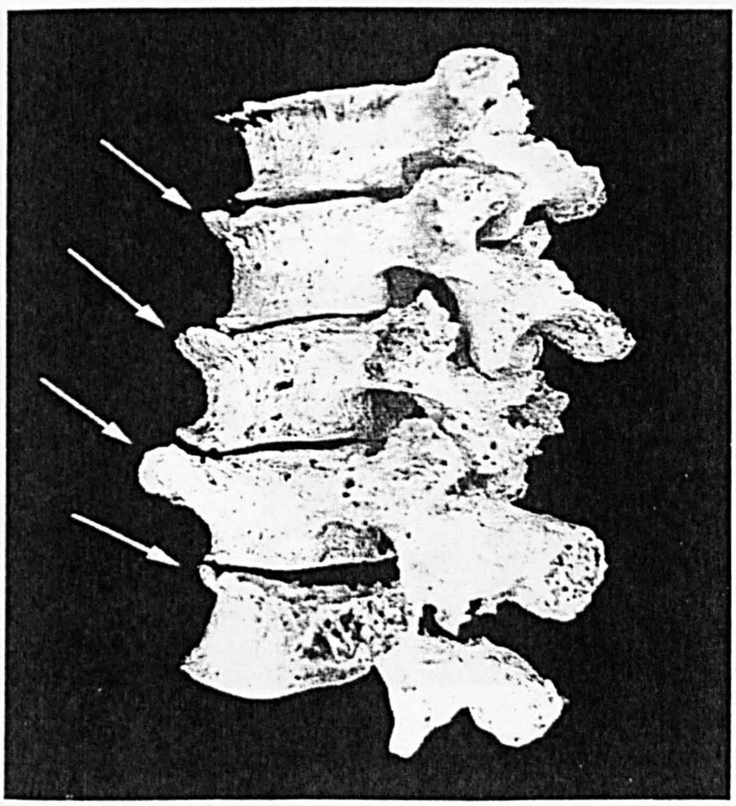


Figure 6.3: Osteophytic development on lumbar vertebrae (Karitsa Tum 5b)

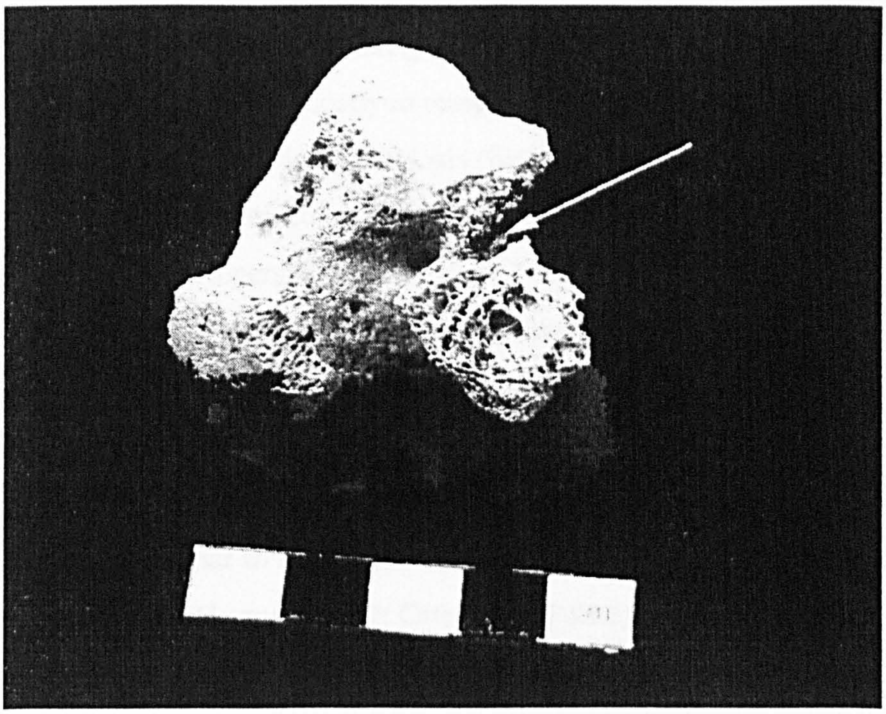


Figure 6.4: Severe degenerative changes causing ankylosis of the ankle (Koilada 45)

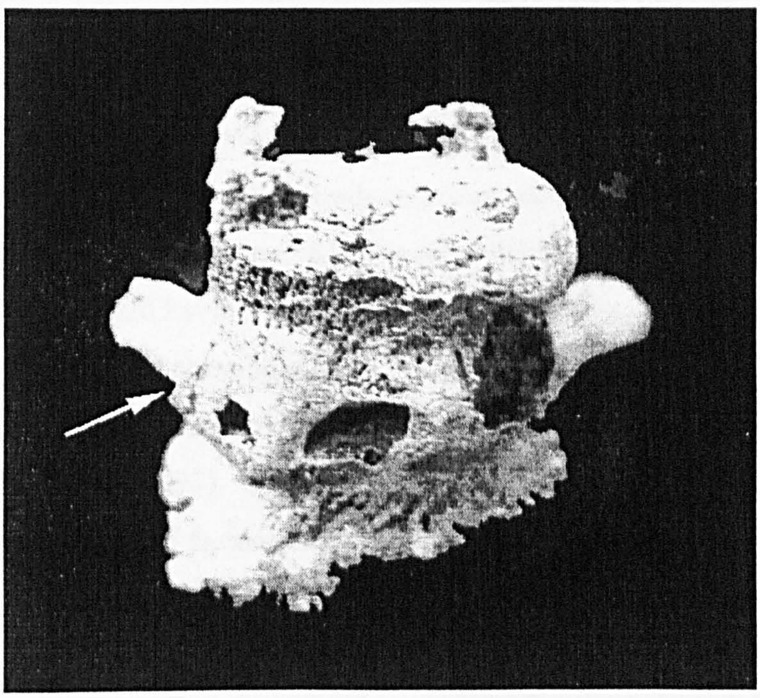


Figure 6.5: Severe degenerative changes causing ankylosis of L5 and S1 (Koilada Lith44)

lesions (Figure 6.1) and eburnation (polishing) in more severe cases (Figure 6.2). *Proliferative* changes refer mostly to marginal bone proliferation, that is, osteophytosis (Figure 6.3) and more rarely to ankylosis (fusion) of joints at the margins across the whole joint surface or any combination of both (Figures 6.4 and 6.5) (Bourke 1967; Rogers et al. 1987; Rogers and Waldron 1995).

Degenerative joint disease is usually described as a multifactorial disorder (Jurmain 1977; 1980; Rogers et al. 1987; Aufderheide and Rodriguez-Martin 1998). Factors which affect the development and severity of the disorder include both *systemic* predisposition, namely, age, sex, metabolism, nutrition, hormones and heredity, and *mechanical-functional stress*, which involves occupational activities, chronic or acute trauma and obesity (Jurmain 1977; Ortner and Putschar 1985). However, the most attractive aspect of the study of osteoarthritis is its possible association with physical and occupational activities (Jurmain 1977; Merbs 1983).

According to the latter, certain patterns of distribution of arthritic changes which are related to the level of physical activity and occupational stress, can be detected in archaeological populations (Ortner 1968; Jurmain 1977; 1980; Waldron and Rogers 1991; Bridges 1992). In particular, alterations in subsistence economy may involve changes in physical and occupational activities and the prevalent view, although debatable (Goodman et al. 1984; Bridges 1992), is that a decrease in the occurrence of osteoarthritis was caused by the introduction and intensification of agriculture in several environmental settings (Larsen 1982; Kennedy 1984; Meiklejohn et al. 1984; Bridges 1991; Meiklejohn and Zvelebil 1991). Local circumstances, including environmental setting and mechanical stress load from everyday tasks, seem variously to influence the prevalence and severity of osteoarthritis worldwide (Jurmain 1977; 1980; Bridges 1989a; 1991; Larsen 1997). Osteoarthritis needs to be considered as a response, therefore, to a variety of factors, rather than just to dramatic temporal or cultural changes.

6.3.2. RESULTS

6.3.2.1. PREVALENCE OF DEGENERATIVE JOINT DISEASE

Table 6.1 and Figure 6.6 provide a picture of the overall prevalence of degenerative changes recorded in the appendicular skeleton and vertebral column of the case study archaelogical populations. The values indicated in Table 6.1 and Figure 6.6 show the standardised rates, obtained as described above in section 6.2. Except for Late Neolithic Makrigialos I, the rest of the populations were affected by the condition, although in low frequencies. The highest prevalence of osteoarthritis was found in Early Neolithic Nea Nikomedeia and the Early Iron Age Olympus tumuli. The rates of occurrence are significantly different between the cemeteries (chi square test: $x^2 = 2002.375 > p = 27.877$, at the 0.001 level of significance), but there is no consistent chronological pattern.

The statistical significance of the differences between the populations was calculated by carrying out a chi-squared test on the proportions of affected versus total individuals observed. These standardised proportions were determined by multiplying the standardised prevalence rate times the size of the standard population. For example, since the standardised rate of the prevalence of degenerative joint disease in Nea Nikomedeia is 11.39 (Table 6.1), the latter has been multiplied with the Ps, that is the total size of the standard population, divided by 100: 11.39 x 4274/100= 487 which is the count on which the chi-square has been computed. The size of the standard population varies depending on the age categories recorded in the archaeological population. Please note that it has subsequently been demonstrated that the above method of calculation of X^2 is incorrect and gives excessively high values of X^2. A more appropriate procedure is to multiply the standardised prevalence rate by the sample size in the archaeological population in order to determine a corrected value for "number of individuals affected". Using the same example as given above, the standardised prevalence rate of 11.39 % is multiplied by the archaeological population size of 466 to give a standardised number of individuals affected of 53.1 The chi-squared test can then be carried out on the standardised number of individuals affected.

The distribution of the lesions by age group (Table 6.2) follows, in general, the expected picture of an age progressive condition, with the frequency of occurrence increasing from the young to old age categories. The difference in the distribution of the cumulative frequencies of arthritic changes between the age categories is statistically significant at EN Nea Nikomedeia (Kolmogorov-Smirnov test: $D_{maxobs} = 0.257 > D_{max0.05} = 0.216$), EBA/LBA Korinos (Kolmogorov-Smirnov test: $D_{maxobs} = 0.589 > D_{max0.05}$

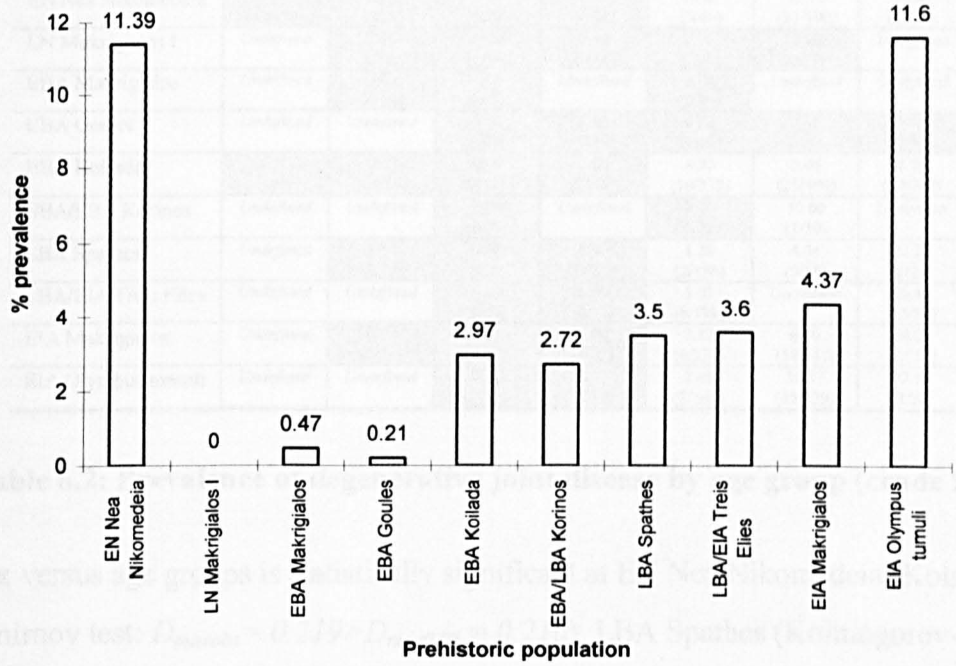
Population	% (NIA [1]/NIO [2])	% Standardised rate (standardised proportion/P_s)
EN Nea Nikomedeia	10.08 47/466	11.39 487/4274
LN Makrigialos I	0.00 0/448	0.00 0/4519
EBA Makrigialos	0.94 1/106	0.47 14/3002
EBA Goules	0.34 1/290	0.21 10/4690
EBA Koilada	3.24 61/1882	2.97 155/5227
EBA/LBA Korinos	4.86 7/144	2.72 105/3858
LBA Spathes	2.98 11/368	3.50 180/5144
LBA/EIA Treis Elies	5.28 21/397	3.60 130/3576
EIA Makrigialos	4.57 32/700	4.37 225/5144
EIA Olympus tumuli	12.63 57/451	11.60 544/4690

Table 6.1: Overall prevalence of degenerative joint disease in the case study populations (raw and standardised data)

[1] Number of Individuals Affected.

[2] Number of Individuals Observed.

Figure 6.6: Prevalence of degenerative joint disease in the case study populations (standardised rates)



=0.487), LBA/EIA Treis Elies (Kolmogorov-Smirnov test: $D_{maxobs}=0.431>D_{max0.05}=0.308$), EIA Makrigialos (Kolmogorov-Smirnov test: $D_{maxobs}=0.386>D_{max0.05}=0.248$) and the EIA Olympus tumuli (Kolmogorov-Smirnov test: $D_{maxobs}=0.504>D_{max0.05}=0.199$).

Nevertheless, although arthritic changes occurred primarily in the old age categories, degenerative lesions were already frequent among *young adults* at EN Nea Nikomedeia and, to a lesser extent, EBA Koilada. In addition, it is worth mentioning that, at EN Nea Nikomedeia and EBA Koilada, there is evidence also of severe arthritic changes such as the development of cysts and fusion of articular joints in the older age categories, in contrast with the milder osteophytosis and pitting commonly recorded in the majority of the case study cemetery populations.

The early development of degenerative joint disease in young adulthood suggests the early involvement of at least part of the prehistoric population in demanding physical activities. In order to clarify possible division of labour, the prevalence of the lesions is next examined by sex versus age groups (Table 6.3).

Table 6.3 includes only sexed individuals of determined age category. The difference in the distribution of the cumulative frequencies of degenerative changes by

Population	Neonate % (NIA/NIO)	Infant % (NIA/NIO)	Child % (NIA/NIO)	Juvenile % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
EN Nea Nikomedeia	0.00 (0/74)	0.00 (0/58)	0.00 (0/15)	0.00 (0/28)	10.86 (5/46)	12.10 (23/190)	36.00 (18/50)	20.00 (1/5)
LN Makrigialos I	*Undefined*	0.00 (0/2)	0.00 (0/16)	0.00 (0/16)	0.00 (0/59)	0.00 (0/7)	*Undefined*	*Undefined*
EBA Makrigialos	*Undefined*	0.00 (0/13)	0.00 (0/5)	*Undefined*	0.00 (0/29)	*Undefined*	*Undefined*	*Undefined*
EBA Goules	*Undefined*	*Undefined*	0.00 (0/7)	0.00 (0/38)	0.00 (0/67)	0.00 (0/56)	0.00 (0/32)	*Undefined*
EBA Koilada	0.00 (0/9)	0.00 (0/244)	0.00 (0/171)	0.00 (0/186)	4.30 (16/372)	5.04 (25/496)	8.26 (20/242)	0.00 (0/47)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/39)	*Undefined*	0.00 (0/31)	10.00 (1/10)	*Undefined*	32.00 (8/25)
LBA Spathes	*Undefined*	0.00 (0/17)	0.00 (0/8)	0.00 (0/27)	1.28 (2/156)	4.34 (3/69)	22.22 (6/27)	0.00 (0/23)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/10)	0.00 (0/17)	3.03 (6/198)	*Undefined*	16.48 (15/91)	*Undefined*
EIA Makrigialos	*Undefined*	0.00 (0/22)	0.00 (0/29)	0.00 (0/72)	2.17 (6/276)	6.80 (10/147)	19.29 (11/57)	21.73 (5/23)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/14)	0.00 (0/19)	2.06 (3/145)	32.37 (45/139)	32.14 (9/28)	*Undefined*

Table 6.2: Prevalence of degenerative joint disease by age group (crude rates) [3]

sex versus age groups is statistically significant at EN Nea Nikomedeia (Kolmogorov-Smirnov test: $D_{maxobs}= 0.219>D_{max0.05} = 0.210$), LBA Spathes (Kolmogorov-Smirnov test: $D_{maxobs}= 0.452>D_{max0.05} = 0.386$), LBA/EIA Treis Elies (Kolmogorov-Smirnov test: $D_{maxobs}= 0.372>D_{max0.05} = 0.295$), EIA Makrigialos (Kolmogorov-Smirnov test: $D_{maxobs}= 0.407>D_{max0.05} = 0.245$) and the EIA Olympus tumuli (Kolmogorov-Smirnov test: $D_{maxobs}= 0.462>D_{max0.05} = 0.200$). Two further observations can be drawn from Table 6.3:

A. While in the early populations there is a tendency for both sex groups to develop the highest frequency of degenerative changes in the same age categories, in the late populations (LBA Spathes, EIA Makrigialos and the Olympus tumuli), there is a clear tendency to *differential manifestation* of the lesions by sex and age. Thus, prime adult men and mature adult women suffered the highest occurrence of arthritic changes in LBA Spathes and the EIA Olympus tumuli, compare with old adult men and mature adult women in EIA Makrigialos.

B. Where degenerative changes are recorded during young adulthood, *male individuals* have the highest rates of osteoarthritis. The differences in the occurrence of the condition among young adults of the two sexes are statistically significant at EN Nea Nikomedeia (chi square test: $x^2= 9.84> p=7.879$, at the 0.005 level of significance) and EBA Koilada (chi square test: $x^2= 8.56> p=7.879$, at the 0.005 level of

Age group / Sex group	EN NEA NIKOMEDEIA				LN MAKRIGIALOS I			
	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
Male	33.33 (7/21)	6.15 (4/65)	44.11 (15/34)	*Undefined*	0.00 (0/5)	0.00 (0/28)	*Undefined*	*Undefined*
Female	0.00 (0/25)	14.70 (20/136)	17.39 (4/23)	0.00 (0/3)	0.00 (0/54)	*Undefined*	*Undefined*	*Undefined*

Age group / Sex group	EBA MAKRIGIALOS				EBA GOULES			
	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
Male	0.00 (0/28)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/37)	*Undefined*	*Undefined*	*Undefined*
Female	*Undefined*	*Undefined*	*Undefined*	*Undefined*	0.00 (0/14)	0.00 (0/69)	0.00 (0/19)	*Undefined*

Age group / Sex group	EBA KOILADA				EBA/LBA KORINOS			
	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
Male	6.91 (15/217)	8.36 (21/251)	8.98 (15/167)	0.00 (0/18)	0.00 (0/3)	*Undefined*	*Undefined*	20.00 (5/25)
Female	0.64 (1/154)	3.25 (8/246)	4.00 (3/75)	0.00 (0/29)	0.00 (0/10)	0.00 (0/28)	*Undefined*	*Undefined*

Age group / Sex group	LBA SPATHES				LBA/EIA TREIS ELIES			
	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
Male	*Undefined*	4.25 (2/47)	*Undefined*	*Undefined*	4.63 (7/151)	*Undefined*	20.37 (11/54)	*Undefined*
Female	1.28 (2/156)	9.09 (2/22)	22.22 (6/27)	4.34 (1/23)	0.00 (0/36)	*Undefined*	10.41 (5/48)	*Undefined*

Age group / Sex group	EIA MAKRIGIALOS				EIA OLYMPUS TUMULI			
	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
Male	0.00 (0/26)	8.10 (6/74)	0.00 (0/23)	21.73 (5/23)	3.79 (3/79)	42.66 (32/75)	0.00 (0/12)	*Undefined*
Female	2.54 (6/236)	6.34 (4/63)	27.90 (12/43)	*Undefined*	0.00 (0/46)	18.57 (13/70)	75.00 (9/12)	*Undefined*

Table 6.3: Prevalence of degenerative joint disease by sex versus age groups (crude rates)

significance). Only in EIA Makrigialos, do women appear to have been most affected.

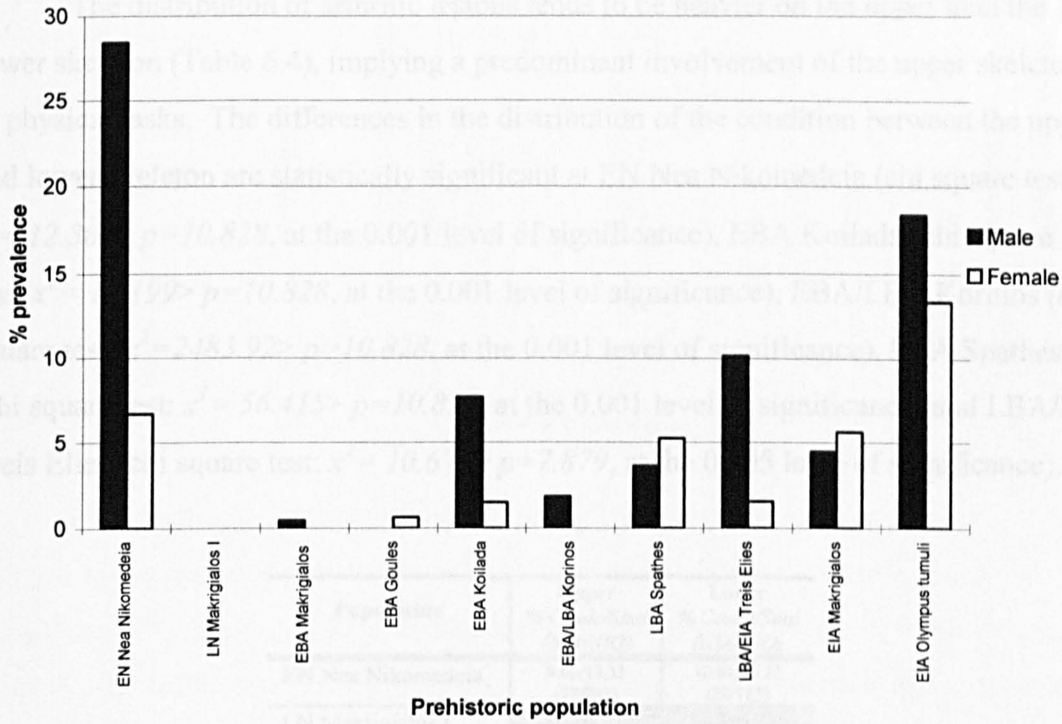
Assuming that the impact of sexual dimorphism is minimal, an earlier development of degenerative lesions by the *male segment* of the late populations, with the exception of EIA Makrigialos, may result from relatively heavy physical activities

[3] Adults of indeterminate age are excluded from this table, but have been included in calculating the overall prevalence of the disease.

and occupational stress suggesting thus *sex differentiation* with regard to the division of workload.

In terms of the overall distribution of arthritic changes by sex group (Figure 6.7), there is a clear prevalence of lesions in *male individuals*. The differences are statistically significant at EN Nea Nikomedeia (chi square test: $x^2= 417.569> p=10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2= 93.328>$ $p=10.828$, at the 0.001

Figure 6.7: Prevalence of degenerative joint disease by sex group (standardised rates)



level of significance), EBA/LBA Korinos (chi square test: $x^2= 10.508> p=7.879$, at the 0.005 level of significance), LBA/EIA Treis Elies (chi square test: $x^2= 104.359>$ $p=10.828$, at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: $x^2= 22.803> p=10.828$, at the 0.001 level of significance). The next section attempts to explore the character of the physical tasks undertaken by the sex groups of the case study populations, by investigating the distribution of degenerative lesions in the upper and lower skeletal elements.

6.3.2.2. Prevalence of Degenerative Joint Disease by Part of Skeleton

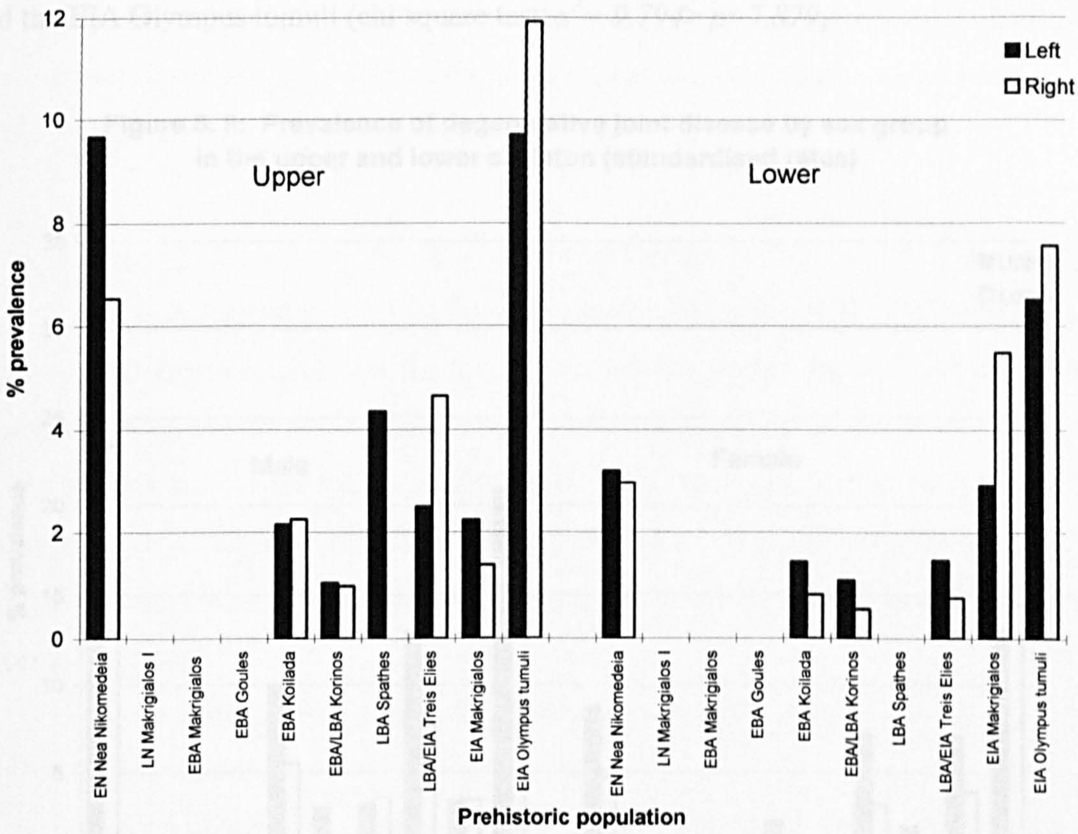
To investigate the anatomical distribution of arthritic changes, the skeleton has been divided into an upper part, which includes the upper limbs, cervical and thoracic vertebrae and thorax, and a lower part, which includes the lower limbs, lumbar and sacral vertebrae. The distribution of degenerative changes by left and right side has also been evaluated; assuming the prevalence of right-handedness in common activities (Merbs 1983), this may enable recognition of occupational stress on articular joints of a particular side.

The distribution of arthritic lesions tends to be heavier on the upper than the lower skeleton (Table 6.4), implying a predominant involvement of the upper skeleton in physical tasks. The differences in the distribution of the condition between the upper and lower skeleton are statistically significant at EN Nea Nikomedeia (chi square test: $x^2 = 12.306 > p = 10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2 = 18.199 > p = 10.828$, at the 0.001 level of significance), EBA/LBA Korinos (chi square test: $x^2 = 2483.92 > p = 10.828$, at the 0.001 level of significance), LBA Spathes (chi square test: $x^2 = 56.415 > p = 10.828$, at the 0.001 level of significance) and LBA/EIA Treis Elies (chi square test: $x^2 = 10.679 > p = 7.879$, at the 0.005 level of significance).

Population	Upper % Crude/Stnd (NIA/NIO)	Lower % Crude/Stnd (NIA/NIO)
EN Nea Nikomedeia	9.60/13.31 (27/281)	10.81/10.22 (20/185)
LN Makrigialos I	0.00/0.00 (0/269)	0.00/0.00 (0/179)
EBA Makrigialos	1.69/0.08 (1/59)	0.00/0.00 (0/45)
EBA Goules	0.55/0.02 (1/180)	0.00/0.00 (0/110)
EBA Koilada	4.00/3.58 (40/999)	2.37/2.30 (21/883)
EBA/LBA Korinos	6.97/8.21 (6/86)	1.72/0.41 (1/58)
LBA Spathes	4.66/5.35 (9/193)	1.14/1.52 (2/175)
LBA/EIA Treis Elies	6.04/4.20 (13/215)	4.39/3.00 (8/182)
EIA Makrigialos	4.93/4.77 (20/405)	4.06/4.46 (12/295)
EIA Olympus tumuli	13.80/11.88 (33/239)	11.32/11.07 (24/212)

Table 6.4: Prevalence of degenerative joint disease in the upper and lower skeleton (crude and standardised rates)

Figure 6.8: Prevalence of degenerative joint disease by side in the upper and lower skeleton (standardised rates)

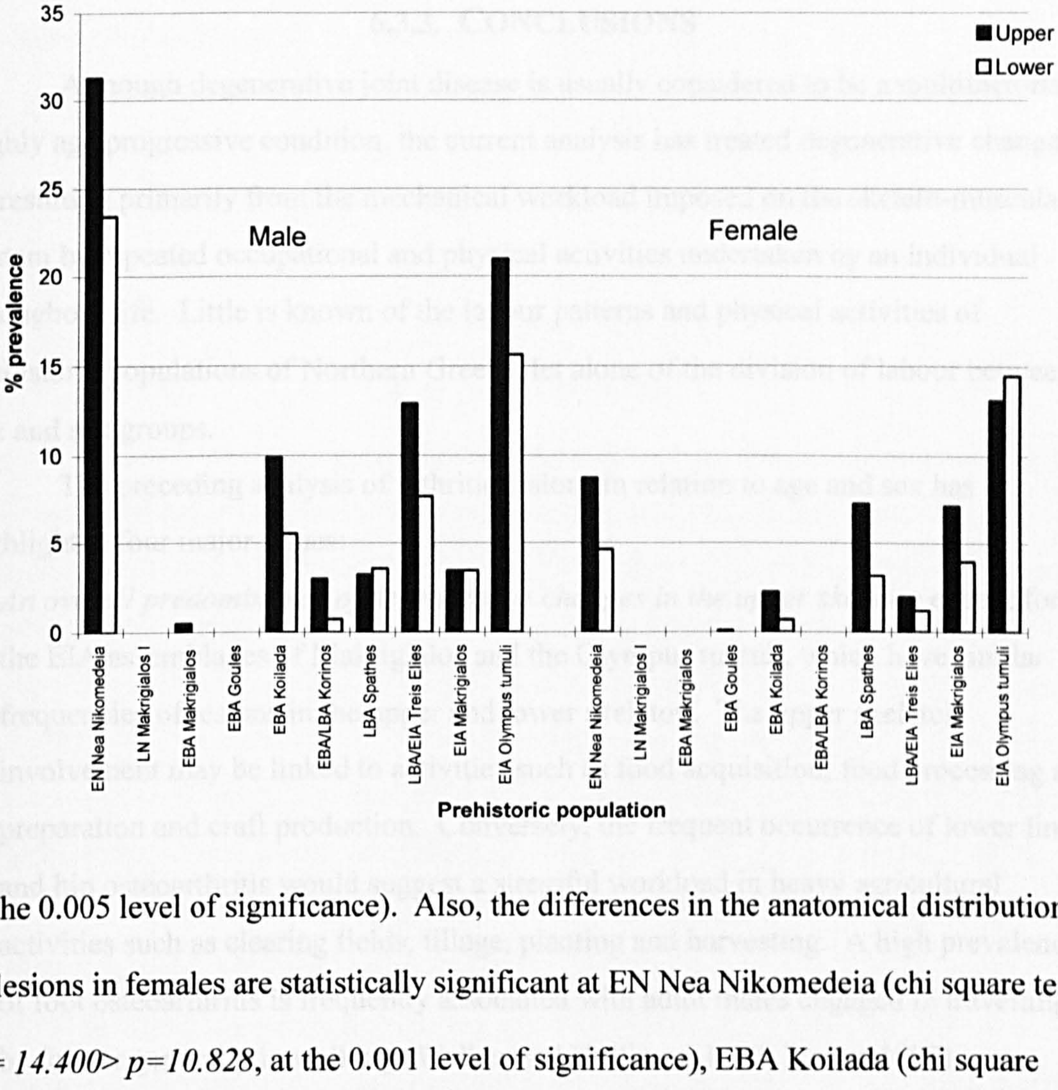


With regard to distribution by side of body (Figure 6.8), it is notable that, contrary to the expected prevalence of right-handedness, EN Nea Nikomedeia, LBA Spathes and EIA Makrigialos have revealed a predominance of upper *left* appendicular skeleton affected by degenerative lesions. The differences between left and right side in the upper skeleton are statistically significant at EN Nea Nikomedeia (chi square test: $x^2= 7.948 > p=7.879$, at the 0.005 level of significance) and LBA Spathes (chi square test: $x^2= 53.604 > p=10.828$, at the 0.001 level of significance), but also in LBA/EIA Treis Elies (chi square test: $x^2= 5.620 > p=5.023$, at the 0.025 level of significance), where right-sided lesions are more frequent than left-sided.

Figure 6.9 represents the distribution of degenerative changes to the upper and lower skeleton by sex group. The results indicate that in both sexes degenerative changes are preferentially associated overall with the upper skeleton. The differences in the anatomical distribution of lesions in males are statistically significant at EN Nea

Nikomedeia (chi square test: $x^2 = 20.154 > p = 10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2 = 10.824 > p = 7.879$, at the 0.005 level of significance) and the EIA Olympus tumuli (chi square test: $x^2 = 9.794 > p = 7.879$,

Figure 6. 9: Prevalence of degenerative joint disease by sex group in the upper and lower skeleton (standardised rates)



at the 0.005 level of significance). Also, the differences in the anatomical distribution of lesions in females are statistically significant at EN Nea Nikomedeia (chi square test: $x^2 = 14.400 > p = 10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2 = 8.494 > p = 7.879$, at the 0.005 level of significance), LBA Spathes (chi square test: $x^2 = 14.957 > p = 10.828$, at the 0.001 level of significance) and EIA Makrigialos (chi square test: $x^2 = 11.230 > p = 10.828$, at the 0.001 level of significance). Overall, the incidence of degenerative lesions is higher in men, especially at EN Nea Nikomedeia.

In the EIA Olympus tumuli, men have a higher frequency of lesions in the upper skeleton, women have more lesions in the lower skeleton.

Overall, the prevalence of lesions in the upper skeleton suggests that both sexes were subject to similar types of stresses. Men appear to have suffered higher stress levels, particularly at EN Nea Nikomedeia.

6.3.3. CONCLUSIONS

Although degenerative joint disease is usually considered to be a multifactorial, highly age progressive condition, the current analysis has treated degenerative changes as resulting primarily from the mechanical workload imposed on the skeleto-muscular system by repeated occupational and physical activities undertaken by an individual throughout life. Little is known of the labour patterns and physical activities of prehistoric populations of Northern Greece, let alone of the division of labour between age and sex groups.

The preceding analysis of arthritic lesions in relation to age and sex has highlighted four major issues:

A. *An overall predominance of degenerative changes in the upper skeleton* except for the EIA assemblages of Makrigialos and the Olympus tumuli, which have similar frequencies of lesions in the upper and lower skeleton. The upper skeleton involvement may be linked to activities such as food acquisition, food processing and preparation and craft production. Conversely, the frequent occurrence of lower limb and hip osteoarthritis would suggest a stressful workload in heavy agricultural activities such as clearing fields, tillage, planting and harvesting. A high prevalence of foot osteoarthritis is frequently associated with adult males engaged in travelling by foot or generally in walking (Walker and Hollimon 1989; Larsen 1997).

B. *The left-side dominance of degenerative changes to the upper skeleton* in EN Nea Nikomedeia, LBA Spathes and EIA Makrigialos contrasts with the expected right-handedness. The left-side upper skeleton dominance may possibly be associated with an activity, such as the grinding of plant foods, involving a certain type of physical movements. Similar evidence from the prehistoric South-eastern USA has associated a pattern of increased osteoarthritis in the left or both arms of Indian females to the method of processing the corn using a mano or metate (Bridges 1989a; 1991).

C. *The early development of degenerative changes.*

a. *Young adult individuals* in EN Nea Nikomedeia and EBA Koilada have a higher prevalence of degenerative changes compared with the relatively lower rates among young adults in the later populations.

b. Among young adults, *men* appear to have suffered most from arthritic lesions in all case study cemetery populations, except for EIA Makrigialos.

D. *Some sexual division of labour* is suggested by the contrasting frequency of degenerative changes in the two sexes.

a. Men and women were both preferentially subject to stress in the upper skeleton.

b. Men suffered higher levels of arthritic lesions than women.

6.4. TRAUMA

6.4.1. INTRODUCTION

Trauma refers to any injury or wound resulting from "violent encounters with environmental hazards, inter- and intraspecies conflicts, and, in rare instances, self-mutilation and suicide" (Merbs 1989). Thus, a number of cultural and social behaviours providing evidence of injury can be classified under the general term of trauma, such as intentional mutilation of teeth, deliberate skull deformation or stress fatigue fractures occurring usually in the vertebral column (Roberts and Manchester 1995; Larsen 1997). In human archaeological populations, the commonest skeletal manifestation of trauma includes various types of *fractures* (Figures 6.10, 6.11, 6.12, 6.13) (Steinbock 1976; Ortner and Putchar 1981; Merbs 1989; Roberts 1991; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998).

The study of trauma has been considered of particular interest by bioarchaeologists and biological anthropologists. Patterns of traumatic lesions, bone affected, degree of severity, evidence of healing and treatment, involvement of medical agency, can clarify the aetiology of trauma and its biological and sociocultural context. The latter includes lifestyle, occupational activities, living environment and availability of medical treatment (Grauer and Roberts 1996).

A significant point with regard to the study of trauma is that it is often not feasible in skeletal assemblages to estimate when the lesion occurred. A healed fracture

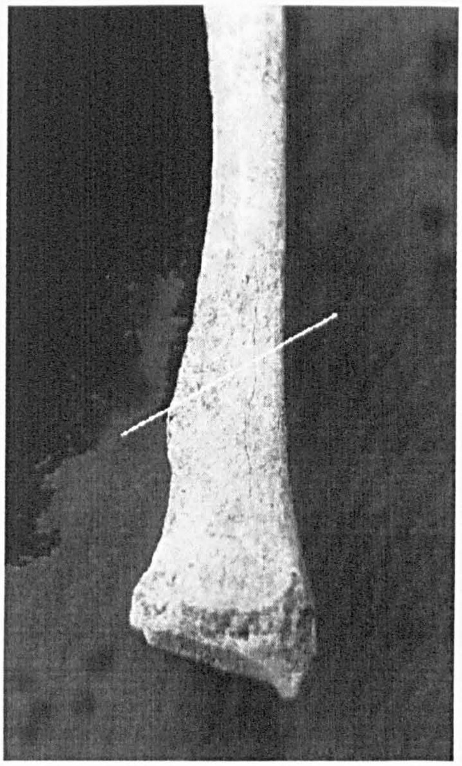


Figure 6.10: Long-term healed oblique fracture on right radius (Koilada 100)

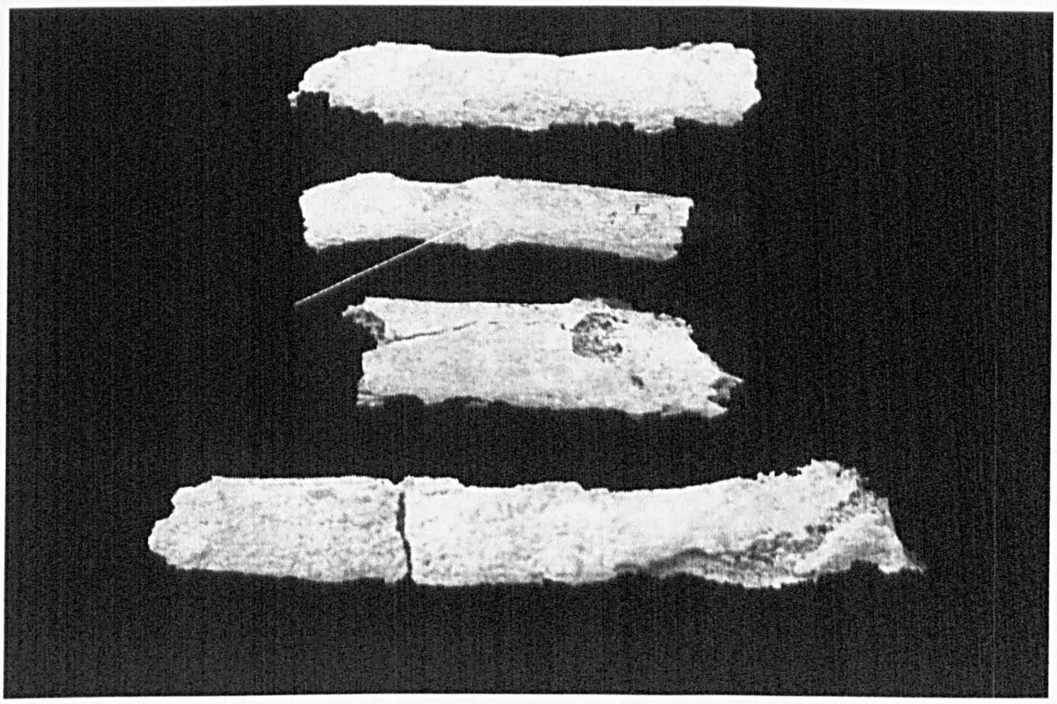


Figure 6.11: Long-term healed fractures on left ribs (Koilada 83)

Figure 6.12: Long-term healed fracture on the left third metecarpal causing degenerative joint disease on the metacarpophalangeal joint (Goules 20)

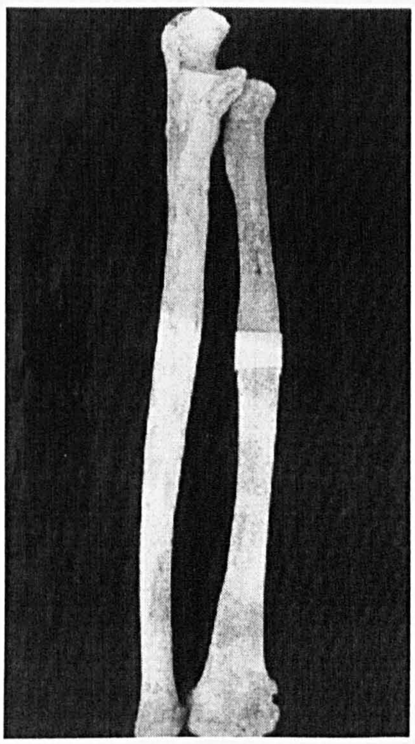


Figure 6.13: Long-term healed fracture on the distal right forearm causing osteophytic development on the radiocarpal joint (Karitsa Tum 5b)

may represent an injury which happened any time before the individual's death, unless there is evidence of active periosteal reaction and new bone formation (Roberts 1991; Larsen 1997). Moreover, fractures during childhood may heal and remodel so well that the fracture may not be visible even in radiography (Roberts 1991: 227), whereas injuries occurring during adulthood usually remain evident throughout life. The skeleton thus bears a cumulative record of fractures suffered during life, so that, even with a constant risk of injury throughout life, a steady increase should be evident in the prevalence of fractures in successive age categories. Any deviation from this pattern would suggest an increased or decreased risk of fractures in a certain age group (Mays 1998: 176).

Three types of trauma are represented in the case study skeletal populations: 1) *fractures* in long bones, 2) *stress fractures* in vertebrae recognised macroscopically by compressed vertebral bodies and 3) a possible *pattern of dental trauma* at EBA Koilada. The overall prevalence of trauma has been based on standardised rates and involves only the two first categories of lesions. Standardisation has not been applied in the evaluation of the prevalence of the condition in the sex groups because it is not considered that the occurrence of trauma can be highly affected by biological age.

6.4.2. RESULTS

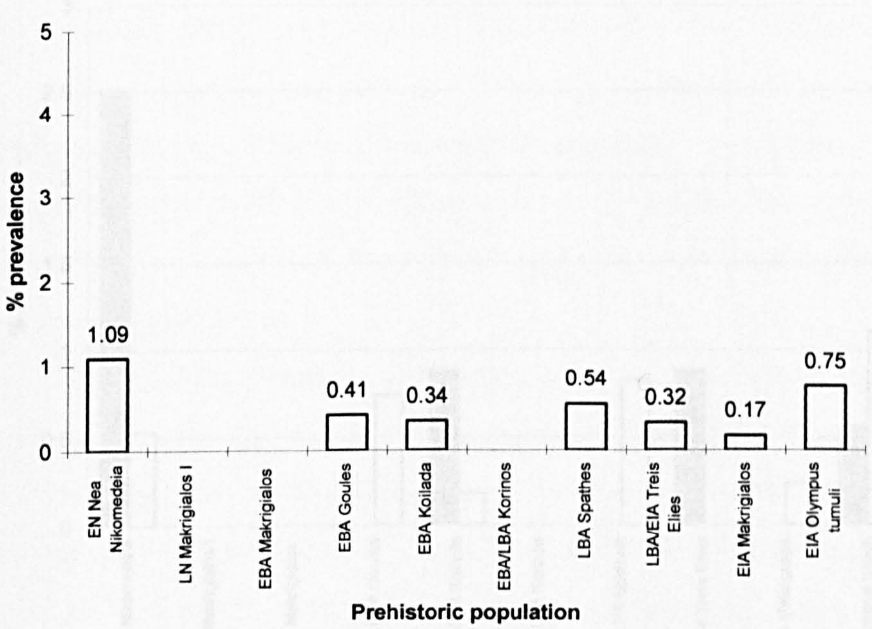
6.4.2.1. OVERALL PREVALENCE OF TRAUMA

Figure 6.14 and Table 6.5 show the low overall prevalence of trauma in the case study cemetery populations (differences between sites are statistically significant, chi square test: $x^2 = 137.987 > p = 27.877$, at the 0.001 level of significance). The figure combines trauma in the appendicular skeleton and the vertebral column and thorax. Only four of the ten skeletal populations (EN Nea Nikomedeia, EBA Koilada, EIA Makrigialos and the EIA Olympus tumuli) have evidence of vertebral and thoracic traumatic lesions as evidenced by compressed vertebrae and healed rib fractures respectively. The highest frequency of trauma has been recorded in EN Nea Nikomedeia, while the late populations tend to have low fracture rates. The LN Makrigialos I, EBA Makrigialos and EBA/LBA Korinos skeletal assemblages have not produced any evidence of traumatic lesions.

Population	% (NIA NIO)
EN Nea Nikomedeia	1.07 5/466
LN Makrigialos I	0.00 0/448
EBA Makrigialos	0.00 0/106
EBA Goules	0.34 1/290
EBA Koilada	0.42 8/1882
EBA/LBA Korinos	0.00 0/144
LBA Spathes	0.54 2/368
LBA/EIA Treis Elies	0.50 2/397
EIA Makrigialos	0.14 1/700
EIA Olympus tumuli	0.66 3/451

Table 6.5: Overall prevalence of trauma in the case study populations (raw data)

Figure 6.14: Prevalence of trauma in the case study populations (standardised rates)

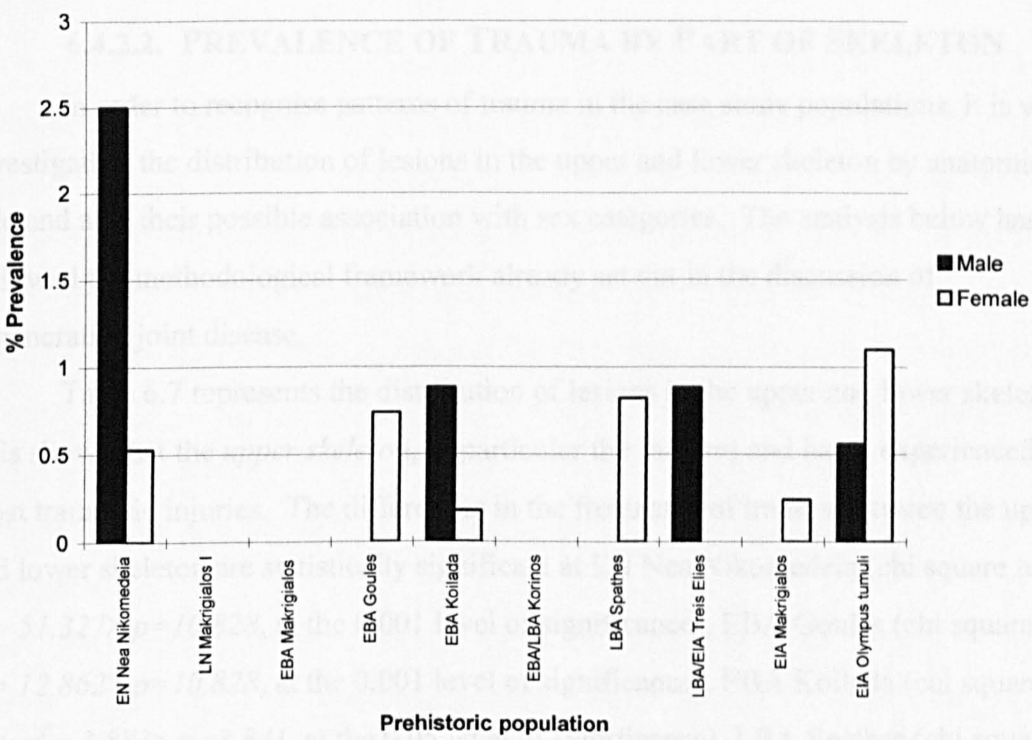


Due to the potential lag between the time when the trauma occurred and the death of the individual affected, the value of the distribution of trauma by age group (Table 6.6) focuses on one significant parameter; the occurrence of traumatic lesions in *juvenility* and *young adulthood*. In particular, the early skeletal assemblages of EN Nea Nikomedeia and EBA Koilada have evidence of early involvement of juveniles and young adults in trauma. Additionally, there is good evidence from LBA/EIA Treis Elies and the EIA Olympus tumuli of adult individuals with fractures occurring in childhood:

Population	Neonate % (NIA/NI0)	Infant % (NIA/NI0)	Child % (NIA/NI0)	Juvenile % (NIA/ NI0)	YA % (NIA/NI0)	PA % (NIA/NI0)	MA % (NIA/NI0)	OA % (NIA/NI0)
EN Nea Nikomedeia	0.00 (0/74)	0.00 (0/58)	0.00 (0/15)	0.00 (0/28)	2.17 (1/46)	2.10 (4/190)	0.00 (0/50)	0.00 (0/5)
LN Makrigialos I	*Undefined*	0.00 (0/2)	0.00 (0/16)	0.00 (0/16)	0.00 (0/59)	0.00 (0/7)	*Undefined*	*Undefined*
EBA Makrigialos	*Undefined*	0.00 (0/13)	0.00 (0/5)	*Undefined*	0.00 (0/29)	*Undefined*	*Undefined*	*Undefined*
EBA Goules	*Undefined*	*Undefined*	0.00 (0/7)	0.00 (0/38)	0.00 (0/67)	1.78 (1/56)	0.00 (0/32)	*Undefined*
EBA Koilada	0.00 (0/9)	0.00 (0/244)	0.00 (0/171)	0.53 (1/186)	0.00 (0/372)	0.80 (4/496)	0.00 (0/242)	0.00 (0/37)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/39)	*Undefined*	0.00 (0/31)	0.00 (0/10)	*Undefined*	0.00 (0/22)
LBA Spathes	*Undefined*	0.00 (0/17)	0.00 (0/8)	0.00 (0/27)	0.64 (1/156)	0.00 (0/69)	3.70 (1/27)	0.00 (0/23)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/10)	0.00 (0/17)	0.00 (0/198)	*Undefined*	2.19 (2/91)	*Undefined*
EIA Makrigialos	*Undefined*	0.00 (0/22)	0.00 (0/29)	0.00 (0/72)	0.00 (0/276)	0.00 (0/147)	1.75 (1/57)	0.00 (0/23)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/14)	0.00 (0/19)	0.68 (1/145)	0.71 (1/139)	4.57 (1/28)	*Undefined*

Table 6.6: Prevalence of trauma by age group (crude rates)

Figure 6.15: Prevalence of trauma by sex group (crude rates)



the fracture line developed along the epiphyseal line of the bone, suggesting injury in childhood when bone development was taking place.

Whereas, in early populations, the highest prevalence of trauma occurs in juveniles and young adults, in the late populations the peak prevalence of trauma is in mature adulthood. During the Late Bronze and Early Iron Age, therefore, it is possible that the occurrence of an accidental injury did not affect the survivorship of the individual, whereas the reverse was true in the Neolithic and Early Bronze Age cemetery populations. These differences in the distribution of trauma among age groups are not, however, statistically significant.

The distribution of trauma by sex group (Figure 6.15) does not follow a consistent pattern and the differences in the distribution of lesions between the sexes are not statistically significant. Contrary to the expected conventional model of men suffering more injuries as a result of a heavier workload, women alone had traumatic lesions at EBA Goules, LBA Spathes and EIA Makrigialos, while women also had a higher prevalence of lesions in the EIA Olympus tumuli. Men match the conventional model of high fracture rates in EN Nea Nikomedeia, EBA Koilada and LBA/EIA Treis Elies.

6.4.2.2. PREVALENCE OF TRAUMA BY PART OF SKELETON

In order to recognise patterns of trauma in the case study populations, it is worth investigating the distribution of lesions in the upper and lower skeleton by anatomical side and also their possible association with sex categories. The analysis below has followed the methodological framework already set out in the discussion of degenerative joint disease.

Table 6.7 represents the distribution of lesions in the upper and lower skeleton. This shows that the *upper skeleton*, in particular the forearm and hand, experienced most traumatic injuries. The differences in the frequency of trauma between the upper and lower skeleton are statistically significant at EN Nea Nikomedeia (chi square test: $x^2 = 51.327 > p = 10.828$, at the 0.001 level of significance), EBA Goules (chi square test: $x^2 = 12.862 > p = 10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2 = 3.883 > p = 3.841$, at the 0.05 level of significance), LBA Spathes (chi square test: $x^2 = 22.662 > p = 10.828$, at the 0.001 level of significance), LBA/EIA Treis Elies (chi square test: $x^2 = 9.732 > p = 7.879$, at the 0.005 level of significance), EIA

Population	Upper *% Crude/Stnd (NIA/NIO)*	Lower *% Crude/Stnd (NIA/NIO)*
EN Nea Nikomedeia	0.35/0.23 (1/281)	1.62/2.68 (3/185)
LN Makrigialos I	0.00/0.00 (0/269)	0.00/0.00 (0/179)
EBA Makrigialos	0.00/0.00 (0/59)	0.00/0.00 (0/45)
EBA Goules	0.55/0.63 (1/180)	0.00/0.00 (0/110)
EBA Koilada	0.40/0.35 (4/999)	0.45/0.73 (4/883)
EBA/LBA Korinos	0.00/0.00 (0/86)	0.00/0.00 (0/58)
LBA Spathes	1.03/1.01 (2/193)	0.00/0.00 (0/175)
LBA/EIA Treis Elies	0.93/0.60 (2/215)	0.00/0.00 (0/182)
EIA Makrigialos	0.24/0.28 (1/405)	0.00/0.00 (0/295)
EIA Olympus tumuli	1.25/1.45 (3/239)	0.00/0.00 (0/212)

Table 6.7: Prevalence of trauma in the upper and lower skeleton (crude and standardised rates)

Makrigialos (chi square test: $x^2 = 6.359 > p = 5.023$, at the 0.025 level of significance) and the EIA Olympus tumuli (chi square test: $x^2 = 30.939 > p = 10.828$, at the 0.001 level of significance). The lower skeleton incurred trauma in only two cemetery populations, that is EN Nea Nikomedeia and EBA Koilada.

With regard to the side affected in the upper skeleton (Figure 6.16), there is a predominance of traumatic injuries on the *left appendicular skeleton* in all the cemetery populations except the EIA Olympus tumuli. The differences in the distribution of trauma by side are statistically significant at EN Nea Nikomedeia (chi square test: $x^2 = 5.042 > p = 5.023$, at the 0.025 level of significance for the upper skeleton and $x^2 = 6.973 > p = 6.634$, at the 0.010 level of significance for the upper skeleton), EBA Goules (chi square test: $x^2 = 17.330 > p = 10.828$, at the 0.001 level of significance), LBA Spathes (chi square test: $x^2 = 30.763 > p = 10.828$, at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: $x^2 = 31.528 > p = 10.828$, at the 0.001 level of significance).

Furthermore, the distribution of trauma by sex groups in the upper and lower skeleton (Figure 6.17) has produced a notable pattern. Women experienced traumatic injuries mostly to the upper appendicular skeleton, whereas, men are most affected on the lower appendicular skeleton. Assuming that the recorded fractures reflect injuries

Figure 6.16: Prevalence of trauma by side in the upper and lower skeleton (standardised rates)

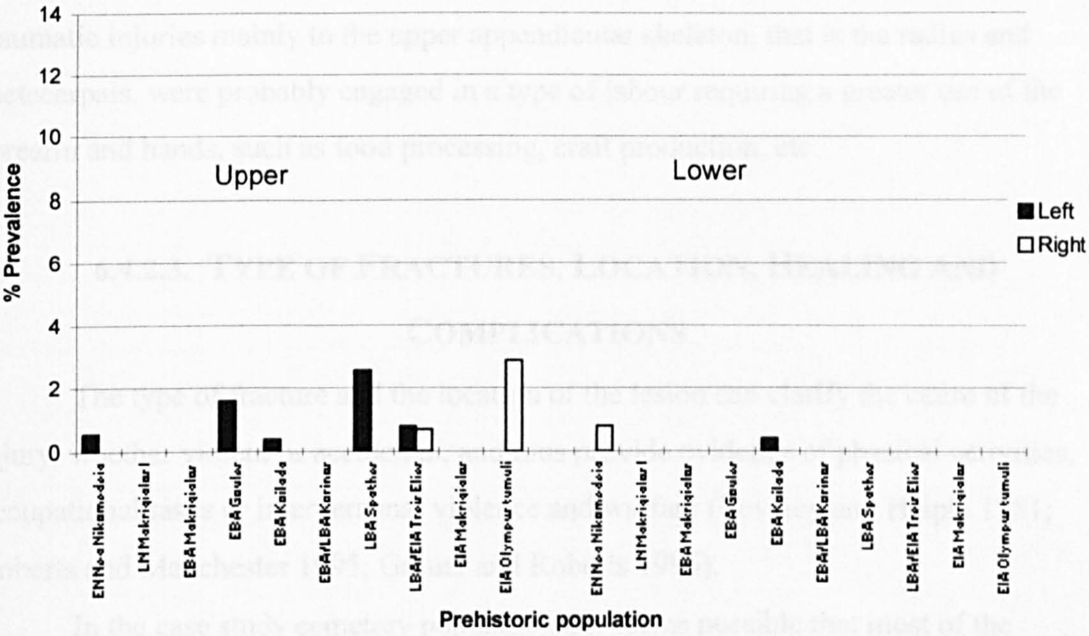
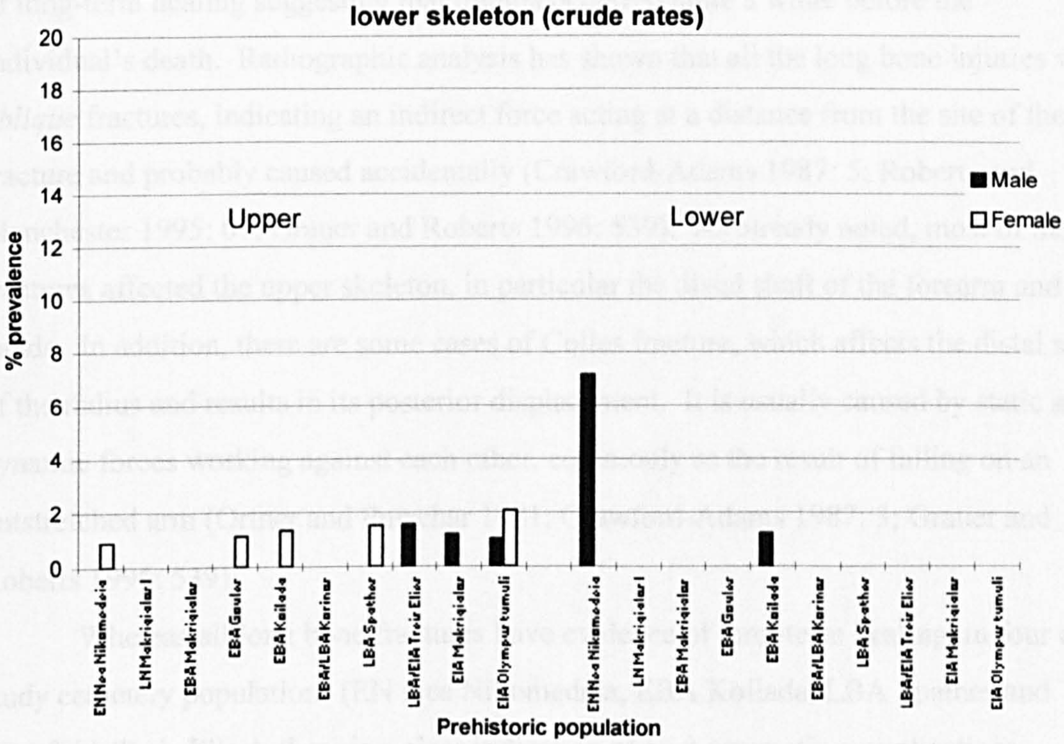


Figure 6.17: Prevalence of trauma by sex group in the upper and lower skeleton (crude rates)



and accidents related to heavy workload and occupational tasks, the occurrence of traumatic lesions of the lower skeleton, that is of the foot, tibia and fibula, may suggest activities such as walking long distances and farming. *Women*, who experienced traumatic injuries mainly to the upper appendicular skeleton, that is the radius and metacarpals, were probably engaged in a type of labour requiring a greater use of the forearm and hands, such as food processing, craft production, etc.

6.4.2.3. TYPE OF FRACTURES, LOCATION, HEALING AND COMPLICATIONS

The type of fracture and the location of the lesion can clarify the cause of the injury, whether violent or accidental, and thus provide evidence of physical activities, occupational tasks or interpersonal violence and warfare (Lovejoy and Heiple 1981; Roberts and Manchester 1995; Grauer and Roberts 1996).

In the case study cemetery populations, it seems possible that most of the fractures resulted from accidental injuries without any evidence of interpersonal violence or warfare. Furthermore, all long bone fractures recorded have clear evidence of long-term healing suggesting that trauma occurred quite a while before the individual's death. Radiographic analysis has shown that all the long bone injuries were *oblique* fractures, indicating an indirect force acting at a distance from the site of the fracture and probably caused accidentally (Crawford-Adams 1987: 5; Roberts and Manchester 1995: 69; Grauer and Roberts 1996: 539). As already noted, most of the fractures affected the upper skeleton, in particular the distal shaft of the forearm and hands. In addition, there are some cases of Colles fracture, which affects the distal shaft of the radius and results in its posterior displacement. It is usually caused by static and dynamic forces working against each other, commonly as the result of falling on an outstretched arm (Ortner and Putschar 1981; Crawford-Adams 1987: 3; Grauer and Roberts 1996: 539).

Whereas all long bone fractures have evidence of long-term healing, in four case study cemetery populations (EN Nea Nikomedeia, EBA Koilada, LBA Spathes and LBA/EIA Treis Elies), there is a clear indication of post-traumatic complications ranging from slight arthritic changes to moderate deformity of the affected site and the development of periosteal reaction on the bone (Table 6.8, Figure 6.18).

EN NEA NIKOMEDEIA				
Bone	Arthritic changes	Periosteal reaction	Malalignment	Shortening
L. radius	+			
R. third metatarsal	+			

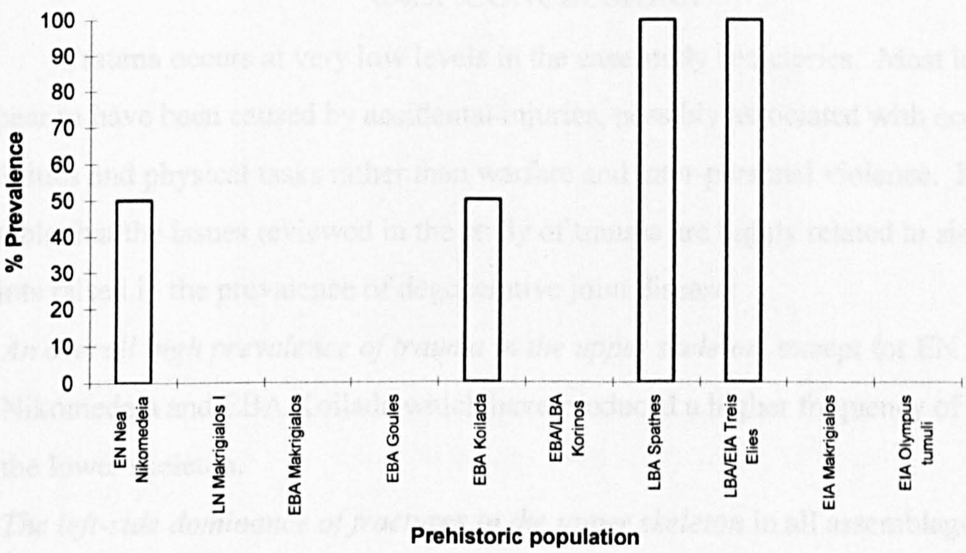
EBA KOILADA				
Bone	Arthritic changes	Periosteal reaction	Malalignment	Shortening
L. tibia			+	+
L. fibula			+	+
L. radius	+		+	
L. second metatarsal		+	+	

LBA SPATHES				
Bone	Arthritic changes	Periosteal reaction	Malalignment	Shortening
L. radius		+	+	+
L. radius	+		+	

LBA/EIA TREIS ELIES				
Bone	Arthritic changes	Periosteal reaction	Malalignment	Shortening
L. radius	+		+	
R. radius	+		+	

Table 6.8: Complications of traumatic lesions in the case study populations

Figure 6.18: Prevalence of bones developing post-traumatic complications



Arthritic changes (Figures 6.19, 6.20 and 6.21) are the commonest condition following traumatic injuries, due to the lack of immobilisation of the affected bone during the healing period and thus the poor movement of the adjacent joints. Also, *malalignment* of the affected bone is often recorded as result of bad reduction and failure to set the fractured bone ends in the right anatomical position (Figure 6.22). In severe conditions, *malalignment* resulted in shortening of the affected limb or long term fusion and bone overlap of the fractured bone ends. The occurrence of bone apposition and consequent shortening of the limb suggests a long-term condition and is possibly associated with a deficiency in significant functions such as the mobility of the affected limbs (Crawford-Adams 1987). Localised *periosteal reaction* comprised a less frequent post-traumatic complication, implying a disruption of soft tissues and contact of the exposed trauma with the external environment (compound fracture) (Merbs 1989: 162).

The evidence of deformity and malalignment in fracture healing, together with the development of other complications, suggests that the treatment of some fractures was not attempted or had failed (Figure 6.13). In particular, immobilisation, which is necessary in the treatment of long bone fractures, especially in bony parts highly involved in skeleto-muscular movements, seems not to have been practised (Crawford-Adams 1987: 33).

6.4.3. CONCLUSIONS

Trauma occurs at very low levels in the case study cemeteries. Most lesions appear to have been caused by accidental injuries, possibly associated with occupational activities and physical tasks rather than warfare and inter-personal violence. It is notable that the issues reviewed in the study of trauma are highly related to similar points raised in the prevalence of degenerative joint disease:

A. *An overall high prevalence of trauma in the upper skeleton*, except for EN Nea Nikomedeia and EBA Koilada which have produced a higher frequency of injuries in the lower skeleton.

B. *The left-side dominance of fractures in the upper skeleton* in all assemblages, except for the EIA Olympus tumuli.

C. *The early occurrence of trauma* in EN Nea Nikomedeia, EBA Koilada and possibly LBA/EIA Treis Elies and the EIA Olympus tumuli, where trauma is associated with juvenile and young adult age categories.

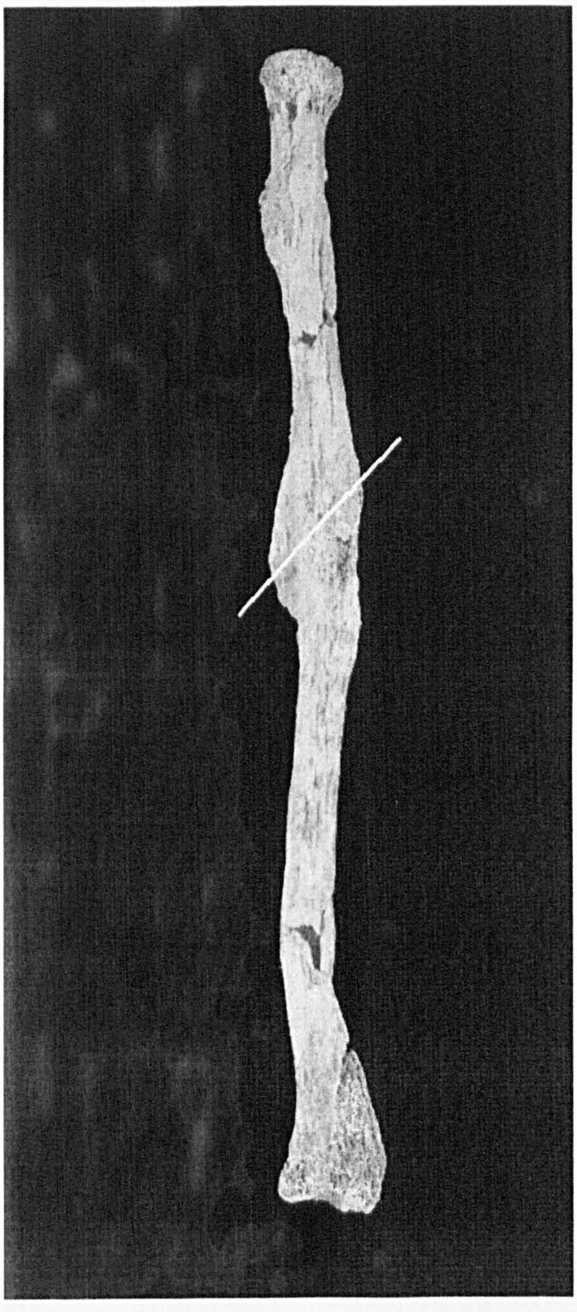


Figure 6.19: Long-term healed oblique fracture on the midshaft of right radius accompanied by malalignment of the affected bone ends (Spathes 14b)

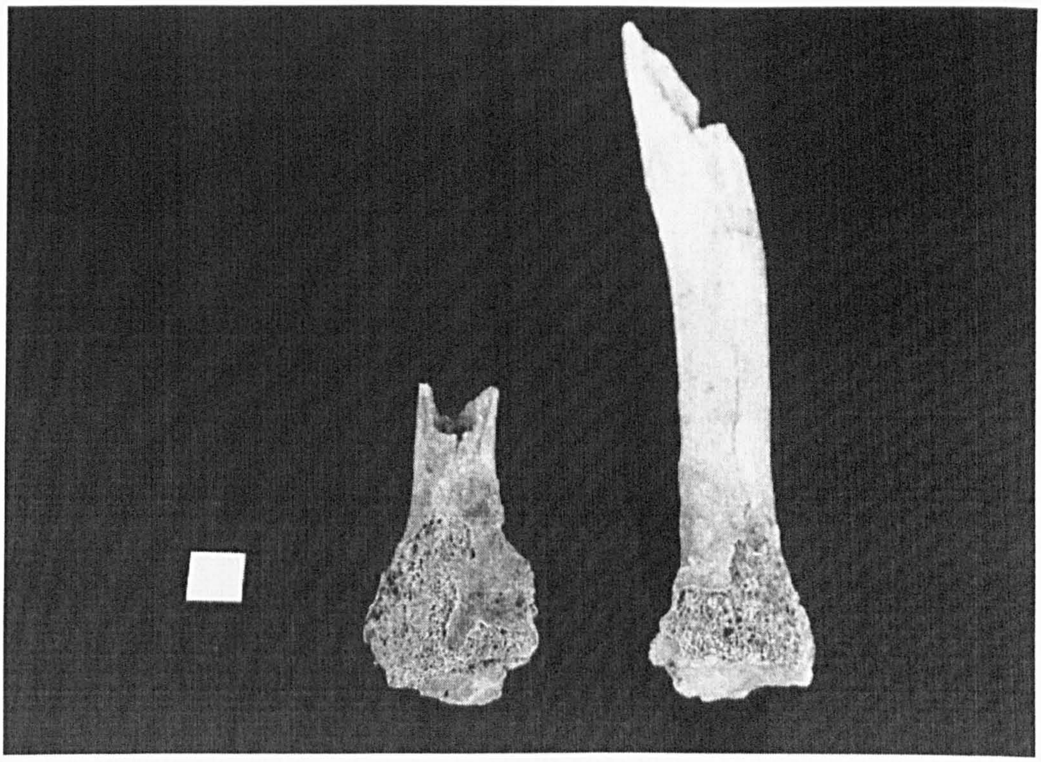


Figure 6.20: Long-term healed fracture on both sides distal radii (Treis Elies 7)

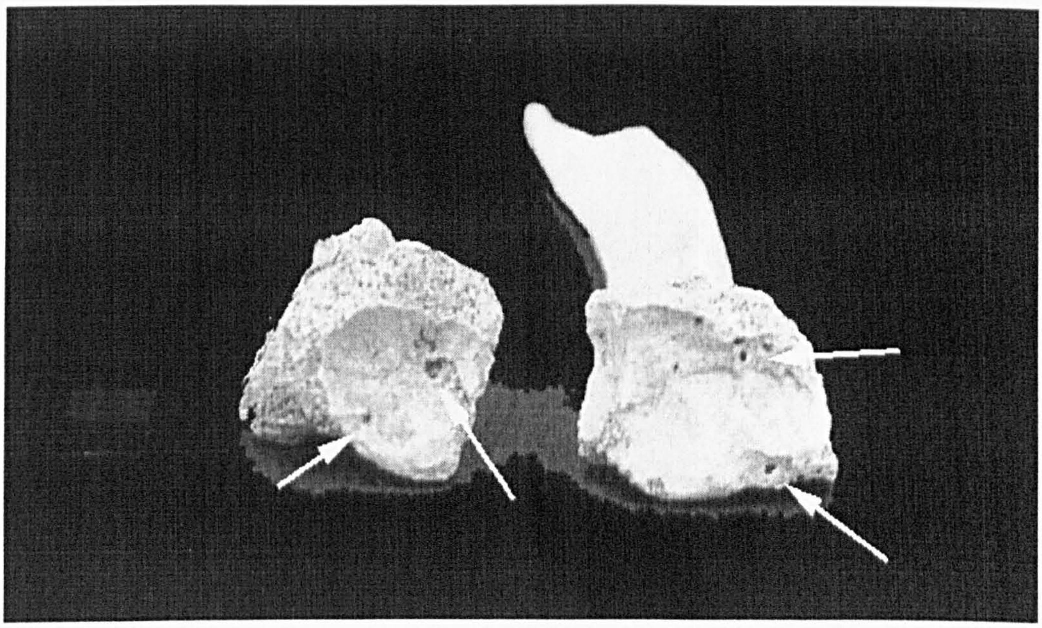


Figure 6.21: Severe degenerative joint disease with evidence of arthritic cysts on the inferior surface of both sides distal radii (Treis Elies 7)

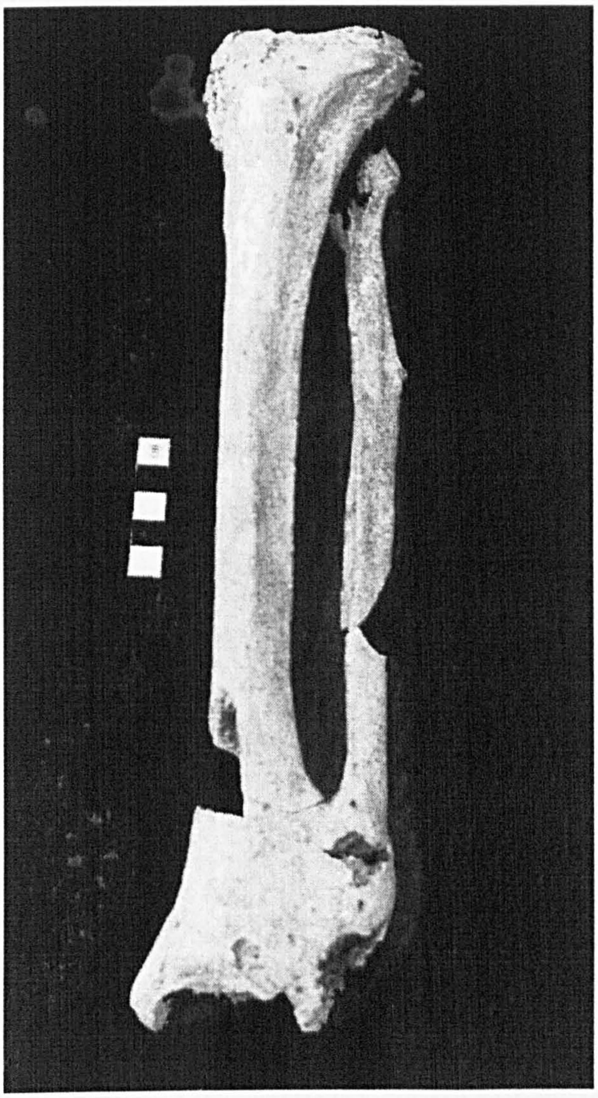


Figure 6.22: Long-term healed fracture on the left distal lower leg causing malalignment and overlapping of the affected bone ends (Koilada 106)

D. *Sexual division of labour.*

a. *Differentiation* in the distribution of trauma by sex groups, with women suffering most injuries in EBA Goules, LBA Spathes, EIA Makrigialos and the EIA Olympus tumuli. Fracture ratios from other prehistoric populations in Greece and Turkey have conversely, shown a greater prevalence of trauma in males (Angel 1974). This is the case also for the majority of archaeological populations (Merbs 1989; Grauer and Roberts 1996) and has been linked with the type of physical and occupational activities engaged in by each sex.

b. *Differentiation* in the distribution of trauma in the upper and lower skeleton. Only men have fractures affecting the lower limb in EN Nea Nikomedeia and EBA Koilada.

6.4.4. DENTAL TRAUMA

Dental trauma may result from an accidental injury, often involving the attached alveolar process and/or adjacent craniofacial bones, or an intentional ritual or cultural activity, such as ritual ablation of teeth. Furthermore, unintentional trauma can be the result of habitual activities performed incorrectly or occurring on a regular basis, such as the use of teeth as tools (Turner and Cadien 1969; Ubelaker et al. 1969; Molnar 1972; Schulz 1977; y'Edynak 1978; Larsen 1985; Irish and Turner 1987; Formicola 1988; Lukacs and Pastor 1988; Cruwys 1989; Lukacs and Hemphill 1990). Dental trauma has often been underestimated since most standard reference books in human osteology and palaeopathology either do not include that condition in their recording methods or draw much attention to culturally related changes such as artificial modifications (Lukacs and Hemphill 1990: 352).

The current discussion focuses on six individuals providing evidence of possible dental trauma from the EBA Koilada cemetery population. The condition has been manifested as grooving on tooth approximal surfaces, particularly the lingual surfaces, on either the maxillary or the mandibular dentition. Most of the cases refer to the anterior teeth (incisors and canines), but two individuals have either a shallow groove on the lingual surface of the second mandibular *premolar* or an interproximal distal groove on the second maxillary *molar*.

Of the six individuals exhibiting dental trauma, two women (Figures 6.23 and 6.24) have produced a distinctive pattern worth investigating. In particular, they display

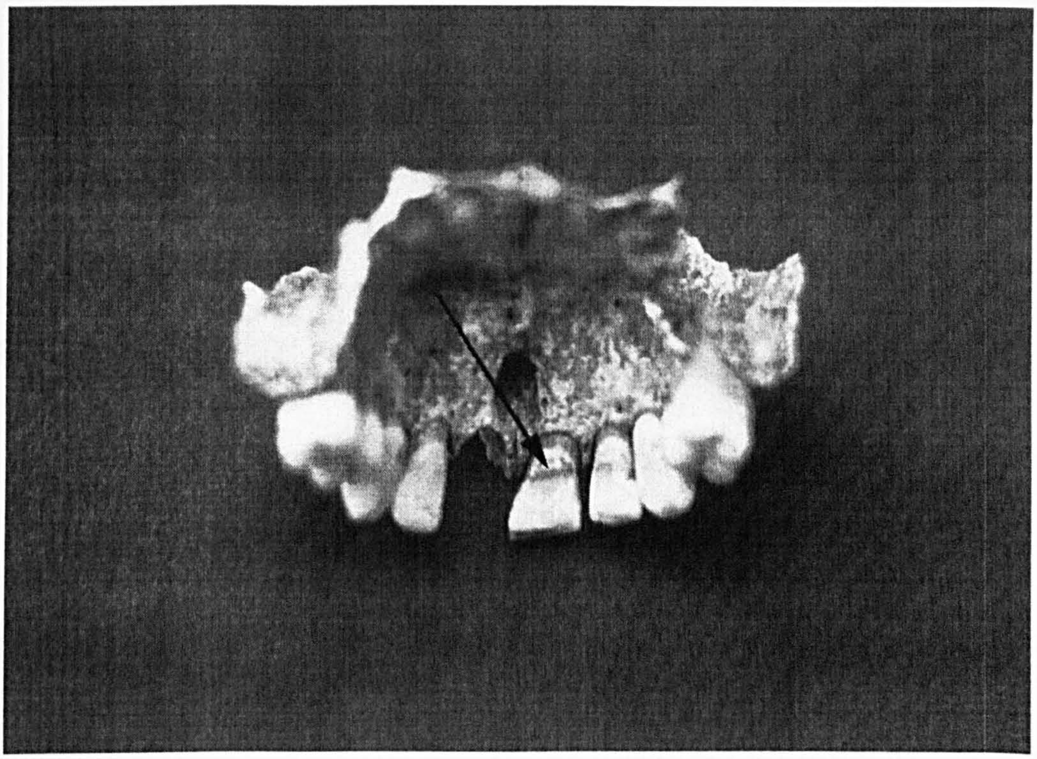


Figure 23: Dental trauma showing shallow groove on the anterior maxillary teeth (Koilada Lith39)

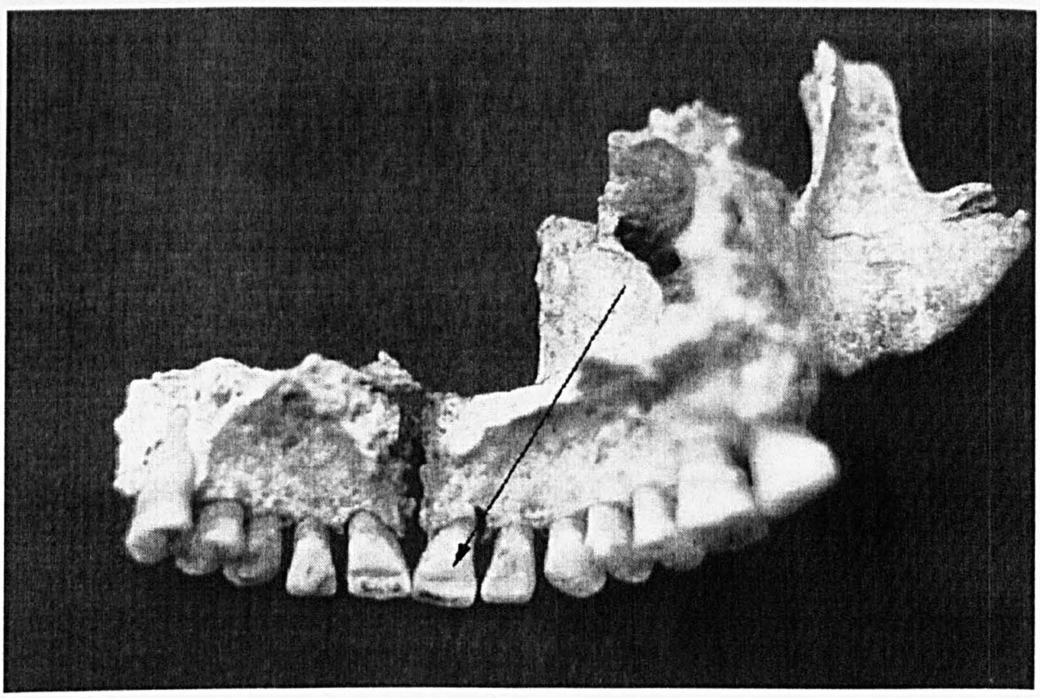


Figure 6.24: Dental trauma showing shallow groove on the anterior maxillary teeth (Koilada Lith2)

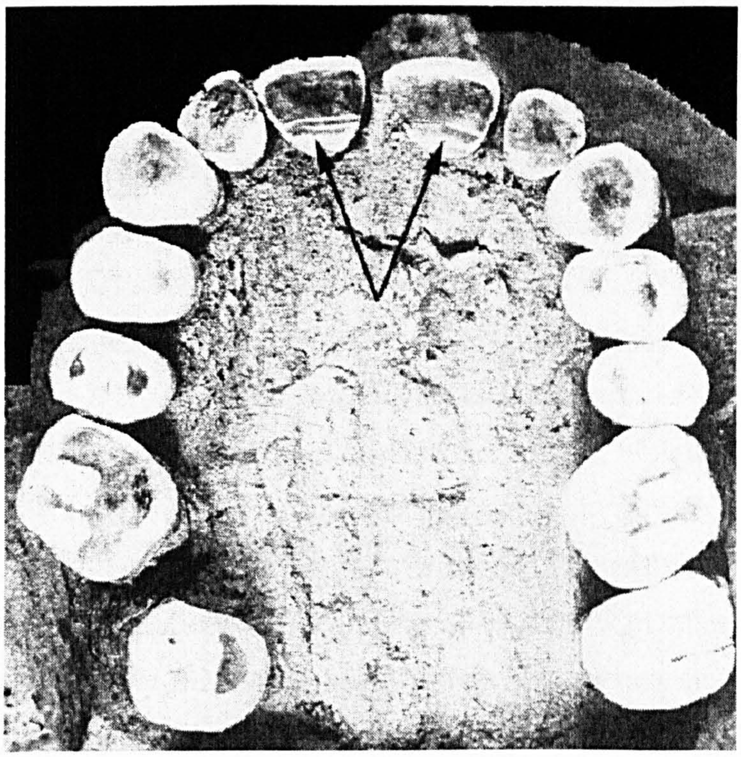


Figure 6.25: Shallow groove on anterior maxillary teeth (Lukacs and Pastor 1988: Figure 12)

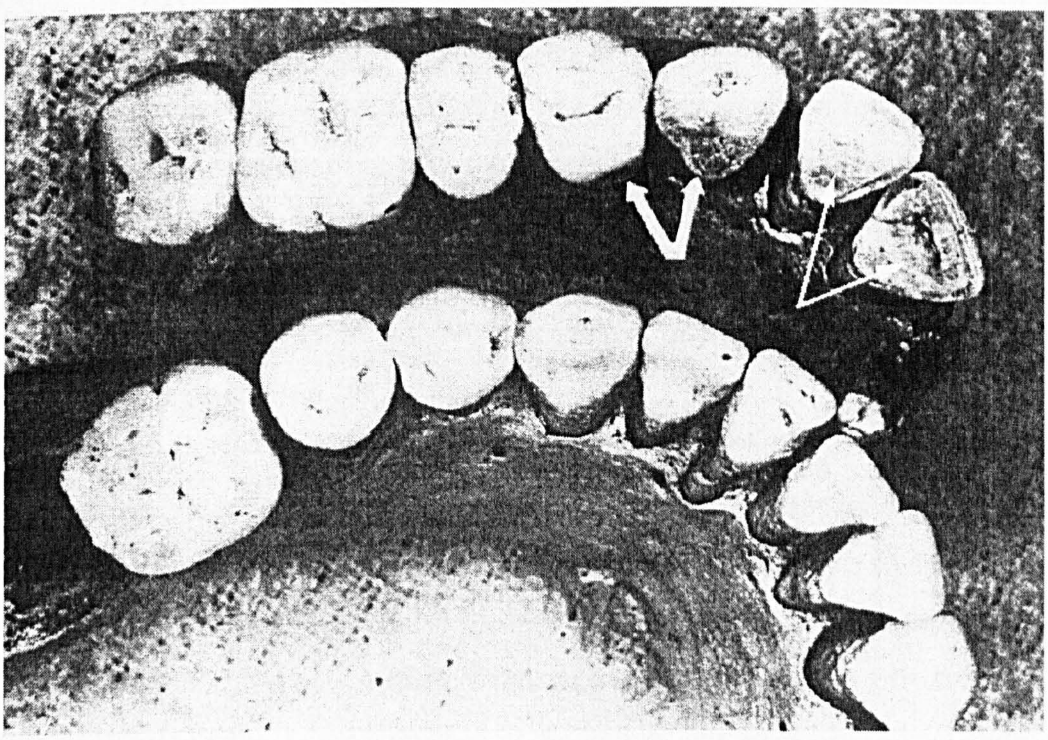


Figure 6.26: Shallow groove on anterior maxillary teeth (Irish and Turner 1987: Figure 1)

linear grooving very strictly located on the lingual surface of the right and left maxillary incisors, just above the cervical area of the teeth, but there is no corresponding wear facet or groove on the mandibular teeth.

A similar pattern of mesio-distal grooves manifested solely on the lingual face of maxillary central incisors has been reported in Lukacs and Pastor's specimen MR 3.162A from prehistoric Pakistan (Lukacs and Pastor 1988: 393, 396: Figure 12) (Figure 6.25) and Irish and Turner's work in prehistoric Panama (Irish and Turner 1987: 210, 211: Figure 1) (Figure 6.26). Evidence of grooving on tooth surfaces has been documented elsewhere especially in New World skeletal series, of Arikara Indians (Berryman et al. 1979), of prehistoric California Indians (Schultz 1977), of American Indians (Ubelaker et al. 1969), and of Eskimo (Turner and Cadien 1969).

The aetiology of the condition is complicated by the lack of ethnographic or historical information on the habitual or dietary activities of the case study populations. A large number of alternative interpretations have been proposed for similar patterns worldwide, depending on the cultural and historical background of the associated population. With regard to *interproximal grooving*, hypotheses range from the use of a probe to eliminate carious lesions (Berryman et al. 1979) to removal of food impacted in the interdental spaces (Ubelaker et al. 1969). For *all types of dental grooving*, interpretations include the use of teeth as tools for habitual or occupational activities. The latter may involve stripping leather thongs, reeds or other plant fibres for the production of a variety of utilitarian objects, such as baskets, or the preparation of vegetable fibres for cordage (Schulz 1977) or holding or pulling fibre, sinew or animal skin between the teeth (Larsen 1985).

With regard to the EBA Koilada dentitions, the close similarity of specimen MR 3.162A of prehistoric Mehrgarh in Pakistan (Lukacs and Pastor 1988) and the dentitions in prehistoric Panama (Irish and Turner 1987) to the two distinctive case study examples (Figure 6.23 and 6.24) may contribute to the interpretation of the latter. According to the first investigators, "the anterior teeth of this individual function more effectively as a clamping device while the material grasped in the teeth of this specimen did not slide through the teeth but was firmly held in place by them" (Lukacs and Pastor 1988: 396). The occupation proposed to demand such firm and forceful stress in prehistoric Pakistan is pulling or holding animal skin between the teeth for softening it. In prehistoric Panama, the recorded maxillary grooving has been associated with the preparation and consumption of grit-covered starchy tubers like manioc; although other causes relating to occupation cannot be ruled out (Irish and Turner 1987: 212).

It should be pointed out here that malocclusion and any other anatomical abnormality have been excluded in all the above cases. Interpretations for prehistoric Pakistan or Panama cannot be applied directly to EBA Koilada, since abrasion patterns can be highly affected by environmental, dietary, cultural and occupational habits which are unknown in the case study prehistoric populations. Microscopic examination will certainly provide further information regarding non-dietary or occupational uses of teeth.

The occurrence of *lingual grooving on maxillary teeth* in only two out of thirty-four women in EBA Koilada is of particular interest. Ethnographic and archaeological studies have linked distinctive dental abrasion patterns with different task and occupational activities characteristic of each sex category (Molnar 1972; Larsen 1985; Irish and Turner 1987). If lingual grooving is likewise related to a particular activity, the two women manifesting this in EBA Koilada may be linked to a particular "specialised" occupation or cultural behaviour.

6.5. VERTEBRAL PATHOLOGY (spondylolysis, sacralisation and spina bifida)

6.5.1. INTRODUCTION

The term *vertebral pathology* includes inherited or stress induced conditions, other than arthritic or traumatic, which may affect the spinal column (Buikstra and Ubelaker 1994: 121). Three types of vertebral pathology have been recorded in the case study prehistoric populations: spondylolysis, sacralisation and spina bifida. All the above defects affect the lower vertebral column, particularly the sacrum, except for spondylolysis, which usually involves the lumbar vertebrae (Bridges 1989b).

Spondylolysis is the separation of the vertebral neural arch in the area between the superior and inferior articular processes (Figure 6.27) (Bridges 1989b: 321; Turkel 1989: 120; Roberts and Manchester 1995: 78; Larsen 1997: 190). Spondylolysis has been assumed to be a congenital defect, but, it seems equally possible that a congenital weakness of the bones predisposes to the separation of the neural arch under stressful conditions (Roberts and Manchester 1995: 78). The latter include repeated excessive mechanical load associated with bending and lifting in the upright posture, involving

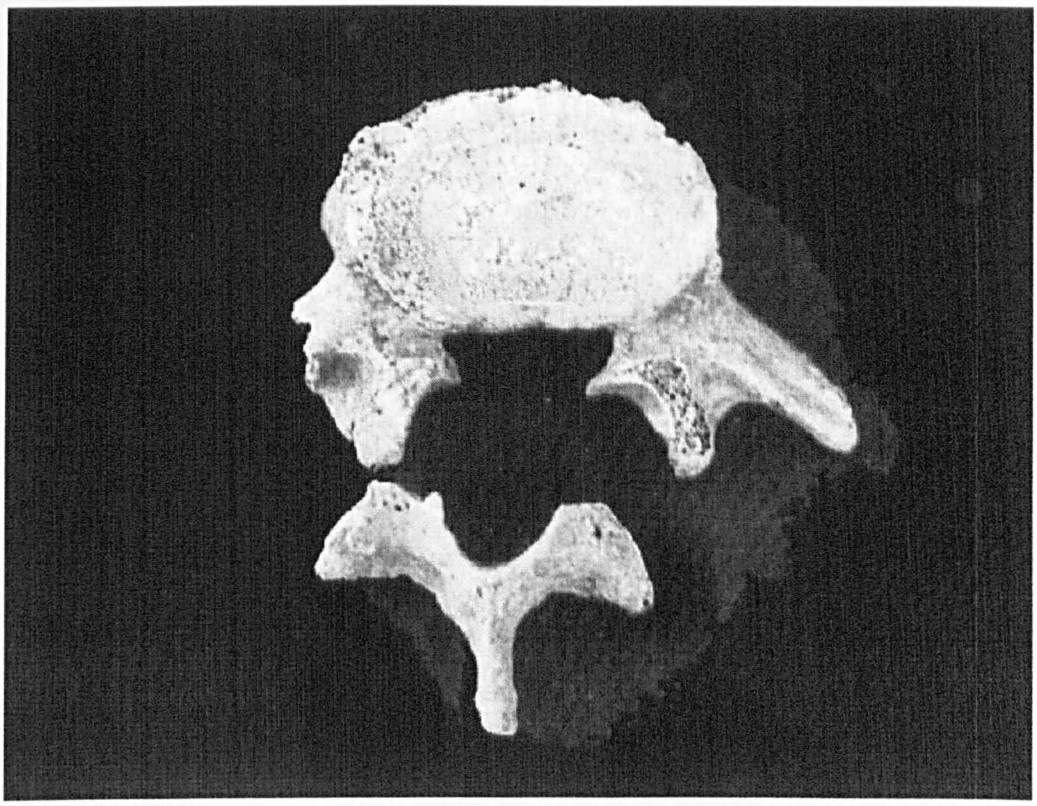


Figure 6.27: Spondylolysis of L5 (Nea Nikomedeia XXI)

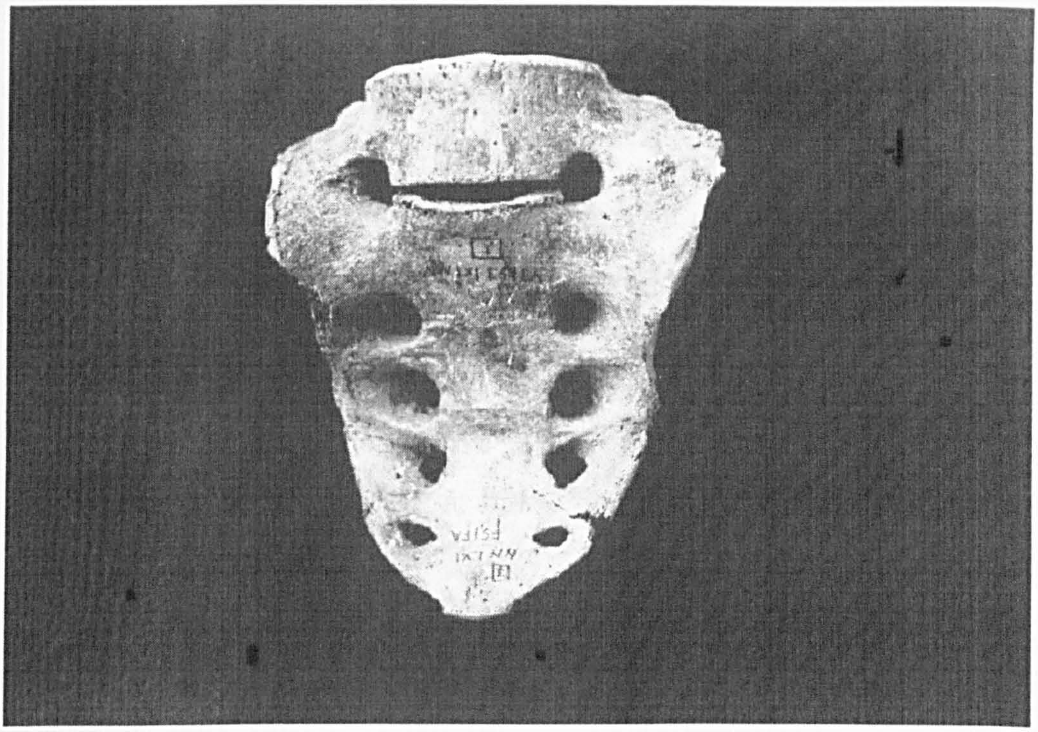


Figure 6.28: Sacralisation of L5 (Nea Nikomedeia I)

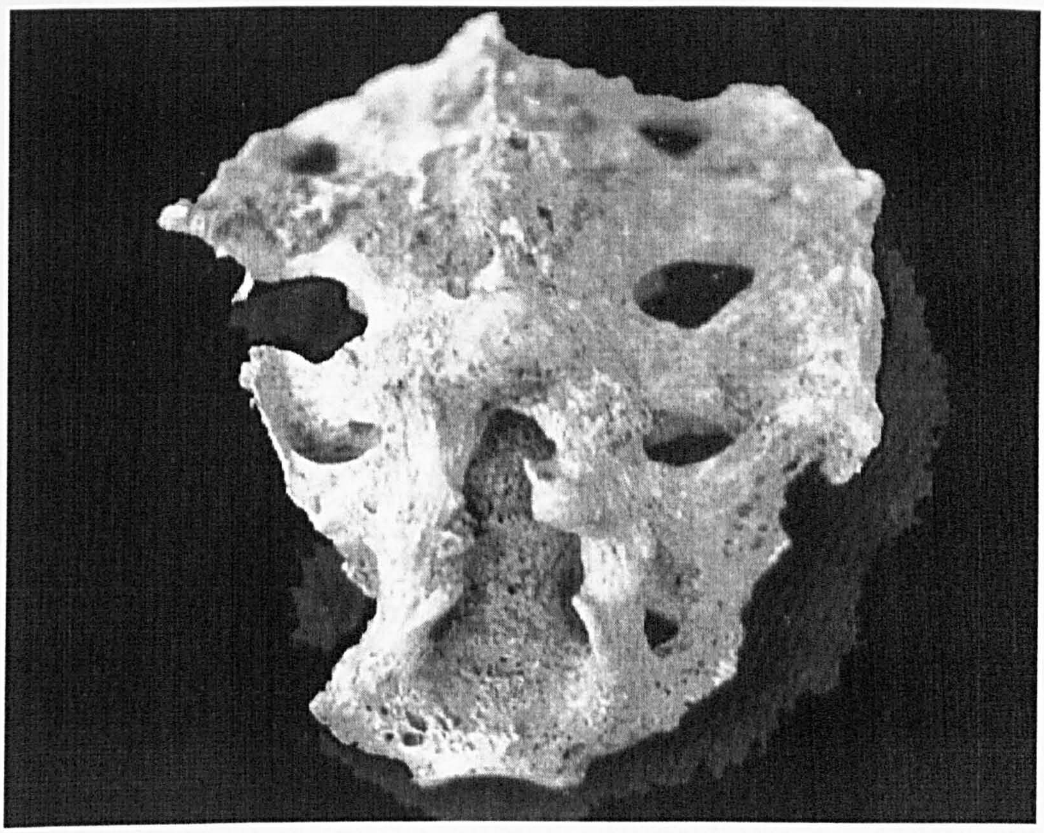


Figure 6.29: Spina Bifida (Nea Nikoemedeia XXI)

thus, hyperflexion and hyperextension of the lower back (Roberts and Manchester 1995: 78; Larsen 1997: 192). Therefore, in modern populations, high levels of the defect have been recorded in labourers involved in mechanically demanding activities along with athletes engaged in specific types of sports such as college football (Bridges 1989b: 326; Larsen 1997: 191). In archaeological populations, the condition has been associated with activity patterns involving heavy mechanical load on the vertebral column (Bridges 1989b).

Sacralisation is the fusion of the fifth lumbar vertebra to the sacrum (Figure 6.28) and is considered a congenital defect (Ortner and Putschar 1981: 355). Similarly, *spina bifida* is a congenital abnormality, which usually affects one or more segments of the sacrum. Specifically, the posterior parts of the sacral segments enclosing the spinal cord are absent so that the spinal canal is exposed, although bridged by cartilage or membrane (Figure 6.29) (Ortner and Putschar 1981: 356; Turkel 1989: 118; Roberts and Manchester 1995: 36).

6.5.2. RESULTS

The overall prevalence of vertebral defects in the case study cemetery populations (Figure 6.30, Table 6.9) is very low, but differences between sites are marked and statistically significant (chi square test: $x^2 = 250.524 > p = 27.877$ at the 0.001 level). Only three out of ten skeletal assemblages, that is EN Nea Nikomedeia, LBA Spathes and the EIA Olympus tumuli, have vertebral abnormalities. The highest frequency of the condition has been revealed in EN Nea Nikomedeia, where in addition, all three defects are in evidence.

The distribution of vertebral abnormalities by sex group (Figure 6.31) is almost evenly balanced between males and females at EN Nea Nikomedeia but is restricted to males in the EIA Olympus tumuli. Although most of the vertebral abnormalities are considered congenitally induced defects, it is possible that they predisposed certain individuals to be susceptible to severe conditions involving the vertebral column (Larsen 1997). The restriction of these abnormalities to only a few individuals in three

Population	% (NIA NIO)
EN Nea Nikomedeia	23.07 6/26
LN Makrigialos I	0.00 0/7
EBA Makrigialos	0.00 0/4
EBA Goules	0.00 0/4
EBA Koilada	0.00 0/73
EBA/LBA Korinos	0.00 0/144
LBA Spathes	5.26 1/19
LBA/EIA Treis Elies	0.00 0/15
EIA Makrigialos	0.00 0/24
EIA Olympus tumuli	9.09 2/22

Table 6.9: Overall prevalence of vertebral abnormalities in the case study populations (raw data)

Figure 6.30: Prevalence of vertebral abnormalities in the case study populations (standardised rates)

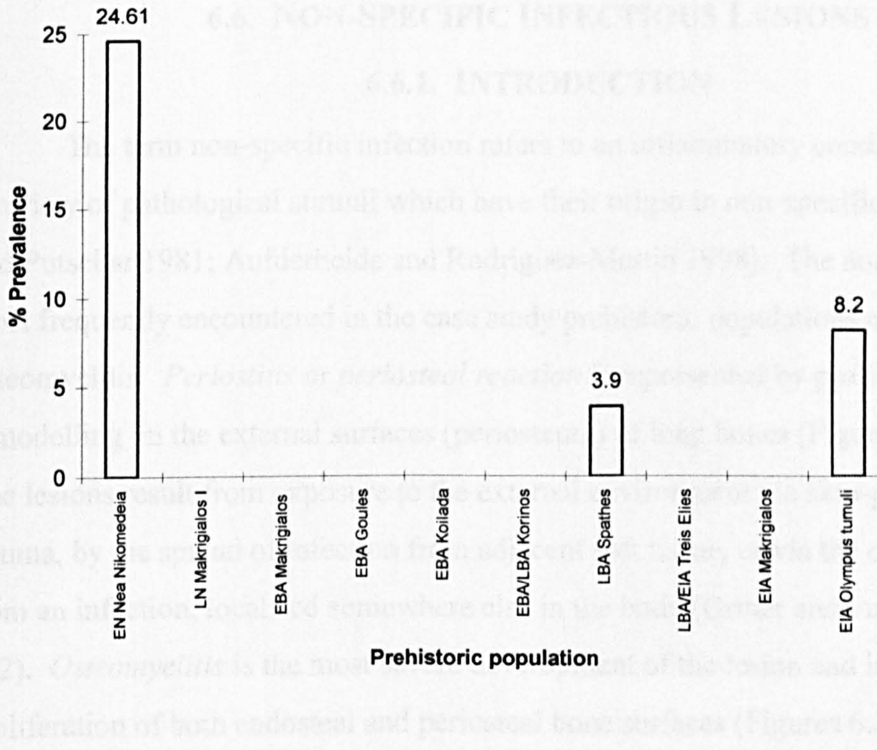
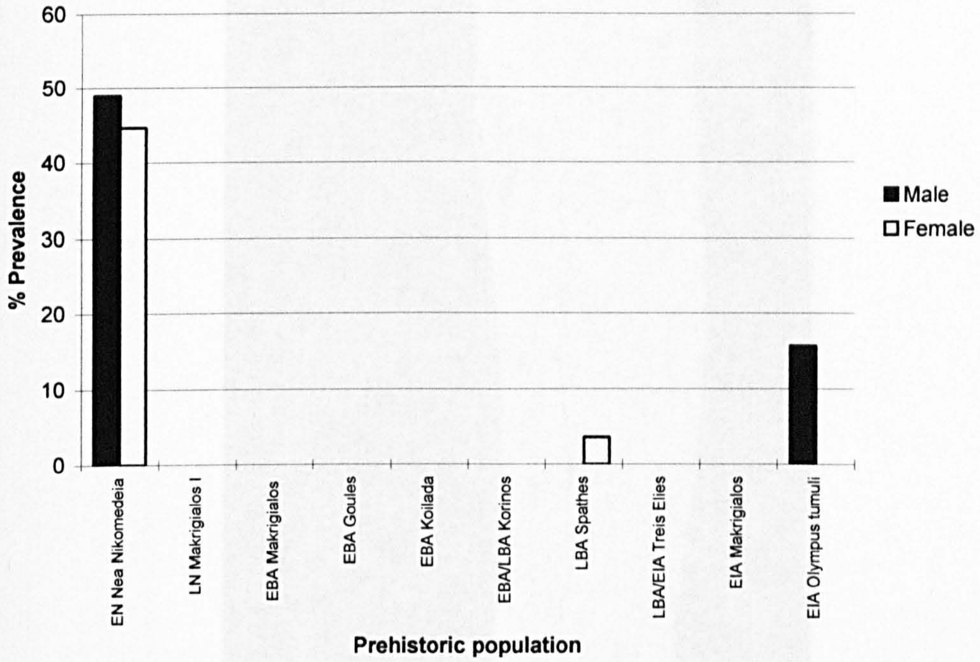


Figure 6.31: Prevalence of vertebral abnormalities by sex group (standardised rates)



cemetery populations may reflect certain occupational activities involving particularly stressful repeated movements for the lower back.

6.6. NON-SPECIFIC INFECTIOUS LESIONS

6.6.1. INTRODUCTION

The term non-specific infection refers to an inflammatory condition produced by a variety of pathological stimuli which have their origin in non-specific bacteria (Ortner and Putschar 1981; Aufderheide and Rodriguez-Martin 1998). The non-specific lesions most frequently encountered in the case study prehistoric populations are periostitis and osteomyelitis. *Periostitis* or *periosteal reaction* is represented by proliferative bone remodelling on the external surfaces (periosteum) of long bones (Figures 6.32 and 6.33). The lesions result from exposure to the external environment via skin-penetrating trauma, by the spread of infection from adjacent soft tissue, or via the circulatory system from an infection, localised somewhere else in the body (Ortner and Putschar 1981: 129, 132). *Osteomyelitis* is the most severe development of the lesion and involves proliferation of both endosteal and periosteal bone surfaces (Figures 6.34 and 6.35)

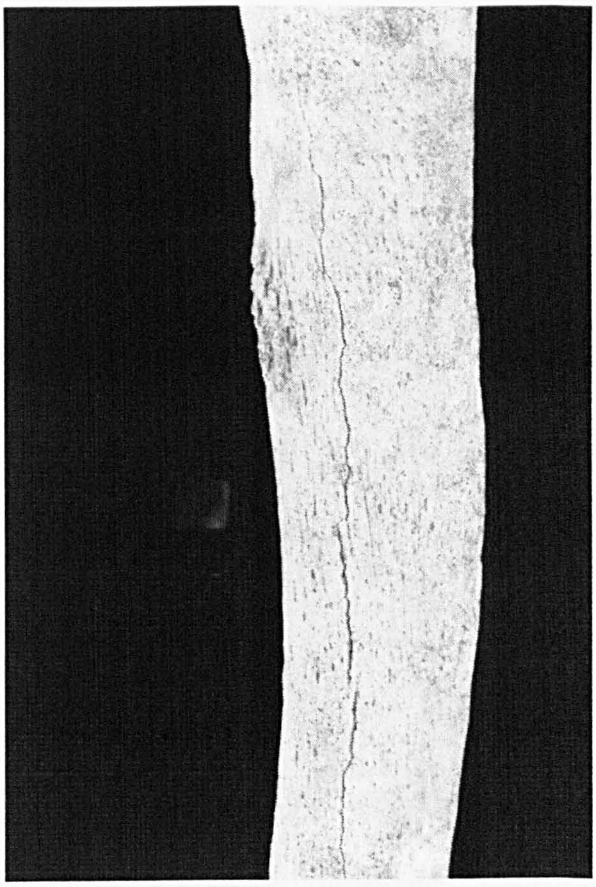


Figure 6.32: Periostitis on the midshaft of left tibia (Spathes 7)

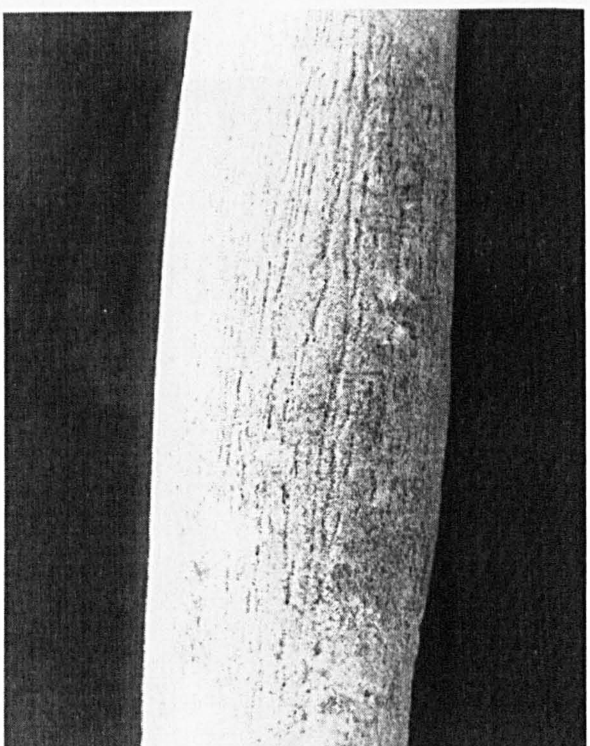


Figure 6.33: Periostitis on on the midshaft of left femur (Makrigialos 19)

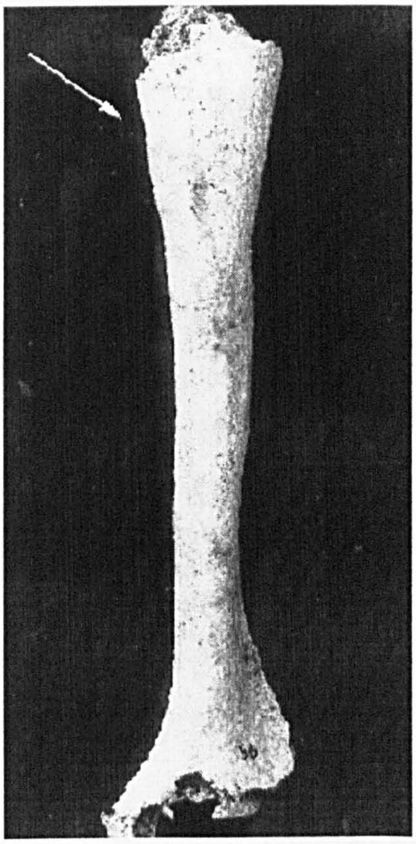


Figure 6.34: Osteomyelitis on the proximal left humerus (Makrigialos 56prim)

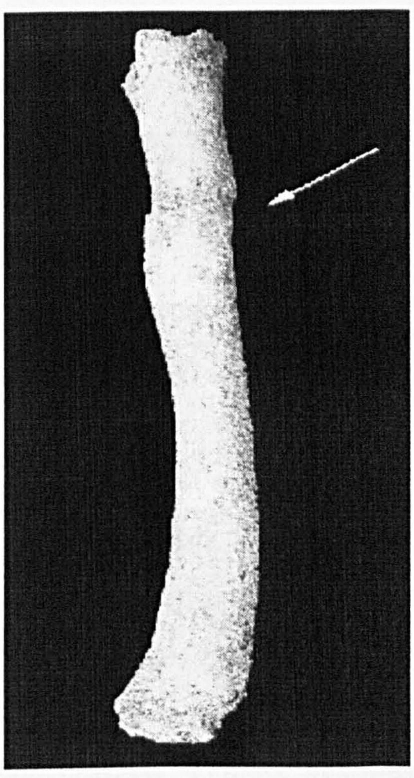


Figure 6.35: Osteomyelitis on the proximal right femur (Makrigialos 260sec)

(Ortner and Putschar 1981: 105). Infection resulting in periostitis is almost never fatal, since it is usually localised to a restricted area of a single bone. Conversely, osteomyelitis, which is a severe version of periosteal reaction, may lead to death if the infection spreads via the circulatory system to vital organs (Larsen 1997: 84).

The occurrence of periosteal reactions and osteomyelitis is quite frequent in archaeological populations. Their prevalence is often associated with increasing population density, sedentary lifestyles and the development of trade networks since the latter encourages the rapid expansion and transmission of bacteria and viruses in populations (Cohen and Armelagos 1984; Cohen 1989; Roberts and Manchester 1995). Factors such as poor diet and sanitation or densely occupied settlements may also lead to an increase of infectious lesions. In particular, a synergy between infection and malnutrition weakens resistance to infectious pathogens which ultimately results in the susceptibility of certain age categories to infectious disease (Mensforth et al. 1978; Lallo and Rose 1979; Goodman and Armelagos 1989).

6.6.2. RESULTS

Overall the prevalence of non-specific infectious lesions is very low (Figure 6.36, Table 6.10). Differences between sites are statistically significant (chi square test: $x^2 = 168.953 > p = 27.877$ at the 0.001 level), but there is no consistent chronological trend from the Neolithic to the Early Iron Age. Three early assemblages, EN Nea Nikomedeia, EBA Makrigialos and EBA Goules, have not produced any evidence of the condition, but the two highest incidences are at LN Makrigialos I and the EIA Olympus tumuli.

The distribution of non-specific lesions by age group (Table 6.11) raises two points:

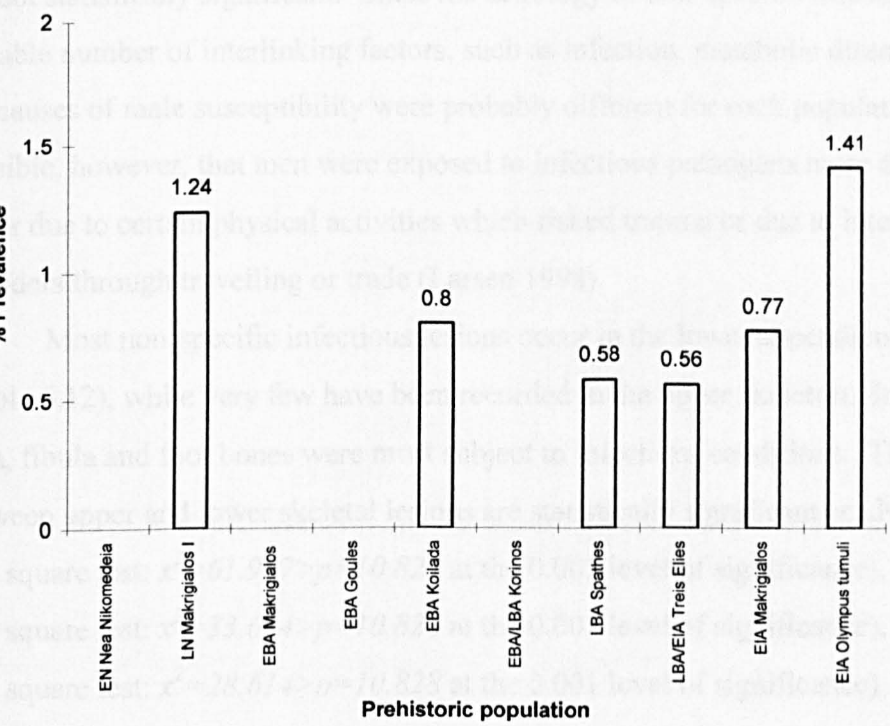
A. Only at EBA Koilada are non-specific infectious lesions recorded among neonates, infants and children. This skeletal assemblage has high rates of neonate and infant mortality (Chapter 4). It is possible, therefore, that non-specific infections early in life contributed to the high mortality rates in these early age categories.

B. Overall, the highest levels of non-specific infectious lesions have been noted in *adult age groups*. How long before an individual's death infection developed cannot be accurately determined, however, so that it is not clear whether the lesions occurred

Population	% (NIA NIO)
EN Nea Nikomedeia	0.00 0/393
LN Makrigialos I	0.53 2/377
EBA Makrigialos	0.00 0/131
EBA Goules	0.00 0/237
EBA Koilada	0.93 15/1604
EBA/LBA Korinos	0.00 0/134
LBA Spathes	0.63 2/315
LBA/EIA Treis Elies	0.88 3/340
EIA Makrigialos	0.82 5/609
EIA Olympus tumuli	1.54 6/389

Table 6.10: Overall prevalence of non-specific infectious lesions in the case study populations (raw data)

Figure 6.36: Prevalence of non-specific infectious lesions in the case study populations (standardised rates)



Population	Neonate % (NIA/NIO)	Infant % (NIA/NIO)	Child % (NIA/NIO)	Juvenile % (NIA/NIO)	YA % (NIA/NIO)	PA % (NIA/ NIO)	MA % (NIA/NIO)	OA % (NIA/NIO)
EN Nea Nikomedeia	0.00 (0/73)	0.00 (0/56)	0.00 (0/12)	0.00 (0/18)	0.00 (0/36)	0.00 (0/153)	0.00 (0/43)	0.00 (0/2)
LN Makrigialos I	*Undefined*	0.00 (0/2)	0.00 (0/13)	0.00 (0/14)	4.08 (2/49)	0.00 (0/6)	*Undefined*	*Undefined*
EBA Makrigialos	*Undefined*	0.00 (0/11)	0.00 (0/5)	*Undefined*	0.00 (0/25)	*Undefined*	*Undefined*	*Undefined*
EBA Goules	*Undefined*	*Undefined*	0.00 (0/6)	0.00 (0/33)	0.00 (0/59)	0.00 (0/48)	0.00 (0/29)	*Undefined*
EBA Koilada	14.28 (1/7)	2.41 (5/207)	2.66 (4/150)	2.51 (4/159)	0.00 (0/313)	0.00 (0/414)	0.47 (1/212)	0.00 (0/34)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/35)	*Undefined*	0.00 (0/29)	0.00 (0/9)	*Undefined*	0.00 (0/22)
LBA Spathes	*Undefined*	0.00 (0/14)	0.00 (0/8)	0.00 (0/22)	0.75 (1/133)	1.81 (1/55)	0.00 (0/22)	0.00 (0/20)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/10)	0.00 (0/14)	0.00 (0/164)	*Undefined*	3.84 (3/78)	*Undefined*
EIA Makrigialos	*Undefined*	0.00 (0/19)	0.00 (0/23)	1.56 (1/64)	0.00 0/241	3.12 4/128	0.00 (0/46)	0.00 (0/180)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/8)	0.00 (0/16)	4.80 (6/125)	0.00 (0/118)	0.00 (0/23)	*Undefined*

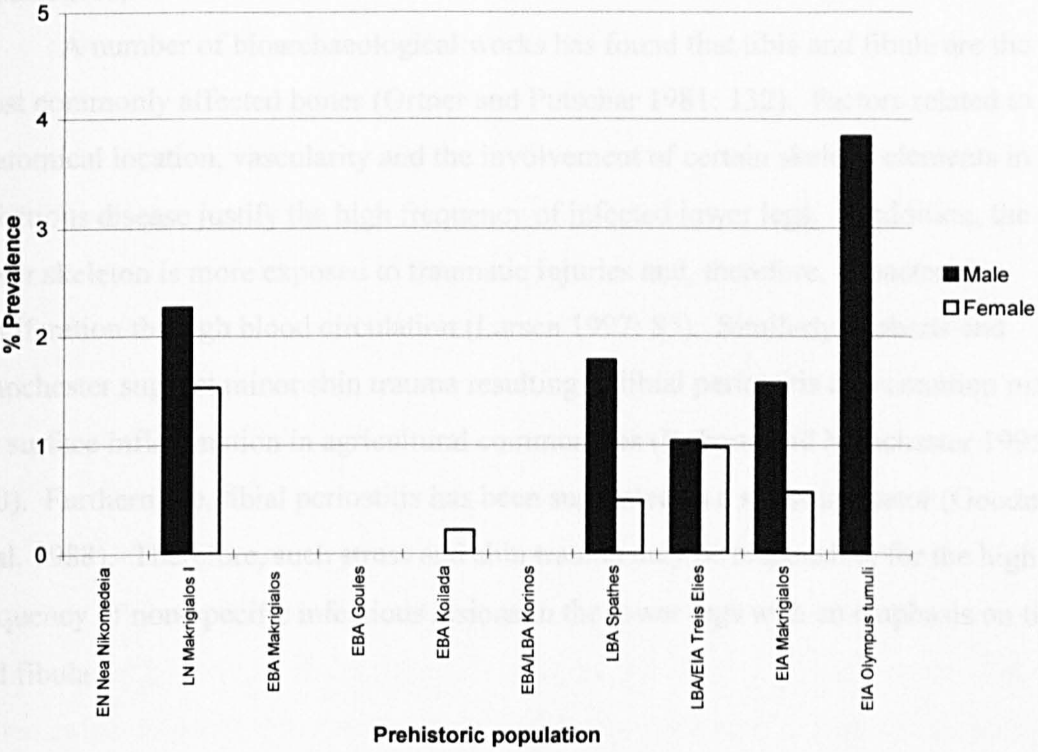
Table 6.11: Prevalence of non-specific infectious lesions by age group (crude rates)

close to the time of death or were long-term pathological conditions successfully sustained by the individual organism.

Figure 6.37 presents the distribution of non-specific infectious lesions by sex group. Overall, males are most affected except for EBA Koilada where only women have manifested the condition. In general, therefore, men seem to have been exposed to pathogens more than women in the case study cemetery populations, but the differences are not statistically significant. Since the aetiology of non-specific infection includes a variable number of interlinking factors, such as infection, metabolic disease and trauma, the causes of male susceptibility were probably different for each population. It is possible, however, that men were exposed to infectious pathogens more than women either due to certain physical activities which risked trauma or due to interaction with outsiders through travelling or trade (Larsen 1998).

Most non-specific infectious lesions occur in the lower appendicular skeleton (Table 6.12), while very few have been recorded in the upper skeleton. In particular, the tibia, fibula and foot bones were most subject to infectious conditions. The differences between upper and lower skeletal lesions are statistically significant at LN Makrigialos I (chi square test: $x^2=61.987>p=10.828$ at the 0.001 level of significance), EBA Koilada (chi square test: $x^2=33.614>p=10.828$ at the 0.001 level of significance), LBA Spathes (chi square test: $x^2=28.614>p=10.828$ at the 0.001 level of significance), EIA

Figure 6.37: Prevalence of non-specific infectious lesions by sex group (crude rates)



Population	Upper *% Crude/Stnd (NIA/NIO)*	Lower *% Crude/Stnd (NIA/NIO)*
EN Nea Nikomedeia	0.00/0.00 (0/234)	0.00/0.00 (0/159)
LN Makrigialos I	0.00/0.00 (0/203)	1.14/2.93 (2/174)
EBA Makrigialos	0.00/0.00 (0/59)	0.00/0.00 (0/45)
EBA Goules	0.00/0.00 (0/153)	0.00/0.00 (0/84)
EBA Koilada	0.12/0.06 (1/794)	1.72/1.53 (14/810)
EBA/LBA Korinos	0.00/0.00 (0/78)	0.00/0.00 (0/56)
LBA Spathes	0.00/0.00 (0/159)	1.28/1.20 (2/156)
LBA/EIA Treis Elies	0.57/0.37 (1/173)	1.19/0.75 (2/167)
EIA Makrigialos	0.29/0.31 (1/338)	1.47/1.28 (4/271)
EIA Olympus tumuli	0.00/0.00 (0/200)	3.17/2.80 (6/189)

Table 6.12: Prevalence of non-specific infectious lesions in the upper and lower appendicular skeleton (crude and standardised rates)

Makrigialos (chi square test: $x^2=14.414>p=10.828$ at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: $x^2=63.369>p=10.828$ at the 0.001 level of significance).

A number of bioarchaeological works has found that tibia and fibula are the most commonly affected bones (Ortner and Putschar 1981: 132). Factors related to anatomical location, vascularity and the involvement of certain skeletal elements in infectious disease justify the high frequency of infected lower legs. In addition, the lower skeleton is more exposed to traumatic injuries and, therefore, to bacterial proliferation through blood circulation (Larsen 1997: 85). Similarly, Roberts and Manchester suggest minor shin trauma resulting in tibial periostitis as a common reason for surface inflammation in agricultural communities (Roberts and Manchester 1995: 130). Furthermore, tibial periostitis has been suggested as a stress indicator (Goodman et al. 1988). Therefore, such stress and shin trauma may be responsible for the high frequency of non-specific infectious lesions in the lower legs with an emphasis on tibia and fibula.

6.7. ANAEMIA

6.7.1. INTRODUCTION

Bioarchaeologists have sought for over a century and a half, first, to distinguish the skeletal traces of the various types of anaemic disorder and, secondly, to understand the aetiology of the condition. A broad definition of anaemia is a reduction below normal in concentration of haemoglobin or red blood cells (Wintrobe 1974). There are a number of types of anaemia, with different causes, but research has focused on *acquired anaemias*, particularly iron deficiency anaemia. Apart from the acquired anaemias, there are also two types of *genetic anaemias* characterised by abnormal haemoglobin, that is thalassaemia and sickle-cell anaemia.

Many variable factors, environmental, geographical, dietary, cultural and pathogenic, have been suggested to contribute to the development of the disease (Hill and Armelagos 1990; Stuart-Macadam 1992a). Specific factors cited in the discussion of the aetiology of anaemia include marshy areas encouraging the presence of *Plasmodium falciparium* (malaria) (Angel 1966; 1972; 1977b; 1978), climate (tropical or temperate), geography (closer or further from the equator) (Hengen 1971), topography (lowland or highland) (Angel 1972; El Najjar et al. 1975; Ubelaker 1984), dietary deficiency and inadequate absorption of iron, particularly related to a high consumption of maize (Lallo et al. 1977; El Najjar 1976) or a diet based on millet and wheat that contains low concentrations of iron (Carlson et al. 1974), a diet dependent on milk (El Najjar 1976), a sedentary lifeway associated with increasingly crowded living conditions (Kent 1986, Kent and Dunn 1996), food preparation techniques (El Najjar et al. 1975) and the interaction between diet, parasitic infection and infectious disease (Carlson et al. 1974; Lallo et al. 1977; Mensforth et al. 1978).

Furthermore, *pathogen load*, affected by the synergy of all the variables above, has been suggested as the major factor in the development of the disease (Stuart-Macadam 1992a; 1992b). Thus, anaemia has been seen as a good indicator of stress, more often described as the *pathogen load* encountered by a population (Stuart-Macadam 1992b: 44). Latterly, the multifactorial nature of the aetiology of the condition has been emphasised so that anaemia is more often represented as a complex phenomenon involving a broad range of synergies. Moreover, the occurrence of porotic hyperostosis, which is the most common skeletal manifestation of anaemic conditions in ancient remains, has been reinterpreted in terms of the attempts of a population to cope with and adapt to its environment (Stuart-Macadam 1992a; 1992b). This contrasts with the majority of hypotheses which treat the prevalence of the disease as a sign of maladaptation or weakness.

It is extremely difficult to differentiate type of anaemia from skeletal evidence alone. Most palaeopathological studies investigating the skeletal manifestations of anaemia are based on lesions of the skull (Ortner and Putschar 1981: 258). It is beyond the scope of the current work to detail the skeletal manifestations of all types of anaemia. Only the lesions commonly found in the case study skeletal material are briefly outlined here.

Porotic hyperostosis is the term used to describe the characteristic lesions of the skull affecting the outer compact layer of bone and the middle layer or diploë, because of the proliferation of bone marrow during anaemia. The dense compact bone is pierced by small holes of varying size and frequency and the diploë is increased in thickness. The lesions occur mainly on the orbital roof, commonly known as *cribra orbitalia* (Figures 6.38, 6.39, 6.40), and/or skull vault, particularly the frontal, parietal and occipital bone (Figure 6.41 and 6.42) (Stuart-Macadam 1987a; 1987b; 1989b). Facial

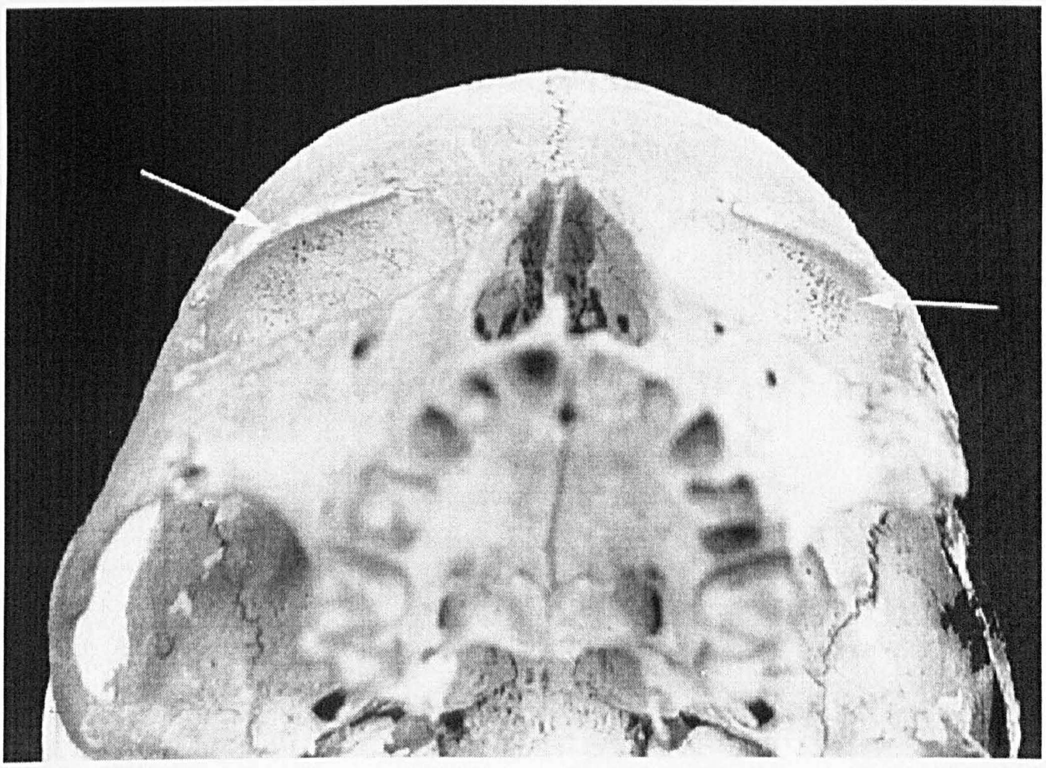


Figure 6.38: Porotic hyperostosis on the roofs of the orbits (Cribra Orbitalia) (Karitsa Tum 15c)

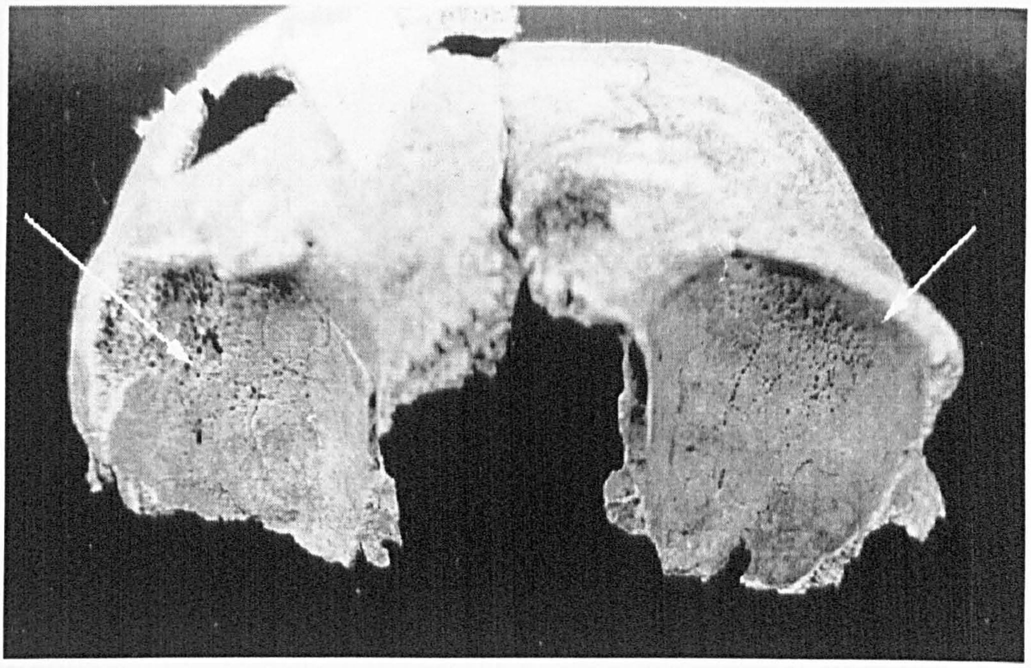


Figure 6.39: Porotic hyperostosis on the roofs of the orbits (Cribra Orbitalia) (Spathes 29East)

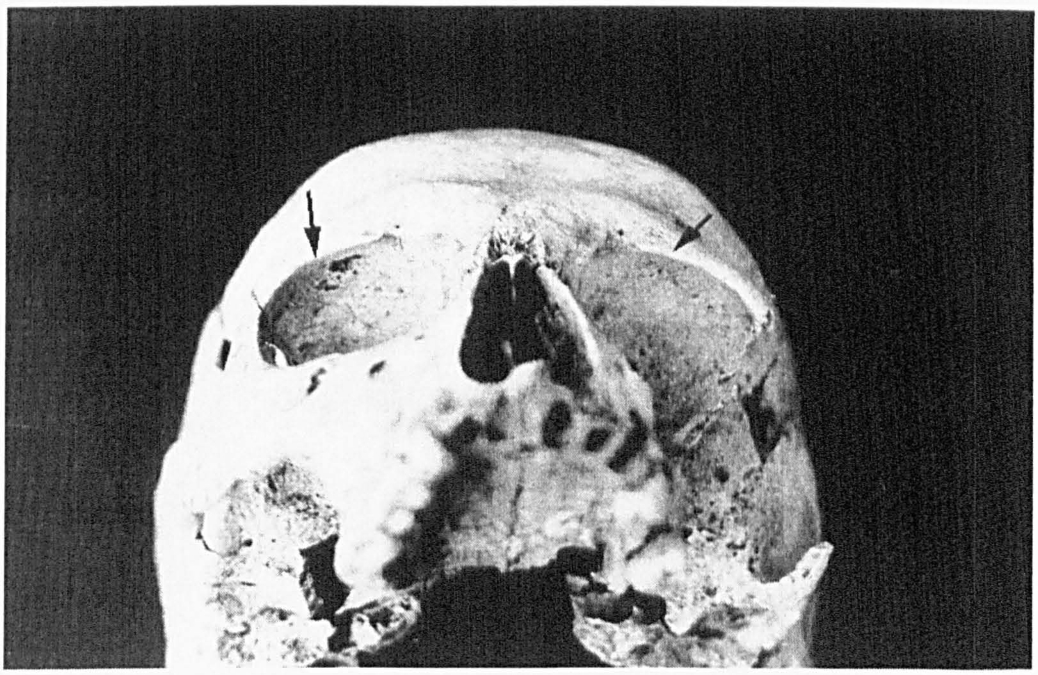


Figure 6.40: Porotic hyperostosis on the roofs of the orbits (Cribra Orbitalia) (Makrigialos 56prim)

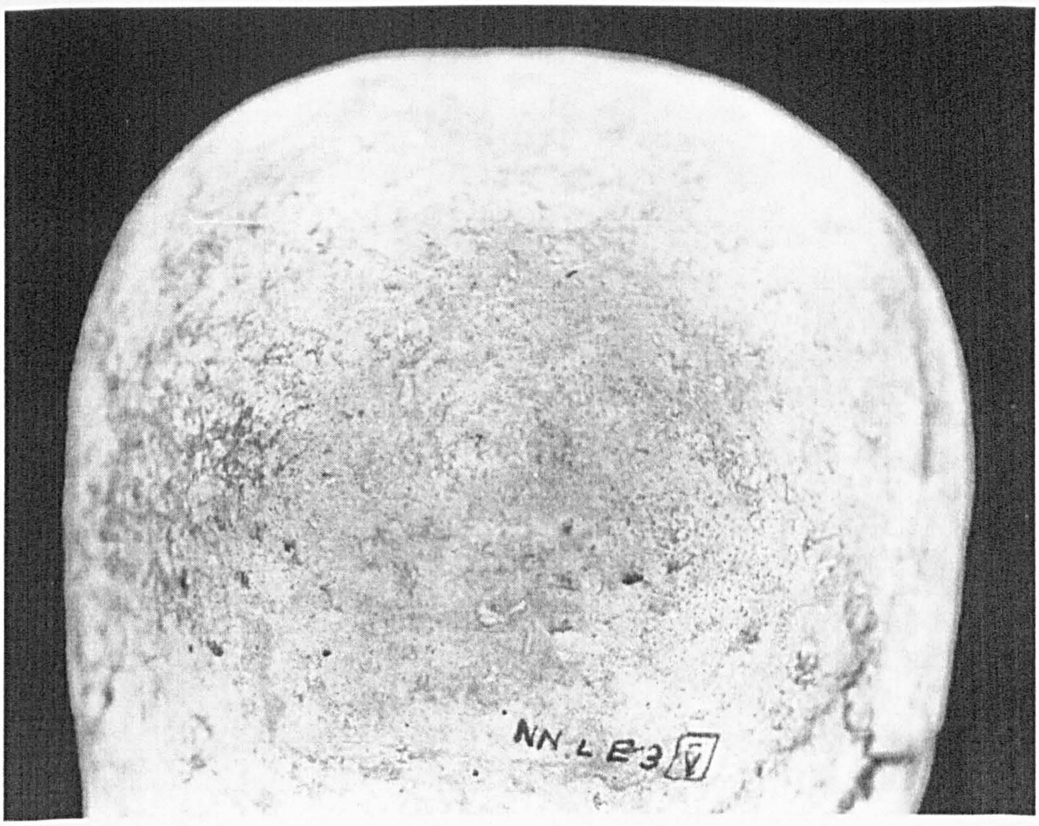


Figure 6.41: Porotic hyperostosis on the occipital (Nea Nikomedeia V)

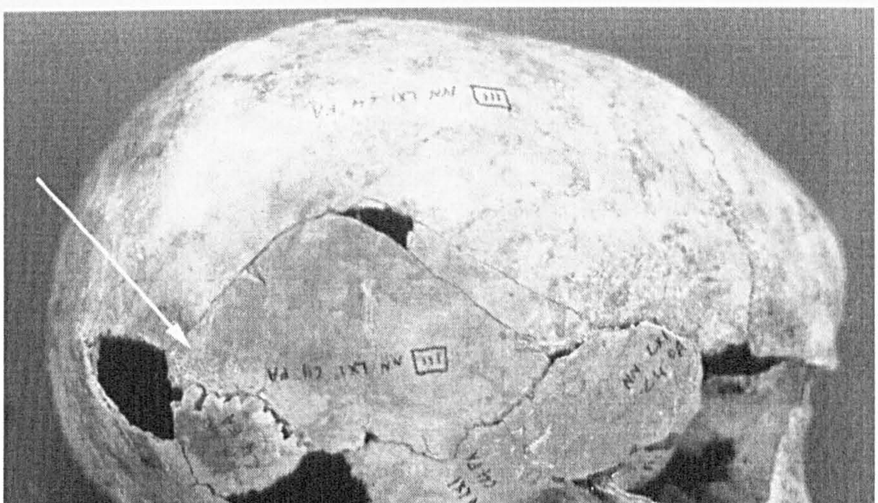


Figure 6.42: Porotic hyperostosis on the right parietal (Nea Nikomedeia III)

changes, common to certain genetic anaemias such as thalassaemia, reflect hypertrophy of the marrow in the facial bones and result in facial morphology sometimes described as "mongolian facies" (Figure 6.43) (Caffey 1951; Tayles 1996). Facial changes are considered diagnostic of thalassaemia especially when associated with both cranial vault and postcranial lesions (Lagia 1993).

In addition to the lesions usually affecting the skull, *postcranial manifestations* are also involved in the condition (Steinbock 1976; Ortner and Putschar 1981; Aufderheide and Rodriguez-Martin 1998). Cranial lesions with similar patterns can occur in 20 different diseases (Lagia 1993). Therefore, the recording of skull lesions alone cannot provide a safe diagnosis of the condition without a parallel evaluation of the postcranial skeleton. To date, very little attention has been given in bioarchaeological studies to postcranial manifestations. Skeletal changes reflect the same bone marrow hyperplasia which causes widening of the medullary cavity at the expense of trabecular and cortical bone, resulting in reduction in distribution and coarsening of trabeculae and extreme thinning and porosity of cortices, respectively (Caffey 1951; Tayles 1996). Thus, skeletal alterations occur mainly in the spine, pelvis and short and long tubular bones (Roberts and Manchester 1995; Lagia 1993; Steinbock 1976).

Bone changes recorded in the case study cemetery populations include *enlarged nutrient foramina* of the short tubular bones (Figures 6.44 and 6.45) and *flaring distal ends* of femora (Figure 6.46). The enlarged nutrient foramina in the small bones of the hands and/or feet, especially in infants and children, suggest increased vascularity (Tayles 1996: 15). The latter has been recorded particularly in cases of genetic anaemias such as thalassaemia and sickle-cell anaemia. Also, bone enlargement due to marrow hyperplasia in the distal femur may produce the Erlenmeyer flask deformity (flaring ends) which is considered characteristic skeletal evidence of thalassaemia (Lagia 1993: 66, 117; Resnick and Niwayama 1988).

Many of the skeletal features outlined above, however, occur in most types of anaemia, so that the differentiation between genetic and acquired anaemias and moreover, the identification of certain types of anaemia from the skeletal evidence alone is extremely difficult. According to clinical studies, severe skull alterations are consistent with hereditary anaemias and especially thalassaemia, while postcranial changes are more mild or rare in acquired anaemias (Steinbock 1976). Two necessary

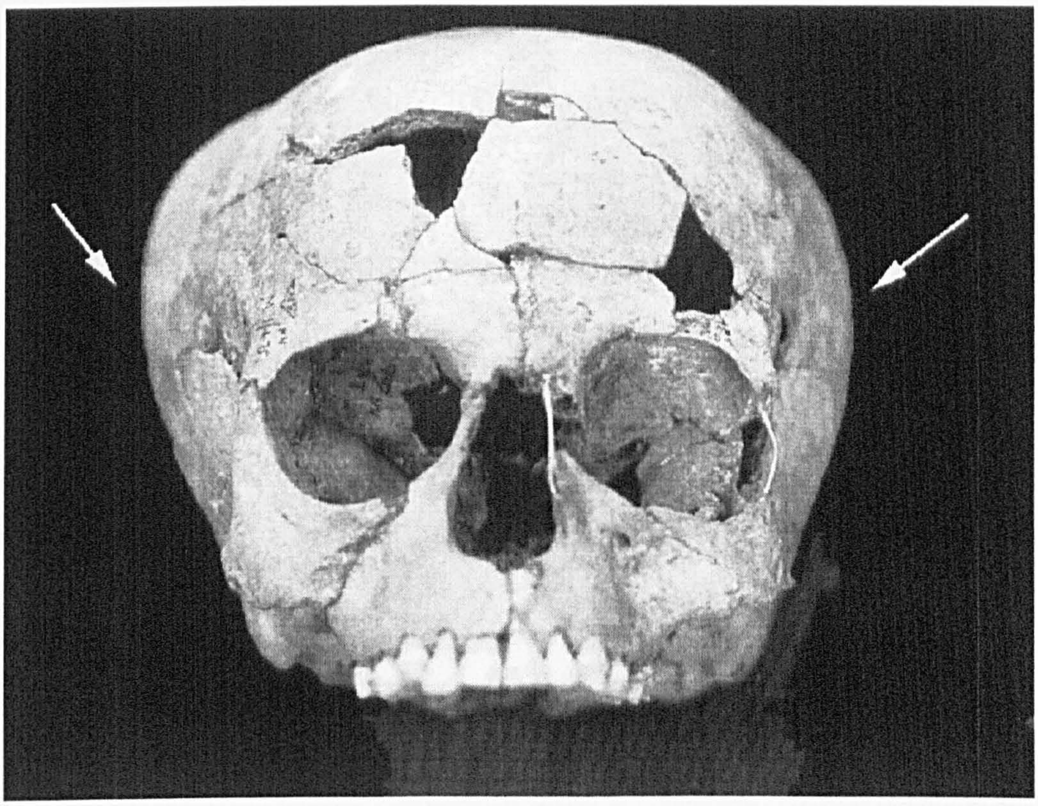


Figure 6.43: Bulgy eminence on both parietals (Nea Nikomedeia XIV)

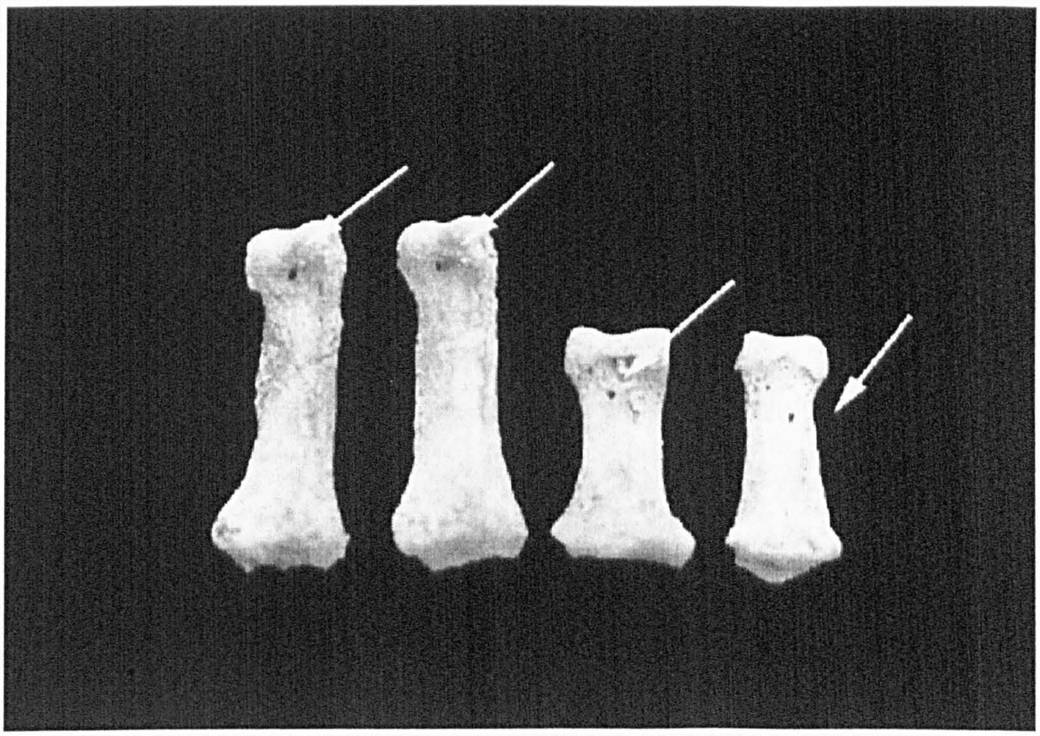


Figure 6.44: Enlarged nutrient foramina on hand phalanges (Nea Nikomedeia X)

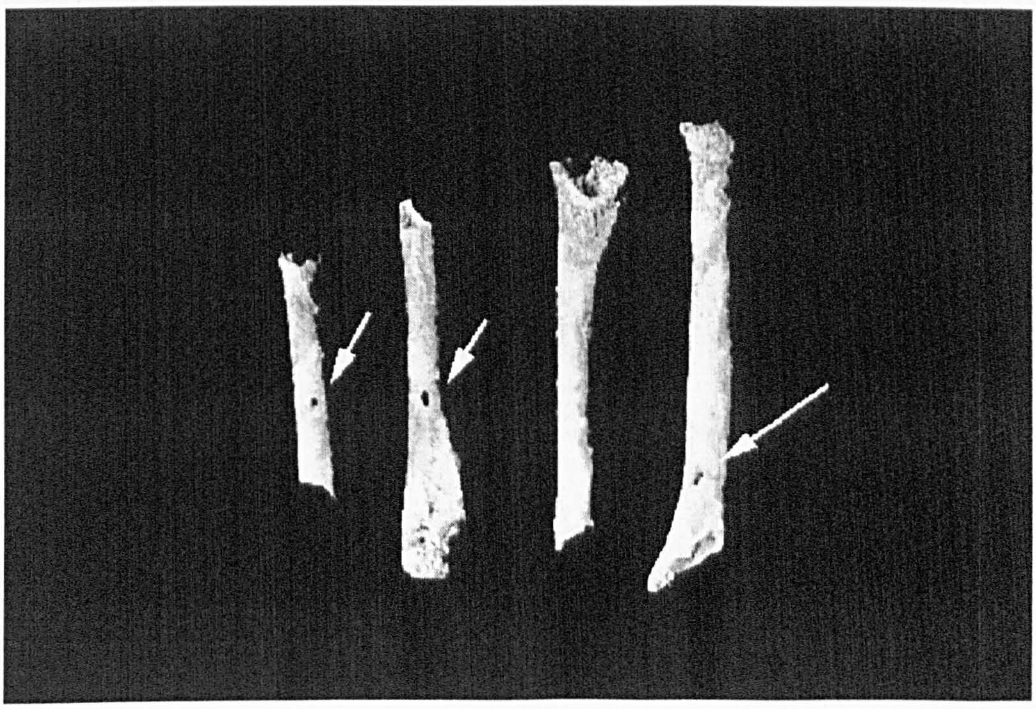


Figure 6.45: Enlarged nutrient foramina on immature long bones (Nea Nikomedeia #3)

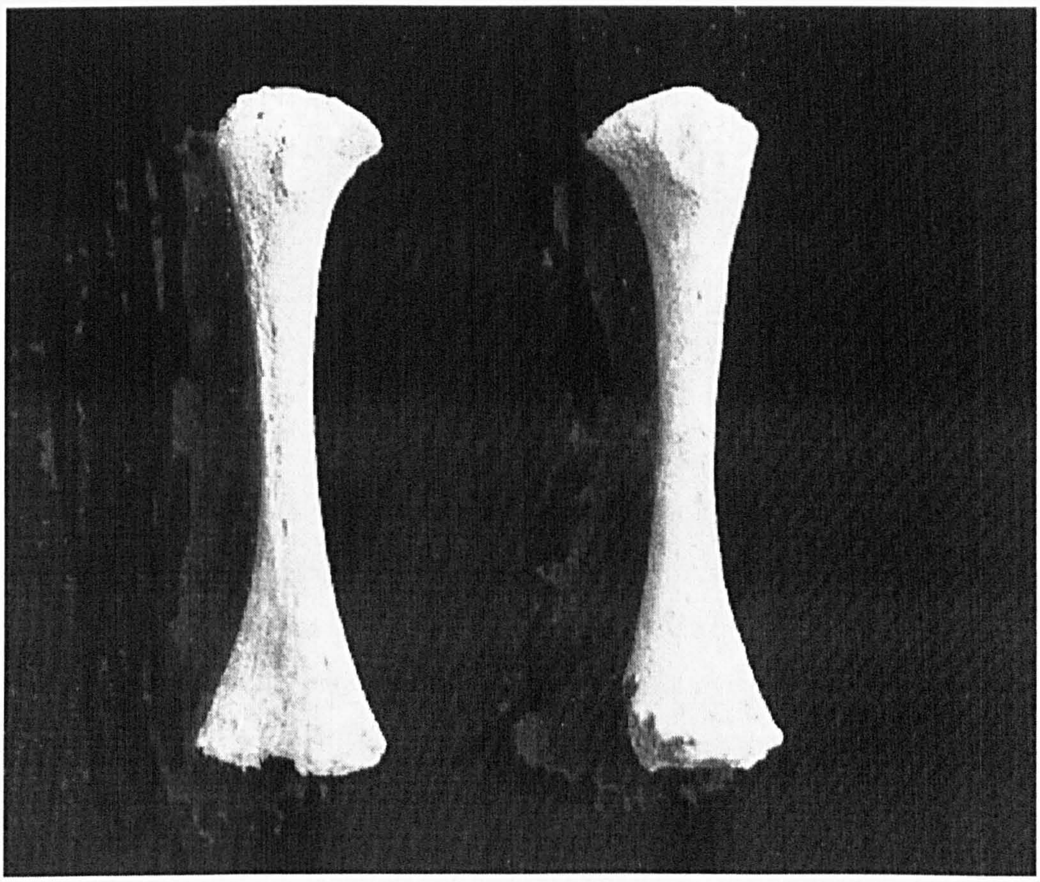


Figure 6.46: Flaring ends of immature femora (Nea Nikoemdeia #8)

preconditions for diagnosis of the disease are recording of the distribution of lesions on the entire skeleton and analysis of the pattern of skeletal changes according to age.

Bone involvement, particularly in genetic anaemias, changes with advancing age (Lagia 1993). Thus, a large number of bioarchaeological studies (e.g. Lallo et al. 1977; Mensforth et al. 1978) has reached the conclusion that, regardless of geographical or cultural background, *porotic hyperostosis* is an indication of childhood episodes of anaemia (Stuart-Macadam 1985), while the majority of adult cases consist of remodelled, and thus healed, indications of the lesion.

Issues of interpretation and definition of anaemias are quite complex even in modern clinical studies. In archaeological populations, factors related to the differential preservation of skeletal remains together with the methodology of ageing human bones can dramatically affect the results of the investigation of the different types of anaemia.

6.7.2. RESULTS

6.7.2.1. PREVALENCE OF ANAEMIA

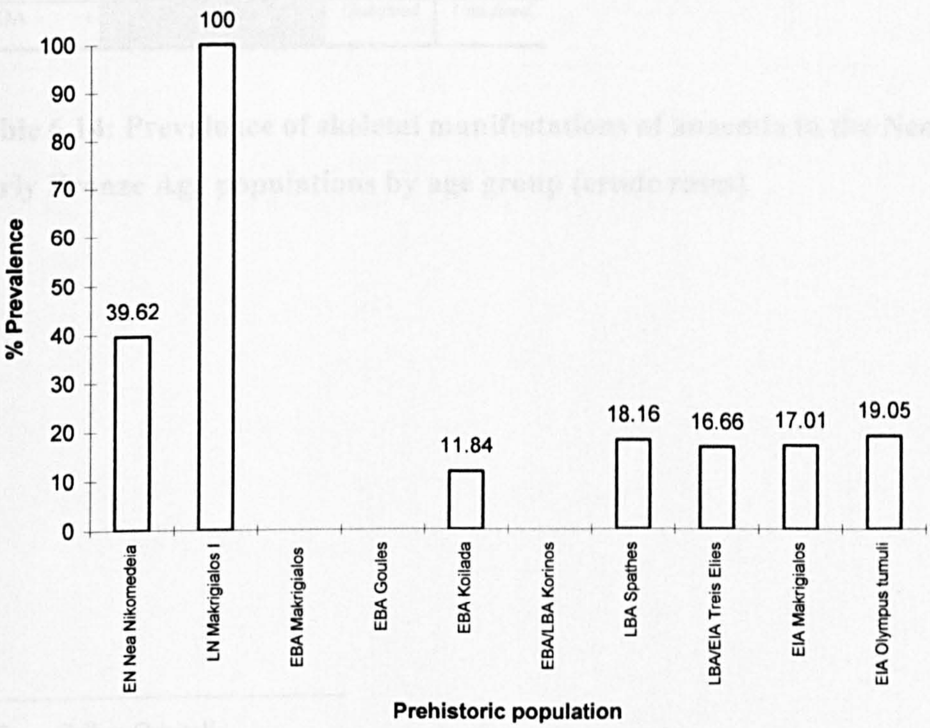
Figure 6.47 and Table 6.13 present the prevalence of anaemia in the case study prehistoric populations recorded by individual count, that is by the number of individuals preserving one or both orbits and/or cranial vault. The differences between sites are statistically significant (chi square test: $x^2=165.714>p=27.877$ at the 0.001 level), but there is no consistent trend in the occurrence of the disorder from the Neolithic to the Early Iron Age. The highest prevalence of anaemia has been provided by the skeletal assemblages of EN Nea Nikomedeia and LN Makrigialos I, although the sample in the latter is extremely small (n=1). Furthermore, several cemetery populations (EBA Makrigialos, EBA Goules and EBA/LBA Korinos) have no evidence of cranial or postcranial manifestations of the condition, possibly because of poor preservation of those skeletal elements (orbits and cranial vault) commonly involved in the osseous manifestations of anaemia.

Tables 6.14 and 6.15 present the distribution of different *skeletal manifestations of anaemia* by age group. *Cribra orbitalia* is the commonest type of lesion recorded in the case study assemblages. EN Nea Nikomedeia, EBA Koilada and LBA Spathes also have evidence of *porotic hyperostosis* on the cranial vault and *postcranial* lesions. The latter are associated only with the subadult age categories. Four points can be stressed

Population	% (NIA NIO)
EN Nea Nikomedeia	50.00 5/10
LN Makrigialos I	100.00 1/1
EBA Makrigialos	0.00 0/8
EBA Goules	0.00 0/15
EBA Koilada	14.75 9/61
EBA/LBA Korinos	0.00 0/11
LBA Spathes	23.07 3/13
LBA/EIA Treis Elies	11.11 1/9
EIA Makrigialos	14.81 4/27
EIA Olympus tumuli	23.07 3/13

Table 6.13: Overall prevalence of anaemia in the case study populations (raw data)

Figure 6.47: Prevalence of anaemia in the case study populations (standardised rates)



	EN NEA NIKOMEDEIA				LN MAKRIGIALOS I			
	CRANIAL		POSTCRANIAL		CRANIAL		POSTCRANIAL	
Age group	CO[4] % *(NIA/NIO)*	PH[5] % *(NIA/NIO)*	ENF[6] % *(NIA/NIO)*	FE[7] % *(NIA/NIO)*	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*
Neonate	*Undefined*	16.66 (1/6)	100.0 (6/6)	25.00 (1/4)	*Undefined*	*Undefined*	*Undefined*	*Undefined*
Infant	60.00 (3/5)	57.14 (4/7)	75.00 (3/4)	33.33 (1/3)	*Undefined*	0.00 (0/1)	0.00 (0/1)	0.00 (0/1)
Child	50.00 (1/2)	0.00 (0/2)	100.0 (1/1)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/2)	0.00 (0/2)
Juvenile	*Undefined*	0.00 (0/1)	*Undefined*	*Undefined*	100.0 (1/1)	0.00 (0/1)	*Undefined*	*Undefined*
YA	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	0.00 (0/3)	*Undefined*	*Undefined*
PA	50.00 (1/2)	0.00 (0/2)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
MA	0.00 (0/1)	100.0 (1/1)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
OA	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*

	EBA KOILADA			
	CRANIAL		POSTCRANIAL	
Age group	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*
Neonate	0.00 (0/1)	0.00 (0/6)	100.0 (1/1)	0.00 (0/1)
Infant	33.33 (4/12)	5.88 (2/34)	4.34 (1/23)	0.00 (0/23)
Child	40.00 (2/5)	0.00 (0/10)	0.00 (0/12)	0.00 (0/14)
Juvenile	33.33 (2/6)	0.00 (0/10)	*Undefined*	*Undefined*
YA	7.14 (1/14)	0.00 (0/18)	*Undefined*	*Undefined*
PA	0.00 (0/13)	0.00 (0/22)	*Undefined*	*Undefined*
MA	0.00 (0/9)	0.00 (0/12)	*Undefined*	*Undefined*
OA	0.00 (0/1)	0.00 (0/2)	*Undefined*	*Undefined*

Table 6.14: Prevalence of skeletal manifestations of anaemia in the Neolithic and Early Bronze Age populations by age group (crude rates)

[4] CO: Cribra Orbitalia.

[5] PH: Porotic Hyperostosis.

[6] ENF: Enlarged Nutrient Foramen.

[7] FE: Flaring Ends.

	LBA SPATHES				LBA/EIA TREIS ELIES			
	CRANIAL		POSTCRANIAL		CRANIAL		POSTCRANIAL	
Age group	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*
Neonate	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
Infant	*Undefined*	0.00 (0/1)	0.00 (0/1)	0.00 (0/1)	*Undefined*	*Undefined*	*Undefined*	*Undefined*
Child	*Undefined*	*Undefined*	0.00 (0/2)	0.00 (0/2)	100.0 (1/1)	0.00 (0/2)	0.00 (0/2)	0.00 (0/2)
Juvenile	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
YA	37.5 (3/8)	11.11 (1/9)	*Undefined*	*Undefined*	0.00 (0/5)	0.00 (0/10)	*Undefined*	*Undefined*
PA	0.00 (0/3)	0.00 (0/3)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
MA	0.00 (0/1)	0.00 (0/1)	*Undefined*	*Undefined*	0.00 (0/3)	0.00 (0/6)	*Undefined*	*Undefined*
OA	0.00 (0/1)	0.00 (0/1)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*

	EIA MAKRIGIALOS				EIA OLYMPUS TUMULI			
	CRANIAL		POSTCRANIAL		CRANIAL		POSTCRANIAL	
Age group	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*	CO % *(NIA/NIO)*	PH % *(NIA/NIO)*	ENF % *(NIA/NIO)*	FE % *(NIA/NIO)*
Neonate	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
Infant	66.66 (2/3)	0.00 (0/3)	0.00 (0/2)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
Child	50.00 (1/2)	0.00 (0/2)	0.00 (0/2)	0.00 (0/2)	50.00 (1/2)	0.00 (0/1)	0.00 (0/1)	0.00 (0/1)
Juvenile	0.00 (0/1)	0.00 (0/4)	*Undefined*	*Undefined*	0.00 (0/1)	0.00 (0/1)	*Undefined*	*Undefined*
YA	8.33 (1/12)	0.00 (0/13)	*Undefined*	*Undefined*	33.33 (2/6)	0.00 (0/6)	*Undefined*	*Undefined*
PA	20.00 (1/5)	0.00 (0/10)	*Undefined*	*Undefined*	0.00 (0/3)	0.00 (0/4)	*Undefined*	*Undefined*
MA	66.66 (2/3)	0.00 (0/3)	*Undefined*	*Undefined*	0.00 (0/1)	0.00 (0/2)	*Undefined*	*Undefined*
OA	0.00 (0/1)	0.00 (0/1)	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*	*Undefined*

Table 6.15: Prevalence of skeletal manifestations of anaemia in the Late Bronze and Early Iron Age populations by age group (crude rates)

concerning the skeletal manifestation of anaemia and the distribution of the disorder by age group:

A. *EN Nea Nikomedeia*, which has the highest prevalence of anaemia (apart from LN Makrigialos I), has the most severe lesions in both the cranial and postcranial skeleton. Apart from the common cribra orbitalia and porotic hyperostosis, other characteristic osseous changes include bulgy eminences and enlarged nutrient foramina on parietals, together with facial changes producing the typical features of "mongoloid facies".

B. Among *the cranial lesions* in the case study cemetery populations, cribra orbitalia occurs both with and without porotic hyperostosis, whereas porotic hyperostosis is always associated with cribra orbitalia. Cribra orbitalia has been seen as the initial osseous involvement in the disorder (McAfee 1958; Caffey 1937; Stuart-Macadam 1989b).

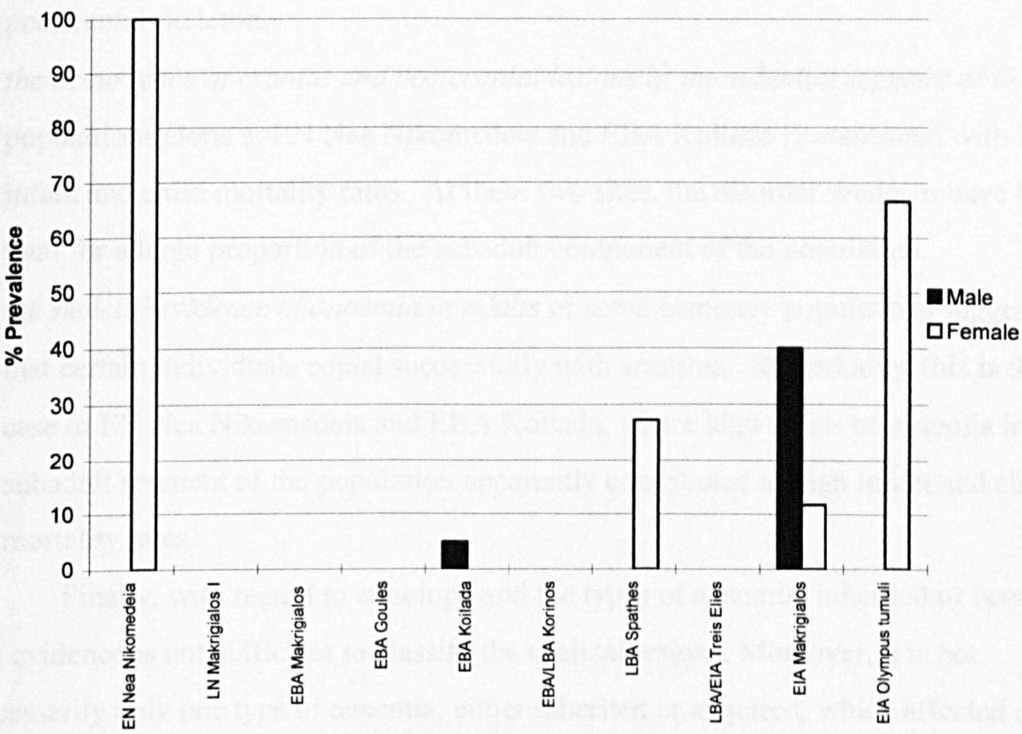
C. Characteristic lesions in the *postcranial skeleton* have been recorded only in the subadult segment of the EN Nea Nikomedeia and EBA Koilada skeletal assemblages. Manifestations include enlarged nutrient foramina in long and short bones and flaring femoral ends.

Overall, *subadults* and in particular infants and children have the highest prevalence of the disorder. In addition, it is of particular interest that the EN Nea Nikomedeia and EBA Koilada skeletal assemblages, which have a high frequency of anaemia, also have *high rates of infant and child mortality*, suggesting that anaemia contributed substantially to deaths in the subadult component of these populations.

D. Cranial lesions also occur in the *adult component* of the case study populations (except for LN Makrigialos I and LBA/EIA Treis Elies), although with significantly lower frequency than in subadults. The cases of cranial lesions in adults can be regarded either as "mild cases of porotic hyperostosis representing thus, the heterozygous state of a genetic anaemia" (Angel 1964; 1966; 1971a) or as "remodelled and thus, healed" cranial lesions (Stuart-Macadam 1985). According to Stuart-Macadam, cranial lesions, in particular porotic hyperostosis, represent a childhood condition since there is no evidence from clinical studies to suggest that "bone alterations caused by hyperplasia can occur in an adult who has only recently acquired anaemia" (Stuart-Macadam 1985).

The majority of adults affected by anaemia survived until young adulthood, except for EN Nea Nikomedeia and EIA Makrigialos where prime and mature adult individuals, respectively, have evidence of the pathological condition. The occurrence of anaemia in adults indicates that some individuals survived after infancy and early childhood, the high-risk age groups for anaemias of genetic type.

Figure 6.48: Prevalence of anaemia by sex group (crude rates)



With regard to the distribution of anaemia by sex group (Figure 6.48), in EN Nea Nikomedeia, LBA Spathes and the EIA Olympus tumuli, *women* are the only adults with evidence of anaemia, while, in EBA Koilada and EIA Makrigialos, *men* have been most affected. According to a number of bioarchaeological studies, there is a tendency for women in certain settings to show higher rates of acquired anaemia than men (Larsen 1997: 39; for further discussion see Stuart-Macadam 1998), usually associated with stresses and iron losses due to pregnancy, lactation and menstruation. On the other hand, assuming a genetic type of anaemia, skeletal manifestations of anaemia represent a childhood episode, and so may indicate the occurrence of physiological stress on females throughout infancy and childhood.

6.7.3. CONCLUSIONS

Throughout this section, it has been emphasised that both the aetiology of anaemia and the definition of the various types of the condition from skeletal evidence alone are problematic. Nevertheless, the skeletal manifestations recorded in the case study skeletal assemblages raise some interesting points:

- *the variability of the skeletal manifestations.* EN Nea Nikomedeia produced both the highest prevalence of anaemia and the most severe skeletal changes in the cranial and postcranial skeleton.
- *the occurrence of cranial and postcranial lesions in the subadult segment* of the populations alone at EN Nea Nikomedeia and EBA Koilada is associated with high infant and child mortality rates. At these two sites, the disorder seems to have been fatal for a large proportion of the subadult component of the population.
- *the skeletal evidence of anaemia in adults* of some cemetery populations suggests that certain individuals coped successfully with anaemia. Remarkably, this is the case in EN Nea Nikomedeia and EBA Koilada, where high levels of anaemia in the subadult segment of the population apparently contributed to high infant and child mortality rates.

Finally, with regard to aetiology and the types of anaemia, inherited or acquired, the evidence is not sufficient to classify the skeletal lesions. Moreover, it is not necessarily only one type of anaemia, either inherited or acquired, which affected all the individuals of the case study assemblages with lesions, while similar skeletal manifestations can result from more than one type of anaemia. It is also striking that even the most severe skeletal changes recorded at EN Nea Nikomedeia are not compatible with the hair-on-end appearance, diploë thickening and thinned outer table, typical of anaemia in other contexts (Lagia 1993). Angel, in his early studies, suggested that *inherited anaemias*, in particular thalassaemia, constituted the primary cause of porotic hyperostosis (Angel 1964; 1966; 1967; 1971a; 1972; 1977b). A high proportion of the modern populations of Western and Central Macedonia (10%-15%) suffer from inherited anaemia, in particular sickle-cell anaemia and thalassaemia (Loukopoulos et al. 1990: Figure 1). Later, however, Angel considered that *acquired anaemias*, in particular iron deficiency anaemia, may also have affected prehistoric populations in Greece (Angel 1971b; 1978).

In the case study populations, to define whether the skeletal manifestations recorded are compatible with inherited or acquired type of anaemia is beyond the aims of this work. The severity of lesions, however, in the cranial and postcranial skeleton at EN Nea Nikomedeia and partly EBA Koilada, is compatible with the inherited type of anaemia as the primary cause of the condition. Moreover, Nea Nikomedeia, Koilada and Makrigialos, during later prehistory, were on or close to marshy areas where the malarial parasite *Plasmodium falciparium* was possibly prevalent contributing thus to direct blood loss and the development of anaemia. The significance of the current work however, focuses on the effects of the lesions in association with certain age and sex categories which have been primarily evaluated in the overall demographic structure and health status of the case study populations.

6.8. ENAMEL HYPOPLASIA

6.8.1. INTRODUCTION

The term enamel hypoplasia refers to the surface dental defects on tooth enamel resulting from the disturbance of enamel formation. Enamel hypoplasia represents episodic disruptions to matrix secretion throughout the growing dentition. The defects commonly appear in archaeological specimens as linear furrowing (Figure 6.49) or circumferential pitting (El Najjar et al. 1978; Goodman et al. 1980; Goodman and Armelagos 1985; Rose et al. 1985; Hillson 1996; Goodman and Rose 1990; 1991; Skinner and Goodman 1992; Goodman and Martin 1992; Hillson 1996). Enamel disruptions can be the result of 1) an hereditary anomaly, 2) a localised trauma or 3) a systemic metabolic disease.

In archaeological populations, the majority of the cases recorded appear to have been caused by systemic metabolic stress during tooth development (Goodman and Rose 1991: 281). The debate regarding the aetiology of such defects has focussed on two related issues: *physiological stress* and *dietary deficiency* (Hillson 1986: 131). Poor conditions of life, including malnutrition, infectious disease and low standards of hygiene, can greatly encourage stress episodes affecting the susceptible age categories of infants and children (Goodman and Rose 1991). Thus, it has been suggested that the aetiology of enamel hypoplasia can be interpreted as a synergistic interaction between under-nutrition and infectious, parasitic or respiratory diseases, usually taking place at

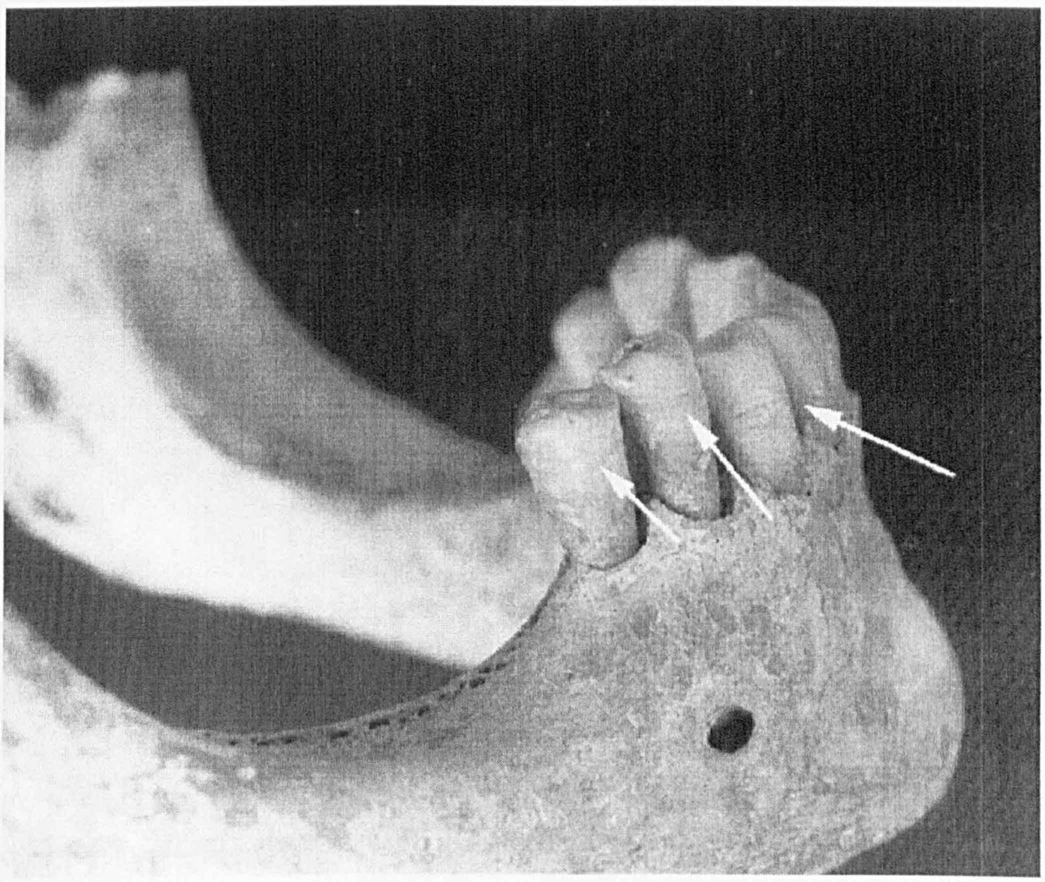


Figure 6.49: Enamel hypoplasia lines on mandibular teeth (Makrigialos 100prim)

the same time during growth development. It is difficult, therefore, to single out one factor as a major cause of dental defects (Rose et al. 1985; Goodman and Armelagos 1988; Goodman and Rose 1991; Goodman and Martin 1992).

Physiological stress may be particularly associated with weaning, that is with a nutritionally inadequate diet provided to infants during the post-weaning period (Cook 1979; Buikstra and Cook 1980; Goodman et al. 1984; Corruccini et al. 1985; for discussion see Katzenberg et al. 1996). The shift from maternal dependence to post-weaning diet and adult foods is a critical period in growth and the development of the immune system of infants and children. It is generally recognised that non-maternal food sources are less sanitary and potentially poorer in nutritional quality, often being deficient in protein (Lowery 1986; Moggi-Cecchi et al. 1994).

6.8.2. METHODOLOGY

Enamel hypoplasia defects have been recognised and measured only macroscopically. The position of all hypoplasias has been measured to the nearest tenth of a millimetre, as the distance from the centre of the hypoplasia to the cemento-enamel junction of the tooth, using sliding calipers. Only tooth crowns with intact surfaces have been examined, while enamel defects on teeth with heavy attrition have not been recorded. The overall prevalence of enamel hypoplasia disruptions has been estimated by tooth count.

The time of development of enamel hypoplasia defects across teeth has been evaluated in order to recognise temporal patterns of growth disruptions for individuals. Age of hypoplasia episodes for each tooth has been determined within half-year intervals using the developmental chronology of Massler et al. (1941), modified for use in hypoplasia research by Swärdstedt (1966) and Goodman et al. (1980), where additionally the distances in millimetres from the cemento-enamel junction to the midpoint of the hypoplasia have been converted to percentages of crown height. The latter scheme has been used, bearing in mind developmental variability due to genetic factors and metabolic stress in different population settings. The frequency of growth disruptions has been compiled by percentage ratio for each cemetery population within half-year age intervals. In order to avoid duplication of hypoplastic events, only teeth of the left side have been measured; in the case of a missing tooth, the right tooth was substituted when available (Hutschinson and Larsen 1990; 1995).

6.8.3. RESULTS

The prevalence of enamel hypoplasia lines (Figure 6.50, Table 6.16) differs significantly between sites (chi square test: x^2=*2454.770>p=27.877* at the 0.001 level),

Population	% (NIA NIO)
EN Nea Nikomedeia	0.66 1/150
LN Makrigialos I	5.26 15/285
EBA Makrigialos	7.14 9/126
EBA Goules	0.00 0/247
EBA Koilada	1.55 20/1287
EBA/LBA Korinos	4.21 8/190
LBA Spathes	14.04 25/178
LBA/EIA Treis Elies	6.94 10/144
EIA Makrigialos	5.91 50/846
EIA Olympus tumuli	17.74 22/124

Table 6.16: Overall prevalence of enamel hypoplasia in the case study populations (raw data)

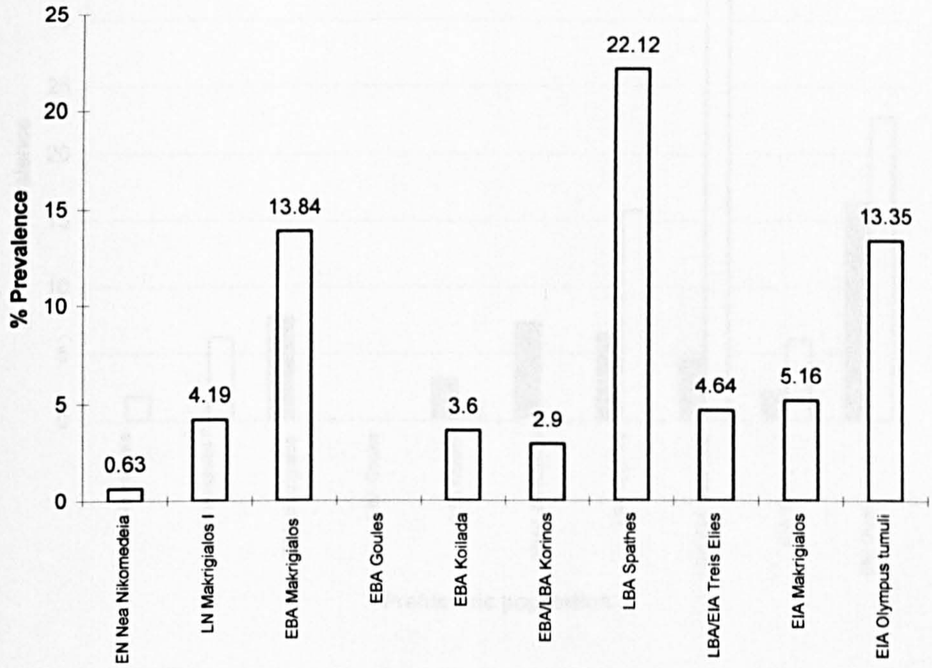
but does not exhibit any chronological trend. The highest frequency of the defect is in LBA Spathes, while EBA Goules has not produced any evidence of enamel hypoplasia. Thus, it seems that local constraints probably affected enamel hypoplasia rates in the case study cemetery populations.

The occurrence of the condition by age group (Table 6.17) can be evaluated mainly with regard to the risk-of-death for individuals exposed to a stress episode during infancy and/or childhood. The difference in the distribution of the cumulative frequencies of the enamel defects between age categories is statistically significant at EBA Koilada (Kolmogorov-Smirnov test: $D_{maxobs} = 0.369 > D_{max0.05} = 0.306$) and EIA Makrigialos (Kolmogorov-Smirnov test: $D_{maxobs} = 0.309 > D_{max0.05} = 0.198$). Overall, it seems that

Population	**Neonate** % *(NIA/NIO)*	**Infant** % *(NIA/NIO)*	**Child** % *(NIA/NIO)*	**Juvenile** % *(NIA/NIO)*	**YA** % *(NIA/NIO)*	**PA** % *(NIA/NIO)*	**MA** % *(NIA/NIO)*	**OA** % *(NIA/NIO)*	**IndAdult** % *(NIA/NIO)*
EN Nea Nikomedeia	*Undefined*	**0.00 (0/15)**	**0.00 (0/26)**	**0.00 (0/24)**	*Undefined*	1.63 (1/61)	**0.00 (0/24)**	*Undefined*	*Undefined*
LN Makrigialos I	*Undefined*	**0.00 (0/3)**	**0.00 (0/35)**	6.89 (2/29)	7.57 (5/66)	**0.00 (0/8)**	*Undefined*	*Undefined*	5.55 (8/144)
EBA Makrigialos	**0.00 (0/2)**	33.33 (2/6)	**0.00 (0/6)**	*Undefined*	23.33 (7/30)	*Undefined*	*Undefined*	*Undefined*	**0.00 (0/93)**
EBA Goules	*Undefined*	*Undefined*	**0.00 (0/60)**	**0.00 (0/20)**	**0.00 (0/73)**	**0.00 (0/28)**	**0.00 (0/28)**	*Undefined*	**0.00 (0/38)**
EBA Koilada	**0.00 (0/7)**	**0.00 (0/77)**	14.10 (2/156)	0.62 (1/161)	5.45 (15/275)	0.55 (2/360)	**0.00 (0/211)**	**0.00 (0/14)**	**0.00 (0/26)**
EBA/LBA Korinos	*Undefined*	*Undefined*	3.50 (2/57)	*Undefined*	4.25 (4/94)	**0.00 (0/12)**	*Undefined*	7.40 (2/27)	*Undefined*
LBA Spathes	*Undefined*	**0.00 (0/7)**	*Undefined*	*Undefined*	20.00 (22/110)	5.12 (2/39)	**0.00 (0/16)**	**0.00 (0/5)**	100.00 (1/1)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	**0.00 (0/14)**	*Undefined*	8.62 (10/116)	*Undefined*	**0.00 (0/10)**	*Undefined*	**0.00 (0/4)**
EIA Makrigialos	*Undefined*	**0.00 (0/44)**	2.85 (1/35)	23.45 (19/81)	7.14 (27/378)	1.36 (3/219)	**0.00 (0/54)**	**0.00 (0/14)**	**0.00 (0/21)**
EIA Olympus tumuli	*Undefined*	*Undefined*	33.33 (2/6)	**0.00 (0/1)**	22.22 (20/90)	**0.00 (0/20)**	*Undefined*	*Undefined*	**0.00 (0/7)**

Table 6.17: Prevalence of enamel hypoplasia by age group (crude rates)

Figure 6.50: Prevalence of enamel hypoplasia in the case study populations (standardised rates)

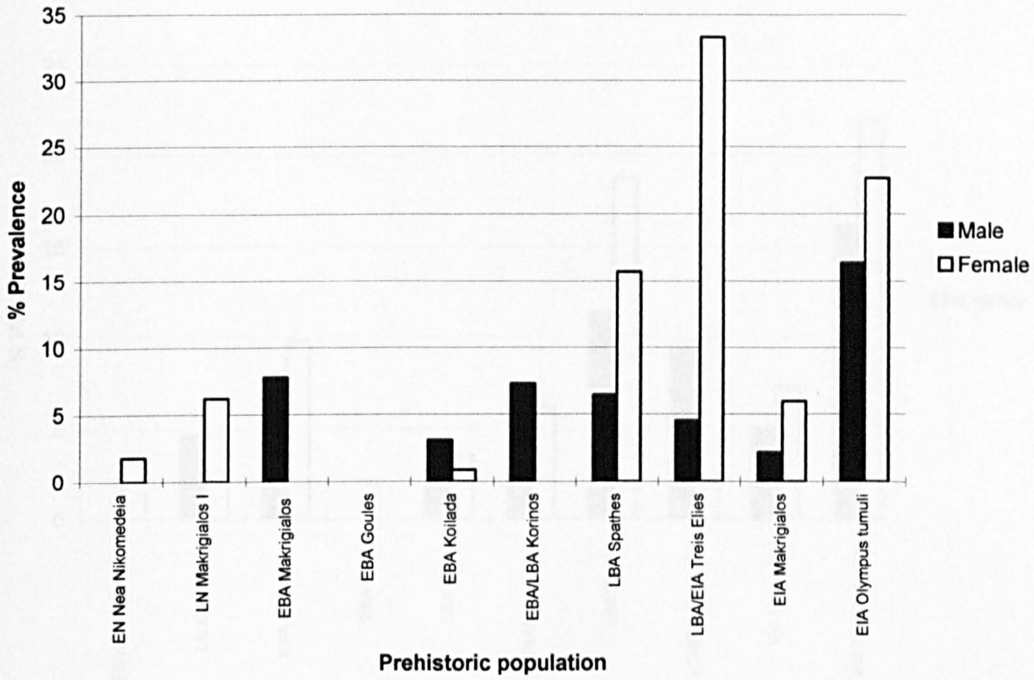


subadults and young adults tend to higher rates of enamel hypoplasia than older individuals. This suggests that individuals who experienced a stress episode during childhood were less likely to reach mature or late adulthood.

Women show higher levels of enamel defects than men (Figure 6.51), but the difference between the sexes is statistically significant only at LBA/EIA Treis Elies (chi square test: $x^2=11.106>p=10.828$ at the 0.001 level of significance). According to epidemiological studies, there is no consistent pattern regarding the prevalence of such defects in either females or males (Goodman and Rose 1990; Goodman et al. 1988). Enamel hypoplasia is a reliable indicator of stress episodes during childhood, however, so the higher frequency of women with enamel disruptions is consistent with girls suffering more stress episodes than boys in their developmental years of infancy and early childhood.

The gradient of *susceptibility of different tooth types* may provide a method for estimating the severity of the physiological stress causing enamel disruptions; the occurrence of hypoplasia lines on less susceptible teeth would indicate more severe

Figure 6.51: Prevalence of enamel hypoplasia by sex group (crude rates)

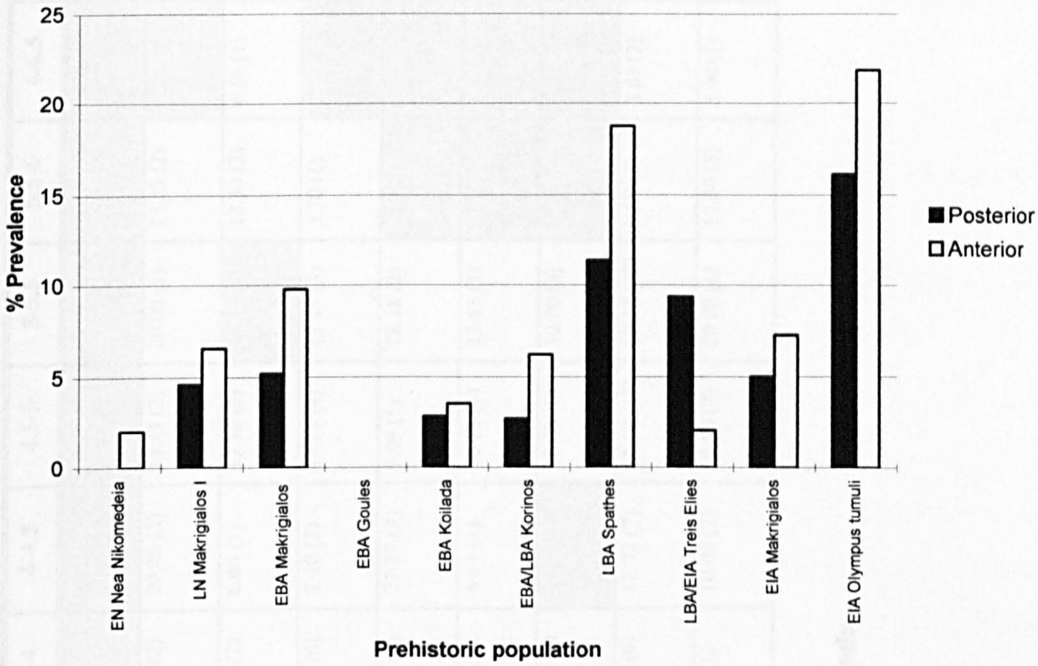


Population	M3 % (NIA/NIO)	M2 % (NIA/NIO)	M1 % (NIA/NIO)	P4 % (NIA/NIO)	P3 % (NIA/NIO)	C % (NIA/NIO)	I2 % (NIA/NIO)	I1 % (NIA/NIO)
EN Nea Nikomedeia	0.00 (0/13)	0.00 (0/20)	0.00 (0/35)	0.00 (0/17)	0.00 (0/16)	0.00 (0/14)	0.00 (0/18)	5.88 (1/17)
LN Makrigialos I	3.22 (1/31)	0.00 (0/45)	1.66 (1/60)	16.66 (5/30)	7.14 (2/28)	11.76 (4/34)	6.25 (2/32)	0.00 (0/25)
EBA Makrigialos	0.00 (0/7)	16.66 (2/12)	5.26 (1/19)	0.00 (0/21)	5.55 (1/18)	4.76 (1/21)	7.14 (1/14)	18.75 (3/16)
EBA Goules	0.00 (0/26)	0.00 (0/36)	0.00 (0/41)	0.00 (0/27)	0.00 (0/30)	0.00 (0/31)	0.00 (0/17)	0.00 (0/14)
EBA Koilada	0.94 (1/106)	2.27 (4/176)	4.65 (10/215)	3.46 (6/173)	1.82 (3/164)	7.95 (14/176)	0.69 (1/143)	0.74 (1/134)
EBA/LBA Korinos	0.00 (0/14)	0.00 (0/28)	4.34 (1/23)	4.16 (1/24)	4.76 (1/21)	20.83 (5/24)	0.00 (0/28)	0.00 (0/28)
LBA Spathes	33.33 (4/12)	9.67 (3/31)	9.67 (3/31)	5.88 (1/17)	8.69 (2/23)	25.00 (8/32)	17.64 (3/17)	6.66 (1/15)
LBA/EIA Treis Elies	0.00 (0/9)	10.00 (2/20)	11.53 (3/26)	11.11 (2/18)	8.69 (2/23)	4.34 (1/23)	0.00 (0/16)	0.00 (0/9)
EIA Makrigialos	0.00 (0/68)	3.96 (4/101)	3.30 (4/121)	4.46 (5/112)	11.40 (13/114)	17.27 (19/110)	3.53 (4/113)	0.93 (1/107)
EIA Olympus tumuli	0.00 (0/11)	25.92 (7/27)	18.75 (6/32)	0.00 (0/10)	15.38 (2/13)	38.46 (5/13)	0.00 (0/12)	33.33 (2/6)

Table 6.18: Prevalence of enamel hypoplasia by tooth category (crude rates)

physiological disruptions (Goodman et al. 1984; Rose et al. 1985). Although there is variation in susceptibility to enamel defects, it seems that anterior dentition, particularly maxillary central incisors and mandibular canines, more frequently displays high prevalences of enamel disturbances (Goodman and Armelagos 1985).

Figure 6.52: Prevalence of enamel hypoplasia in posterior versus anterior dentition



In the case study cemetery populations (Figure 6.52, Table 6.18), there is a high occurrence of enamel disruptions on the anterior dentition (incisors and canines) in all cemetery populations except for LBA/EIA Treis Elies. If enamel hypoplasia on the less susceptible posterior dentition is associated with more extreme episodes of physiological stress, therefore, the LBA/EIA Treis Elies population may have suffered severe stress conditions during the developmental years.

The estimated time period of the enamel disruption events in the case study cemetery populations (Table 6.19) covers a broad span, ranging from 6 to 12 months in LBA Spathes to 6.5 to 7 years in LN Makrigialos I and EBA Koilada. The peak frequencies of stress episodes appear relatively late, between 3 and 5.5 years.

Population	Half year intervals												
	0-1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	6-6.5	6.5-7
EN Nea Nikomedeia *N= 1* [8]					100.00 (1)								
LN Makrigialos I *N= 15*		6.66 (1)				13.33 (2)	13.33 (2)	20.00 (3)	13.33 (2)	20.00 (3)	13.33 (2)		6.66 (1)
LN Makrigialos II *N= 15*		6.66 (1)		6.66 (1)	13.33 (2)	20.00 (3)	13.30 (2)	6.66 (1)	13.30 (2)		13.30 (2)	6.66 (1)	
EBA Koilada *N= 27*		7.40 (2)	3.70 (1)	7.40 (2)	11.11 (3)	7.40 (2)	22.22 (6)	7.40 (2)	14.81 (4)	11.11 (3)	3.70 (1)		3.70 (1)
EBA/LBA Korinos *N= 11*					9.09 (1)		27.27 (3)	27.27 (3)	9.09 (1)	18.18 (2)			
LBA Spathes *N= 22*	4.54 (1)	9.09 (2)	13.63 (3)	4.54 (1)	9.09 (2)	9.09 (2)	9.09 (2)	4.54 (1)	18.18 (4)	13.63 (3)			
LBA/EIA Treis Elies *N= 10*			10.00 (1)	10.00 (1)		20.00 (2)	10.00 (1)		20.00 (2)	30.00 (3)			
EIA Makrigialos *N= 55*			5.45 (3)	1.81 (1)	7.27 (4)	9.09 (5)	16.36 (9)	12.72 (7)	18.18 (10)	18.18 (10)	9.09 (5)	3.63 (2)	
EIA Olympus tumuli *N= 20*			5.00 (1)	10.00 (2)	10.00 (2)	10.00 (2)	5.00 (1)	10.00 (2)	10.00 (2)	20.00 (4)	15.00 (3)	5.00 (1)	

Table 6.19: Frequency distribution of enamel hypoplasia lines by half-year periods

[8] N corresponds to the total of computed enamel hypoplasia events in each cemetery population

6.8.4. CONCLUSIONS

The evidence of enamel defects in the case study cemetery populations suggests four points:

A. Stress conditions experienced during the developmental years of infancy and early childhood predisposed the individuals affected to *risk of early death.*

B. *The differential prevalence of enamel disruptions in sex groups* may indicate greater exposure of females to stress episodes during the developmental years of infancy and early childhood.

C. *The prevalence of defects on the posterior dentition* at LBA/EIA Treis Elies may indicate severe stress episodes affecting certain individuals.

D. *The peak frequency between 3 and 5.5 years* in the case study cemetery populations is consistent with the peak in hypoplasia prevalence of most archaeological studies (Hutschinson and Larsen 1990: Table 4.3; 1995: Table 6.6). However, clinical studies suggests an earlier time period, that is 0.5-1 year, for the peak frequency of enamel hypoplasia defects (Goodman and Rose 1990). Thus, it is worth exploring briefly the potential contributors to enamel hypoplasia in the case study populations.

Primary factors causing growth disruptions including dental defects are considered to be nutritional deficiency, poor living conditions, infectious disease and the stress of weaning with the associated shift to a poor diet (Cook 1979; Buikstra and Cook 1980; Goodman et al. 1984; Goodman and Armelagos 1985; Goodman et al. 1988; Corruccini et al. 1985; Hutchinson and Larsen 1990; Goodman and Rose 1990; 1991; Goodman and Martin 1992; Hutchinson and Larsen 1995; Katzenberg and Pfeiffer 1995; Katzenberg et al. 1996). The effects of weaning, that is cessation of breast feeding, are highly variable even in contemporary communities, so that it is not possible to determine them in archaeological populations (Blakey et al. 1994; see discussion by Katzenberg et al. 1996). To a certain extent, the post-weaning period, due to separation from maternal food sources and maternal dependence in general, was critical to the development and physiology of children and early juveniles. Moreover, due to loss of the mother's milk enriched in certain nutrients, that time interval coincides with a *reduction in host resistance* and with a transitional period in the development of the individual's own immune system (Larsen 1987). Additionally, increasing pathogen load and nutritional deficiencies would create stress conditions for the more susceptible age groups, that is infants and children. It seems likely, therefore, that the late peak frequency of enamel defects in the case study assemblages may result from a combination of post-weaning stress and the associated increase in pathogen load which contributed to a reduced immune system in the affected early age categories.

The evidence for late weaning may also have implications for fertility levels in the case study populations. Because of the contraceptive effects of nursing and lactational amenorrhea, weaning can be associated with the renewal of the menstrual cycle and thus fecundity with obvious consequences for birth spacing and population growth (recent bibliography on this issue includes Stuart-Macadam and Dettwyler 1995; Katzenberg et al. 1996; Schurr 1998). Long birth intervals, implied by late weaning, indicate reduced birth rates and are linked to low levels of fertility and slow population growth.

6.9. DISCUSSION

The analysis of health status patterns in the case study skeletal assemblages has focused on two broad categories: 1) bone lesions associated with *mechanical load and occupational activities* repeatedly exercised on the skeleto-muscular system; and 2) pathological conditions associated with *physiological stress and stress episodes* affecting the individual during lifetime. Despite the limitations of the evidence and current methodology, some stimulating observations have been made concerning the relationship of health patterns with certain population segments defined by sex and/or age and with the demographic structure of the case study cemetery populations.

As regards the conditions associated with *mechanical load*:

A. *The upper skeleton* is the primary focus of degenerative joint changes and traumatic injuries, suggesting the importance of physical activities involving the upper limbs.

B. *The occurrence of degenerative changes, trauma and vertebral abnormalities in young individuals*. Given that skeletal manifestations such as degenerative changes require a certain time to develop, it seems likely that children and adolescents actively participated in strenuous physical activities.

C. *Participation of both sexes* in similar work patterns with some evidence of a quantitative *division of labour* suggested by the differential distribution of traumatic lesions between the sexes.

D. *The prevalence of left-side involvement of the upper skeleton*, contrary to the expected right-handedness, in some populations, which may reflect particular types of physical activities such as food processing and preparation.

The evidence of *physiological stress* during the developmental years of infancy, childhood and early adolescence has illuminated four aspects of the demographic structure of the case study assemblages:

A. The association of non-specific infectious lesions, anaemia and enamel disruptions with *high subadult mortality* in certain cemetery populations suggests that the subadult component of certain populations was highly susceptible to physiological stress factors.

B. A high prevalence of physiological stress indicators in the *young adult segment* of certain skeletal assemblages suggests that individuals experiencing a stress episode in the developmental years incurred a significant risk of death in early adulthood.

C. A high prevalence of physiological stress indicators in the *mature and old adult segment* of certain skeletal assemblages suggests that the affected individuals coped successfully with stress episodes during the developmental years.

D. The distribution of non-specific infectious lesions, anaemia and enamel disruptions by sex groups suggests *a differential exposure of sex groups to physiological stress* in certain populations.

Finally, the overall health patterns are investigated in relation to the geographical and chronological groupings described in Chapter 4. In the conventional model, declining health status would be associated with low nutritional status, dietary deficiencies, increased sedentism, dense housing, aggregation of the population in larger centres, and population interaction due to exchange networks. This model cannot be directly applied to the case study assemblages because there is very little evidence for the broader social and economic context of the cemetery populations.

Figures 6.53 and 6.54, representing the prevalence of pathological conditions in temporal and geographical groupings, have not produced clear patterns. Figure 6.53 shows a predominance of degenerative changes, non-specific infection and enamel hypoplasia *in the late populations*. These temporal differences are statistically significant for degenerative joint disease (chi square test: $x^2=135.620>p=10.828$ at the 0.001 level of significance), non-specific infection (chi square test: $x^2=10.201>p=7.897$ at the 0.005 level of significance) and enamel hypoplasia defects (chi square test:

Figure 6.53: Prevalence of pathological conditions by archaeological period (standardised rates)

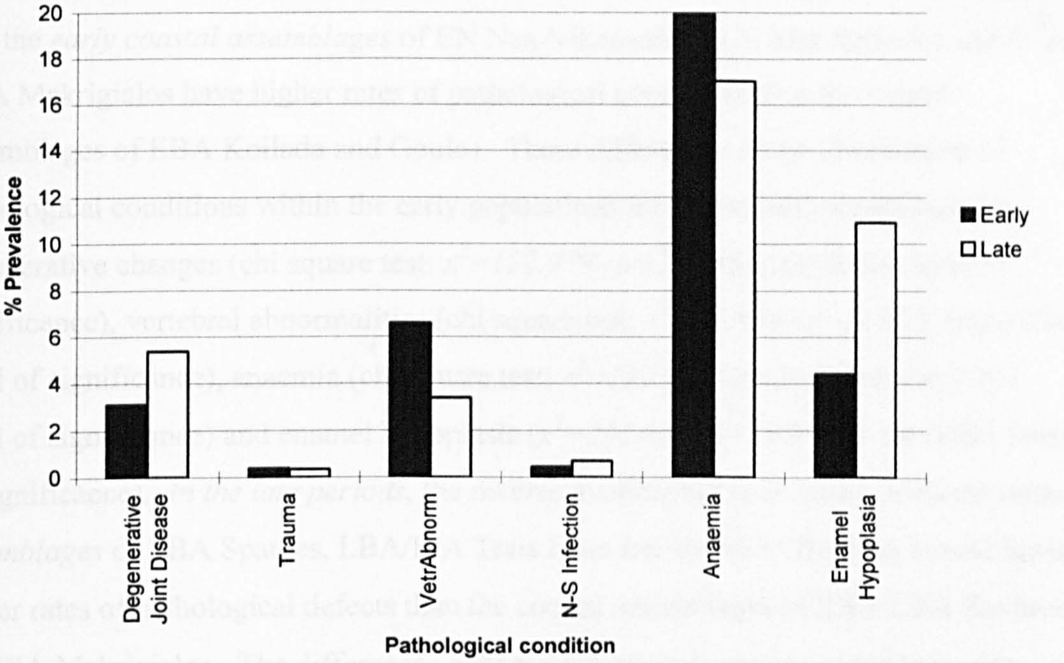
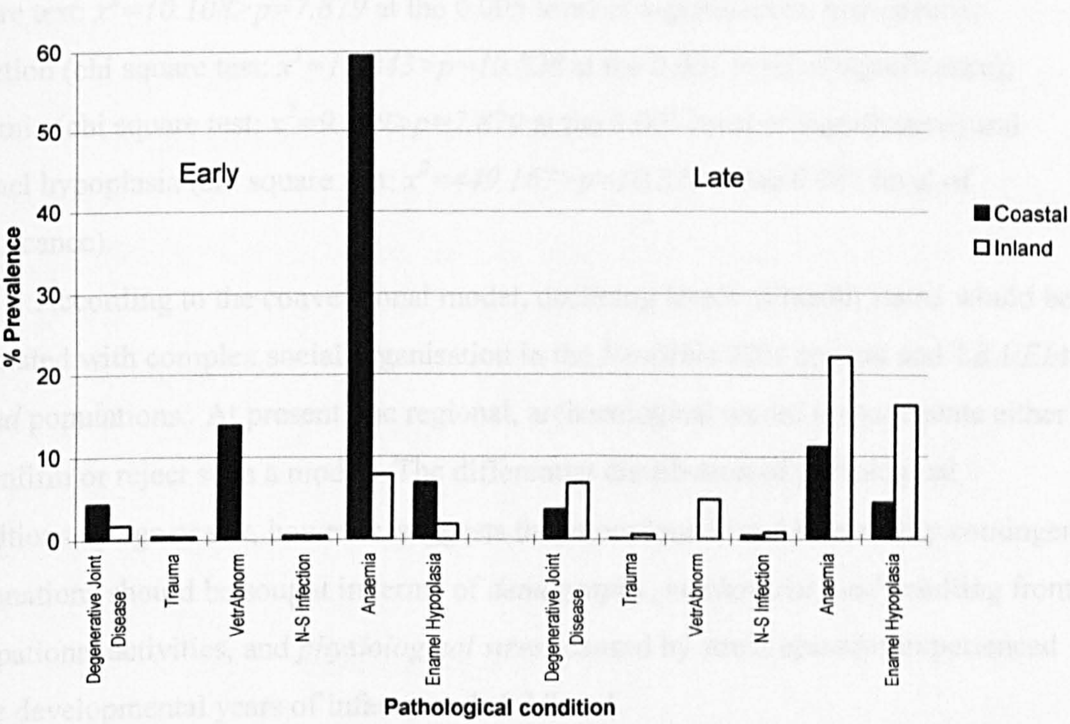


Figure 6.54: Overall prevalence of pathological conditions in the case study populations (standardised rates).



$x^2=399.670>p=10.828$ at the 0.001 level of significance) but also for vertebral abnormalities (chi square test: $x^2=6.992>p=6.634$ at the 0.01 level of significance), which are more frequent in the early populations. Furthermore, Figure 6.54 indicates that the *early coastal assemblages* of EN Nea Nikomedeia, LN Makrigialos I and II [9] and EBA Makrigialos have higher rates of pathological conditions than the inland assemblages of EBA Koilada and Goules. These differences in the distribution of pathological conditions within the early populations are statistically significant for degenerative changes (chi square test: $x^2=122.979>p=10.828$ at the 0.001 level of significance), vertebral abnormalities (chi square test: $x^2=47.904>p=10.828$ at the 0.001 level of significance), anaemia (chi square test: $x^2=111.085>p=10.828$ at the 0.001 level of significance) and enamel hypoplasia ($x^2=201.407>p=10.828$ at the 0.001 level of significance). *In the late periods*, the reverse relationship is revealed, with the *inland assemblages* of LBA Spathes, LBA/EIA Treis Elies and the EIA Olympus tumuli having higher rates of pathological defects than the coastal assemblages of EBA/LBA Korinos and EIA Makrigialos. The differences between inland and coastal assemblages are statistically significant in all pathological conditions: degenerative changes (chi square test: $x^2=107.617>p=10.828$ at the 0.001 level of significance), trauma (chi square test: $x^2=36.682>p=10.828$ at the 0.001 level of significance), vertebral abnormalities (chi square test: $x^2=10.108>p=7.879$ at the 0.005 level of significance), non-specific infection (chi square test: $x^2=11.843>p=10.828$ at the 0.001 level of significance), anaemia (chi square test: $x^2=9.739>p=7.879$ at the 0.005 level of significance) and enamel hypoplasia (chi square test: $x^2=449.167>p=10.828$ at the 0.001 level of significance).

According to the conventional model, declining levels of health status would be associated with complex social organisation in the *Neolithic/EBA coastal* and *LBA/EIA inland* populations. At present, the regional, archaeological record is inadequate either to confirm or reject such a model. The differential distribution of pathological conditions by age or sex, however, suggests that more locally and historically contingent explanations should be sought in terms of *demography*, *mechanical load* resulting from occupational activities, and *physiological stress* caused by stress episodes experienced in the developmental years of infancy and childhood.

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9 The phase II Makrigialos assemblage has been accounted in the discussion of geographical and chronological grouping.

CHAPTER 7: DIETARY INDICATORS AND ORAL HEALTH STATUS

7.1. INTRODUCTION

The study of nutritional and dietary status, together with dietary reconstruction of past populations, has been an important field of investigation throughout the history of physical anthropology. There is a vast literature referring to the oral health status of skeletal remains at a regional and inter-regional level ranging from prehistory to modern times all over the world (Armelagos 1969; Frayer 1989; Greene 1972; Hodges 1989; Larsen 1984; Machiarelli 1989; Molnar and Molnar 1985; Powell 1985; Turner 1979; y'Edynak and Fleisch 1983). However, the major interest of anthropologists has focused on transitions in subsistence history, such as from foraging to farming, on the introduction of new foods, such as the adoption of maize in the New World, and on the development of new methods of food processing, such as the introduction of fire and cooking.

As already discussed in Chapter 6, anthropologists and archaeologists have drawn particular attention to the introduction of agriculture and its consequences for the oral health status of past human populations. It has been suggested that the adoption of agriculture led to a deterioration in the oral health status of human populations (Cohen and Armelagos 1984). As Cohen suggests (1977), early non-agricultural diets appear to have been high in minerals, protein, vitamins and trace nutrients but relatively low in starch. In the transition to agriculture, there was a growing emphasis on starchy, highly caloric food of high productivity and storability which would have increased the carrying capacity and allowed an increase in the size of the population. However, the Cohen and Armelagos model of decline in the oral health status of past human populations with the adoption and intensification of agriculture has been vigorously debated (Wood et al. 1992), since a number of factors affect oral health status other than dietary intake, such as genetic variability. In many regions of the world there is no evidence that the adoption and intensification of agriculture was associated with dramatic and rapid changes in dental health (Hodges 1989). It seems that each population responds biologically to its environment in a unique way which is determined by a combination of inter-population genetic variation, local ecological setting and the process of intensification (Lukacs and Minderman 1992). Another complicating factor is the collection, production or consumption of particular foods which may be associated with the emergence and development of social ranking and social stratification (Wing and Brown 1979; Gilbert 1985; Hildebolt et al. 1988; 1989).

With regard to the contribution of physical anthropology, prehistoric diets can be assessed by macroscopic and chemical methods applied to the surviving tissues of the oral cavity, including the teeth and the bone supporting them (Lukacs 1989). Macroscopic methods refer to the recording and scoring of dental conditions, such as caries, calculus, antemortem tooth loss and periapical abscesses. Chemical methods, on the other hand, include a series of analytical techniques which seek to determine the chemical properties of the foods consumed during life. In addition to the study of skeletal remains, other evidence can also contribute to the dietary reconstruction of past human populations, such as direct remnants of food residues (seeds, animal bones, shells), artefacts related to food processing and consumption, and written literature and iconography, where this is available (Garnsey 1999).

In Northern Greece, in particular, as already discussed in Chapter 2, knowledge of subsistence practices and dietary intakes is very deficient and derives mainly from the archaeobotanical and archaozoological evidence of a few excavated prehistoric settlements. However, the relative dietary contributions of animals and plants cannot be accurately inferred from the existing data.

It has been argued, on indirect evidence that, domesticated seed crops of both cereals and pulses provided the bulk of dietary energy requirements in the Neolithic. Further diversity seems to have been introduced by the cultivation of new crops, including millet, walnut and chestnut in the Late Bronze Age (Halstead 1994: 200, 201). Similarly, domesticated animals such as sheep, goat, cow and pig are present from the Early Neolithic while the occurrence of wild species such as deer, boar, hare etc. increases from the Early Bronze Age onwards (Halstead 1987: 74). The evidence of mortality curves from the recovered animal bones shows that most animals, domestic and wild, were eaten, indicating, a broadly "meat" strategy (Halstead 1987). Furthermore, the contribution of marine food is quite dubious. There has been considerable debate as to its relative contribution to the overall dietary requirements of the prehistoric inhabitants of the coastal Aegean (Bintliff 1977; Gallant 1985). Artefacts related to fishing, and occasionally food remnants such as fish bones and shellfish testify to the occurrence of marine resource consumption. However, it is quite difficult to determine whether these resources constituted a basic component of the daily food intake of the case study prehistoric populations. Instead, it is possible that, as has been argued for classical antiquity, from close examination of ancient fishing techniques and modern fish catches, "the role of fishing in the diet and economy would have been on the whole, subordinate and supplementary" (Gallant 1985: 43).

This chapter attempts, first, to assess the oral health status of the case study prehistoric populations and, secondly, to advance existing knowledge of their diet. The argument will focus on two main bodies of evidence.

- The distribution of dental disease as evidenced by the *macroscopic examination* of teeth and bone supporting them. One aim of this analysis will be to associate patterns of dental disease and diet with population subgroups defined by age and sex.
- The results of a pilot *stable isotope analysis* of selected samples from various sites in the case study area.

7.2. DENTAL PALAEOPATHOLOGY

7.2.1. METHODOLOGY

The dental sample on which this analysis has been based consists of 4027 permanent and deciduous teeth recovered from the case study skeletal assemblages. Similarly to the skeletal palaeopathology, the methodological standards applied have been determined by two factors:

1. the differential preservation of the skeletal material and the poor condition of dental arcades, and
2. the differential demographic structure of the case study cemetery populations.

First, the *tooth count method* (Lukacs 1992) has been adopted in order to overcome the constraints of differential preservation varying between skeletal populations. The primary advantage of the tooth count recording system is that it can be applied to loose teeth and so is not affected by the preservation of the attached bone tissue. Also, this method maximises sample size and thus the statistical reliability of the results obtained. The major disadvantage of the method is that it considers dental lesions occurring in the same mouth as independent events, even though more than one tooth in the same dentition is very likely to show the same dental lesion (Mays 1998:148). Secondly, the differential demographic picture of the case study assemblages has been overcome by standardising the crude prevalences of the dental lesions as already described in detail in the methodology section of Chapter 6. The crude rates of occurrence of dental disease have thus been weighted with reference to a standard population which is the overall total of teeth classified by age and sex groups separately.

Dental lesions investigated include antemortem tooth loss, caries, calculus and periapical abscesses. Until very recently there was a lack of standardised methods and techniques for the recording of palaeopathological conditions including dental lesions, preventing the accurate comparison of dental disease between skeletal populations. Systematic discussion of dental disease together with standards of recording are usually absent from basic human osteology books, with the exception of Brothwell's *Digging up bones* (1981) where standardised scales of dental lesions are established. Also, Lukacs (1989), Hillson (1979; 1996) and, more recently, Larsen (1997) have provided well referenced reviews of methods for the recording and description of dental disease, while the recently edited *Standards for data collection from human skeletal remains* (Buikstra and Ubelaker 1994) has established a benchmark for the systematic standardised description of pathological conditions applied to human skeletal databases.

7.2.2. CARIES

7.2.2.1. INTRODUCTION

Dental caries is a disease process characterised by the focal demineralisation of dental hard tissues by organic acids produced by bacterial fermentation of dietary carbohydrates, especially sugars (Lukacs 1989; Larsen et al. 1991; Larsen 1997). Carbohydrates that support oral flora are metabolised differentially according to their molecular weights. Therefore, the cariogenicity of a particular diet is largely determined by the proportion of readily metabolised carbohydrates that it contains (Powell 1985: 314). Bacterial breakdown of carbohydrate food residues present in the mouth produces the acids responsible for caries cavities. Fats, oils and meats (including fish) are non-cariogenic, and protein residues in the mouth may actually inhibit the growth of the microorganisms responsible for dental caries (Mays 1998: 149).

There are a number of factors involved in the development of cariotic lesions, such as the exposure of tooth surfaces to the oral environment, the presence of dental plaque, and diet. In addition to the above essential factors, other important influences on the development, location and severity of the disease include tooth crown size and morphology, enamel defects, occlusal attrition, food texture, oral and plaque pH, speed of food consumption, some systemic diseases, age, heredity, salivary composition and flow, nutrition, periodontal disease, enamel elemental composition, presence of fluoride and other geochemical factors, and dental hygiene practices (Larsen 1983: 2; Molnar and Molnar 1985; Powell 1985: 314-316; Meiklejohn et al. 1988: 276; Larsen et al. 1991: 179; Larsen 1997: 65).

Caries appear in archaeological specimens in a variety of forms and range in ascending order of size and severity of the lesion, from dark eroded regions of the tooth enamel to irregularly walled cavities penetrating the surface enamel (Figures 7.1 and 7.2) (Lukacs 1989: 267; Buikstra and Ubelaker 1994: 54, 55).

A large number of studies has investigated the prevalence of caries and its association with dietary changes in archaeological samples. Various workers have documented a trend to increased dental decay with the introduction of carbohydrates in general and refined sugar in particular (Larsen et al. 1991: 180). Recent surveys of a large number of archaeological and anthropological populations (Turner 1979; Turner and Machado 1983) conclude that agriculturalists generally display far more carious teeth than do non-agriculturalists, perhaps because hunter-gatherers rely more on the consumption of animal protein (Costa 1980; Larsen 1997), or those of mixed economies (Powell 1985: 320; Walker and Erlandson 1986). In the New World, a high prevalence of caries is often associated with the introduction of maize as a substantial dietary component (Larsen 1983), while, in the Old World, the introduction and intensification of agriculture is associated with an increasing development of cariotic lesions (Brinch and Møller-Christensen 1949; Cohen and Armelagos 1984; Meiklejohn et al. 1984; Meiklejohn and Zvelebil 1991).

Furthermore, dental caries and dental calculus tend to be mutually exclusive so that, when recorded, they should provide good indicators of the protein versus carbohydrate content of the diet (Hillson 1979: 150). At this point it is important to note that both conditions may be seen in the same mouth, where arrested carious lesions in crown fissures are often covered with calculus. At a population level, however, there may be a slight inverse relationship between caries and calculus frequencies (Hillson 1996: 260).

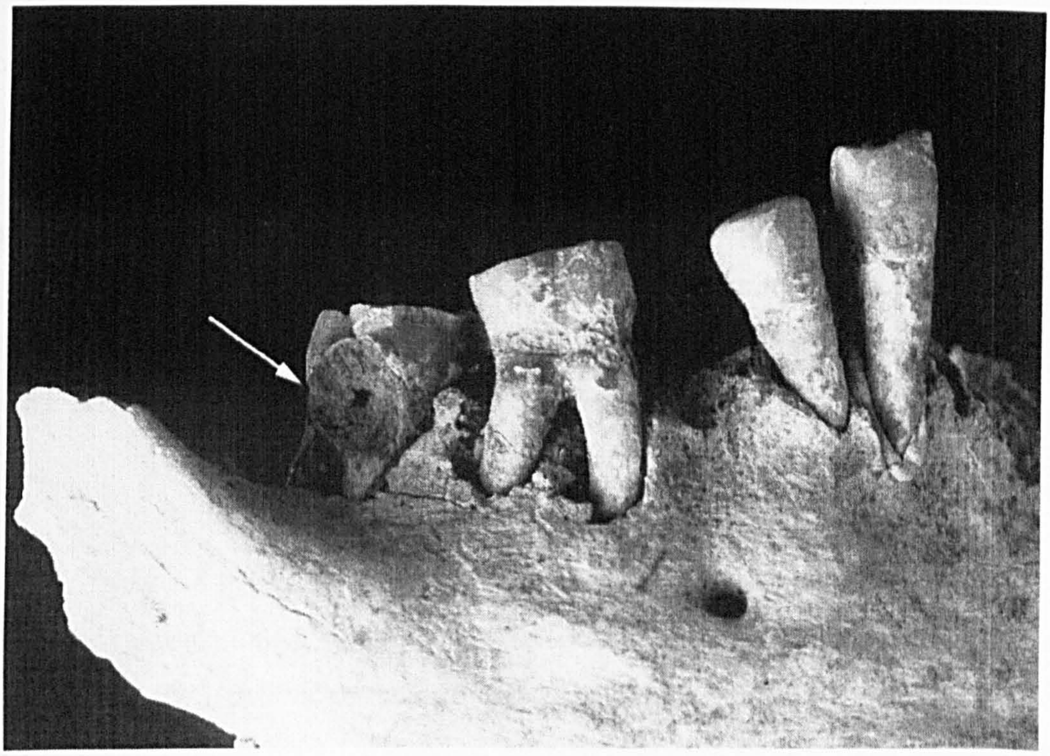


Figure 7.1: Severe caries on right mandibular molar (Makrigialos 19)

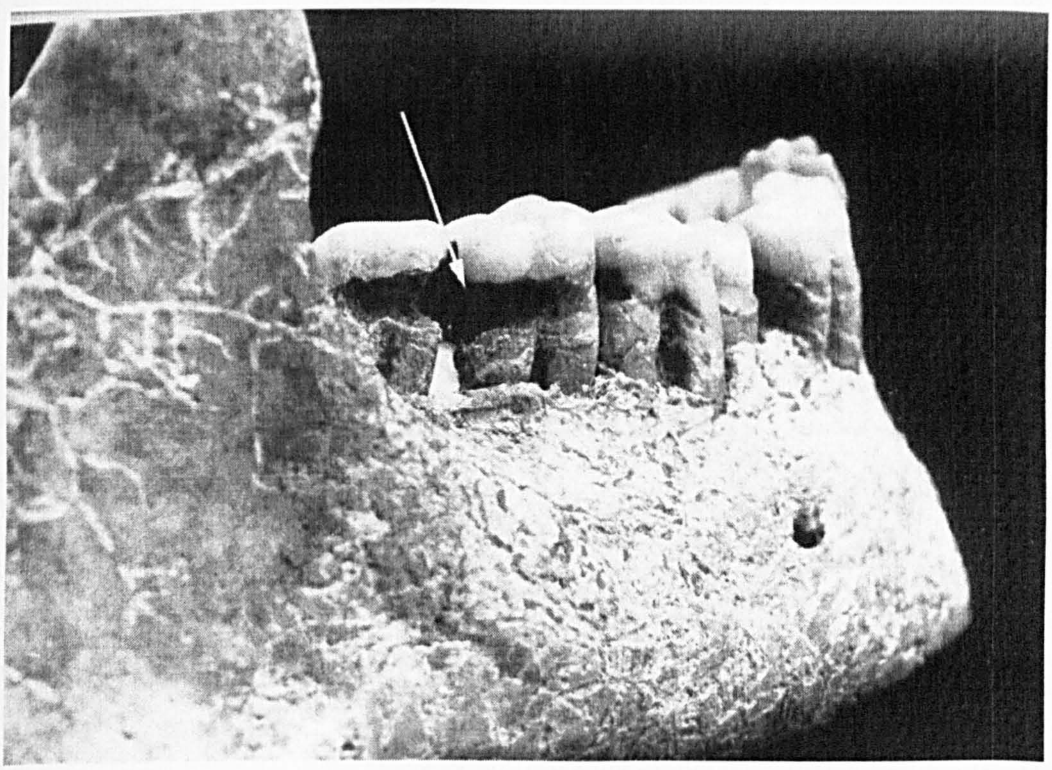


Figure 7.2: Severe caries on right mandibular molars (Makrigialos 260prim)

Diets that contain rough-textured foods and/or abrasive particles are less cariogenic than diets that are more refined in texture and contain soft, processed food (Powell 1985: 314). It is not always the case, however, that a high prevalence of caries is associated with domesticated plants. The consumption of sticky, high-carbohydrate, non-domesticated plants or fruits can result in extensive caries (Hartnady and Rose 1991). For example, the high prevalence of caries in Mesolithic sites of Portugal and Sicily has been attributed to the consumption of cariogenic non-agricultural foods or sweet sticky fruits such as figs (Lubell et al. 1994; Larsen 1997).

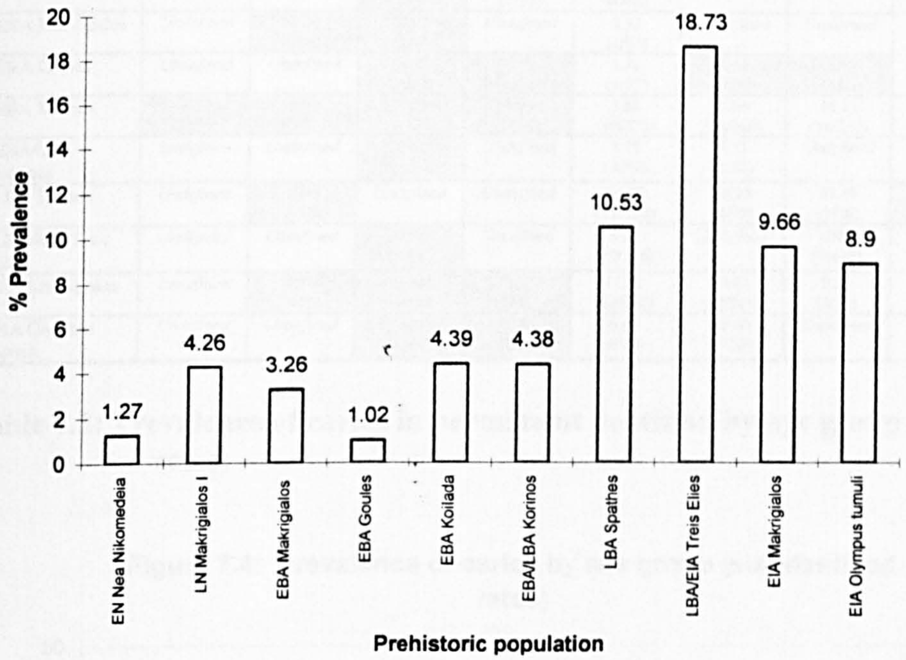
7.2.2.2. RESULTS

Table 7.1 and Figure 7.3 present the prevalence of caries in the case study prehistoric populations. An initial observation is the increasing development of carious lesions from the Neolithic to the Early Iron Age period. EN Nea Nikomedeia and EBA Goules have produced the lowest rates of caries, while the highest frequency occurs in LBA/EIA Treis Elies. The difference in the frequency of lesions between the cemeteries

Population	% (NIA/NIO)
EN Nea Nikomedeia	2.00 3/150
LN Makrigialos I	3.92 10/255
EBA Makrigialos	6.34 8/126
EBA Goules	1.35 3/222
EBA Koilada	5.51 71/1287
EBA/LBA Korinos	3.15 6/190
LBA Spathes	11.23 20/178
LBA/EIA Treis Elies	13.88 20/144
EIA Makrigialos	9.92 84/846
EIA Olympus tumuli	8.87 11/124

Table 7.1: Overall prevalence of caries in permanent dentition of the case study populations (raw data)

Figure 7.3: Prevalence of caries in the case study populations (standardised rates)



is statistically significant (chi square test: $x^2=1386.681> p=27.877$, at the 0.001 level of significance).

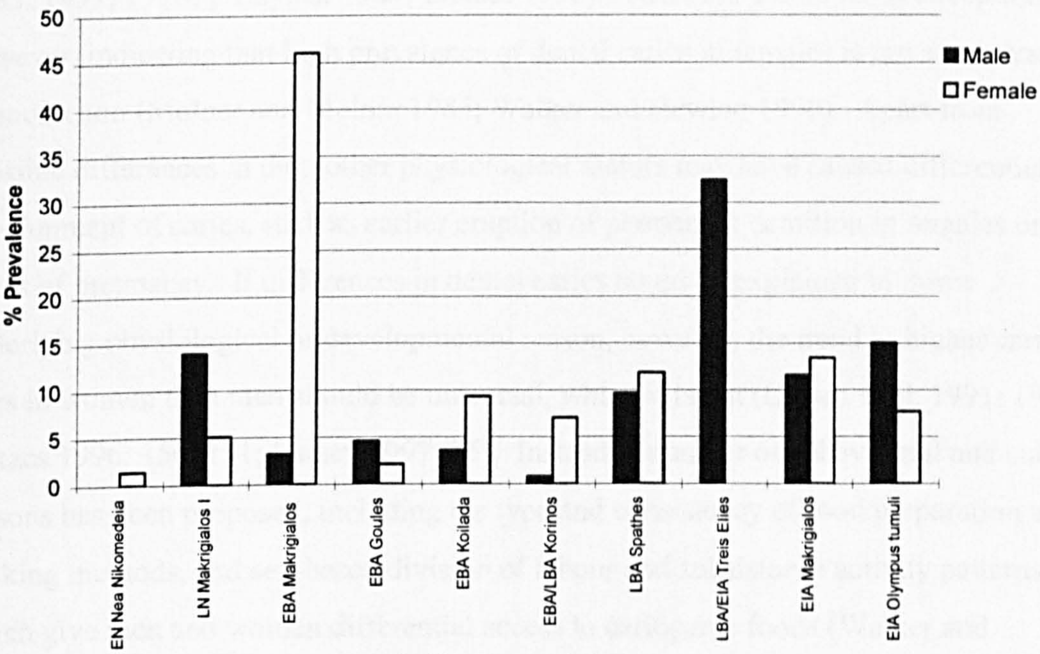
The overall distribution of caries by age group (Table 7.2) shows the expected picture of an age progressive condition, with increasing frequency of lesions during adulthood. The distribution of the cumulative frequencies of caries between age categories is only statistically significant at EBA Koilada (Kolmogorov-Smirnov test: $D_{maxobs}= 0.342>D_{max0.05}= 0.165$) and LBA/EIA Treis Elies (Kolmogorov-Smirnov test: $D_{maxobs}= 0.46>D_{max0.05}= 0.327$).

The standardised rates of carious lesions in the two sexes are presented in Figure 7.4. The difference between the sexes in the incidence of caries is statistically significant at EN Nea Nikomedeia (chi square test: $x^2=5.289> p=5.023$, at the 0.025 level of significance), LN Makrigialos I (chi square test: $x^2=44.374> p=10.828$, at the 0.001 level of significance), EBA Makrigialos (chi square test: $x^2=294.652> p=10.828$, at the 0.001 level of significance), EBA Goules (chi square test: $x^2=9.861> p=7.879$, at the 0.005 level of significance), EBA Koilada (chi square test: $x^2=31.570> p=10.828$, at the 0.001 level of significance), EBA/LBA Korinos (chi square test: $x^2=25.747> p=10.828$,

Population	Neonate % Crude (NIA[1]/NIO[2])	Infant % Crude (NIA/NIO)	Child % Crude (NIA/ NIO)	Juvenile % Crude (NIA/ NIO)	YA % Crude (NIA/ NIO)	PA % Crude (NIA/ NIO)	MA % Crude (NIA/ NIO)	OA % Crude (NIA/ NIO)	IndAdult % Crude (NIA/ NIO)
EN Nea Nikomedeia	*Undefined*	**0.00 (0/15)**	**0.00 (0/26)**	**0.00 (0/24)**	*Undefined*	**0.00 (0/61)**	12.50 (3/24)	*Undefined*	*Undefined*
LN Makrigialos I	*Undefined*	*Undefined*	**0.00 (0/16)**	3.44 (1/29)	6.06 (4/66)	*Undefined*	*Undefined*	*Undefined*	3.47 (5/144)
EBA Makrigialos	*Undefined*	**0.00 (0/6)**	**0.00 (0/6)**	*Undefined*	3.33 (1/30)	*Undefined*	*Undefined*	*Undefined*	8.33 (7/84)
EBA Goules	*Undefined*	*Undefined*	**0.00 (0/60)**	**0.00 (0/20)**	1.36 (1/73)	**0.00 (0/28)**	**0.00 (0/3)**	*Undefined*	5.26 (2/38)
EBA Koilada	**0.00 (0/7)**	**0.00 (0/77)**	**0.00 (0/156)**	**0.00 (0/161**	3.63 (10/275)	6.66 (24/360)	16.11 (34/211)	17.64 (3/14)	**0.00 (0/26)**
EBA/LBA Korinos	*Undefined*	*Undefined*	**0.00 (0/57)**	*Undefined*	3.19 (3/94)	8.33 (1/12)	*Undefined*	7.40 (2/27)	*Undefined*
LBA Spathes	*Undefined*	**0.00 (0/7)**	*Undefined*	*Undefined*	10.00 (11/110)	10.25 (4/39)	31.25 (5/16)	**0.00 (0/5)**	**0.00 (0/1)**
LBA/EIA Treis Elies	*Undefined*	*Undefined*	**0.00 (0/14)**	*Undefined*	8.62 (10/116)	*Undefined*	100.0 (10/10)	*Undefined*	**0.00 (0/4)**
EIA Makrigialos	*Undefined*	**0.00 (0/44)**	**0.00 (0/35)**	**0.00 (0/81)**	11.11 (42/378)	14.61 (32/219)	9.25 (5/54)	7.14 (1/14)	19.04 (4/21)
EIA Olympus tumuli	*Undefined*	*Undefined*	**0.00 (0/6)**	**0.00 (0/1)**	6.66 (6/90)	25.00 (5/20)	*Undefined*	*Undefined*	**0.00 (0/7)**

Table 7.2: Prevalence of caries in permanent dentition by age group (crude rates)

Figure 7.4: Prevalence of caries by sex group (standardised rates)



at the 0.001 level of significance), LBA/EIA Treis Elies (chi square test: x^2=*437.382> p=10.828*, at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: x^2=*25.827> p=10.828*, at the 0.001 level of significance). These differences may reflect differential access by the two sex groups to cariogenic foodstuff. There is no consistent trend, however, as to whether males or females were more subject to caries.

[1] NIA: Number of Individuals Affected.
[2] NIO: Number of Individuals Observed.

7.2.2.3. CONCLUSIONS

The prevalence of caries varies between the case study cemetery populations. Overall, the early populations, of the Neolithic and Early Bronze Age, tend to have lower rates of carious lesions than their counterparts in the Late Bronze and Early Iron Ages. This may indicate that, contrary to arguments based on indirect archaeobotanical and archaeological evidence (e.g. Halstead 1994), the development of an overwhelmingly starch-based diet did not take place in Northern Greece until the end of the Bronze Age.

In addition, there is sex differentiation in the frequency of caries with the more severely affected sex varying from cemetery to cemetery. A wide range of studies on the differential development of dental disease between sex groups has revealed significantly higher caries rates in females than males worldwide, suggesting a diet richer in plant carbohydrates for women and in animal protein (meat) for men (Larsen 1983; 1997; 1998; y'Edynak 1989; Lukacs 1996). There are a number of exceptions, however, indicating that high prevalence of dental caries in females is not a universal phenomenon (Molnar and Molnar 1985; Walker and Hewlett 1990). Apart from possible differences in diet, other physiological factors may have caused differential development of caries, such as earlier eruption of permanent dentition in females or the stress of pregnancy. If differences in dental caries could be explained by some underlying physiological or developmental reason, however, the trend to higher caries rates in women than men should be universal, which it is not (Larsen et al. 1991: 194; Lukacs 1996: 150, 151; Larsen 1997: 75). Instead, a number of behavioural and cultural reasons has been proposed, including the type and consistency of food preparation and cooking methods, and sex-based division of labour and subsistence activity patterns which give men and women differential access to cariogenic foods (Walker and Erlandson 1986: 380; Lukacs 1996: 151, 152).

7.2.3. CALCULUS

7.2.3.1. INTRODUCTION

Dental calculus is the mineralisation of bacterial plaque. It accumulates at the base of a living plaque deposit and is attached to the surface of the tooth (Figures 7.5,

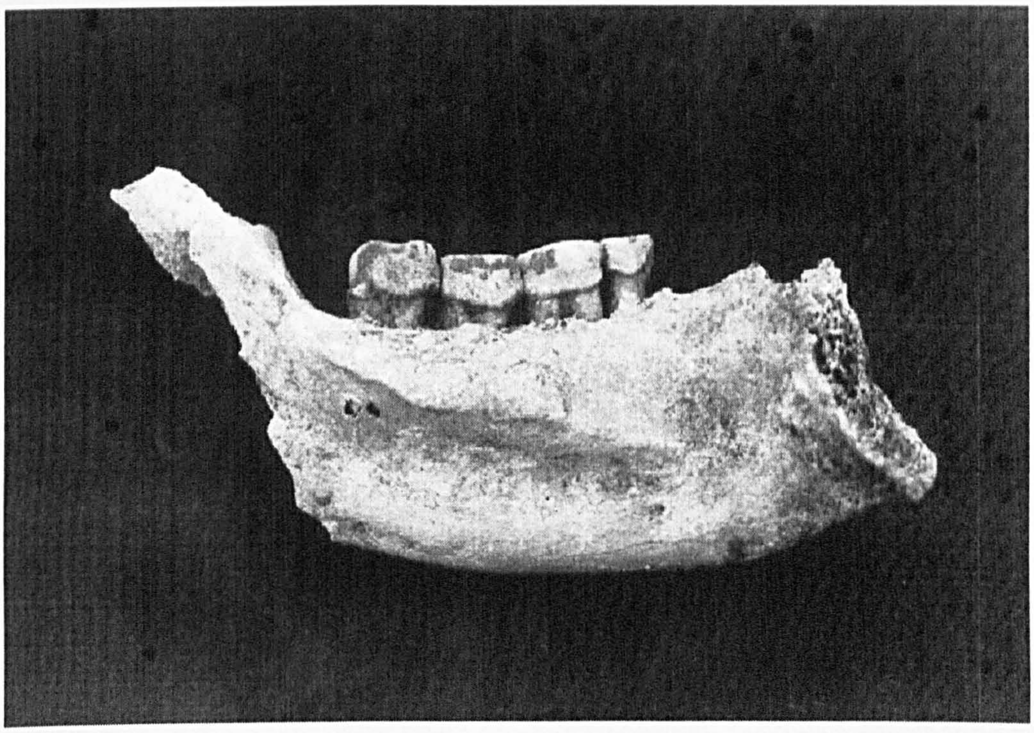


Figure 7.5: Moderate calculus deposits on the lingual surface of posterior mandibular teeth (Koilada Lith10)

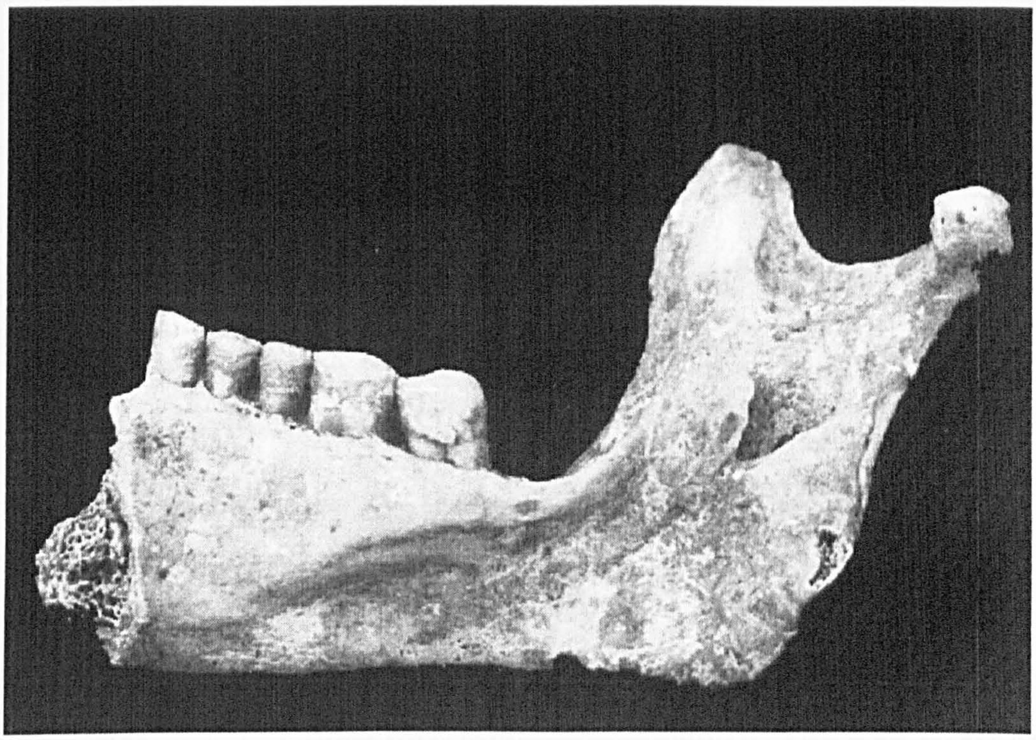


Figure 7.6: Moderate to slight calculus deposits on the lingual surface of posterior mandibular teeth (Koilada Lith21)

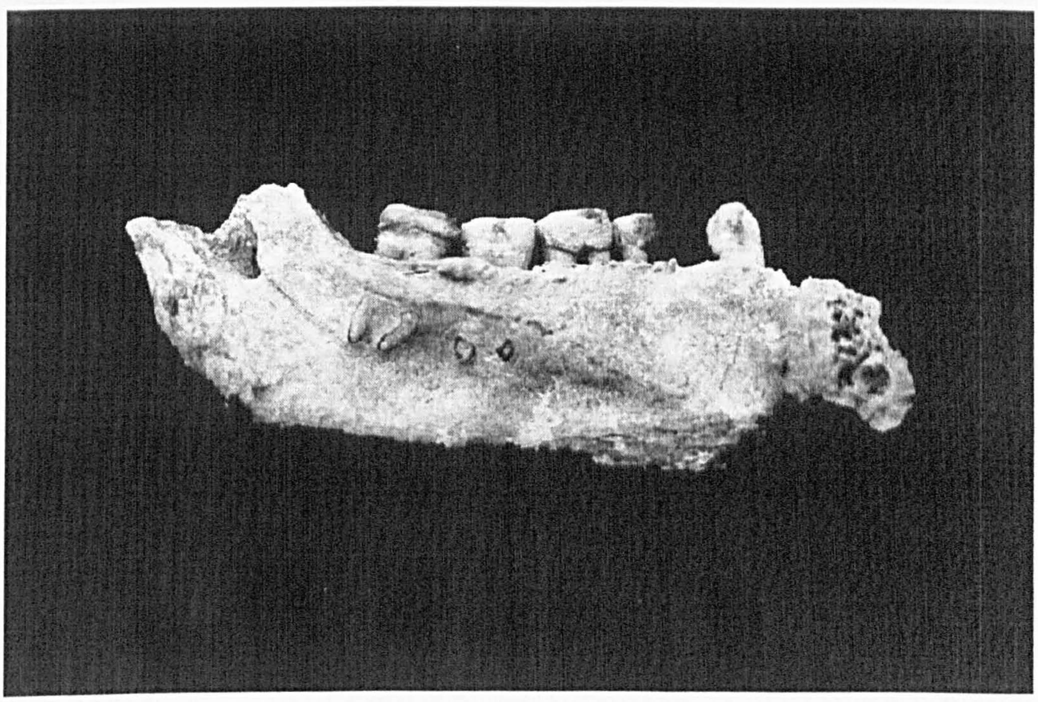


Figure 7.7: Moderate to heavy calculus deposits on the lingual surface of posterior mandibular teeth (Koilada Lith19)

7.6 and 7.7) (Lukacs 1989: 267; Hillson 1996: 255). Rates of calculus accumulation are difficult to estimate accurately since many deposits suffer postmortem loss (Buikstra and Ubelaker 1994: 56). Factors that lead to calculus formation relate to those variables which can affect plaque accumulation such as poor oral hygiene or carbohydrate consumption (Hillson 1996: 259). The inter-relationship between caries and calculus rates has already been explained along with the implications for dietary intake at a population level.

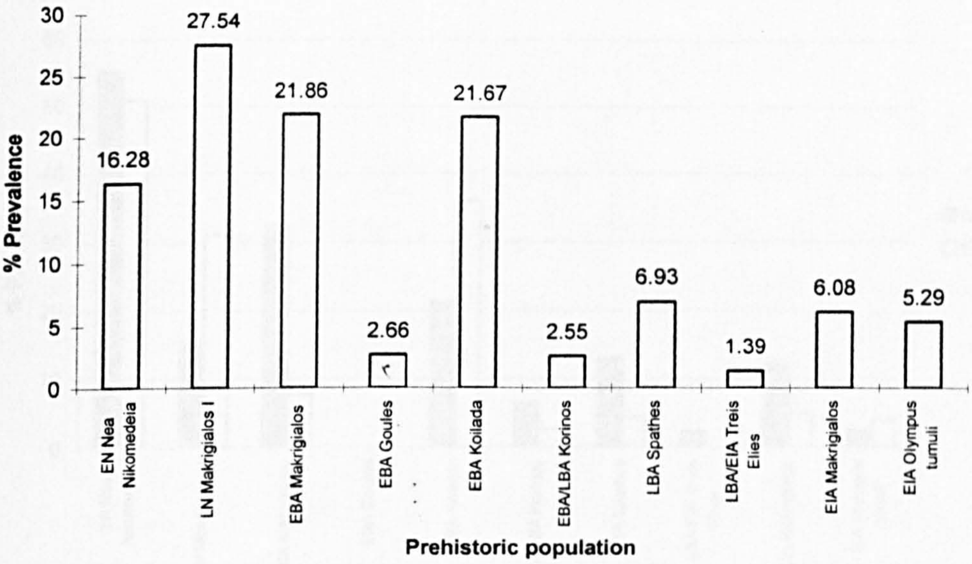
7.2.3.2. RESULTS

The prevalence of calculus in the case study prehistoric cemetery populations (Table 7.3, Figure 7.8) reveals an interesting pattern. In contrast to the caries rates which were significantly higher in the later periods, calculus deposits are more frequent in the early populations of the Neolithic assemblages and EBA Koilada. The differences in the prevalence of the condition in the cemetery populations are statistically significant (chi square test: $x^2=3111.40> p=27.877$, at the 0.001 level of significance).

Population	% (NIA/NIO)
EN Nea Nikomedeia	27.33 41/150
LN Makrigialos I	21.17 54/255
EBA Makrigialos	23.80 30/126
EBA Goules	2.70 6/222
EBA Koilada	22.22 286/1287
EBA/LBA Korinos	9.47 18/190
LBA Spathes	7.86 15/178
LBA/EIA Treis Elies	2.08 3/144
EIA Makrigialos	6.97 59/846
EIA Olympus tumuli	2.41 3/124

Table 7.3: Overall prevalence of calculus in permanent dentition of the case study populations (raw data)

Figure 7.8: Prevalence of calculus in the case study populations (standardised rates)

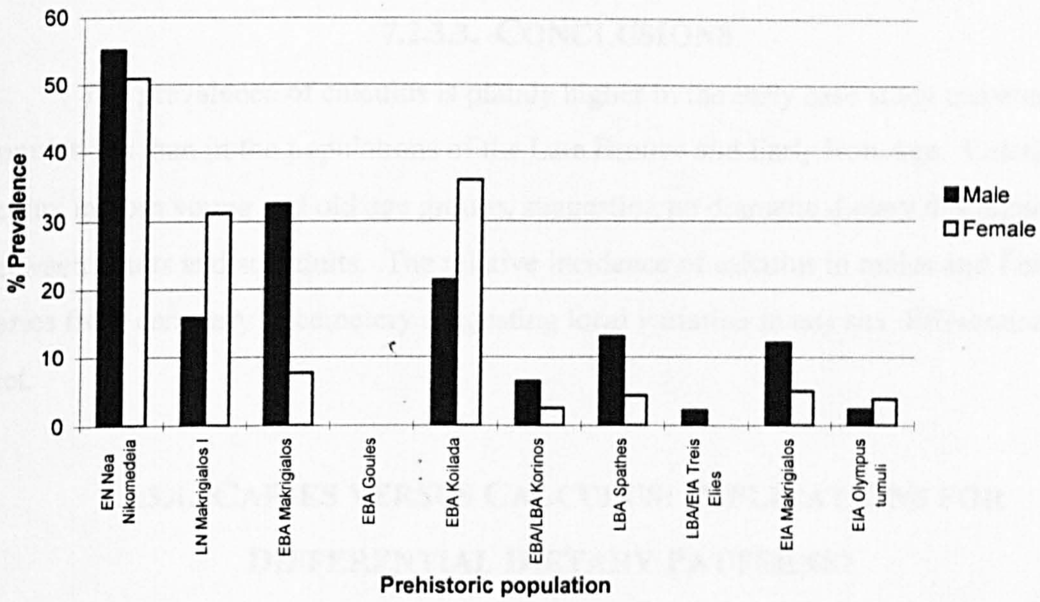


Population	Neonate *% Crude (NIA/ NIO)*	Infant *% Crude (NIA/ NIO)*	Child *% Crude (NIA/ NIO)*	Juvenile *% Crude (NIA/ NIO)*	YA *% Crude (NIA/ NIO)*	PA *% Crude (NIA/ NIO)*	MA *% Crude (NIA/ NIO)*	OA *% Crude (NIA/ NIO)*	IndAdult *% Crude (NIA/ NIO)*
EN Nea Nikomedeia	*Undefined*	0.00 (0/15)	0.00 (0/26)	0.00 (0/24)	*Undefined*	52.45 (32/61)	37.50 (9/24)	*Undefined*	*Undefined*
LN Makrigialos I	*Undefined*	*Undefined*	0.00 (0/16)	24.13 (7/29)	40.90 (27/66)	*Undefined*	*Undefined*	*Undefined*	13.88 (20/144)
EBA Makrigialos	*Undefined*	0.00 (0/6)	0.00 (0/6)	*Undefined*	30.00 (9/30)	*Undefined*	*Undefined*	*Undefined*	25.00 (21/84)
EBA Goules	*Undefined*	*Undefined*	0.00 (0/60)	25.00 (5/20)	0.00 (0/73)	0.00 (0/28)	0.00 (0/3)	*Undefined*	2.63 (1/38)
EBA Koilada	0.00 (0/7)	0.00 (0/77)	6.41 (10/156)	5.59 (9/161)	24.00 (66/275)	39.16 (141/360)	26.54 (56/211)	0.00 (0/14)	15.38 (4/26)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/57)	*Undefined*	2.12 (2/94)	0.00 (0/12)	*Undefined*	59.25 (16/27)	*Undefined*
LBA Spathes	*Undefined*	0.00 (0/7)	*Undefined*	*Undefined*	8.18 (9/110)	10.25 (4/39)	6.25 (1/16)	0.00 (0/5)	0.00 (0/1)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/14)	*Undefined*	2.58 (3/116)	*Undefined*	0.00 (0/10)	*Undefined*	0.00 (0/4)
EIA Makrigialos	*Undefined*	0.00 (0/44)	0.00 (0/35)	11.11 (9/81)	4.49 (17/378)	12.32 (27/219)	9.25 (5/54)	7.14 (1/14)	0.00 (0/21)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/6)	0.00 (0/1)	10.00 (2/90)	5.00 (1/20)	*Undefined*	*Undefined*	0.00 (0/7)

Table 7.4: Prevalence of calculus in permanent dentition by age group (crude rates)

With regard to the distribution of the condition by age groups (Table 7.4), it is interesting to note the prevalence of calculus deposits in subadult and young age categories. Calculus deposits have been recorded on the permanent dentition of

Figure 7.9: Prevalence of calculus by sex group (standardised rates)



children in EBA Koilada and *juveniles* in LN Makrigialos I, EBA Goules, EBA Koilada and EIA Makrigialos. The condition has also been observed on the deciduous dentition of *infants* in EN Nea Nikomedeia (5/75, 7%) and *children* in EBA Koilada (6/26, 23%). The distribution of the cumulative frequencies of calculus between age categories is statistically significant at EBA Koilada (Kolmogorov-Smirnov test: $D_{maxobs}= 0.312 > D_{max0.05}= 0.091$), EBA/LBA Korinos (Kolmogorov-Smirnov test: $D_{maxobs}= 0.81 > D_{max0.05}= 0.336$) and EIA Makrigialos (Kolmogorov-Smirnov test: $D_{maxobs}= 0.19 > D_{max0.05}= 0.183$).

Considering now the distribution of calculus formation between sex groups (Figure 7.9), most skeletal assemblages have revealed higher calculus rates in males. The higher incidence of calculus in men is statistically significant at EBA Makrigialos (chi square test: $x^2=40.014 > p=10.828$, at the 0.001 level of significance), EBA/LBA Korinos (chi square test: $x^2=14.153 > p=10.828$, at the 0.001 level of significance), LBA Spathes (chi square test: $x^2=40.160 > p=10.828$, at the 0.001 level of significance), LBA/EIA Treis Elies (chi square test: $x^2=18.157 > p=10.828$, at the 0.001 level of significance) and EIA Makrigialos (chi square test: $x^2=42.314 > p=10.828$, at the 0.001 level of significance). Conversely, women have significantly higher rates of calculus at LN Makrigialos I (chi square test: $x^2=99.167 > p=10.828$, at the 0.001 level of significance) and EBA Koilada (chi square test: x^2=*129.942> p=10.828*, at the 0.001 level of significance).

7.2.3.3. CONCLUSIONS

The prevalence of calculus is plainly higher in the early case study cemetery populations than in the populations of the Late Bronze and Early Iron Age. Calculus occurs in both young and old age groups, suggesting no dramatic dietary discrepancies between adults and subadults. The relative incidence of calculus in males and females varies from cemetery to cemetery suggesting local variation in any sex differentiation in diet.

7.2.3.4. CARIES VERSUS CALCULUS: IMPLICATIONS FOR DIFFERENTIAL DIETARY PATTERNS?

One of the intriguing topics in the investigation of dietary patterns is the interaction between caries and calculus. The two conditions tend to be mutually exclusive due to the mechanisms which produce them in the mouth. Caries is related to dietary carbohydrate levels which also affect plaque pH levels and increase acidity to the point at which tooth enamel dissolves. Dietary protein, conversely, results in increased alkalinity of plaque, deposition of mineral materials from the saliva and the development of calculus (Hillson 1979; 1996; Meiklejohn et al. 1988; Frayer 1989). Therefore, at a population level, high caries versus low calculus rates suggest a diet rich in carbohydrates, while the opposite relationship suggests a high level of animal protein, and in particular meat, consumption.

In the case study cemetery populations (Figure 7.10), the early assemblages tend to have high calculus and low caries rates, whereas the late populations show the reverse pattern suggesting that the early populations consumed high levels of meat, while the diet of the late populations was richer in carbohydrates. The difference in the prevalence of the two conditions in each cemetery is statistically significant at EN Nea Nikomedeia (chi square test: x^2=*522.424> p=10.828*, at the 0.001 level of significance), LN Makrigialos I (chi square test: x^2=*686.206> p=10.828*, at the 0.001 level of significance), EBA Makrigialos (chi square test: x^2=*448.172> p=10.828*, at the 0.001

Figure 7.10: Prevalence of caries versus calculus in the case study populations (standardised rates)

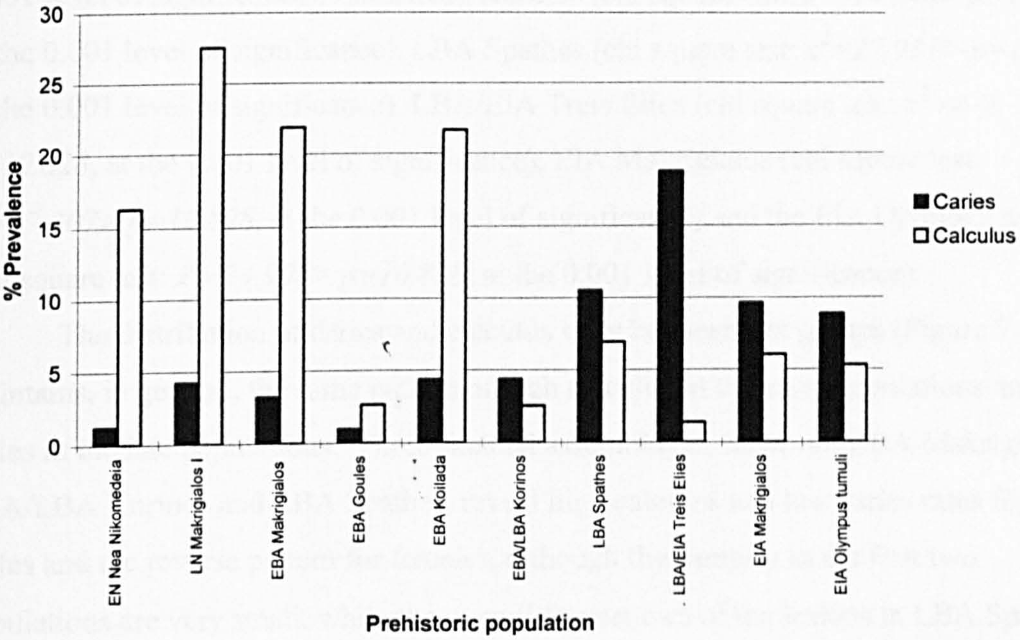
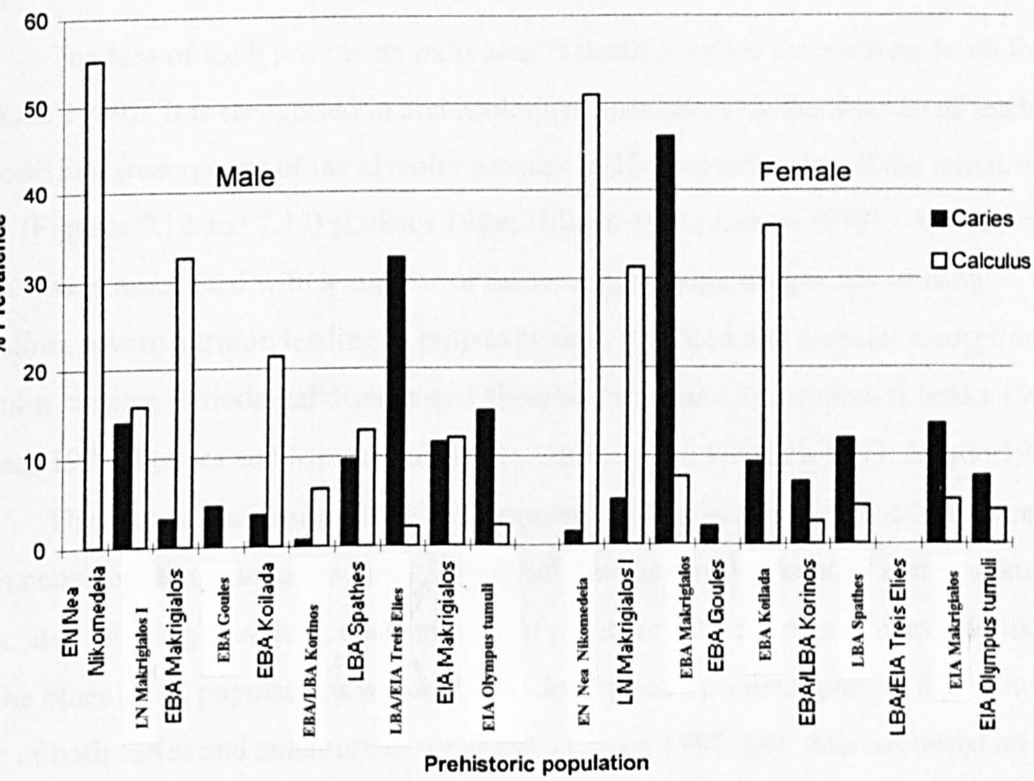


Figure 7.11: Prevalence of caries versus calculus by sex group (standardised rates)



level of significance), EBA Goules (chi square test: $x^2=26.017> p=10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2=638.002> p=10.828$, at the 0.001 level of significance), EBA/LBA Korinos (chi square test: $x^2=14.948> p=10.828$, at the 0.001 level of significance), LBA Spathes (chi square test: $x^2=27.931> p=10.828$, at the 0.001 level of significance), LBA/EIA Treis Elies (chi square test: $x^2=476.747> p=10.828$, at the 0.001 level of significance), EIA Makrigialos (chi square test: $x^2=37.307> p=10.828$, at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: $x^2=34.908> p=10.828$, at the 0.001 level of significance).

The distribution of caries and calculus rates between sex groups (Figure 7.11) maintains, in general, the same pattern of high calculus in the early populations and high caries in the late populations. Three skeletal assemblages, however, EBA Makrigialos, EBA/LBA Korinos and LBA Spathes, reveal high calculus and low caries rates for males and the reverse pattern for females, although the samples in the first two populations are very small, while the overall frequencies of the lesions in LBA Spathes are very low.

7.2.4. ANTEMORTEM TOOTH LOSS

7.2.4.1. INTRODUCTION

The loss of teeth prior to an individual's death is called antemortem tooth loss (Lukacs 1989). It is recognised in archaeological specimens by the absence of teeth, the remodelling (resorption) of the alveolar process and by repositioning of the remaining teeth (Figures 7.12 and 7.13) (Lukacs 1989; Hillson 1996; Larsen 1997). Antemortem tooth loss is associated with a number of factors, including cariogenesis causing infection, severe attrition leading to pulp exposure, infection and alveolar resorption and calculus causing periodontal disease and alveolar resorption and trauma (Lucaks 1989; Lukacs 1992; Lukacs and Minderman 1992; Littleton and Frohlich 1993; Larsen 1997).

The presence of caries in skeletal populations and antemortem tooth loss are often considered interacting factors. The simultaneous development of both lesions is associated with high levels of consumption of plant carbohydrates or processed foods. On the other hand, populations whose diet is dominated by animal protein have low rates of both caries and antemortem tooth loss (Larsen 1997: 80). Studies based on detailed recording of the lesions, including patterns of distribution in the mouth by tooth

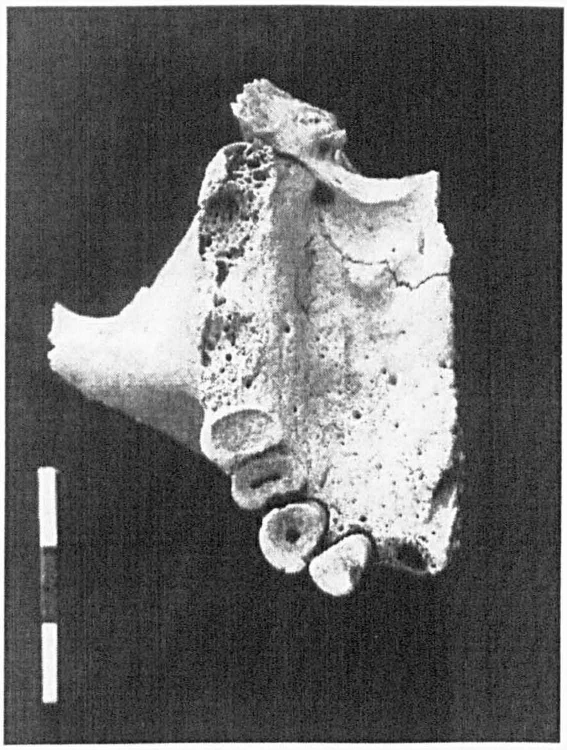


Figure 7.12: Antemortem tooth loss on left posterior maxillary dentition (Makrigialos 260prim)

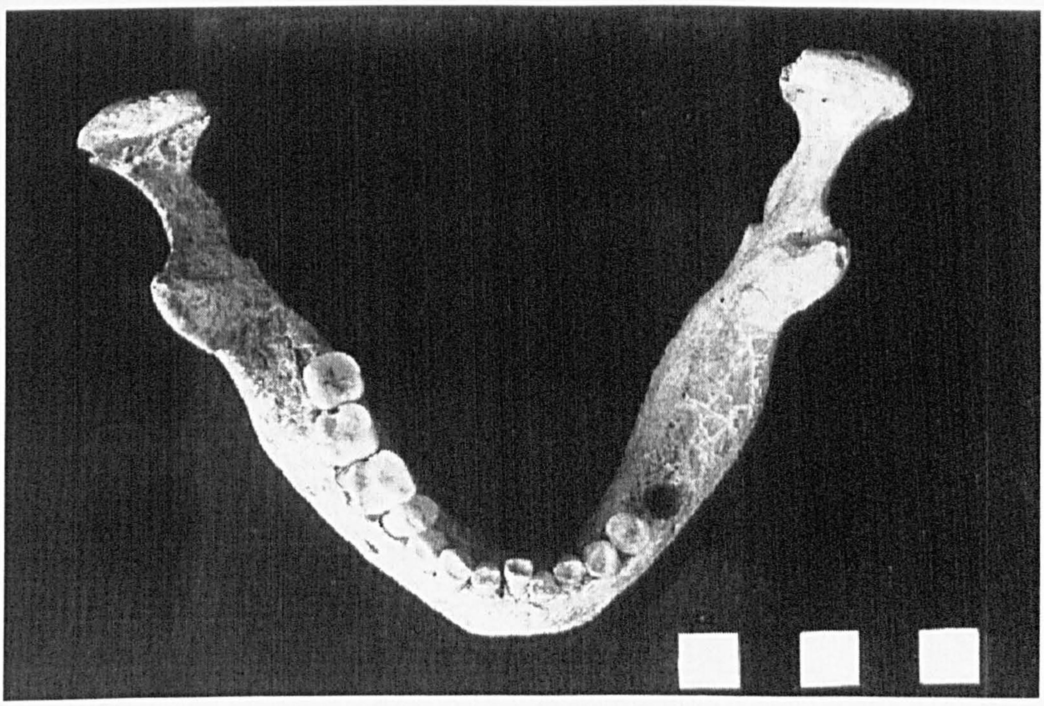


Figure 7.13: Antemortem tooth loss on left posterior mandibular dentition (Makrigialos 260prim)

class, posterior teeth again being more susceptible, contribute significantly to the investigation of their aetiology in large skeletal populations (Hillson 1996: 265). Modern studies suggest that the increased caries rates observed in a shift from foraging to farming also led to high levels of tooth loss prior to death (Cassidy 1984; Cook 1984; Larsen 1997).

The occurrence of antemortem tooth loss in the case study prehistoric cemeteries has been calculated as the number of teeth lost prior to death divided by the total number of teeth considered to have been initially present during life in the dental arcades preserved, that is the teeth still present plus the total lost antemortem (Lukacs 1992: 138).

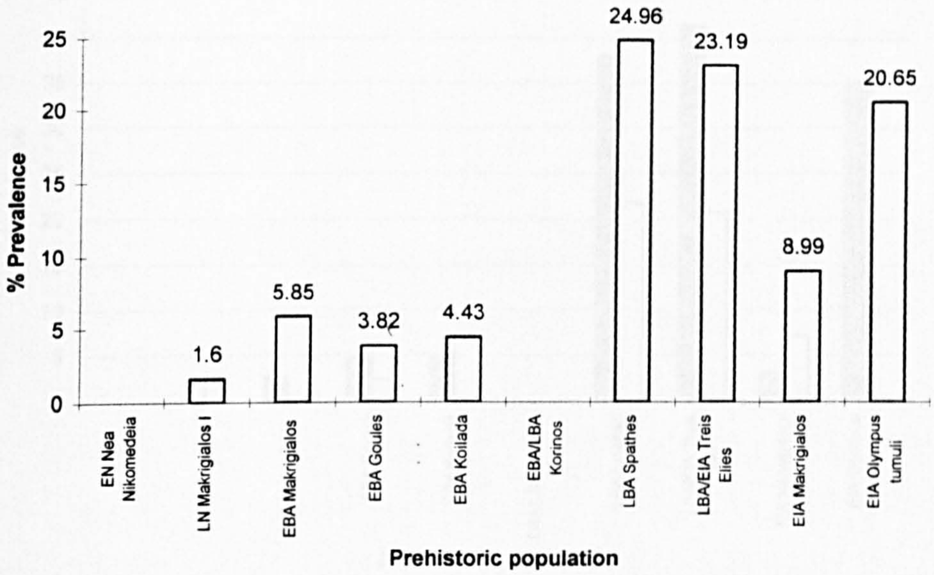
7.2.4.2. RESULTS

Antemortem tooth loss in the case study cemetery populations (Table 7.5, Figure 7.14) is highest in the Late Bronze and Early Iron Age. Rates are lower in the early populations, two of which, EN Nea Nikomedeia and EBA/LBA Korinos, have no

Population	% (NIA/NIO)
EN Nea Nikomedeia	0.00 0/150
LN Makrigialos I	1.27 2/157
EBA Makrigialos	0.78 1/127
EBA Goules	4.32 10/232
EBA Koilada	5.15 70/1357
EBA/LBA Korinos	0.00 0/190
LBA Spathes	26.14 63/241
LBA/EIA Treis Elies	37.66 87/231
EIA Makrigialos	6.20 56/902
EIA Olympus tumuli	12.05 17/141

Table 7.5: Overall prevalence of antemortem tooth loss in permanent dentition of the case study populations (raw data)

Figure 7.14: Prevalence of antemortem tooth loss in the case study populations (standardised rates)

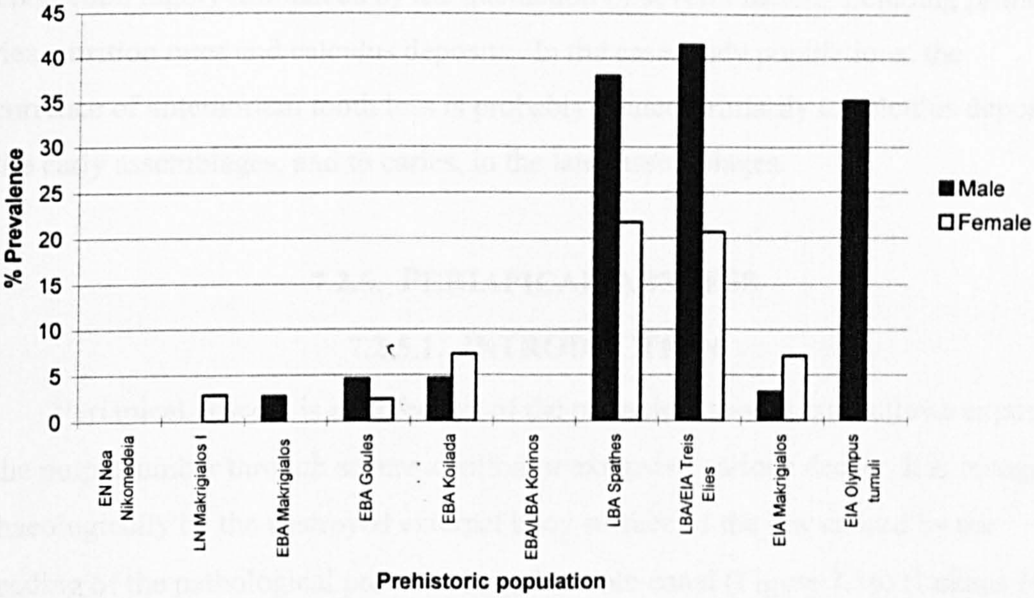


Population	Neonate *% Crude (NIA/ NIO)*	Infant *% Crude (NIA/ NIO)*	Child *% Crude (NIA/ NIO)*	Juvenile *% Crude (NIA/ NIO)*	YA *% Crude (NIA/ NIO)*	PA *% Crude (NIA/ NIO)*	MA *% Crude (NIA/ NIO)*	OA *% Crude (NIA/ NIO)*	IndAdult *% Crude (NIA/ NIO)*
EN Nea Nikomedeia	*Undefined*	**0.00 (0/15)**	0.00 (0/26)	**0.00 (0/24)**	*Undefined*	**0.00 (0/61)**	**0.00 (0/24)**	*Undefined*	*Undefined*
LN Makrigialos I	*Undefined*	*Undefined*	0.00 (0/16)	0.00 (0/29)	2.94 (2/68)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/144)
EBA Makrigialos	*Undefined*	**0.00 (0/6)**	0.00 (0/6)	*Undefined*	3.22 (1/31)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/84)
EBA Goules	*Undefined*	*Undefined*	0.00 (0/60)	0.00 (0/20)	2.66 (2/75)	6.66 (2/30)	0.00 (0/3)	*Undefined*	13.63 (6/44)
EBA Koilada	0.00 (0/7)	0.00 (0/77)	0.00 (0/156)	0.00 (0/161	2.13 (6/281)	5.26 (20/380)	10.97 (26/237)	56.25 (18/32)	0.00 (0/26)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/57)	*Undefined*	**0.00 (0/94)**	**0.00 (0/12)**	*Undefined*	**0.00 (0/27)**	*Undefined*
LBA Spathes	*Undefined*	**0.00 (0/7)**	*Undefined*	*Undefined*	13.38 (17/127)	23.52 (12/51)	30.43 (7/23)	75.00 (15/20)	92.30 (12/13)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/14)	*Undefined*	15.32 (21/137)	*Undefined*	86.84 (66/76)	*Undefined*	0.00 (0/4)
EIA Makrigialos	*Undefined*	0.00 (0/44)	0.00 (0/35)	0.00 (0/81)	3.81 (15/393)	3.09 (7/226)	20.58 (14/68)	17.64 (3/17)	44.73 (17/38)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/6)	0.00 (0/1)	3.22 (3/93)	33.33 (10/30)	100.0 (4/4)	*Undefined*	0.00 (0/7)

Table 7.6: Prevalence of antemortem tooth loss in permanent dentition by age group (crude rates)

evidence of antemortem tooth loss. The differences in the occurrence of the condition between the case study assemblages are statistically significant (chi square test: x^2=*4189.707*> *p*=*27.877*, at the 0.001 level of significance).

Figure 7.15: Prevalence of antemortem tooth loss by sex group (standardised rates)



The distribution of antemortem tooth loss by age group (Table 7.6) conforms to the expected picture of an age progressive condition, with a steady increase of the disease from young to older age categories. The distribution of the cumulative frequencies of antemortem tooth loss between age categories is statistically significant at EBA Koilada (Kolmogorov-Smirnov test: $D_{maxobs}= 0.418 > D_{max0.05}= 0.166$), LBA Spathes (Kolmogorov-Smirnov test: $D_{maxobs}= 0.416 > D_{max0.05}= 0.199$), LBA/EIA Treis Elies (Kolmogorov-Smirnov test: $D_{maxobs}= 0.65 > D_{max0.05}= 0.184$), EIA Makrigialos (Kolmogorov-Smirnov test: $D_{maxobs}= 0.492 > D_{max0.05}= 0.187$) and the EIA Olympus tumuli (Kolmogorov-Smirnov test: $D_{maxobs}= 0.605 > D_{max0.05}= 0.351$).

Men in particular during later periods suffered significantly more antemortem tooth loss (Figure 7.15) at EBA Goules (chi square test: $x^2=7.760> p=6.643$, at the 0.010 level of significance), LBA Spathes (chi square test: $x^2=113.912> p=10.828$, at the 0.001 level of significance), LBA/EIA Treis Elies (chi square test: $x^2=207.275> p=10.828$, at the 0.001 level of significance) and the EIA Olympus tumuli (chi square test: $x^2=587.861> p=10.828$, at the 0.001 level of significance), while women suffered significantly higher levels of antemortem tooth loss at LN Makrigialos I (chi square test: $x^2=26.632> p=10.828$, at the 0.001 level of significance), EBA Koilada (chi square test: $x^2=8.054> p=7.879$, at the 0.005 level of significance) and EIA Makrigialos (chi square test: $x^2=587.861> p=10.823$, at the 0.001 level of significance).

7.2.4.3. CONCLUSIONS

The aetiology of antemortem tooth loss, as discussed earlier, is a complicated phenomenon highly influenced by the interaction of several factors including primarily caries, attrition rates and calculus deposits. In the case study populations, the occurrence of antemortem tooth loss is probably related primarily to calculus deposition, in the early assemblages, and to caries, in the later assemblages.

7.2.5. PERIAPICAL ABSCESS

7.2.5.1. INTRODUCTION

Periapical abscess is an infection of the periapical tissues and follows exposure of the pulp chamber through severe attrition or extensive carious decay. It is recognised archaeologically by the destroyed external bony surface of the jaw caused by the spreading of the pathological process along the tooth canal (Figure 7.16) (Lukacs 1989: 271; Buikstra and Ubelaker 1994: 55; Hillson 1996: 285).

7.2.5.2. RESULTS

Table 7.7 and Figure 7. 17 show that periapical abscesses occur at low levels in only a few of the cemetery populations. The differences in the prevalence of the condition between the affected populations are statistically significant (chi square test: $x^2=238.563< p=27.877$, at the 0.001 level of significance).

The distribution of periapical abscesses by age group (Table 7.8) shows the greatest frequencies of the condition in the older age categories, as expected in long-standing infectious lesions. The differences in the distribution of the lesions by age group are not statistically significant in any of the case study skeletal assemblages.

With regard to the distribution of the condition between sex groups (Figure 7.18), women suffered significantly higher rates at EBA Koilada (chi square test: $x^2=25.649> p=10.828$, at the 0.001 level of significance), LBA Spathes (chi square

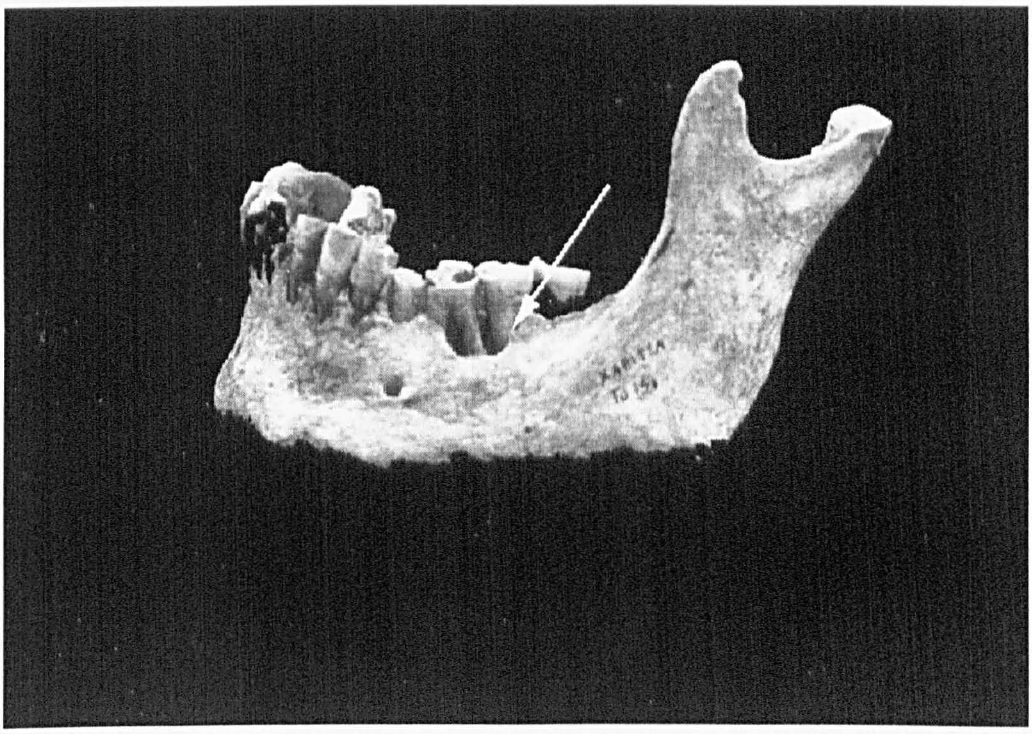
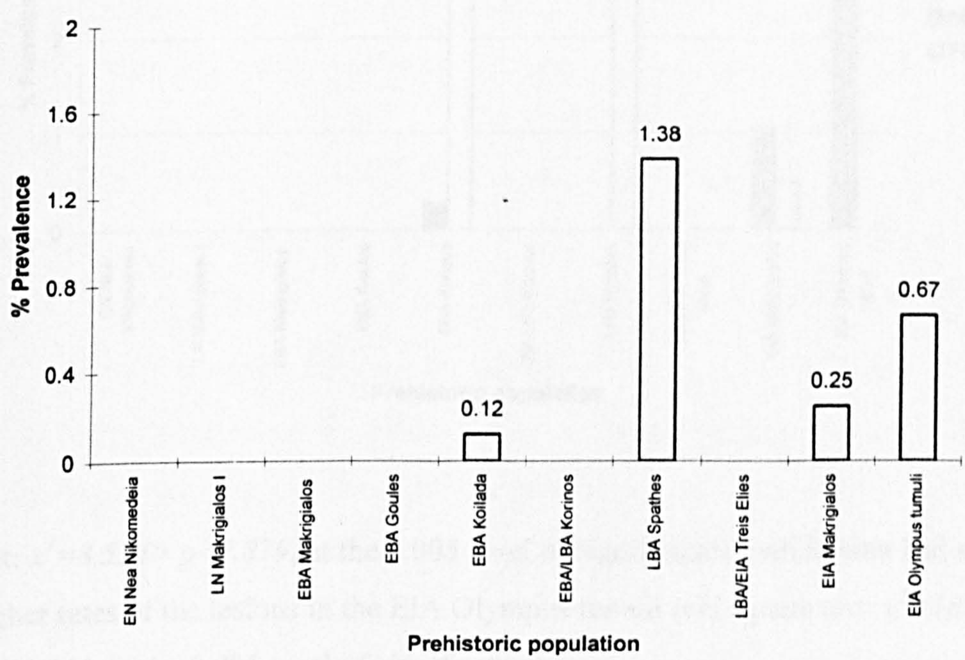


Figure 7.16: Large periapical abscess on left mandible (Karitsa Tum15i)

Population	% (NIA NIO)
EN Nea Nikomedeia	0.00 0/150
LN Makrigialos I	0.00 0/255
EBA Makrigialos	0.00 0/126
EBA Goules	0.00 0/222
EBA Koilada	0.38 5/1287
EBA/LBA Korinos	0.00 0/190
LBA Spathes	2.80 5/178
LBA/EIA Treis Elies	0.00 0/144
EIA Makrigialos	0.47 4/846
EIA Olympus tumuli	0.80 1/124

Table 7.7: Overall prevalence of periapical abscesses in the case study populations (raw data)

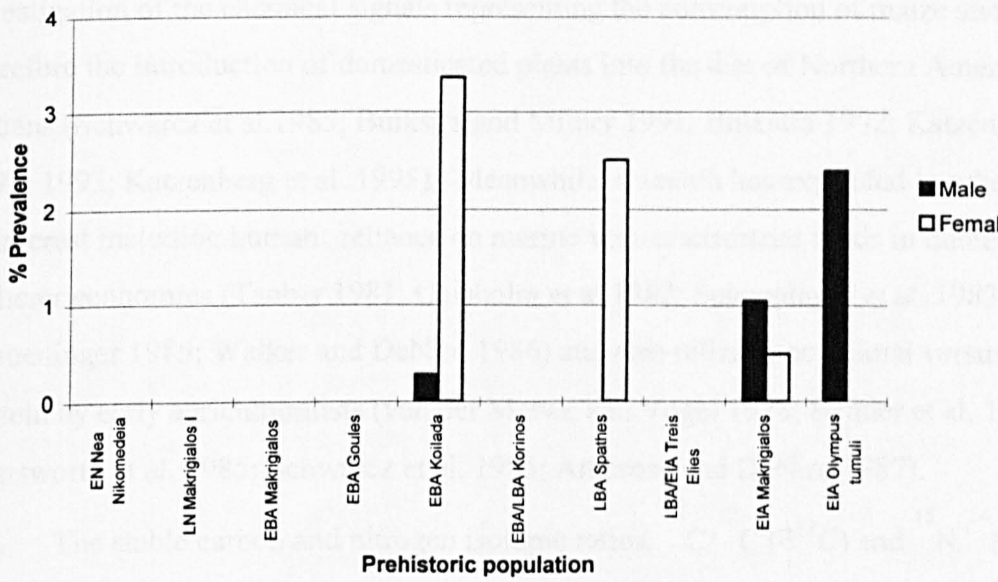
Figure 7.17: Prevalence of periapical abscesses in the case study populations (standardised rates)



Population	Neonate % Crude (NIA/ NIO)	Infant % Crude (NIA/ NIO)	Child % Crude (NIA/ NIO)	Juvenile % Crude (NIA/ NIO)	YA % Crude (NIA/ NIO)	PA % Crude (NIA/ NIO)	MA % Crude (NIA/ NIO)	OA % Crude (NIA/ NIO)	IndAdult % Crude (NIA/ NIO)
EN Nea Nikomedeia	*Undefined*	0.00 (0/15)	0.00 (0/26)	0.00 (0/24)	*Undefined*	0.00 (0/61)	0.00 (0/24)	*Undefined*	*Undefined*
LN Makrigialos I	*Undefined*	*Undefined*	0.00 (0/16)	0.00 (0/29)	0.00 (0/66)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/144)
EBA Makrigialos	*Undefined*	0.00 (0/6)	0.00 (0/6)	*Undefined*	0.00 (0/30)	*Undefined*	*Undefined*	*Undefined*	0.00 (0/84)
EBA Goules	*Undefined*	*Undefined*	0.00 (0/60)	0.00 (0/20)	0.00 (0/73)	0.00 (0/28)	0.00 (0/3)	*Undefined*	0.00 (0/38)
EBA Koilada	0.00 (0/7)	0.00 (0/77)	0.00 (0/156)	0.00 (0/161	0.00 (0/275)	0.00 (0/360)	2.36 (5/211)	0.00 (0/14)	0.00 (0/26)
EBA/LBA Korinos	*Undefined*	*Undefined*	0.00 (0/57)	*Undefined*	0.00 (0/94)	0.00 (0/12)	*Undefined*	0.00 (0/27)	*Undefined*
LBA Spathes	*Undefined*	0.00 (0/7)	*Undefined*	*Undefined*	2.72 (3/110)	0.00 (0/39)	6.25 (1/16)	20.00 (1/5)	0.00 (0/1)
LBA/EIA Treis Elies	*Undefined*	*Undefined*	0.00 (0/14)	*Undefined*	0.00 (0/116)	*Undefined*	0.00 (0/10)	*Undefined*	0.00 (0/4)
EIA Makrigialos	*Undefined*	0.00 (0/44)	0.00 (0/35)	0.00 (0/81)	0.26 (1/378)	0.91 (2/219)	1.85 (1/54)	0.00 (0/14)	0.00 (0/21)
EIA Olympus tumuli	*Undefined*	*Undefined*	0.00 (0/6)	0.00 (0/1)	0.00 (0/90)	5.00 (1/20)	*Undefined*	*Undefined*	0.00 (0/7)

Table 7.8: Prevalence of periapical abscesses in permanent dentition by age group (crude rates)

Figure 7.18: Prevalence of periapical abscess by sex group (standardised rates)



test: $x^2=8.554 > p=7.879$, at the 0.005 level of significance), while men had significantly higher rates of the lesions in the EIA Olympus tumuli (chi square test: $x^2=18.841 > p=10.828$, at the 0.001 level of significance).

7.2.5.3. CONCLUSIONS

Periapical abscesses occurred at low levels, particularly in the older age categories. Periapical abscess results from pulp exposure through severe caries or attrition. In the case study populations, *severe caries* seem to be the primary cause of the condition, but the affected skeletal assemblages also showed *heavy tooth wear*. It is possible, therefore, that an interaction between caries and heavy wear caused necrosis and exposure of pulp chambers resulting in periapical abscesses in the affected populations.

7.3. STABLE ISOTOPE ANALYSIS

7.3.1. INTRODUCTION

Stable isotope analysis of bone collagen for the reconstruction of past human diets began in the late 1970's (Vogel and van der Merwe 1977; DeNiro and Epstein 1978; van der Merwe et al. 1981; van der Merwe 1982; Richards and van Klinken 1997). One of the initial contributions of the analysis to palaeodietary studies was the investigation of the chemical signals representing the consumption of maize and therefore the introduction of domesticated plants into the diet of Northern American Indians (Schwarcz et al.1985; Buikstra and Milner 1991; Buikstra 1992; Katzenberg 1992; 1993; Katzenberg et al. 1995). Meanwhile, research has expanded in other areas of interest including human reliance on marine versus terrestrial foods in hunter-gatherer economies (Tauber 1981; Chisholm et al 1982; Schoeninger et al. 1983; Schoeninger 1985; Walker and DeNiro 1986) and also reliance on animal versus plant protein by early agriculturalists (van der Merwe and Vogel 1978; Bender et al. 1981; Farnsworth et al. 1985; Schwarcz et al. 1985; Ambrose and DeNiro 1987).

The stable carbon and nitrogen isotopic ratios, $^{13}C/^{12}C$ ($\delta^{13}C$) and $^{15}N/^{14}N$ ($\delta^{15}N$), vary between populations depending on normal components of the diet and any atmospheric constituents that may be incorporated into the human body (Schwartcz and Schoeninger 1991). Stable isotope analysis has made four major contributions to reconstruction of past human diet:

A. *The distinction of C_3 and C_4 plants.* The major differences in carbon occur between *two photosynthetic pathways (C_3 and C_4)* used by plants, which are then absorbed as food by humans. C_3 plants include temperate grasses, all trees and shrubs, all fruits and nuts, and cultivated roots and tubers. C_4 plants, on the other hand, are predominately tropical grasses including some important domesticates such as maize, millet and rice (Keegan 1989: 227). C_4 plants have heavier or less negative $\delta^{13}C$ than do C_3 plants (Figure 7.19) (Katzenberg 1992: 106).

B. *The distinction of nitrogen-fixing and non-fixing plants.* With regard to the nitrogen isotope distributions, the primary distinction is between trophic levels and between those plants and bacteria that fix nitrogen directly from air, *nitrogen fixers*, and those plants that rely on soil nitrogen (Keegan 1989: 228). Because the $\delta^{15}N$ value of atmospheric nitrogen is approximately 0‰ and the $\delta^{15}N$ value of soils averages around 10‰, plants which fix atmospheric nitrogen (i.e. legumes) have lower $\delta^{15}N$ values than plants which do not fix nitrogen (Figure 7.19) (Katzenberg 1992: 107).

C. *The distinction of marine and terrestrial foodstuffs.* The main carbon source for marine plants and animals has a $\delta^{13}C$ value of approximately 0‰ whereas CO_2 in the atmosphere, the main source of carbon for terrestrial plants and animals, has a $\delta^{13}C$ value of -7‰. Similarly, $\delta^{15}N$ of marine organisms is typically higher than that for terrestrial ones, with some values ranging above 20% (Figure 7.19) (Katzenberg 1992: 112).

D. *The distinction between freshwater and marine foodstuff.* Sea grasses have $\delta^{13}C$ values like those of C_4 plants, whereas cold water plankton values are closer to those of C_3 plants. Furthermore, the $\delta^{13}C$ or $\delta^{15}N$ of aquatic plants (from lakes and rivers) and the fish that feed on them may vary widely, reflecting the contribution of carbon or nitrogen sources respectively (Figure 7.19) (Schwartcz and Schoeninger 1991: 304).

The isotopic compositions of tissues thus vary as result of the metabolic pathways that produced them. Isotopic methods are not able to distinguish between every individual food type in the diet and so should be considered as an additional tool to identify consumption profiles of the relative contributions of different food groups in past human diets (Keegan 1989: 232). In an archaeological context, diagenic issues must also be considered and, to this end, comparative analysis of the bone collagen isotopic composition of the prehistoric fauna consumed by humans may be useful (Vogel and van der Merwe 1977; Burleigh and Brothwell 1981; DeNiro and Epstein

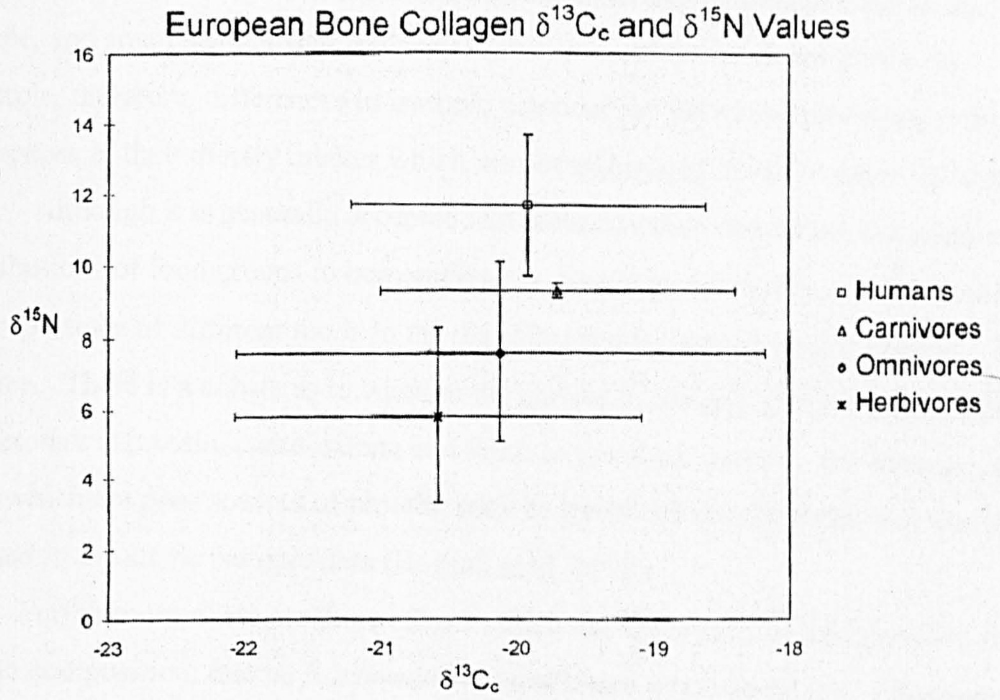


Figure 7.19: European bone collagen delta 13C and delta 15N values (Richards and van Klinken 1997: Figure 8)

1978; 1981; Bender et al. 1981; Keegan and DeNiro 1988; Keegan 1989; Richards and van Klinken 1997).

7.3.2. SAMPLING: LIMITATIONS AND AIMS OF THE ANALYSIS

The current work represents a limited pilot analysis of stable carbon and nitrogen isotopes conducted by Dr G. J. van Klinken in the Oxford Research Laboratory for Archaeology and History of Art. A primary problem affecting stable isotope analysis in archaeological specimens is sampling. Laboratory work on populations with known diets and under given environments has demonstrated that differences due to sex, bone sample, and small sample size are small (Schwarcz and Schoeninger 1991). In principle, therefore, differences in isotopic composition between individuals reflect differences in their dietary intakes which are not influenced by some other variable.

Although it is generally accepted that isotopic ratios can reflect the relative contributions of food groups to human diet, the degree to which it is possible to quantify the proportions of different foods in the diet from stable isotopic data is open to question. There is a debate as to whether the carbon in collagen derives from all parts of the diet, that is protein, carbohydrate and lipid, or just from protein. For instance, plant foods which are poor sources of protein, such as fruits and starchy roots, may not be reflected in the stable isotopic data (Bonsall et al. 1997).

Furthermore, there are three effects which can influence the interpretation of isotopic composition: that is, *fractionation*, *trophic* and *diagenic* effects. *Fractionation* is the estimation of differences in ratios of stable isotope between the diet consumed by the prehistoric human populations and their bone collagen (van der Merwe 1982, Schoeninger and Moore 1992). A well-controlled study of the fractionation between human bone collagen and diet has not been carried out. At the present time the most reasonable estimate of the difference in carbon stable isotopes between diet and collagen appears to be on the order of 3-5 ‰. Similarly, for the ratios of nitrogen stable isotopes, it is suggested that the bone collagen value in adult human is often more than 3 ‰ more positive than that of diet (Schwarcz and Schoeninger 1991: 306). *Diagenic* effects, postmortem processes that may have altered the bone chemistry, need to be considered as well. Fresh bone contains two phases, a collagen or bone protein phase and an apatite or bone mineral phase. Collagen requires essential amino acids for its formation and, therefore, largely reflects the $\delta^{13}C$ of the protein component in contrast to the apatite signatures which represent the whole diet including carbohydrates and fats in addition to protein (Larsen 1997: 272). Bone collagen is supposed to be less affected by diagenesis than apatite where the carbonate of the bone mineral is reactive with the carbonate of the burial environment (Keegan 1989: 230). In addition to the factors described above, environmental variables such as annual rainfall, vegetation, altitude, temperature, the salinity of the soil and even the use of fertilisers can also influence the results of the isotopic ratios (Ambrose 1991, 1993).

To date stable isotope analysis has focused on two main issues:

- The first aim was to investigate *distinctions between human skeletal populations* (coastal/inland and lowland/upland) from the case study region. To minimise the effect of temporal variation, the samples have been selected from populations belonging to the same relative chronological period, the Late Bronze Age. Thirteen permanent posterior teeth have been analysed from the coastal cemetery of *Korinos*, located about 3 km inland from the modern coast, from *Spathes*, some 60 km inland and at 1000-1100 masl on the westward slopes of mount Olympus, and from *Rymnio* (not one of the case study skeletal assemblages), located 200 km inland and at 650 masl, near the modern town of Kozani, in Western Macedonia.
- The second aim had two aspects: 1) the investigation of possible *temporal variations* between human skeletal populations settled in the same region and 2) the exploration of possible *differences between population subgroups* within the same cemetery. In order to test these questions, the site of Makrigialos was selected, because it offered skeletal material from the Neolithic, Early Bronze, Classical, Roman and Byzantine periods.

Samples of bone collagen were taken from human femoral midshafts of both phases of Late Neolithic Makrigialos (22 samples), and from the Early Bronze Age (6 samples) and Early Iron Age Makrigialos cemeteries (14 samples). In addition to the prehistoric samples, a total of 10 human bone samples was taken from the Classical necropolis (5th and 4th century BC).

Finally, in order to control climatic and environmental differences which may have affected the results of the human bone analysis, a number of animal bones was also analysed. Fifteen (15) samples of animal bones (distal humeri) were provided from

Neolithic Makrigialos while another group of animal bones sampled from settlement deposits near the Late Bronze Age cemeteries is still under analysis. The species included in the animal bone sampling are red deer (*Cervus elaphus*), a terrestrial herbivore, and domesticated pig (*Sus domesticus*) and boar (*Sus scrofa*), as omnivores. The diet of domesticated pigs may have differed from that of wild boar, both because of their presumed restricted mobility and because they may have been fed a certain amount of human food refuse (Bonsall et al. 1997: 70).

7.3.3. RESULTS

The results of the stable isotope analysis are set out in Tables 7.9 (the Late Bronze Age sites), 7.10 (Makrigialos skeletal assemblages) and 7.11 (the animal bone samples). The numerical values of both human and animal bone samples are plotted on a bi-variate scatter diagram (Figure 7.20), while the mean values of stable isotope ratios are represented in Figure 7.21. A t-test for independent samples on SPSS has been applied in order to distinguish any significant differences in the mean values of the skeletal assemblages. Moreover, in order to control diagenic changes, bone collagen samples with values showing atomic C/N ratios outside the range of 2.9-3.2 have been excluded from the analysis (DeNiro 1985, Schoeninger et al. 1989).

Figures 7.20 and 7.21 thus, representing $\delta^{15}N$ versus $\delta^{13}C$ values of the current analysis, reveal three interesting patterns:

A. *A distinctive temporal trend from the Neolithic to the Classical period* in which the samples show increasingly less negative $\delta^{13}C$ values and more positive $\delta^{15}N$ values through time. The only exception to the general trend is the Late Bronze Age, which averages data from a number of different locations. The 2 tailed t-test shows a statistically significant difference in $\delta^{13}C$ mean values between the EBA and LBA assemblages (t-test: *t-value* = *-3.16*, $p=0.006 \leq 0.05$), in $\delta^{15}N$ mean values between the LBA and EIA assemblages (t-test: $\delta^{15}N$: *t-value* =*3.40*, $p=0.002 \leq 0.05$) and in $\delta^{15}N$ mean values between the EIA and Classical assemblages (t-test: *t-value* = *-3.96*, $p=0.001 \leq 0.001$). The human bone samples with less positive $\delta^{15}N$ values - closer to the animal bone values - are assumed to be the individuals who most heavily relied on plants, while, on the other hand, the more positive values of the Late Bronze Age

Figure 7. 20: Mean values of stable isotope ratios from Northern Greece

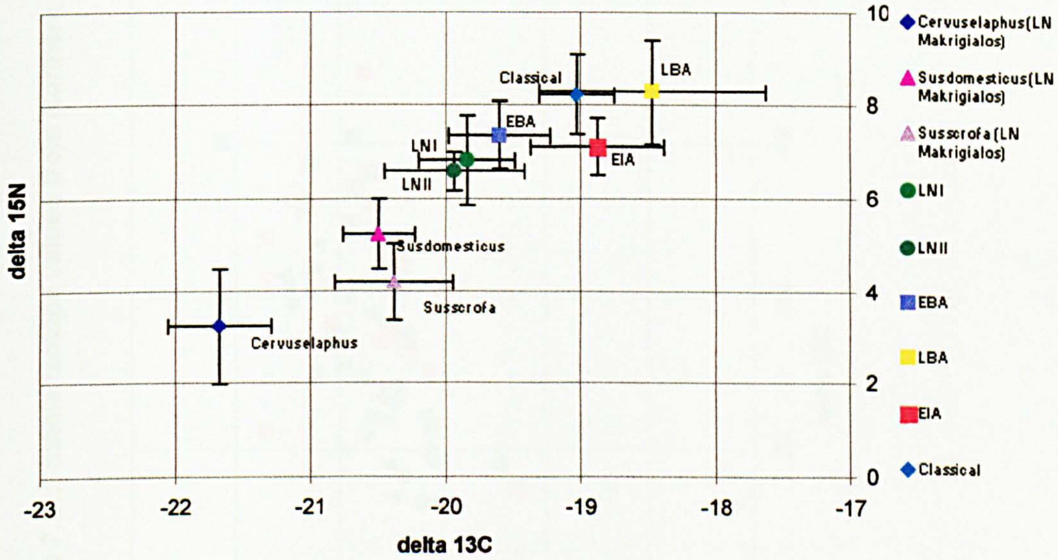
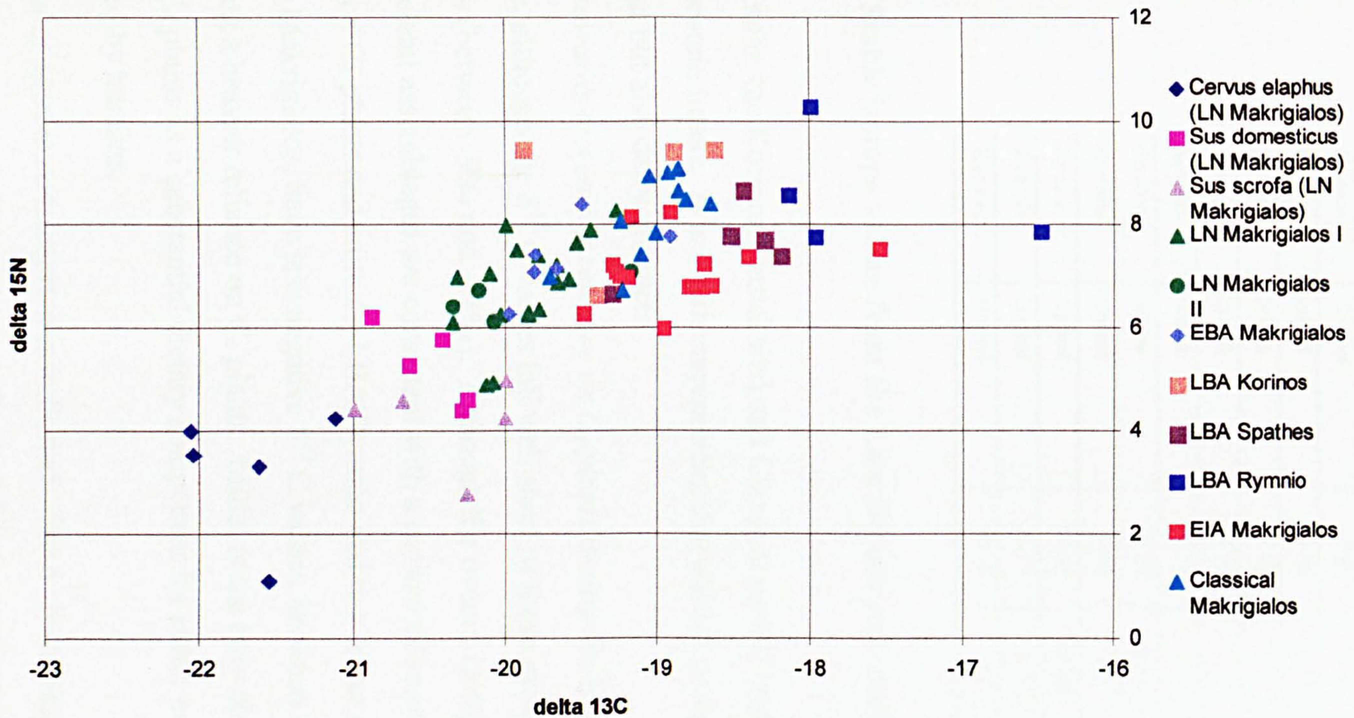


Figure 7.21: Stable isotope values from Northern Greece



Site	Location	d13C	d15N
Korinos	Coastal	-19.40	6.64
Korinos	Coastal	-19.88	9.45
Korinos	Coastal	-18.89	9.41
Korinos	Coastal	-18.62	9.46
Spathes	Inland	-18.43	8.66
Spathes	Inland	-18.29	7.71
Spathes	Inland	-18.19	7.40
Spathes	Inland	-18.51	7.79
Spathes	Inland	-19.30	6.66
Rymnio	Upland	-17.96	7.75
Rymnio	Upland	-17.99	10.28
Rymnio	Upland	-18.13	8.57
Rymnio	Upland	-16.48	7.85

Table 7.9: Stable isotope values from the Late Bronze Age skeletal assemblages

(in particular, the Korinos coastal site) and Classical period imply high levels of animal protein intake. It is worth emphasising that animal protein intake includes not only meat but also dairy products.

B. *A trend towards increasing reliance on C_4 plants* during the Late Bronze and Early Iron Age, although the δ^{13} C values fall well short of those expected for a pure diet of C_4 plants (between -9‰ and -14‰). Although the overall isotopic results of the study skeletal assemblages are consistent with a *terrestrial source* of dietary intake focused on C_3 plants and animals, LBA Rymnio and to a lesser extent, LBA Spathes and EIA Makrigialos, have less negative δ^{13} C values, between -16.48 and -18.7, suggesting a heavier reliance on C_4 plants. Millet is the only obvious candidate among C_4 plants as a substantial dietary component for either humans or animals consumed by humans.

C. *No signal of marine consumption* is indicated. The δ^{15} N values, with a maximum of 9.46‰, do not provide any evidence of a significant contribution of marine resources in the diet. Both Makrigialos and Korinos are coastal sites and the gulf of Thessaloniki, into which big rivers flow, now provides a productive area for fishing. In addition, the large number of marine shellfish and modest number of fish bones

Dating	Loc[3]/Gr no[4]	Sex	Age	d13C	d15N	Dating	Loc/Gr no	Gr type[5]	Sex	Age	d13C	d15N
LN I	Ditch	?	A[6]	-19.65	6.88	EBA	2	Pit	M	YA	-19.97	6.27
LN I	Ditch	M[7]	PA[8]	-19.77	6.36	EIA	100/947	Cist	F	YA	-18.95	5.98
LN I	Ditch	?	A	-19.99	7.98	EIA	99/947	Cist	F	YA	-19.25	7
LN I	Ditch	?	Juv[9]	-19.53	7.64	EIA	101/947	Cist	F	PA	-19.17	8.14
LN I	Ditch	?	A	-19.92	7.51	EIA	49/945	Cist	F	MA	-18.7	6.79
LN I	Ditch	F[10]	YA[11]	-19.44	7.89	EIA	111/947	Cist	M	OA	-18.39	7.37
LN I	Ditch	M	YA	-20.31	6.98	EIA	4A/945	Chamber	F	YA	-19.48	6.28
LN I	Ditch	?	A	-19.78	7.4	EIA	11secA	Chamber	F	YA	-18.78	6.8
LN I	Ditch	?	Su[12]	-20.34	6.11	EIA	166(2)/947	P/W [13]	F	YA	-19.19	6.98
LN I	Ditch	?	A	-19.58	6.93	EIA	155/947	P/W	M	MA	-18.91	8.22
LN I	Ditch	?	A	-20.03	6.25	EIA	260pri/947	P/SC [14]	F	MA	-18.63	6.82
LN I	Ditch	?	A	-20.12	4.89	EIA	183/947	P/SC	F	YA	-18.68	7.23
LN I	Ditch	?	A	-20.1	7.04	EIA	54sec/947	P/SC	M	YA	-19.29	7.21
LN I	Ditch	M	PA	-19.27	8.28	EIA	56pri/947	P/SC	M	PA	-17.55	7.53
LN I	Settlement	?	A	-19.66	7.2	EIA	46(B)/047	P/SC	?	Child	-19.27	7.09
LN I	Settlement	?	A	-19.84	6.26	Class					-19.23	6.73
LN I	Settlement	?	A	-19.84	6.26	Class					-19.05	8.93
LN I	Settlement	?	A	-20.08	4.93	Class					-18.64	8.39
LN II	Settlement	?	A	-20.17	6.73	Class					-18.85	9.09
LN II	Settlement	?	A	-20.07	6.12	Class					-19.7	6.98
LN II	Settlement	?	A	-20.34	6.41	Class					-19.01	7.83
LN II	Settlement	?	A	-19.17	7.09	Class					-18.8	8.48
EBA	35	F	A	-19.81	7.09	Class					-19.11	7.41
EBA	3	M	A	-19.66	7.14	Class					-18.85	8.65
EBA	28	M	A	-19.5	8.39	Class					-18.92	8.99
EBA	24	?	Inf[15]	-18.91	7.78	Class					-18.86	9.07
EBA	33	M	YA	-19.8	7.42	Class					-19.24	8.06

Table 7.10: Stable isotope values from the Makrigialos skeletal assemblages

[3] Loc: Location.
[4] Gr no: Grave number.
[5] Gtype: Grave type.
[6] A: Adult.
[7] M: Male.
[8] PA: Prime Adult.
[9] Juv: Juvenile.
[10] F: Female.
[11] YA: Young Adult.
[12] Su: Subadult.
[13] P/W: Pit with wooden cover.
[14] P/SC: Pit covered with schist.
[15] Inf: Infant.

provided by the deposits of Neolithic Makrigialos (Pappa pers. comm.), together with artefacts associated with fishing technology found in the Classical cemetery (Bessios pers. comm.) suggest a contribution of marine resources to the diet. Studies of marine ecology and classical accounts of fishing technology, however, indicate a rather limited role for fish in ancient Greek diets. Two other sites in Greece have provided isotopic values which have similarly produced no marine signal. Late Neolithic samples from the coastal site of Alepotrypa Cave, in the southern Peloponnese, have given $\delta^{13}C$ values for both collagen (mean = -19.9‰) and apatite

Species	d13C	d15N
Cervus elaphus	-22.05	4.01
Cervus elaphus	-21.55	1.1
Cervus elaphus	-22.04	3.55
Cervus elaphus	-21.12	4.24
Cervus elaphus	-21.61	3.31
Sus domesticus	-20.63	5.27
Sus domesticus	-20.28	4.4
Sus domesticus	-20.88	6.2
Sus domesticus	-20.24	4.6
Sus domesticus	-20.41	5.78
Sus scrofa	-20.25	2.77
Sus scrofa	-20.99	4.42
Sus scrofa	-19.99	4.98
Sus scrofa	-20	4.24
Sus scrofa	-20.67	4.58

Table 7.11: Stable isotope values from the LN Makrigialos II animal bone samples

(mean = -13.1‰) which indicate a diet largely focused on terrestrial C_3plants and animals (Papathanasiou et al. 1995; Larsen 1997: 282). An Early Christian site on the island of Kos in the Dodecanese, located on the coast of the island, also gave isotopic values which do not indicate any marine consumption ($\delta^{13}C$= -17.4‰ and $\delta^{15}N$= 9‰) (van Klinken et al. in press).

In addition to the overall chronological trend in dietary composition, some observations are also possible for individual skeletal assemblages:

Figure 7.22: Distribution of stable isotope values from EIA Makrigialos by sex group

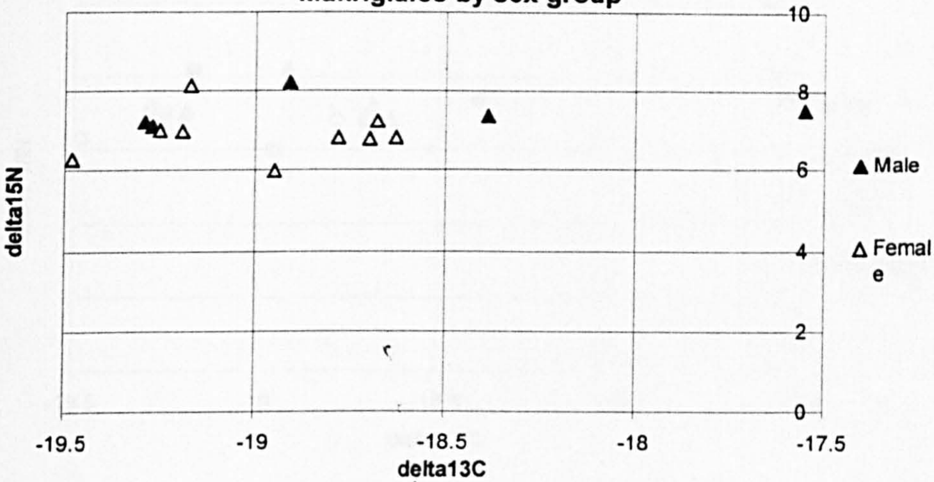


Figure 7.23: Distribution of stable isotope values from EIA Makrigialos by age group

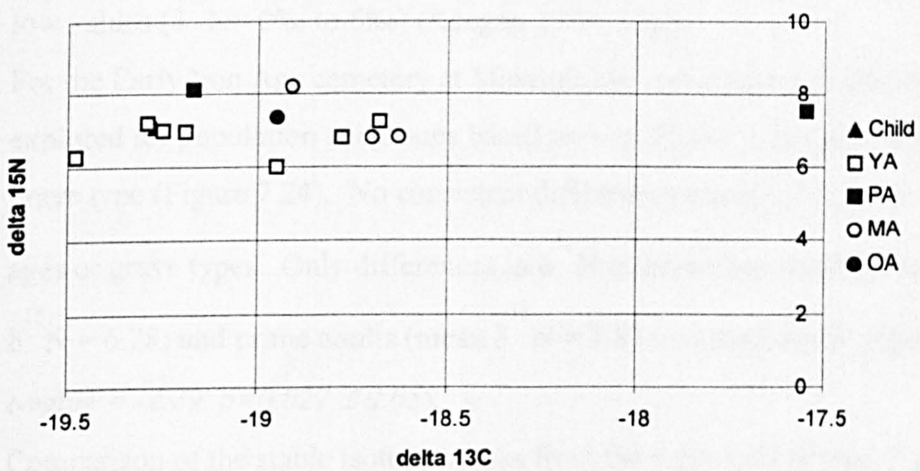
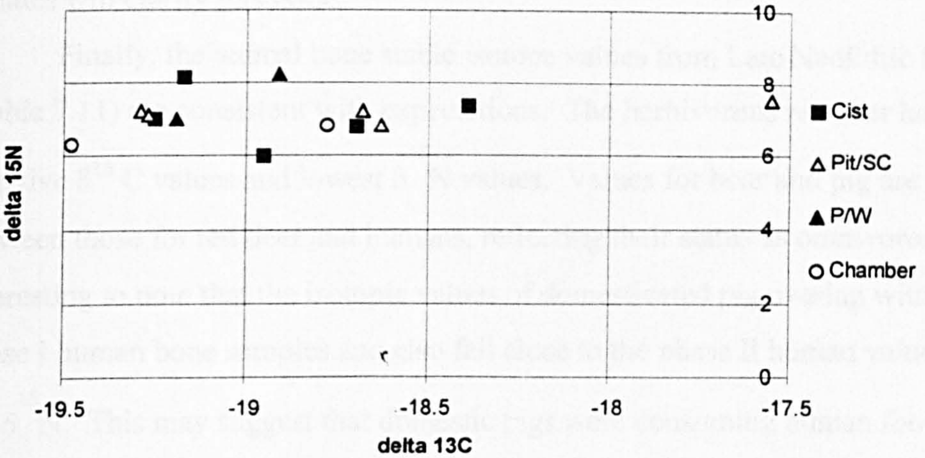


Figure 7.24: Distribution of stable isotope values from EIA Makrigialos by grave type



A. At Late Neolithic Makrigialos I, there are *no statistically significant differences in isotopic values* between samples from the ditch and the settlement deposits, suggesting that people buried in different loci shared similar types of dietary intake.

B. Two samples from Late Neolithic Makrigialos I have particularly low $\delta^{15}N$ values which may indicate relatively heavy *consumption of legumes*. Legumes, because they fix nitrogen directly from the air (with $\delta^{15}N$= 0‰), are characterised by extremely low values ($\delta^{15}N$= 0‰ to 6‰) (Keegan 1989: 226).

C. For the Early Iron Age cemetery at Makrigialos, stable isotope values have been explored for population subgroups based on sex (Figure 7.22), age (Figure 7.23) and grave type (Figure 7.24). No consistent differences emerge, however, between sexes, ages or grave types. Only differences in $\delta^{15}N$ mean values between young (mean $\delta^{15}N = 6.78$) and prime adults (mean $\delta^{15}N = 7.83$) are statistically significant (t-test: *t-value = -2.79, p=0.027 ≤0.05*).

D. Comparison of the stable isotope values from the three Late Bronze Age cemeteries do not suggest a significant use of marine foods near the coast. Use of marine resources should be reflected in more positive $\delta^{13}C$ and $\delta^{15}N$ values (Johansen et al. 1986; Katzenberg 1992), but the coastal site of Korinos has more negative $\delta^{13}C$ values (mean $\delta^{13}C = -19.19$) than the two inland sites (Spathes: mean $\delta^{13}C = -18.54$, Rymnio: mean $\delta^{13}C = -17.64$). It is possible that a climatic contrast between the hotter inland and cooler coast resulted in this gradient in values (van Klinken pers. comm.). In the future, it is expected that ongoing isotopic analysis from the same sites will clarify this issue.

Finally, the animal bone stable isotope values from Late Neolithic Makrigialos II (Table 7.11) are consistent with expectations. The herbivorous red deer have the most negative $\delta^{13}C$ values and lowest $\delta^{15}N$ values. Values for boar and pig are intermediate between those for red deer and humans, reflecting their status as omnivores. It is interesting to note that the isotopic values of domesticated pig overlap with those of the phase I human bone samples and also fall close to the phase II human values, especially for $\delta^{15}N$. This may suggest that domestic pigs were consuming human food refuse.

7.4. DISCUSSION

The macroscopic investigation of dental pathologies and stable isotope analysis address different aspects of diet. Macroscopic investigation indirectly reveals particular types of dietary intake such as the consumption of meat and carbohydrates, and stable isotopic analysis reflects consumption profiles after their metabolism through the human body. Neither approach identifies the total range of foods nor the proportions in which they were consumed by past populations. Both approaches suggest that all skeletal assemblages shared a *terrestrial type* of diet involving both agricultural and animal products.

The overall distribution of pathological conditions suggests higher meat consumption by the Neolithic and Early Bronze Age populations and a higher consumption of carbohydrates in the Late Bronze and Early Iron Ages. The stable isotope values, conversely, suggest an *increase in animal protein intake* from the Neolithic to the later periods. In part, this contradictory picture may be illusory, because the macroscopic investigation has included a significantly *broader series* of skeletal assemblages, distributed quite widely in space, whereas the stable isotope analysis has focused primarily on one site. It is perhaps significant in this context that macroscopic investigation of EIA Makrigialos produced relatively similar frequency of caries and calculus, implying a relative balance between meat and carbohydrate consumption, which may be compatible with the stable isotope analysis.

Additionally, it is not known whether the stable isotope values reflect the carbon derived from all parts of the diet or just from protein (Larsen 1997). Thus, the carbohydrates which, according to the macroscopic investigation, were more important may not be reflected by the stable isotope analysis. Moreover, stable isotope analysis measures intake of all kinds of animal protein and cannot distinguish between meat and other types of protein such as dairy products. Thus the apparent contradiction between dental and stable isotope data may reflect an increasing contribution of dairy products intake in the later periods. This would be consistent with the model of adoption of secondary products during the Bronze Age (Sherratt 1981).

One of the great values of the assessment of oral health status is the opportunity to explore the association of particular dietary patterns with certain population segments, defined by sex and/or age. With allowance for the age-progressive nature of much dental disease, the distribution of major pathological conditions such as caries and calculus in all age categories does not imply any age-related distinction in dietary patterns in most of the cemetery populations. Women in general seem to have had higher access to cariogenic foodstuff, whereas men were heavier meat consumers.

Finally, the prevalence of dental disease is explored for geographical and chronological groupings (Figure 7.25 and 7.26):

A. *The early populations have produced notably higher calculus rates than the late populations*, whereas the late populations have higher caries, antemortem tooth loss rates and frequency of periapical abscess. The differences in the prevalence of the conditions between early and late populations are statistically significant; calculus (chi square test: $x^2=1422.582> p=10.828$, at the 0.001 level of significance), caries (chi square test: $x^2=761.445> p=10.828$, at the 0.001 level of significance), antemortem tooth loss rates (chi square test: $x^2=1576.496> p=10.828$, at the 0.001 level of significance) and periapical abscess (chi square test: $x^2=58.873> p=10.828$, at the 0.001 level of significance).

B. *The overall prevalence of dental disease is thus higher in the late populations*. This pattern may reflect increasing dominance of the diet by carbohydrates, but might have been caused by other factors, such as the introduction of new cooking methods or techniques of food preparation. Changes in cooking may also have contributed to the apparent contradiction between dental and isotopic data.

Figure 7.25: Prevalence of dental disease by archaeological period (standardised rates)

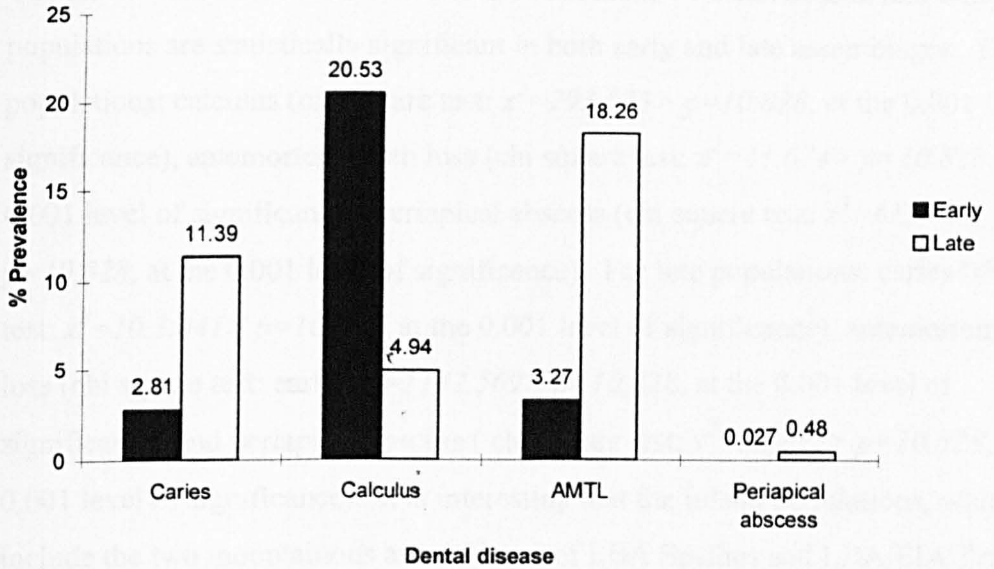
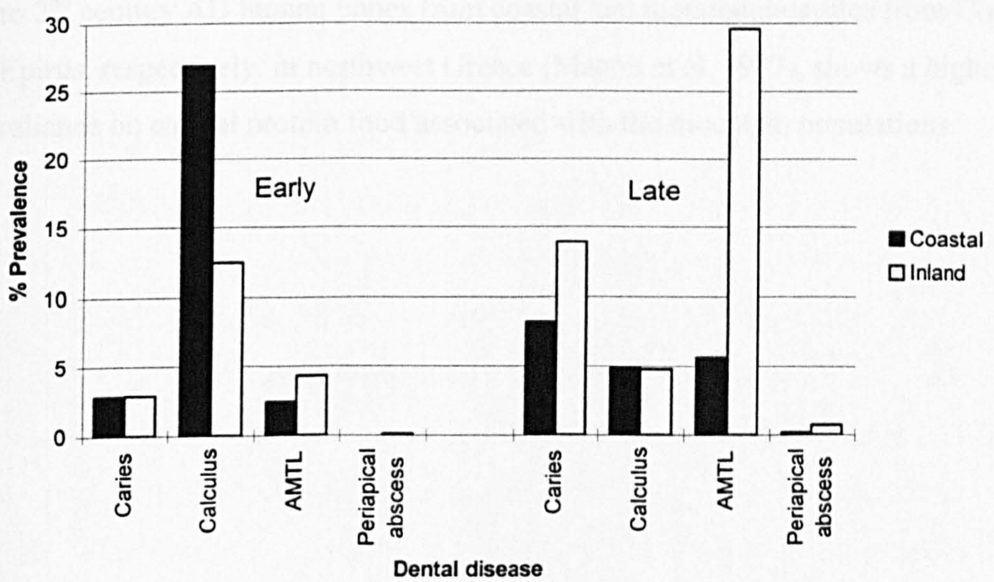


Figure 7.26: Overall prevalence of dental disease in the case study populations (standardised rates)



C. *Inland populations have higher rates of caries, antemortem tooth loss and periapical abscess than the coastal populations*, in both early and late skeletal assemblages. The differences in the prevalence of the conditions between coastal and inland populations are statistically significant in both early and late assemblages. For early populations: calculus (chi square test: $x^2=293.573 > p=10.828$, at the 0.001 level of significance), antemortem tooth loss (chi square test: $x^2=41.674 > p=10.828$, at the 0.001 level of significance), periapical abscess (chi square test: $x^2=61.365 > p=10.828$, at the 0.001 level of significance). For late populations: caries (chi square test: $x^2=10.3.041 > p=10.828$, at the 0.001 level of significance), antemortem tooth loss (chi square test: early: $x^2=1142.569 > p=10.828$, at the 0.001 level of significance) and periapical abscess (chi square test: $x^2=23.892 > p=10.828$, at the 0.001 level of significance). It is interesting that the inland populations, which include the two mountainous assemblages of LBA Spathes and LBA/EIA Treis Elies, suggest diets rich in carbohydrate with low meat consumption. This perhaps suggests that these upland sites were occupied by mixed farmers rather than by specialised pastoralists and thus lends slight support to the argument that specialised pastoralism did not take place in prehistoric Greece (for a broad discussion see Chang 1993 and more recently Halstead 1996). Conversely, trace element analysis of 8th century BC to 2nd century AD human bones from coastal and mountainous sites from Corfu and Epirus, respectively, in northwest Greece (Magou et al. 1997), shows a higher reliance on animal protein food associated with the mountain populations.

CHAPTER 8: CONCLUSIONS

Previous research on the prehistoric archaeology of Greek Macedonia has been limited mainly to aspects of material culture and settlement patterns and, to a lesser degree, subsistence. The time period covered by this study extends from the Neolithic to the Early Iron Age and involves a series of transformations in types of settlement, in spatial organisation at the inter-site level, in subsistence patterns and the differential management of agricultural and pastoral resources, and in the differential production, consumption and distribution of pottery, metal, bone and other artefacts.

Overall, the evidence from the Neolithic and Early Bronze Age is consistent with small-scale societies in which the basic household unit was the nuclear family. Around the transition to the Bronze Age, there is some evidence suggesting the mobilisation of materials and ideas at a broader level beyond the confines of the local community. This is indicated by the production, consumption and distribution of fine, painted pottery, craft specialisation, the introduction of metal work and the development of long-distance exchange networks extending to Thessaly, the Aegean islands and the Balkans. Conversely, in the Late Bronze and Early Iron Ages, residential units tend to expand to more than one household, and hierarchies emerge at the inter-site and, in Central Macedonia, possibly also at the intra-site level. Nucleated habitation possibly develops in the Early Iron Age, while there is expanding exchange with the South (evident particularly in the introduction of Mycenaean and "Mycenaeanising" types of artefacts), the Balkans and Central Europe.

Similarly, burial practices give evidence of differentiation through time in the organisation of mortuary programmes at the inter- and intra-cemetery level. Overall, the Neolithic is characterised by poor assemblages with very scanty evidence of mortuary treatment, little emphasis on the visibility of the dead and a total lack of elaborate associated artefacts, although the recent discoveries at Makrigialos argue for a different situation by the end of the period. In phase I at Makrigialos, most individuals were disposed of in openly accessible, communal areas and there is also some evidence of differential mortuary treatment. From the Bronze Age onwards, well defined cemeteries are located at a distance from the associated settlements, suggesting emphasis both on the separation of the living from the deceased and on the visibility of the burial ground. Furthermore, there is evident care in the treatment of the deceased, coupled with a tendency towards standardisation at the intra-cemetery level, indicated by common burial practices (position and orientation of the body, standard sets of grave goods often placed in particular positions, and possible differential treatment by age and/or sex groups). By the Early Bronze Age, there are also indications of the clustering of burials suggesting the organisation of cemeteries around small groups, perhaps related to families. This becomes the rule in the Late Bronze Age when more than one individual is accommodated in the common grave types as multiple/secondary burials. This period also shows a clear standardisation in mortuary treatment focused on the adoption of certain grave types and associated grave goods. At the same time, there is a striking accumulation of distinctive artefacts and personal items, often made of rare or exotic materials and including sealstones, jewellery, weaponry and Mycenaean or "Mycenaeanising" pottery. These grave goods suggest an emphasis on the display of individual social identity. Finally, in the Early Iron Age, although the earlier standardisation in the overall treatment of the deceased continues, there is a clear tendency towards heterogeneity in burial assemblages at the level of the cemetery, apparent in the wider use of grave markers, the development of more elaborate grave types (such as the chamber tombs at Makrigialos), and the association of certain individuals or family groups with relatively "rich" or "poor" grave goods. Early Iron Age burial practices also witness an overall emphasis on lineage identity as indicated by the strong evidence of clustering at the intra-cemetery level, e.g. in tumuli and chamber tombs.

Within the constraints imposed by the non-publication of excavated cemeteries and the poor preservation of the skeletal material, this thesis has analysed prehistoric burials from Central and Western Greek Macedonia from two principal points of view: 1) the reconstruction of aspects of life history (Chapters 4, 6 and 7); and 2) mortuary treatment and the manipulation of the deceased as revealed by the human skeletal remains alone (Chapter 5).

With regard to the former, the parameters considered include demographic profiles (Chapter 4), patterns of health (Chapter 6) and oral status and diet (Chapter 7). The analysis has been conducted at two scales: 1) an overall comparison at the inter-population level; and 2) intra-population investigation of the same parameters for subgroups defined by age and/or sex.

With regard to comparison at the inter-population level, it is important to note that, except for diet, no consistent association has been found between demographic profiles or health status and any archaeological period or region. Instead, local conditions, defined by environmental and social factors, seem to have affected the quality of life as reconstructed for the case study prehistoric populations. With the exception of EN Nea Nikomedeia and LN Makrigialos, no associated settlement has been excavated so that there is a total lack of independent evidence for economic and social factors, living conditions, settlement and subsistence patterns associated with the case study populations.

Overall, a tendency towards declining levels of health and oral status is suggested by the Late Bronze and Early Iron Age populations, while EN Nea Nikomedeia, EBA Koilada and EIA Makrigialos reveal high levels of infant and child mortality. With regard to occupational activities, most of the case study populations show a substantial involvement of the upper skeleton in occupational stress and physical workload. EIA Makrigialos and the EIA Olympus tumuli, however, reveal a similar level of arthritic changes in the lower skeleton. Overall, the greater involvement of the upper skeleton in arthritic changes and traumatic injuries can be linked to relatively undemanding physical activities, such as food preparation and processing, while physical stress in the lower skeleton may reflect heavy agricultural activities such as clearing fields, tillage, planting and harvesting, together with travelling on foot. As regards the dental evidence for dietary patterns, there are significant increases through time in rates of caries, antemortem tooth loss and periapical abscesses. These observations are consistent with a shift from a high level of meat consumption in the Neolithic/Early Bronze Age to greater reliance on carbohydrate based foodstuffs such as fruits and nuts (the introduction of which in the Late Bronze Age is suggested palynologically - Chapter 2) and starchy products in the Late Bronze/Early Iron Age.

The demographic analysis (Chapter 4) reaches three interesting conclusions:

1) *Certain age categories are excluded* from the case study assemblages. For example, neonates, that is individuals under 1 year old, are absent from the Late Bronze and Early Iron Age assemblages, while only prime adult males (and women of all age categories) are represented at LBA Spathes. With regard to the immature skeletal material, preservation bias must be considered, but their total absence from burial assemblages cannot be explained solely by such extrinsic factors. At LBA Spathes, the emphasis on prime adult males could possibly be interpreted in terms of flawed techniques of ageing, although this usually favours the young adult age category

(Chapter 4). Alternatively, the evidence could be interpreted at face value, in terms of the deliberate disposal of prime adult men together with female individuals of varying age. In both the above cases, the programme of funerary behaviour practised by the living seems to have involved the conscious exclusion of certain age groups from the common burial ground. For example, neonates may not have been recognised as eligible members of the community.

2) *Females are over-represented* in most skeletal assemblages. Moreover, given that preservation bias favours male skeletons (Chapter 4), it is likely that the majority of unsexed individuals were in fact female and that the prevalence of women in the case study cemetery populations has been underestimated. Three different factors may have contributed to this pattern: a) matrilocal residence whereby women revealed stronger links to their place of residence, b) the long-term absence of men from home and, in consequence, their burial off-site, and c) systematic male infanticide. Thus, contrary to the common perception of women as possessing low status in non-western societies with men dominating the major economic and social roles, in the case study populations women seem to have been valued members of the community, perhaps because of their significant contribution to the production and processing of food and to the reproduction of the future labour force (Derevenski 1997).

3) *High mortality rates* are observed in certain population subgroups, e.g. in subadults (especially in early assemblages) and in males and females in early and late populations, respectively. High mortality rates have been the focus of much debate concerning the meaning of average age-at-death in past skeletal series. The primary issue is whether average-age-at death represents mortality rates or fertility levels in a skeletal population (Sattenspiel and Harpending 1983; Buikstra et al. 1986; Johansson and Horowitz 1986; Milner et al. 1989). It has been suggested that low average age-at-death, represented by frequent deaths among young individuals, indicates that more individuals entered the population through higher fertility; conversely, high average age-at-death, represented by frequent deaths among older individuals, indicates a decrease in birth rates (Buikstra et al. 1986; Johansson and Horowitz 1986; Milner et al. 1989). According to this view, high infant mortality may be consistent with high fertility levels and so associated with an increase in population size. Assuming that no great fluctuations have affected the size of the case study populations, therefore, the skeletal assemblages with high mortality among

infants, children and young individuals (i.e. EN Nea Nikomedeia, EBA Koilada and EIA Makrigialos) might suggest increasing fertility levels contributing to an increase in population size. This interpretation may be contradicted, however, by another line of evidence namely the possible indications of late weaning and long birth intervals from enamel hypoplasia lines (see below).

Chapter 6 examines aspects of health status and their association with population subgroups defined by age and/or sex. Five points can be distinguished:

1) *Certain age/sex categories are susceptible to physiological stress factors.* In particular, as discussed earlier, certain cemetery populations have high levels of infant and child mortality: e.g. EN Nea Nikomedeia, EBA Koilada and EIA Makrigialos where this is associated with a high prevalence of anaemia as indicated by severe cranial and postcranial manifestations. Similarly, the differential exposure of the sexes to physiological stress factors is clearly suggested by the contrasting frequency of anaemia, non-specific infections and enamel hypoplasia in the two sexes in various cemeteries. A high frequency of physiological stress factors cannot be seen as the result of biological susceptibility alone. Given that physiological stress relates to the overall pathogen load of the cemetery populations, it is possible that harsh living conditions, possible aggregation of population, increased exposure to pathogenic agents (possibly due to travelling and extended trade contacts), poor nutrition, and changing patterns of food preparation, may all have contributed to the weakness of the immune system of certain population segments (for further discussion see Larsen 1997).
2) *The late age of weaning*, suggested by the late peak frequency in the development of enamel hypoplasia lines (3 to 5.5 years), may have further implications for fertility levels in the case study populations. Breast feeding may be associated with the contraceptive effects of nursing and lactational amenorrhea and thus with long birth spacing (see, for example, Stuart-Macadam and Dettwyler 1995; Katzenberg et al. 1996; Schurr 1998). Long birth intervals indicate reduced birth rates and so are linked to low levels of fertility and slow population growth. If this interpretation of the hypoplasia evidence is accepted, the supposed demographic expansion in the Neolithic and Early Iron Age in the study area, already discussed in Chapter 2 (Demoule and Perlès 1993; Halstead 1994; Andreou et al. 1996; Andreou and Kotsakis in press b; Grammenos et al. 1997), are brought into question. On the other

hand, this argument is at odds with the tentative interpretation (above) of the age-at-death evidence. In order to resolve this issue, it is necessary both to explore the hypoplasia evidence on a larger and statistically more valid dental sample and to test the late weaning argument independently with analytical methods such as stable nitrogen isotopes (Schurr 1998).

3) *The moderate participation of adolescents and young adults* in occupational activities is suggested by the development of changes to the skeleto-muscular system, such as osteoarthritis and trauma, in young individuals at EN Nea Nikomedeia, EBA Koilada, LBA Spathes, LBA/EIA Treis Elies and the EIA Olympus tumuli. This point is of particular significance given that age-progressive changes to the skeleto-muscular system need a long time before they affect the bone. The start of repetitive physical stress, therefore, can be reliably associated with late childhood and adolescence. The role of children and adolescents in the workforce has been under-estimated or totally ignored in the archaeological literature (Derevenski 1994; 1997). Bearing in mind that, in most prehistoric populations, demographic analyses suggest that half of the living individuals were children (Chamberlain 1997), it is important to acknowledge the active participation of these population segments in economic and social life. In non-western pre-industrial societies, children and adolescents are not just passive recipients of parental care but they "form a significant part of the workforce" (Scott 1997). The need for young workers in the context of early farming in Greece has been discussed by Halstead (1989). Because children (and old people) could have undertaken relatively undemanding physical tasks such as weeding and herding, it has been proposed that this need was a substantial incentive to Neolithic demographic growth (Halstead 1989: 72).

4) *An equal participation of the two sexes* in labour is suggested by the distribution of changes to the skeleto-muscular system in the case study assemblages. In particular, both sexes reveal similar patterns of lesions referable to osteoarthritis, trauma and vertebral abnormalities especially in the upper skeleton. As regards osteoarthritis, however, some sex-based division of labour is suggested, with men overall carrying a heavier physical workload than women. Similarly, some sexual differentiation can be seen in the involvement of the upper and lower skeleton, with women engaged in types of labour, such as food processing and craft production, requiring greater use of the forearm and arm. It has often been assumed that, because of biological

constraints, women (like children and adolescents) made only a minimal contribution to the overall production and economy of the community (Brown 1970; Leacock 1978; Ember 1983; Burton and White 1984; Gibbs 1987; Grauer 1991; Miller 1993; Grauer and Stuart-Macadam 1998). It is also commonly assumed that women held a low status in society (Leacock 1978), with their roles usually linked solely to child care and the entertainment of men. Women's activities were strictly confined to physically undemanding work, typically taking place in limited areas in and around settlement sites (for a recent review see Derevenski 1997). However, as Chapman states for Balkan prehistoric cemeteries, "the increased divergence of economic resources in the Copper Age stimulates the emergence of a more gendered division of labour, gained from the production of food and clothing available to females controlling the domus, associated also with the expanded importance of secondary products in the domestic domain" (Chapman 1997: 137, 138).

5) There is some *evidence of specialised occupational activities*: a) the preferential involvement of the left side of the upper skeleton, contrary to the expectation of right-handedness, perhaps suggesting activities related to food processing; b) the distinct pattern of dental trauma in two women only from EBA Koilada; and c) the restriction of vertebral abnormalities (suggesting particularly stressful repeated movements of the lower back) to only a few individuals in three cemetery populations. These cases suggest that, apart from the ordinary activities carried out by all members of the case study communities, there were some specialised economic roles practised by certain individuals. Furthermore, it is striking that, in certain cemetery populations, the specialised activities were possibly sex-based, as in EBA Koilada, where only women manifested the distinctive dental trauma, and in the EIA Olympus tumuli, where only men had vertebral abnormalities.

Chapter 7 analyses oral health status and implications for diet and explores differences in dietary patterns between age and/or sex groups. Apart from the significant overall shift from meat consumption in the Early Bronze Age to carbohydrate-based foodstuffs in the Late Bronze/Early Iron Ages, three crucial points can be underlined:

1) *A high reliance on carbohydrate-based foodstuffs* is evident in high mountain (e.g. LBA Spathes and LBA/EIA Treis Elies on mount Olympus) and coastal populations (e.g. EIA Makrigialos and EBA/LBA Korinos). The dietary regime of prehistoric

populations in these two environments has been subject to considerable discussion. Mountain populations might be expected to reveal a high level of meat consumption, given the widespread assumption that the occupation of the mountains involved a pastoral adaptation (e.g. Kilian 1973; McNeile 1992). The results of the macroscopic examination, however, contradict the hypothesis of specialised pastoralism in prehistoric Greece and give support to the opposite model, that is of mixed farming practised even in the high mountain regions (Halstead 1990a; 1990b; 1994; 1996). Similarly, it is notable that a similar reliance on carbohydrate-based foodstuffs is implied also at coastal sites, where a high contribution of marine foodstuffs might be expected (e.g. Bintliff 1977). On the contrary, the stable isotope analysis suggests a terrestrial diet, rich in agricultural products.

2) *Similar types of diet were consumed by both the subadult and adult segments* of the case study populations, as is suggested by the distribution of dental conditions in all age categories. This picture is compatible with equal membership of children and adolescents in the community of adults, at least as regards dietary access. This suggestion, together with the moderate participation of adolescents and young adults in physical work (Chapter 6), leads to the conclusion that these young age categories were active participants in the social and economic life of the case study communities (Chamberlain 1997; Lillie 1997; Rega 1997).

3) *An overall similarity of diet consumed by the two sexes* is indicated by the distribution of dental conditions and, in particular, by the relative frequencies of caries and calculus. There is, however, some weak evidence of differential dietary access, on the basis of sex, in certain skeletal assemblages: EBA Makrigialos and EBA/LBA Korinos (albeit with small dental samples) and LBA Spathes and LBA/EIA Treis Elies. The general similarity of diet, together with the active participation of both sexes in physical labour, suggests that, overall, women were not of lower status than men in the case study communities. Nevertheless, there is some evidence of sexual division of labour (as regards the intensity of physical work) and of slight differential access to certain food categories, especially for some Late Bronze/Early Iron Age assemblages and these differences in turn may imply particular sex roles in the affected populations (Kestle 1988; Grauer and Stuart-Macadam 1998).

Apart from these biological inferences and their association with age and/or sex groups, this thesis has also explored the manipulation of the deceased through time based solely on the skeletal populations and published contextual information (Chapter 5). Two major issues have been discussed in detail:

1) *The treatment of the deceased in Neolithic Makrigialos*, focusing in particular on the phase I assemblage because of the availability of contextual information and archaeological records. Contrary to the previous consensus that the Neolithic mortuary record (Demoule and Perlès 1993) emphasised individual identity and was dominated by intramural burials, the recent evidence from Late Neolithic Makrigialos I is consistent with the incorporation of the deceased into a group identity. Moreover, most phase I burials at Makrigialos took place in openly accessible areas, continuously used and seen by the living community (Ditch A and the large pit in sector Ξ). Furthermore, a limited number of burials in Ditch A and the large pit in sector Ξ gave evidence of a formal mortuary programme with grave structure, articulated burial position and occasional associated grave goods. This suggests emerging differential manipulation of the deceased, in contrast to the accepted picture of homogeneity and social equality in mortuary treatment during the Neolithic (Demoule and Perlès 1993).
2) *Variation in the minimum number of individuals* held within a single burial assemblage from the Bronze Age onwards. The skeletal evidence, together with information on mortuary treatment from preliminary excavation reports, allows certain inferences with regard to the perception of the mortuary arena as a site of social interaction between the community of the living and the deceased. As already described at the beginning of this section, the Bronze and Early Iron Age assemblages reveal a striking diversity in the manipulation of the deceased, ranging from the common practice of single inhumations in the Early Bronze Age to multiple/secondary burials in the Late Bronze Age and the occurrence of both single and multiple burials in the Early Iron Age. Single inhumations of the Early Bronze Age emphasise individual identity, which is reinforced occasionally by additional furnishing, clothing or grave goods. Conversely, the Late Bronze Age saw systematic adoption of multiple/secondary burials emphasising lineage-group identity, although items such as carved sealstones, special jewellery, pots and bronze weapons (often recalling Mycenaean or "Mycenaeanising" types) also imply

recognition of the individual identity of the deceased. The co-occurrence of single and multiple/secondary burials in the Early Iron Age argues for a complex picture of differential treatment of the deceased. Burial practices during this period reinforce lineage identity, developed in the preceding period, by the broad use of tumuli alongside the emergence of more visible differences in social display and social ranking such as the selective use of chamber tombs by particular small kin groups.

The ultimate aim of this research has been the integration of biological inferences drawn from osteological examination of the case study assemblages with other forms of archaeological evidence from excavated sites in Central and Western Greek Macedonia. First, there are no major differences between age and/or sex groups in the overall biological quality of life. All age groups and both sexes appear to participate actively in labour and share similar types of diet, although, in most cemetery populations, there is some evidence that men, in general, carried a heavier workload than women. Similarly, there is some weak evidence, particularly in some Late Bronze Age assemblages, of differential access to dietary items. Mortuary treatment, however, and the manipulation of the deceased from Bronze and Early Iron Age cemetery populations argue strongly for sex-based differentiation in mortuary behaviour, indicated by burial positions and orientations at EBA Koilada and EIA Makrigialos, respectively, by some grave types at EBA Koilada, and by associated grave goods in the Late Bronze and Early Iron Age assemblages. It seems, therefore, that relative equality between the sexes in the economic roles filled during life is largely not reflected in the sex-based mortuary programme. A similar contrast between strongly sex-based mortuary behaviour and relative equality in quality of biological life has been inferred for the Early Bronze Age Mokrin cemetery in Hungary (Rega 1995; 1997).

Secondly, one interpretation of the over-representation of female individuals has been in terms of preferential male infanticide, which would imply that women were valued members of these prehistoric communities. In this case, female burials might be expected to display high expenditure in grave types, additional grave furniture and associated grave goods. Only EIA Makrigialos, however, reveals a possible association of exotic craft products with female burials (Karliabas 1998) and so supports the interpretation of mortality rates as evidence that women were more highly valued than men. The other preliminary excavation reports do not suggest that high value items were particularly associated with female individuals and so perhaps imply a similar level of funerary investment for both sexes. At this point, however, it is necessary to emphasise the overall lack of mortuary analyses which address such questions for the study area.

Thirdly, the Late Bronze and Early Iron Age assemblages demonstrate that certain age categories, principally neonates, were excluded from the common cemeteries. In EIA Makrigialos there is also some evidence that infants and children were excluded from chamber tombs thought to hold small family-related groups (Karliabas 1998). The high infant and child mortality associated with hereditary types of anaemia does not solely reflect the weak immune system of the individuals affected but also the mother's health status, since hints of a late age of weaning suggest that infants and young children were possibly highly dependent on the mother. These early age categories were not obviously active, productive members of the community, although they were considered, to a certain extent, as proper members since they were buried in the common cemeteries. On the other hand, biological evidence of work-related physical stress and diet indicates that children and adolescents participated actively in social and economic life. This implies that, in the case study prehistoric communities, childhood marks the passage to membership of the adult community, as reflected in quality of life, while infancy represents a transitional stage where the individual's identity is still defined by the parents. There is some differential mortuary treatment based on age, although the contextual information comes from a very restricted number of cemeteries, mainly EBA Koilada and EIA Makrigialos. For example, certain grave types and grave goods, sometimes particularly rich, are associated with infant and child burials, reinforcing the previous suggestion that such individuals were ascribed their status by their parents since they were too young to have acquired it during life.

Lastly, the variation through time in the minimum number of individuals held in one burial assemblage (Chapter 5) is consistent with the evidence from settlements suggesting a shift in the size of household units (Chapter 2), from a single nuclear family in the early phases of the Bronze Age to expanded residential units comprising more than one household from the Late Bronze Age onwards. Similarly, the mortuary programme indicates a shift from single burials in the Early Bronze Age to multiple/secondary burials in the Late Bronze Age and then to the broad adoption of tumulus cemeteries in the Early Iron Age. The picture of horizontal social organisation derived from settlement evidence is broadly comparable, therefore, with that from mortuary evidence. Moreover, the mortuary picture is not clearly consistent with vertical social differentiation, as might have been expected of the late populations in particular. There is evidence of "rich" and "poor" assemblages in Late Bronze/Early Iron Age cemeteries, but it is not apparent whether these reflect individual or lineage-group identity when encountered in multiple/secondary burials in simple grave structures, chamber tombs or tumuli. In the case of EIA Makrigialos, it is also striking that rich assemblages do not occur only in chamber tombs but in simple grave types as well. Chapter 5 has already discussed the association in the Early Iron Age of new burial types, that is the chamber tomb and the tumulus, with the emergence of more visible differences in social display and social ranking by particular groups. It is likely, therefore, that differentiation within the Early Iron Age communities of the study area was primarily horizontal, representing competition between small family-groups, rather than vertical, between high- and low status individuals. At the moment, contextual information is too sparse to allow this debate to proceed further. As regards biological inferences, however, the stable isotope analysis of individuals buried in different grave types at EIA Makrigialos (Chapter 7) did not provide any evidence of differential access to dietary items, suggesting that all individuals, independently of grave type, consumed a broadly similar diet. It is possible, therefore, that the means used by the suggested small competing family-groups of the Early Iron Age to establish social power and identity were not defined by the biological quality of life but by other symbolic or ideological parameters such as the use of the past and links to the ancestors, as is clearly projected in the structure of the chamber tomb (Chapter 5).

This study does not exhaust the potential of analyses of cemetery populations from Greek Macedonia. Complementary analytical work is needed, involving particularly chemical and microscopic methods. Moreover, the results of the macroscopic examination of the skeletal assemblages need to be thoroughly integrated with the as yet largely unpublished contextual information for the cemetery populations. Additionally, there is a need for comparative study with the neighbouring areas of the Balkans, Thessaly and southern Greece. The latter areas have drawn the attention of specialists, but with mortuary or osteological analysis taking place in isolation from each other (Introduction). There has been a general failure to intégrate the mortuary and biological evidence from burial assemblages. At present, there is little potential for detailed comparison with mortuary data from Northern Greece because of the poor contextual information from the study area and the scarcity of population studies in neighbouring areas which cover a broad time span in a variety of environmental zones.

The principal aims of this thesis were to explore aspects of the biological quality of life of the prehistoric populations and shed some light on population subgroups usually neglected in the archaeological record. Within the constraints of poor preservation and of a scarcity of published archaeological information, the current work has attempted to proceed beyond the grave goods and burial practices which make up the mortuary picture of the case study communities and to view the occupants of the grave assemblages as bodies of once living human beings and not as discarded skeletons.

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