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A Bioarchaeological Investigation of Cultural Change in Dorset, England (Mid-to-Late Fourth Century B.C. to the End of the Fourth Century A.D.)

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ABSTRACT

This paper discusses the results of the first regional and bioarchaeological analysis of health in Late Iron Age and Roman Britain. This tested the hypothesis that cultural and environmental changes in Dorset would result in changes to demography, stature, dental health, and infectious disease. The study observed change to all health variables, supporting environmental and archaeological evidence for the introduction of urban centres, changes in living conditions, greater population movement, and development of the agricultural economy. Importantly, the study demonstrated that these responses did not reflect changes observed in other areas of Britain or Gaul.

INTRODUCTION

The transformation of mid-to-late Iron Age communities in response to Roman colonisation has been encapsulated by the term Romanization, a process now considered to be a practice of adoption and adaptation that was subject to regional, community and individual heterogeneity.[1] Our understanding of how communities changed has received limited input from environmental archaeology, despite research frameworks highlighting the contribution these data can make to interpretations.[2] Human remains represent a unique form of evidence with which to explore how communities responded to Roman contact and colonisation, because the skeleton has the ability to record independently biological responses to environment and culture. Osteological data have been successfully employed outside Britain to analyse the biological consequences of incorporation into the Roman Empire, and to explore life within Roman Italy.[3] Within Britain, Roberts and Cox[4] have conducted an overview of Iron Age and Romano-British health at the national level but, in contrast to this study, they were unable to study all the material themselves using a standardised recording system, and were reliant upon

1 Amongst others: Hingley 2005 and Webster 2001. For a critique of the term Romanization see Mattingly 2006, xii; Hingley 2005.
2 Haselgrove *et al.* 2001.
3 Lovell and Whyte 1999; Prowse *et al.* 2007.
4 Roberts and Cox 2003, 2007.

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the quality of each osteological report.[5] This paper aims to contribute to our understanding of health in the Roman Empire by testing the hypothesis that cultural and environmental changes would result in changes to demography, stature, dental health, and infectious disease.

The heterogeneous nature of Romanization has been explored by examining changes in architecture, material culture, mortuary rites, and environmental data. This evidence has shown that the first towns were constructed in the Roman period, and new housing technologies introduced, such as hypocausts and drainage. The range of foods consumed and their preparation, with the introduction of new vessel types, show that communities also adapted their diets over time. This evidence has been supported by recent stable isotope analyses of late Iron Age and Romano-British populations from northern England (Yorkshire).[6] The wider environment was also transformed post-Conquest, with the intensive exploitation of natural resources by the metal and pottery industries, and the specialisation of agriculture with the use of ploughshares, mechanised mills for cereal processing, and the introduction of new vegetables and fruits. The connections between Britain and the Continent were more varied, which promoted trade and the migration of people. The influence of the Roman army upon urban centres in the Romano-British period is another source of diversity. Many cemeteries were initially used by the military, which may in some cases have resulted in higher numbers of male adults, and because the army recruited from conquered territories, cemeteries contain individuals of diverse origins who often continued their existing food-ways.[7]

The social systems of communities in both periods have been shown to be highly complex and subject to regional variation.[8] In the broadest terms, Iron Age communities are considered to be hierarchical and organised according to status and honour, with power held by a few individuals who controlled access to resources using a client network. In the Romano-British period, communities were organised using existing divisions of Iron Age groups and governed as *civitates*, run by a council of the indigenous élite who were allowed to keep many existing power hierarchies to ensure stability. Britain was ruled by a governor, drawn from the consuls at Rome, and in A.D. 197 the province was sub-divided into *Britannia Superior* and *Britannia Inferior*.[9] Our knowledge of daily life in both periods is inadequate. We do not know how status differences affected access to food, housing conditions, and occupation during the Iron Age and, in particular, how these varied between communities. Additionally, we do not know how communities were organised according to gender and age identities, and how these changed with Roman contact and colonisation. In both periods, these problems are exacerbated by the continuing bias of regional differences and, overall, analysis and interpretation of both periods has traditionally excluded human remains, and made limited use of other bioarchaeological data.[10]

From an osteological perspective, our understanding of the Iron Age population is also inadequate, because most communities practised an archaeologically invisible mortuary rite until the first century A.D., and only a small number of cemeteries has been identified in northern, central and southern England. As a whole, samples from this period have been subject to limited osteological research. Dorset and east Yorkshire are currently the only locations where several mid-to-late Iron Age cemeteries have been identified, because these communities practised

5 Due to disparities in recording quality and publication, not all of the material available could be incorporated, creating a bias in the distribution of diseases (in some periods), and an under-estimation of overall prevalence rates (Roberts and Cox 2003, 26–30).

6 Hingley 1989; Cool 2006; Jay and Richards 2006; Mattingly 2006; Müldner and Richards 2007.

7 King 1999; Mattingly 2006.

8 Creighton 2000; James 2001; Haselgrove and Moore 2007; Haselgrove and Pope 2007.

9 Cunliffe 1991, 541–8; Mattingly 2006, 54, 126, 128–30.

10 Haselgrove and Moore 2007; James and Millett 2001; Mattingly 2006.

inhumation in settlements and/or cemeteries. However, Dorset is the only county to show continuity into the Romano-British period and to exhibit no break in mortuary practices.[11] Overall, more samples exist from the Romano-British period, as cremation and/or inhumation rites were practised throughout England, and many organised cemeteries (rural and urban) have been excavated. The majority of urban cemeteries excavated are from southern England, and, in contrast to the Iron Age, many aspects of health have been investigated. Nevertheless, due to the lack of regional studies in British osteology, analysis of both periods has been either cemetery-specific or in the form of case-studies, which have frequently separated health from its bioarchaeological context.[12] For example, no other temporal analyses of Romanization at the regional level have been published. Roberts and Cox were the first to examine temporal change at the national level, and demonstrated that health did change in the Romano-British period. They observed that the national prevalence of dental and specific infections increases, and male stature increases and female stature decreases.[13]

The bioarchaeological analysis of cultural and environmental change remains under-developed in British palaeopathology.[14] In contrast, a wide variety of Contact literature has been generated by the bioarchaeological analysis of Native American human remains.[15] The publication edited by Larsen and Milner has shown that colonisation can affect dental health, stature, and the prevalence of infectious diseases. Contact literature is important for the analysis of European human remains from any period of cultural change, because it has challenged assumptions about how health-statuses respond to transformations of political and economic systems, and environmental conditions. This literature has concluded that a uniform response in health may not be found and that many communities can successfully adapt to significant cultural and environmental transformations.[16]

EVIDENCE FROM HUMAN REMAINS: BIOARCHAEOLOGY

Individuals recovered from archaeological contexts are biased by their method of disposal (e.g. cremation or excarnation) and burial location (e.g. earth or water), which are also influenced by gender, age, and social status variables. Therefore, a cemetery population available for analysis may not be an accurate reflection of the living community, particularly as the sample is acted upon by additional taphonomic agents that decrease the number of individuals present at the time of excavation.[17] Excavation of historical cemeteries has shown that even when bone preservation is very good and the entire cemetery is excavated, there will be disparities between the skeletal sample and burial registers.[18] It should also be recognised that archaeologically derived samples of human remains are biased by hidden heterogeneities, such as intra-individual variation in 'frailty' to disease and death. For example, those displaying osseous or dental responses to disease are 'healthier', and the frequency of active responses will be greater in the dead population compared to those affected in the living.[19]

11 Carr 2007; Roberts and Cox 2003, 26–30; Whimster 1981. It is acknowledged that this view of Iron Age burial practices is changing due to finds, such as Yarnton (Hey *et al*. 1999).
12 Roberts and Cox 2003, 22–3, 26–30.
13 Roberts and Cox 2003, 106, 163.
14 Roberts and Cox 2003, 26–30.
15 e.g. Verano and Ubelaker 1992.
16 Larsen and Milner 1994.
17 Waldron 1994, 10–17.
18 For example, Saunders *et al*. (1995, 74–5) who analysed a post-medieval cemetery from Ontario (Canada) that was in use from 1821 till 1874, reported that 710 individuals less than 15 years old were identified in the burial registers, whereas only 282 were identified during excavation.
19 Wood *et al*. 1992, 344–5, 349, 352–4.

Health and disease are produced or maintained by numerous interrelated causes whereby no single mechanism is responsible for causing disease or poor health. A population's or individual's health is directly linked to their living environment, culture, and social status. The wider environment determines health with regard to weather and climate, chemical concentrations in water (e.g. iodine and fluorine), and trace elements in the soil. The local environment contains constructed and defined areas that are lived in and used according to socio-cultural conventions.[20] It is also influenced by technology in addition to cultural factors, such as sharing dwellings with animals and methods of sanitation.[21]

The importance of the relationship between health status and social status has been exemplified by many palaeopathological studies, and socio-cultural factors have been shown to influence health and well-being. Society and culture influence health, because they permeate and frequently determine the entire life course.[22] Poor diet and social conditions allow infectious and metabolic diseases to flourish, and can result in a failure to achieve the growth potential. If such conditions are experienced during childhood, an individual's well-being during adulthood will be directly affected.[23]

In this study, a bioarchaeological approach has been used to investigate how environment and culture affected community health.[24] Within British literature, this type of analysis is frequently termed 'biocultural' as it connects osteological data with archaeological and historical evidence for culture, environment, and society.[25] Its aims are '(1) to assess the biological condition of human populations and its consequences for the biological and cultural reproduction of the society and (2) to consider the selective effects of culture on the population under study and its survival … the biocultural approach places emphasis on the integration and inter-relatedness of biological and cultural systems'.[26] In summary, a bioarchaeological framework aims to interpret osteological data using all available archaeological evidence in order to provide a holistic understanding of past communities.

ARCHAEOLOGICAL EVIDENCE FOR TEMPORAL CHANGE IN DORSET

The study is based upon communities who were identified by the Romans as the Durotriges. Archaeologically, these groups have been shown to have a regionally distinct material culture and mortuary rite.[27] The communities living in this region practised an inhumation burial rite from the mid-to-late Iron Age to the end of the Romano-British period, and many cemeteries were used in both periods. These factors make this study distinctive, because it does not encounter the biases of inter-regional heterogeneity and temporal changes in mortuary practice.[28]

These communities inhabited the modern county of Dorset, which is located in south-west England (FIG. 1). The county has a long history of archaeological excavation, and over the past fifty years, new sites have been identified due to road and building construction, particularly in the county town of Dorchester. The county is 2,652 km^2 and has three large river systems, which

20 Howe 1976a, 1–15.
21 Howe 1976b, 4–6; McElroy and Townsend 1996, 26.
22 Steckel and Rose 2002; Rousham and Humphrey 2002, 127.
23 McElroy and Townsend 1996, 100–5, 111–17; Roberts and Cox 2003, 7.
24 Bioarchaeology is defined as, 'the contextual analysis of human populations from archaeological sites … focusing on the osteobiography of individuals and the biocultural adaptations of populations as viewed through the lens of archaeological context' (Beck 2006, 83).
25 Roberts and Cox 2003, 13.
26 Bush and Zvelebil 1991, 5.
27 Blackmore *et al*. 1979; Cunliffe 1991, 159–70; Papworth 2007.
28 See Mattingly 2006; Haselgrove and Moore 2007.

FIG. 1. A map showing the location of Dorset in south-west England .
(*Drawn by K. Waddington*)

join the sea on the south coast. During the Iron Age, the climate was characterised by wet and cold periods until *c.* 150 B.C., when it became milder and warmer, but from A.D. 80 the climate returned to pre-Roman conditions.[29] In both periods, the landscape was a mosaic of grasslands, woods, heath-lands, and fields. During the Iron Age, the mixed agricultural economy expanded and in the Romano-British period underwent rapid development with an increase in cultivated land and herd size. This transformation was accompanied by greater exploitation of natural resources to support iron-working, pottery and tile production, and salting.[30]

Environmental and material-culture evidence for dietary changes in Britain has shown that inter- and intra-regional differences existed, reflecting variation in community tradition and location, environment and economy, the influence of the Roman army, migration of individuals, and access to urban markets.[31] As Cool states, 'there was no more a single Roman way of doing things, any more than there was a single native way'.[32] Therefore, evidence specific to Dorset is presented. Environmental evidence for diet in the Iron Age has shown that a range of domesticates were kept for meat, including chickens, sheep, pigs, and cows. Cattle and sheep herds were also managed for wool, milk, and fat production. Wild resources were exploited but to a far lesser extent, and included freshwater fish, marine molluscs, and wild game (e.g. deer and hares). The Durotriges had extensive trade networks within Britain and Europe, and excavation of a harbour on the coast at Hengistbury Head has shown that wine from Italy and

29 Lamb 1981, 55–7.
30 Dark and Dark 1998, 18, 30–2, 114.
31 Hurst 1999; King 1999; Hawkes 2001; Albarella 2007; Dobney and Ervynck 2007.
32 Cool 2006, 172.

perishables such as figs, corn and chamomile were also imported. In the Romano-British period, there is an increase in the consumption of marine resources, and the introduction of new crops such as plums, cabbage, and pears. In both periods, hulled barley, oats, and emmer/spelt were grown, with bread wheat becoming more popular in Roman times.[33]

Richards *et al*.'s stable isotope study of 48 Dorset individuals from Poundbury Camp, using nitrogen and carbon stable isotopes from late Iron Age (N=13) and Romano-British (N=35) individuals, provides a glimpse into mortuary status and diet in Dorset. Their study showed that marine resources formed a substantial part of the Romano-British diet, particularly for those buried in lead coffins, whereas individuals buried in wooden coffins showed continuation of the late Iron Age diet, with the consumption of terrestrial plants and animals and small quantities of marine foods.[34]

Late Iron Age settlements in Dorset consisted of thatched roundhouses, which were often over 13 m in diameter, located in circular ditched enclosures or in fortified hilltop settlements. Within the settlements a range of activities took place, including metalworking, cereal storage, and textile production.[35]

The town of Dorchester (*Durnovaria*) was founded in *c*. A.D. 65 and had a forum, amphitheatre, and public bath-house, with water supplied to the town via an aqueduct. It was the only urban centre in the county during this period and was a centre of local government, becoming part of *Britannia Superior* in A.D. 197. It contained wooden and/or stone houses constructed in an L-shape or centred on a courtyard. The household plots contained wells, cesspits or latrine buildings, and many of the dwellings contained ovens, drains and hypocaust systems. Although *Durnovaria* was a creation of the early Roman period probably succeeding a fort, there is no evidence of a long-term military presence in the county, and no cemetery has been identified as having military origins. Rural settlement is poorly understood, complicated by the lack of knowledge concerning settlement densities, land tenure, and social organisation. In rural Dorset, small nucleated settlements containing stone and/or wooden cottages, high-status villas, and roundhouses have been found dispersed throughout the county. Villa complexes often contained bath-houses, hypocaust systems, and latrine buildings.[36] Unfortunately, bioarchaeological data concerning living conditions and sanitation in both periods are very poorly understood, and such data have yet to be recovered from Dorset. Existing environmental samples from England are not complete enough to investigate indicator groups, and are dominated by military and urban samples from York and London.[37]

The inhumation mortuary rite is one of the defining characteristics of this region, and began in the mid-to-late first century B.C., with the use of formal cemeteries close to or within settlements and hillforts. Hamlin's mortuary analysis of late Iron Age Dorset has shown that a range of status groups, as evidenced by grave-goods, were inhumed and this rite was afforded to both sexes and all age-groups.[38] Burials were either single or multiple inhumations, using a common layout

[33] Maltby 1981; 1993; Buckland-Wright 1987; Cunliffe 1991, 161–4; Allen 1993a; 1993b; Ede 1993; Hamilton-Dyer 1993; 1999; van der Veen and O'Connor 1998; Gale 2003, 130.

[34] Richards *et al*. 1998.

[35] Groube and Bowden 1982, 41–6; Gale 2003, 99–114.

[36] Wacher 1981, 318–22; Groube and Bowden 1982, 48; Woodward 1993, 359–75.

[37] Keeley 1987; Bryant 1990; Hurst 1999. Indicator groups are based upon environmental data (i.e. groups of plants, invertebrates and vertebrates), which when found together can be understood to 'be parts of a package of evidence concerning particular aspects of the past' (Kenward and Hall 1997, 666). Kenward and Hall (1997) have used indicator groups to identify (amongst others) human occupation floors.

[38] Hamlin 2007. It should be noted that an earlier examination of late Iron Age status groups was conducted by Blackmore *et al*. (1979), who also identified four mortuary statuses based upon the inclusion of metal objects, jewellery, faunal remains, pottery and shale-work. Critiques of the use of grave-goods to identify biological sex, social status, and gender are discussed by (amongst others) Henderson (1989, 77–83) and Beck (1995).

and alignment, with the body placed in a crouched or extended position, and accompanied by a consistent range of grave-goods, which included pottery, jewellery and butchered meat. In the Romano-British period, burials also took place in formal urban and rural cemeteries with the body placed in an extended position, usually within a coffin. The earlier range of grave-goods continued, but also incorporated 'Roman' items such as hobnailed shoes. Minority rites of gypsum, decapitation, and prone burial have also been identified, as well as high-status burials in stone and/or lead coffins within mausolea.[39] As both periods practised an inhumation mortuary tradition, the cemeteries of Dorset can be reliably analysed as a group at the regional level over time.

MATERIALS AND METHODS

The study was based upon 270 sexed adult individuals from the county of Dorset. 115 mid-to-late Iron Age (male N = 64, female N =51) and 155 Romano-British (male N = 96, female N = 59) individuals derived from 21 cemetery or settlement contexts, which were located in the south, east and west of the county (Table 1; FIGS 2–4). Unfortunately, due to inter-cemetery

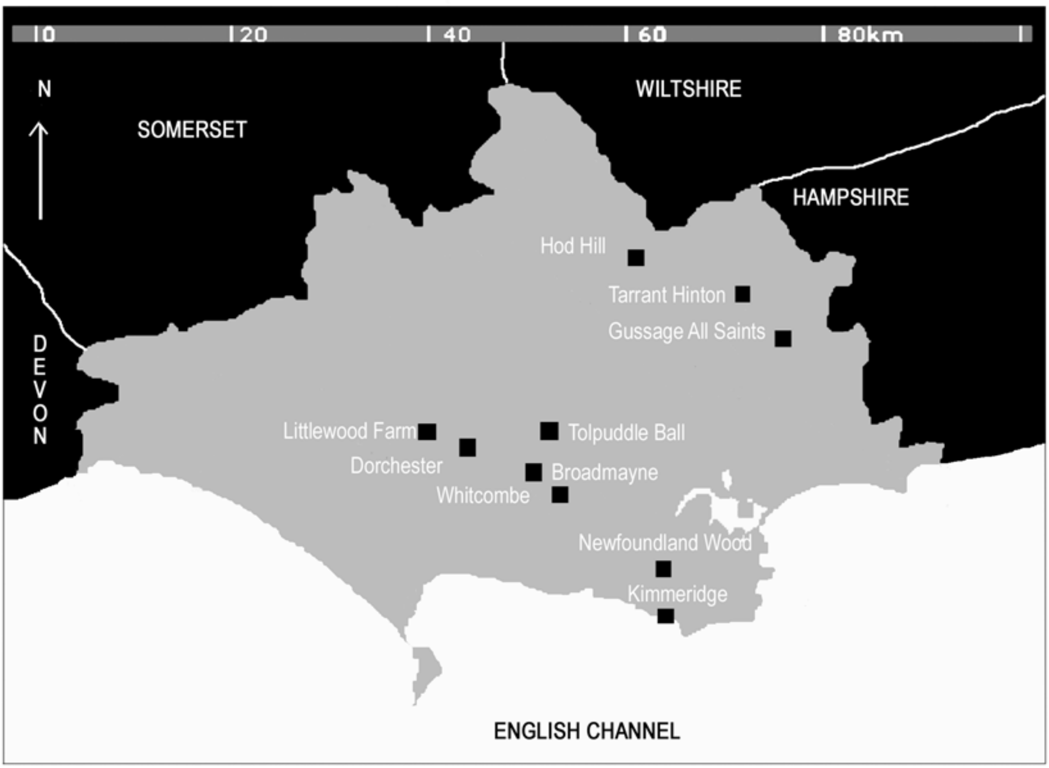

FIG. 2. A map of the county of Dorset showing the location of sites outside the environs of Dorchester (*Durnovaria*).

[39] Leech 1980, 342; Whimster 1977; 1981, 42; Woodward, A. 1993, 216–39; Millett 1997, 124, 128; Taylor 2001, 65–80. In Iron Age Dorset, the following unparalleled examples have also been found: a chariot burial from Fordington, and a double burial containing weaponry, horse equipment, metal utensils and glass beads from Lychett Minster (Taylor 2001, 75). No human remains from these burials were available for study.

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TABLE 1. SITE TYPE, LOCATION, DATE* AND SAMPLE SIZE

Site Name	Type	Location	Date	Males	Females	Total
1. Albert Road	Cemetery: rural	Dorchester	RBP	9	2	11
2. Alington Avenue	Cemetery: rural	south-east of Dorchester	LIA	4	4	8
			RBP	24	15	39
3. Broadmayne	Isolated burial (associated with a settlement)	south-east Dorset	LIA	1	-	1
4. Crown Buildings	Cemetery: rural/urban	Dorchester	RBP	1	-	1
5. Flagstones (Dorchester bypass)	Cemetery: rural	south-west of Dorchester	LIA	1	3	4
6. Gussage All Saints	Settlement	north-east Dorset	MLIA	4	4	8
	Rural		RBP	1	-	1
7. Hod Hill	Hillfort	north Dorset	RBP	1	-	1
8. Kimmeridge	Isolated burial (associated with a cemetery)	south Dorset	LIA	-	1	1
9. Littlewood Farm	Fort (isolated burial)	north-west of Dorchester	RBP	1	-	1
10. Maiden Castle	Hillfort	south-west of Dorchester	LIA	32	26	58
11. Maiden Castle Road (Dorchester bypass)	Cemetery: rural	south-west of Dorchester	RBP	5	6	11
12. Newfoundland Wood	Settlement	south Dorset	LIA	1	-	1
13. Fordington Old Vicarage	Cemetery: rural/urban	Dorchester	RBP	5	2	7
14. Poundbury Camp	Cemetery: rural/urban	north-west of Dorchester	LIA	8	5	13
			RBP	40	23	73
15. Poundbury Pipeline	Cemetery: rural/urban	north-west of Dorchester	RBP	-	3	3
16. Southfield House	Cemetery: rural/urban	Dorchester	RBP	-	1	1
17. Tarrant Hinton	Settlement	north-east Dorset	MLIA	1	1	2
18. Tolpuddle Ball	Cemetery: rural	east Dorset	MLIA	3	2	5
			RBP	3	4	7
19. Western Link (Dorchester bypass)	Cemetery: rural	north-west of Dorchester	LIA	4	3	7
			RBP	6	3	9
20. Whitcombe	Cemetery	south-east Dorset	LIA	5	2	7

* mid-to-late Iron Age (MLIA), late Iron Age (LIA), Romano-British period (RBP)

References: 1. Stacey 1987; 2. Davies *et al.* 2002; 4. Sparey-Green *et al.* 1981; 5. Smith *et al.* 1997; 6. Wainwright 1979; 7. Richmond 1968; 8. O'Connell 2000; 9. Putnam 1998; 10. Wheeler 1943; 11. Smith *et al.* 1997; 12. Toms 1970; 13. Startin 1982; 14. Farwell and Molleson 1993; 15. Davies and Grieve 1986; 16. Davies and Thompson 1987; 17. Graham 2006; 18. Hearne and Birkbeck 1999; 19. Smith *et al.* 1997; 20. Aitken and Aitken 1991.

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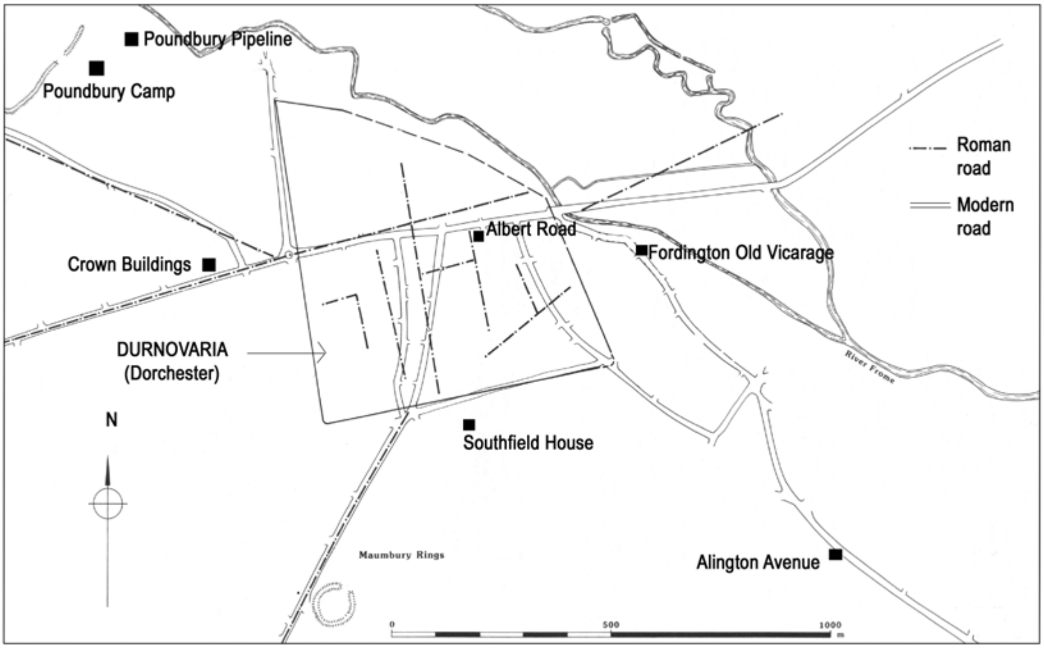

FIG. 3. A map showing the location of sites in the immediate environs of Dorchester (*Durnovaria*) (after Smith *et al.* 1997).

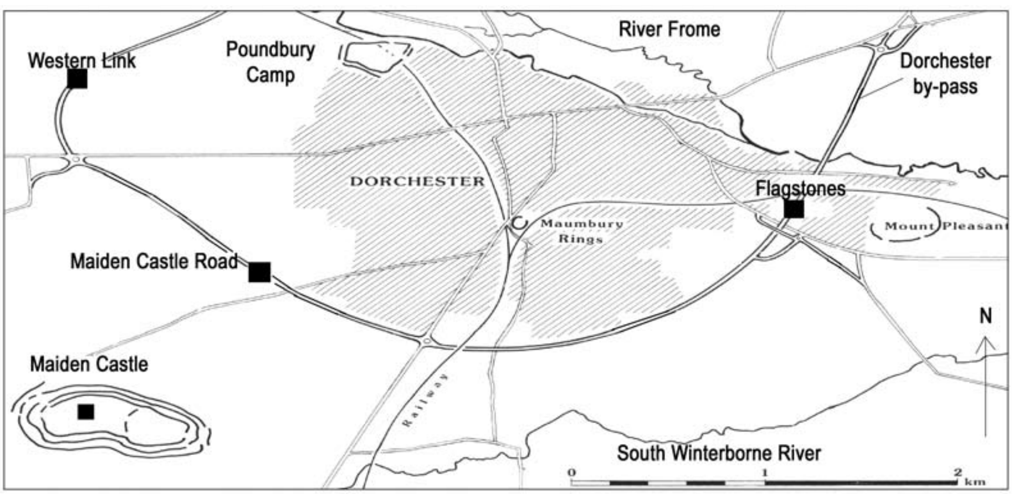

FIG. 4. A map showing the location of sites in the wider environs of Dorchester (*Durnovaria*) (after Smith *et al.* 1997).

differences in phasing and the inability to categorise consistently burials from the earliest phases of Roman occupation, a transition sample could not be identified.

The majority of burial contexts were located in or near to *Durnovaria*, which is in the south-west of the county. The majority of cemeteries and burial contexts included in this research were excavated from the middle to the end of the twentieth century. Unfortunately, due to differences in excavation techniques, dating methods (material culture phasing or carbon 14), and the inability of many excavations to uncover cemeteries in their entirety,[40] it was not possible to provide a more discrete chronology, particularly during the Romano-British period. Therefore, the burial contexts were divided into mid-to-late Iron Age (mid-to-late fourth century B.C. to first century A.D.) and Romano-British (first century A.D. to the end of the fourth century A.D.).[41]

Seven cemeteries date from the mid-to-late Iron Age, eight are from the Romano-British period, and five were used in both periods. Individuals were included in the sample if they were from articulated inhumations, dated contexts, and conformed to stages zero (excellent) to three (weathered compact bone) of preservation.[42] Only at Poundbury Camp was a sampling strategy employed, because the sample was too large (N = 1,442) to be recorded within the parameters of the study.[43]

From the outset, it was recognised that temporal changes in health could only be investigated if the osteological data were recorded in a repeatable and standardised format. Therefore, the widely accepted osteological standards edited by Buikstra and Ubelaker[44] were used to record skeletal and dental inventories, age, sex, and pathology. Assessment of biological sex was achieved by scoring the morphology of the skull and pelvis.[45] Age-at-death was determined using the pelvis.[46] Individuals were divided into the age-ranges stated in Buikstra and Ubelaker: young adult (20–35 years old), middle adult (36–50 years old), older adult (more than 50 years old), and adult (over 20 years old).[47]

In order to test the hypothesis, four types of osteological data were chosen for analysis: age-at-death, dental health, stature, and infectious disease.[48] Contact studies in the Americas and examination of temporal changes in British archaeological populations have proven these to be

40 For example, Poundbury Camp. In many cases, this was due to the rescue context of the excavation, or limited by road building (i.e. Tolpuddle Ball).

41 The dating evidence was reliant upon the information supplied in each site report, and the date and context of the excavation. This ranged from carbon 14 dates or pottery chronologies to body positioning. Unavoidably, this resulted in inter-site differences in the quality of dating, as well as the reliability of those dates — problems affecting any archaeological study that uses modern and historical excavation reports and archives. In light of these irreparable problems and in an attempt to minimise dating error, burial contexts were divided into mid-to-late Iron Age or Romano-British based upon published or archive data. It is accepted that many individuals buried during the transition phase may have been incorrectly dated by the excavator.

42 Buikstra and Ubelaker 1994, 98.

43 All late Iron Age individuals were recorded and the Romano-British cemetery was treated as a whole. Contexts that were truncated, disarticulated, poorly preserved, and only had skulls present were excluded, and 63 contexts were then randomly selected (Redfern 2005).

44 Buikstra and Ubelaker 1994. It should be noted that the study was begun before standards generated upon British material were published — Brickley and McKinley 2004.

45 The pelvic girdle is 95 per cent and the skull 90 per cent accurate for the determination of biological sex (Krogman and Isçan 1986, 259, 391). However, it is quite normal for archaeological samples to have more males present, as a systematic bias of sexing skeletons as male exists, exacerbated by older females appearing 'male' due to hormonal changes (Weiss 1972, 240–1; Walker 2005, 389–91).

46 Methods used: stage of pubic symphysis and auricular surface degeneration, and age-related changes in sternal rib end morphology (Buikstra and Ubelaker 1994; Isçan and Loth 1986a; 1986b).

47 Buikstra and Ubelaker 1994, 9.

48 Non-specific forms of infectious disease: periosteal new bone formation, osteitis, and osteomyelitis. Specific infectious disease (exact causative organism is known): tuberculosis and leprosy (see Roberts and Manchester 2005, 164–206).

key areas of change in response to cultural and environmental transformations.[49] It is recognised that these variables represent individual-specific and age-dependent responses to multiple stressors and buffers, and the results are biased by the osteological paradox.[50]

Age-at-death refers to the mean age generated by the analysis of degenerative changes observed in a skeleton. Following demographic conventions, an individual is assigned to an age range, as precise estimates of chronological age are not usually available. Additionally, it is typical for archaeologically derived samples to have an over-representation of young adults and a lack of individuals aged over 50 years old, due to unavoidable differences between individuals, and methodological problems.[51] Adult mortality rates vary according to age: risk of death is lower in early adulthood; after this age, risk rises with increasing age. Mortality risk is not equal in a population, as it is directly related to occupation and biological sex. For example, throughout the life span males have a higher rate of death compared to females.[52]

Dental health is governed by diet and status, as these influence the range, quality, and quantity of foods consumed and how they are prepared.[53] In this study, carious lesions, ante-mortem tooth loss, and enamel hypoplastic defects were focused upon. Carious lesions are produced by bacteria in dental plaque that cause tooth destruction; their prevalence is influenced by the consumption of carbohydrates and dairy products, and dental hygiene practices.[54] Ante-mortem tooth loss is produced by a number of dental diseases, including carious lesions and bone loss caused by periodontal disease. Teeth can also be lost due to cranio-facial trauma or metabolic diseases.[55] Enamel hypoplastic defects have multifactorial origins and are caused by short-lived disruptions to ameloblasts during secretion of the enamel matrix, which produce lines or pits of incomplete enamel formation. They have been subject to numerous investigations and shown to be associated with status, stressed populations, and stature. In a review of their development and environmental and cultural origins, it was concluded that they are a non-specific indicator of systemic physiological stress.[56]

Attained stature is the result of genetics and environment, and is influenced by nutrition and infection, with many studies showing a correlation between social status and height. Adult stature is biased by the loss of non-survivors due to child mortality, and the bias of catch-up growth; however it is a reliable indicator of non-specific stress and is not limited by small sample size.[57] The evidence for infectious disease in skeletal remains is biased by a number of factors: short-term infections rarely leave skeletal markers, many diseases result in the creation of new bone formation (which can also be produced by localised traumas), and inter-individual differences in frailty and susceptibility to disease exist. Nevertheless, specific infectious diseases are systemic, resulting in bone formation and destruction, and lesion distribution and appearance can be used to diagnose diseases such as tuberculosis. It has been proposed that the majority of

49 Roberts and Cox 2003; Steckel and Rose 2002.

50 Wood *et al.* 1992.

51 Ageing is a highly individual phenomenon, once adulthood is reached age-related degenerative changes are more variable and less distinctive changes occur. These changes are also biased by intra-skeleton variation in ageing, and the unknown variations caused by environment and genetic factors. Ageing methods are generated from the study of modern or historical samples where chronological age and biological sex are known for most individuals. The methods assume that the reported ages are biologically correct and the biological age markers are similar regardless of age and sex. Additionally, the representativeness and reliability of the sample are taken for granted (Usher 2002).

52 Chamberlain 2006, 25; Kemkes-Grottenthaler 2002; Stinson 1985.

53 Roberts and Manchester 2005, 63.

54 Hillson 1998, 269–79.

55 Ortner 2003, 383–403, 602.

56 Guatelli-Steinberg and Lukacs 1999.

57 Bogin 2001; Ulijaszek *et al.* 2000. Catch-up-growth is growth that occurs following a period of illness (when growth is slowed), which occurs at an increased rate of up to three times the normal velocity.

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proliferative bone formation observed in archaeological populations was caused by infection, and that non-specific responses to trauma may be differentiated, as they usually consist of a localised reaction.[58]

For each sexed adult, the dental variables were recorded and diagnosed following the descriptions in Buikstra and Ubelaker.[59] The frequencies of dental features were calculated per individual (number of affected individuals/total number of recorded individuals). The prevalence of carious lesions was also calculated per tooth using all teeth available for analysis (number of affected teeth/total number of recorded teeth). Ante-mortem tooth loss was calculated using the number of observable dental positions (number of affected dental positions/total number of dental positions recorded). Enamel hypoplastic disease prevalence was calculated per individual based upon its presence or absence in the dentition, and by the presence of a defect in the left maxillary and mandibular incisors and canines. The right side was substituted if the left was unobservable. Inter- and intra-population differences were analysed using a Fisher's exact two-tailed test, with the level of significance set at $P < 0.05$.[60]

Stature was calculated using the right femoral length using the formulae for each sex given by Trotter and Gleser[61] and the maximum length measurement described by Buikstra and Ubelaker.[62] The left side was substituted if the right was broken, had been repaired, was warped or distorted, had evidence of trauma, or was not present. A single complete femur, rather than multiple long bones was used, because intra- and inter-individual differences existed in the number of long bones available for study, which would have reduced the number of individuals for whom stature could be calculated. Inter- and intra-population differences were analysed using a paired Student T-test with the level of significance set at $P < 0.05$.[63]

Osteological evidence for infectious diseases was recorded by bone affected, side, section, aspect, disease type, and activity level.[64] New bone formation which could be directly associated with trauma was excluded from this study. The classification of osseous change followed Buikstra and Ubelaker's definitions,[65] and the diagnosis of specific infectious diseases followed Resnick[66] and Ortner.[67] Disease prevalence was calculated per individual (number of affected individuals/total number of recorded individuals) and by bone/s affected, i.e. humerus (number of affected bones/total number of bones recorded). Inter- and intra-population differences were analysed with a Fisher's exact two-tailed test, with the level of significance set at $P < 0.05$.[68]

RESULTS

DEMOGRAPHY

In the Iron Age, males have the highest number of individuals in the young and older adult age groups. It is only in the middle adult group that both sexes show equal age-at-death percentages. The lowest percentages were observed in both sexes for older adult age groups (FIG. 5).

The majority of the Romano-British adult sample died before reaching older adulthood, with

58 Wood *et al.* 1992; Ortner 2003, 206–14.
59 Buikstra and Ubelaker 1994, 47–57.
60 The type of statistical test was chosen based upon the guidelines published by Mays *et al*. 2004, 10–11.
61 Trotter and Gleser 1952; 1958.
62 Buikstra and Ubelaker 1994, 82.
63 See note 60.
64 State of activity relates to whether the lesion was active, healing, or healed at the time of death. Buikstra and Ubelaker 1994, 114–15.
65 Buikstra and Ubelaker 1994, 118–19.
66 Resnick 2002, 2375–2624.
67 Ortner 2003, 179–342.
68 See note 60.

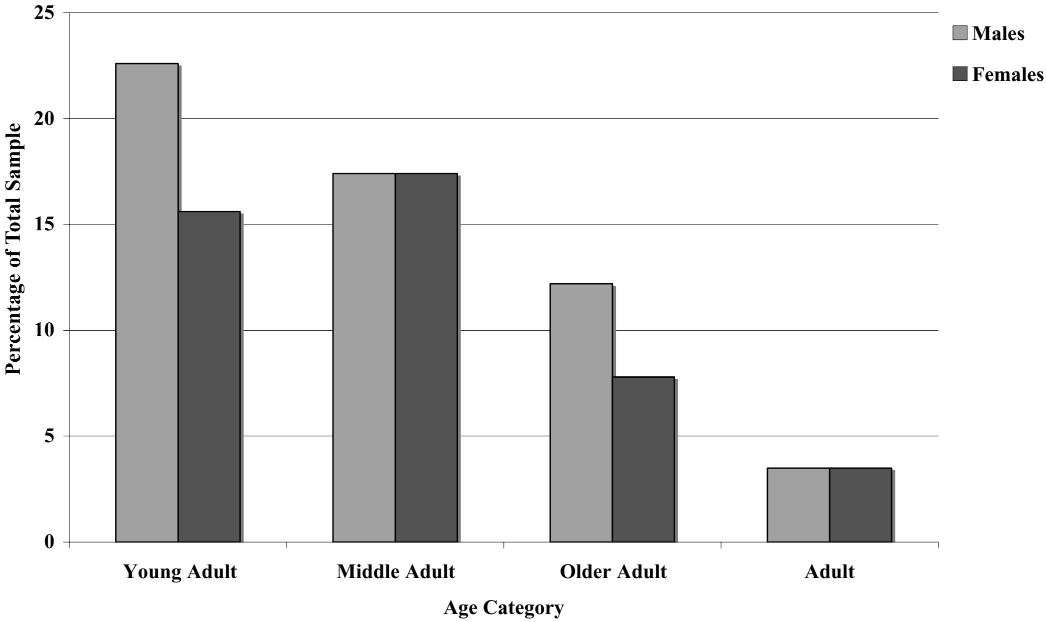

FIG. 5. A graph displaying the mid-to-late Iron Age demographic results.

the highest percentage of males in the young adult age group.[69] Unlike the Iron Age, male mortality exceeds that of females in all age groups, with the greatest disparities observed in the young to older adult groups. The female pattern also changes from the Iron Age, with the highest percentage of Romano-British females dying in middle adulthood (FIG. 6).

DENTAL HEALTH

In both sexes, the prevalence rate of carious lesions increases in the Romano-British period (Table 2). Female teeth showed the greatest increase, where the prevalence rate increases from 6.3 per cent (58) to 43.7 per cent (396). In males, despite more teeth and individuals being affected in the Romano-British period, there is very little difference between prevalence rates. No results were found to be statistically significant: between the sexes in the Iron Age (P = 0.8519) and Romano-British period (P = 0.8690), between males over time (P = 1.0000) and females over time (P = 1.0000).

In both periods, the ante-mortem tooth-loss data showed sex differences in prevalence rates, and the rate decreases in the Romano-British period. The greatest difference between the sexes was observed in the Iron Age, with 27 per cent (344) of male and 46.8 per cent (500) of female dental positions affected. However, in females, the number of individuals affected does not change over time, despite the prevalence rate of affected dental positions decreasing in the Romano-British period. No results were found to be statistically significant: between the sexes in the Iron Age (P = 0.8339) and Romano-British period (P = 0.6114), between males over time (P = 0.1300) and females over time (P = 0.3034).

69 The subadult demography of middle to late Iron Age and Romano-British Dorset is published in Redfern 2007.

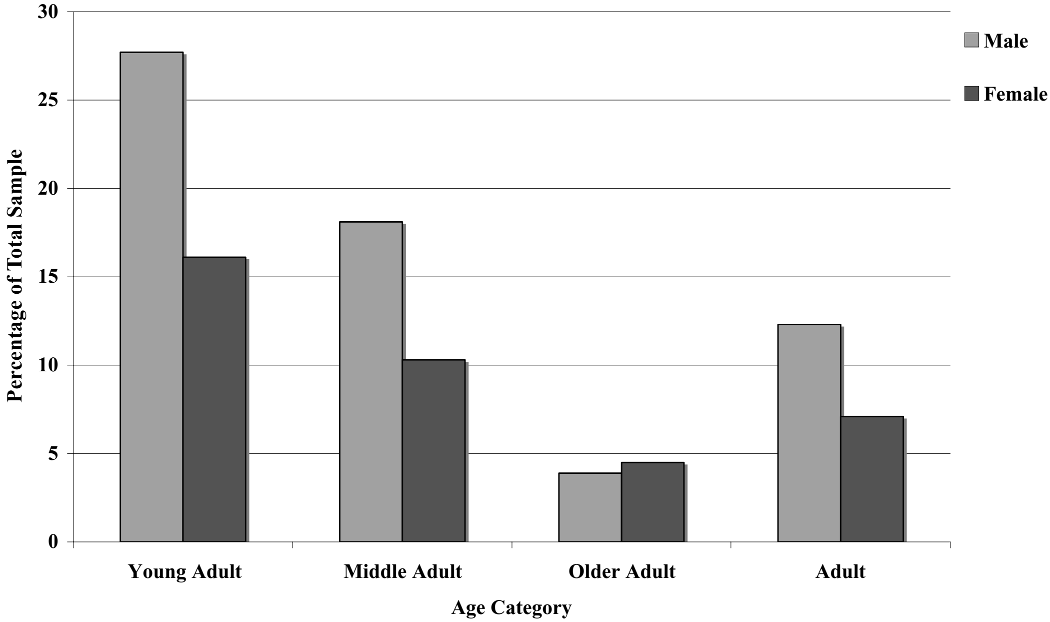

FIG. 6. A graph displaying the Romano-British period demographic results.

TABLE 2. PREVALENCE RATE OF CARIOUS LESIONS AND ANTE-MORTEM TOOTH LOSS IN MID-TO-LATE IRON AGE (MLIA) AND ROMANO-BRITISH PERIOD (RBP) ADULTS*

Date	Sex	Prevalence rate	Carious lesions	Ante-mortem tooth loss (ATML)
MLIA	Male	Per individual	45.3% (29)	71.9% (46)
		Per tooth	6.6% (75)	-
		Per dental position	-	27% (344)
	Female	Per individual	43.1% (22)	74.5% (38)
		Per tooth	6.3% (58)	-
		Per dental position	-	46.8% (500)
	Pooled	Per tooth	6.5% (133)	-
		Per dental position	-	36.2% (844)
RBP	Male	Per individual	45.8% (44)	59.4% (57)
		Per tooth	6.5% (115)	-
		Per dental position	-	17.4% (342)
	Female	Per individual	44.1% (26)	74.5% (38)
		Per tooth	43.7% (396)	-
		Per dental position	-	18.3% (241)
	Pooled	Per tooth	22.2% (511)	-
		Per dental position	-	17.4% (583)

* Values in parentheses indicate absolute values.

The prevalence rate of enamel hypoplastic defects by individual is low in both periods, and only linear defects were observed. The highest prevalence rate was observed in Romano-British females (23.7 per cent, 14) and the lowest in Iron Age females (11.8 per cent, 6) (Table 3). In the Iron Age, twice the numbers of males are affected compared to females, but this disparity between the sexes decreases in the Romano-British period. The majority of enamel hypoplastic defects were observed on the maxillary incisors and mandibular canines. No results were found to be statistically significant: between the sexes in the late Iron Age ($P = 0.4393$) and Romano-British period ($P = 0.3008$), between males over time ($P = 0.8324$) and females over time ($P = 0.1383$).

TABLE 3. PREVALENCE RATE OF ENAMEL HYPOPLASTIC DEFECTS IN MID-TO-LATE IRON AGE (MLIA) AND ROMANO-BRITISH PERIOD (RBP) ADULTS*

Date	**Sex**	**Per individual**	**Maxillary incisors**	**Maxillary canines**	**Mandibular incisors**	**Mandibular canines**
MLIA	Male	19% (12)	19% (14)	20% (7)	14% (10)	13.9% (6)
	Female	11.8% (6)	6.9% (4)	6.4% (2)	14.7% (9)	12.5% (5)
	Pooled	15.6% (18)	-	-	-	-
RBP	Male	16.7% (16)	15% (15)	17.3% (9)	13.1% (14)	17.9% (12)
	Female	23.7% (14)	23.8% (15)	21.05% (8)	19.3% (12)	25.6% (10)
	Pooled	19.3% (30)	-	-	-	-

* Values in parentheses indicate absolute values of the right dentition. The left was scored if the right was unobservable.

STATURE

In the Iron Age, stature could be calculated for 49 males and 42 females. Mean male stature was 169.2 cm and female was 156.2 cm (FIG. 7; see also Table 7). The standard deviation from the mean in males was 4.989 and in females 6.915. The difference between the means was statistically significant ($t = 24.9516$, $P < 0.001$) at the 95 per cent confidence level. In the Romano-British period, stature could be calculated for 71 males and 32 females. Mean male stature was 169 cm and female 153 cm (FIG. 7; see also Table 7). The standard deviation from the mean was 4.898 in males and 6.12 in females. The difference between the means was statistically significant ($t = 13.1944$, $P < 0.001$) at the 95 per cent confidence level. The range of male stature does change over time but mean male stature does not, despite a decrease in the height of the shortest males, <146 cm compared to >158 cm in the late Iron Age. In the Romano-British period, the range of female stature also changes, with an increase in the height of the tallest individuals (>170 cm compared to >166 cm) and a decrease in the height of the smallest individuals (>134 cm compared to >137 cm), and mean stature decreases by 3.2 cm. These temporal changes in the range of statures observed were found to be significant. In males, $t = 9.1461$ and $P < 0.0001$, and in females $t = 3.8608$ and $P < 0.0005$.

INFECTIOUS DISEASE

In both periods, no evidence for osteitis or osteomyelitis[70] was observed, and the majority

[70] Osteitis is inflammation that affects the inner structures of a bone and osteomyelitis is caused by the introduction of pyogenic bacteria into bone due to trauma or soft tissue infection. It results in infection of the bone marrow that usually results in exit of pus via a sinus on skin surface (Ortner 2003, 51, 180–1, 183).

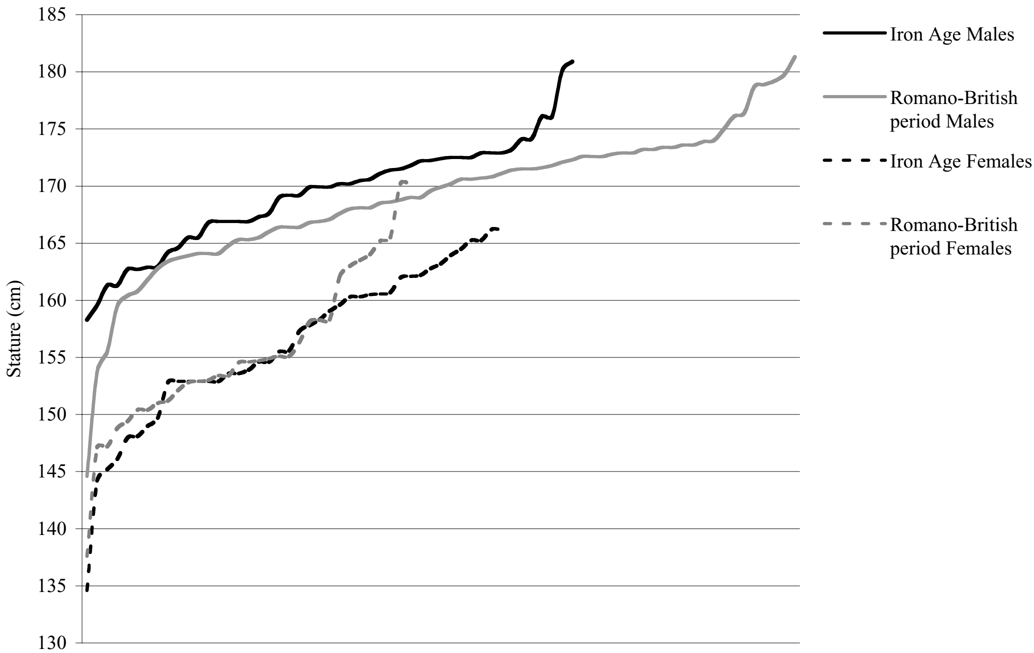

FIG. 7. A graph showing stature by sex in the mid-to-late Iron Age and the Romano-British periods.

TABLE 4. THE LOCATION OF PROLIFERATIVE BONE FORMATION IN MID-TO-LATE IRON AGE (MLIA) AND ROMANO-BRITISH PERIOD (RBP) ADULTS*

Period	Sex	Prevalence rate	Ribs	Femora	Tibiae	Fibulae	Meta-tarsals	Pedal Phalanges
MLIA	Male	Per individual	-	75% (48)	21.8% (14)	-	-	-
		Bone affected	-	11.6% (10)	89.1% (97)	7.4% (8)	-	-
	Female	Per individual	2.1% (1)	7.8% (4)	72.5% (37)	11.8% (6)	-	-
		Bone affected	11.8% (6)	8.4% (8)	77.3% (75)	20.7% (12)	-	-
RBP	Male	Per individual	1.04% (1)	14.2% (9)	55.5% (35)	31.7% (20)	1.04% (1)	1.04% (1)
		Bone affected	0.8% (7)	10.8% (18)	41.8% (71)	25.3% (40)	1.4% (10)	0.5% (3)
	Female	Per individual	-	1.7% (1)	35.6% (21)	15.2% (9)	-	-
		Bone affected	-	2.1% (2)	45.2% (42)	19.8% (19)	-	-

* Values in parentheses indicate absolute values of elements observed.

of proliferative bone formation observed was periosteal new bone formation, with the tibiae predominantly affected (Table 4). In both periods, males have higher prevalence rates; however the difference between the number of males and females affected in each period was not statistically significant (Iron Age $P = 0.4955$ and Romano-British period $P = 0.3929$). The prevalence rates decrease over time, particularly in females; however only the difference between the numbers of males affected was found to be statistically significant ($P = 0.0331$).

Only two individuals, an adult female (late Iron Age) and older adult male (Romano-British period), have evidence for bone formation to the visceral surface of the ribs, in both cases woven new bone formation was present. These people had suffered a chronic and long-lived pulmonary condition, brought on by tuberculosis or atmospheric pollutants.[71] Another Romano-British middle adult male has thick deposits of healing new bone formation bilaterally on his foot bones. The observed changes do not conform to leprosy and may have been caused by a localised infection resulting from soft tissue injury.[72]

The only specific infectious disease observed was tuberculosis, which was recorded in three individuals and in all cases was healed (Table 5). In the late Iron Age, a middle adult male has

TABLE 5. PREVALENCE AND LOCATION OF TUBERCULOSIS IN MID-TO-LATE IRON AGE (MLIA) AND ROMANO-BRITISH PERIOD (RBP) ADULTS*

Period	**Sex**	**Prevalence rate**	**Lumbar vertebrae**	**Sacral vertebrae**	**Right Femur**
MLIA	Male	Per individual	1.6% (1)	-	-
		Bone affected	1.3% (3)	-	-
RBP	Female	Per individual	1.6% (1)	1.6% (1)	1.6% (1)
		Bone affected	1.2% (2)	3.2% (4)	2.2% (1)

* Values in parentheses indicate absolute values of elements observed.

evidence for destruction to the lower spine (1st–3rd lumbar vertebrae) (1.6 per cent of all late Iron Age males). In the Romano-British period, two middle adult females were affected (3.4 per cent of Romano-British females). One female has destructive lesions to the lower spine (4th and 5th lumbar vertebrae and superior aspect of the 1st sacral vertebra) and the other has suffered destruction of the surgical neck in the right femur; the femoral head is present but the trabecular bone has been obliterated leaving a cortical 'shell'. The femoral diaphysis now terminates at the intertrochanteric line and the medullary cavity is sealed by remodelled trabeculae (FIG. 8).

The identification of tuberculosis in the late Iron Age sample is the earliest identified case of this disease in Britain; unfortunately, biomolecular analysis of the vertebrae and ribs was unable to categorise the form of tuberculosis.[73] Despite being the only individual to be recognised from prehistoric Britain, it can be assumed that many others in their community were affected by the disease but have not been identified, because the infection failed to develop an osseous response before death, or remained dormant.[74]

71 Roberts *et al*. 1998.
72 Ortner 2003, 206–7, 263–71.
73 The burial dates to 400–230 B.C. at 95 per cent confidence calibrated carbon 14 date (Mays and Taylor 2003). Tuberculosis in humans is predominantly caused by *Mycobacterium tuberculosis* or *Mycobacterium bovis* (Roberts and Buikstra 2003, 4–5).
74 Roberts and Buikstra 2003, 19–20.

FIG. 8. Anterior view of the proximal right femur, ilium, and ischium. The figure shows that there is no evidence for ante-mortem destruction of the hip joint. The destruction of the right femoral surgical neck is clearly observed, forming a wide ‘C’ shape.

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DISCUSSION

TEMPORAL CHANGES IN DEMOGRAPHY AND STATURE

In both periods, the demographic profile of both sexes conformed to historical and contemporary clinical data for greater female longevity and corresponded to models of human mortality curves, in which after 15 years of life there is an accelerated rise in mortality risk, particularly for males.[75] Both samples have fewer females than males present; due to the good preservation of bone in Dorset, it is unlikely to be the result of taphonomic factors.[76] Therefore, the result is most likely to be biased by osteological ageing methods and the more male appearance of older female skeletons. This result is frequently observed in archaeological populations, because it is very common for samples to have more males than females present; it should also be noted that mortality rates do not reflect living sex ratios.[77] In the present study, the late Iron Age sample is biased by the Maiden Castle cemetery being dominated by young and middle adults who had probably died from a violent encounter(s).[78]

The greater number of males aged between 20 and 50 years old conforms to the lower life expectancy of males. The peak in mortality rate during young adulthood is known as the 'accident hump', reflecting an increased risk of death for males between the ages of 15 and 24 years due to their adoption of adult responsibilities, development of masculine behaviours, and engagement in risk-taking activities.[79] In the mid-to-late Iron Age, the greatest risk of death for males was during young adulthood, where risk appears to have been related to violence[80] — the decrease in risk in middle adulthood suggests that their association with violent activities diminished, perhaps because of changing social roles.

In the Romano-British period, the demographic profile changes, with fewer individuals surviving to older adulthood. There was greater male mortality in all age groups, and female mortality risk was only high during young adulthood. These changes are most probably influenced by increased migration and changes to cultural and environmental stressors and buffers. However, the results are comparable to Parkin's life tables of median life expectancy in the Roman Empire, where there is a peak in mortality rates between the ages of 15 and 35 years, followed by a steady decline to 80 years old.[81] Parkin proposes that the average life expectancy was 25 years old, which may explain the peak in mortality rates for males (N = 43, 44.8 per cent) and females (N = 25, 42.4 per cent) in young adulthood. These results, Parkin suggests, represent a population with high fertility and mortality rates, where only 30 per cent of those reaching 5 years old will live until 45 years old.[82]

In both periods, the greatest risk of death for females was during young adulthood, which most probably relates to their risk during pregnancy and parturition; unfortunately, it is not known

75 Austad 2001, 6; Hazzard 2001, 451; Wood *et al.* 2002, 137.

76 Bello *et al.* 2006.

77 Weiss's (1972) study of 12,064 archaeological and pre-industrial individuals from North America, Africa, Japan, Europe, and Australia demonstrated that the majority of populations had an excess of males (33/43 samples). Hoppa and Saunders 1998, 10.

78 Redfern 2005. See also note 77.

79 Wood *et al.* 2002, 138–9; Courtenay 2002, 298; 2003, 13.

80 It should be noted that the Maiden Castle cemetery is attritional but contains individuals killed in small skirmishes (Bishop and Knüsel 2005, 209; Redfern 2005). For an examination of warfare and ritualised violence in Iron Age communities, see Craig *et al.* (2005) and James (2007). Redfern (2005; 2007; in press) presents the results from Dorset.

81 Parkin 1992, 151.

82 Parkin 1992, 92–3. Frier (2002, 89, 100–1) cautions that demographic results from the Roman period are likely to vary temporally and regionally, therefore these results may indicate patterns specific to Dorset.

when menstruation and menopause occurred in these populations.[83] Only one female (late Iron Age) in the present study had full-term peri-natal remains (37 to 38.5 weeks) adhering to the inner surface of the ilium, suggesting that the foetus was *in utero* at the mother's death, or that the foetus had not been delivered and the female died during parturition.

In Romano-British cemeteries, it is common to encounter greater numbers of male skeletons, for example Davison's study of 25 urban cemeteries from England found that 62 per cent of the sample was male and 38 per cent female.[84] In the present study, a similar result was obtained — 61.9 per cent male and 38.1 per cent female — indicating that this result can be found at all scales of analysis, and not solely in urban cemeteries. The extent to which this result reflects long-term change, or is biased by intensive short-term changes is not clear.[85] In addition to underlying causes associated with osteological methodologies, Crowe observes that national datasets are overly reliant upon urban cemeteries from southern England; many have only been partially excavated, and we are only able to examine a small proportion of the once-living population.[86] The proposed over-representation of males has also been suggested to reflect the practice of infanticide; however statistical analysis of infant age-at-death questions the extent to which British evidence supports this explanation.[87] Alternatively, given the variability in the Romano-British mortuary record by region and site-type, it may be that gender was another factor influencing burial rite and location.

The statistical significance of the mid-to-late Iron Age and Romano-British stature results, provides evidence for an increase in environmental and cultural stressors during the Romano-British period.[88] This is interesting as cultural buffers such as food production and housing conditions may have improved during this period. It is most probable that the results are biased by an increase in the range of population origins and thus the effects of Romanized life-ways elsewhere in the Empire. The results also suggest that decreased rates of growth were more likely to occur in the Romano-British period,[89] and episodes of disease and or compromised nutrition experienced by individuals were greater than in the late Iron Age. These findings contrast to the lack of significance in enamel hypoplastic defect results, indicating underlying differences between health indicators.[90] Differences in stature between the mid-to-late Iron Age and Romano-British females were found to be significant, despite a lack of mortuary evidence for an overall decrease in status,[91] suggesting that intra-female status differences (e.g. in occupation or origin) were more influential upon stature after the Roman conquest.

83 Although these events are noted in Roman texts, they refer to Mediterranean populations and, as such, are not suitable for use in Britain as differences in the timing of these events exist between populations, families, and generations. The evidence for females with parturition 'scars' in the Poundbury Camp sample is also rejected, because such 'scars' are unreliable indicators of child-bearing and it is not possible to sex adolescent skeletons reliably (Clark 1994, 76, 88; Cox 2000; Flemming 2000, 273, 283, 361; Scheuer and Black 2000, 15–16).

84 Davison 2000, 232.

85 For example, at Kempton cemetery (Bedford) detailed analysis of phasing has shown that in the early and middle periods of use more males were present (Boylston 2000).

86 Crowe 2001, 145–6.

87 Gowland and Chamberlain (2002). Cf. Mays 1993; 2003. Parkin's (1992, 98–101) assessment of data from the Empire concludes that infanticide may have taken place, but did not result in a skewing of demographic ratios. In the current study, in the middle to late Iron Age sex ratios were 1.3:1 and 1.6:1 in the Romano-British period — at birth the sex ratio is expected to be 1.06:1 and in adulthood, 1:1 (Rousham 1999, 37–8).

88 For example, environmental stressors would include denser housing and climatic changes. Cultural stressors include access to food, a change in social status, and the treatment of children.

89 Redfern 2007.

90 Multiple indicators are used, as 'all indicators provide unique information … they are neither perfectly reliable nor perfectly indicative of underlying concepts … [and] each measure provides related but different information' (Goodman and Martin 2002, 49).

91 This result specifically refers to Dorset (Hamlin 2007; Redfern 2005).

The range of male stature increases in the Romano-British period and there is greater overlap with the female data (FIG. 7). The statistical difference between males over time contrasts to the small rise in male stature observed in the Romano-British period (0.2 cm). Greater variation in stature could have been influenced by increased population variation, greater male environmental sensitivity, physical activity levels, and inability for some males to achieve catch-up growth.[92] The reasons for the plateauing of stature, despite environmental and cultural improvements, suggest that localised factors not readily identifiable in the archaeological record were responsible.

DIET

The lack of statistical significance for changes in dental health is unexpected, in the light of the considerable environmental and material culture evidence for changes in food preparation and consumption.[93] 'Romanization' of diet did not result in statistically significant results; nevertheless, the 37.4 per cent increase in female teeth with evidence of a carious lesion shows that considerable changes had taken place, supporting the stable isotope and environmental data. The increase may have developed due to greater access within communities to sweetened foods and wine, and/or an increase in fructose consumption from the introduction of new types of fruits. Richards *et al.*'s study identified two young adult females who had migrated from the Mediterranean, raising the possibility that the increase was also influenced by the dental health of migrants.[94] The Romano-British period did see a reduction in ante-mortem tooth loss rates, which could be associated with changes in hygiene practices; however mid-to-late Iron Age practices are unknown and the extent to which exogenous cultural practices were disseminated throughout the Empire is not clear.[95]

The intra-tooth differences in the prevalence of enamel hypoplastic defects are biased by a number of factors, including disparities in enamel thickness and tooth development, and thus the results of this study are not considered meaningful, particularly as they were macroscopically observed.[96] The lack of statistical significance between periods indicates that the results cannot be directly related to Roman rule in Dorset, particularly as the Romano-British results are probably biased by individuals who developed an enamel hypoplastic defect in response to stressors experienced elsewhere in the Empire. Following Guatelli-Steinberg and Lukacs' review of sex differences in human samples, the Dorset results conform to the hypothesis that in studies where only indirect evidence of stress exists, the sex differences will be insignificant.[97]

Romano-British period females had the highest enamel hypoplastic defect prevalence rates in the study (Table 3) but this does not provide evidence for preferential male buffering, particularly in Dorset.[98] In addition to the lack of statistical significance, biological and mortuary evidence in Dorset does not show a decrease in female status and health over time; the population includes individuals from elsewhere in the Empire, and the associations between these factors and environmental change are not currently understood.[99] Therefore, this result reflects multi-

92 Ulijaszek *et al.* 2000.
93 Dobney 2001; Hawkes 2001; Cool 2006.
94 Richards *et al.* 1998, 1251.
95 Jackson 2000, 120.
96 Hillson and Bond 1997; Reid and Dean 2000.
97 Guatelli-Steinberg and Lukacs 1999, 115–16.
98 Guatelli-Steinberg and Lukacs 1999, 116.
99 Redfern 2005; Hamlin 2007.

factorial responses to greater variation in population origin, and a decline in subadult health in the Romano-British period,[100] rather than inter-gender differences in status.[101]

LOCAL LIVING CONDITIONS: SPECIFIC INFECTIOUS DISEASE

Roberts has identified risk factors and socio-cultural factors responsible for tuberculosis in archaeological communities; those applicable to Dorset are animals, poor hygiene, occupation, and travel/migration.[102] In the mid-to-late Iron Age, cattle and sheep formed an important part of the agrarian economy and evidence suggests that dairy products formed a significant part of the community's diet. Tuberculosis may have been transmitted via animal husbandry (e.g. milking) or the use of dung as fuel. Wild animals could have been responsible for transmitting the disease to the human (and animal) population, as badgers and deer are known carriers and their remains have been identified in late Iron Age Dorset. Examination of material culture has shown that bones, sinew, hides and fleece were all processed to make objects and utensils. All are potential vectors of tuberculosis, even after extensive processing.[103] Local environmental conditions would have played a significant role in the exposure, as micro-environments often increase the risk of respiratory pathogen transmission. Reconstruction of roundhouses has shown that if fuels do not burn adequately, particulates can be produced which irritate the lungs and cause coughing, thereby spreading tuberculosis via droplet infection — lengthy social contact increases the likelihood of contracting the disease, although transmission can take a long time.[104] Travel may have aided the transmission of this disease in the late Iron Age; the port at Hengistbury Head shows that the Durotriges had trading networks within Britain and with mainland Europe, which may have provided the opportunity for people to come into contact with infected individuals from other communities.[105]

In the Romano-British period, the increase in the number of individuals with osseous changes diagnostic of tuberculosis suggests that the infection was more widespread, probably a consequence of incorporation into the Empire. During this period, the agricultural economy expanded, thereby increasing the number of individuals exposed to vectors associated with agrarian occupations and the manufacture of secondary products. Greater variation in housing conditions would have increased differences between micro-environments; additionally, levels of hygiene and sanitation may have been dwelling-specific and dependent upon status/occupation. In *Durnovaria*, private bath-houses and plumbed houses have been identified, showing that some homes had high levels of sanitation. In the surrounding countryside, a variety of micro-environments would have existed due to the presence of high- and low-status housing and differences in settlement size.[106] Alland proposes that if cultural practices change in a

[100] Redfern 2007.

[101] Sparse epigraphic evidence from mortuary contexts has been found in Dorset (Grindsell 1958, 192), and although it is very likely that slaves were present, no conclusive evidence has been found to identify such individuals. There is limited evidence for slave populations being more 'stressed', for example Manzi *et al.*'s (1997) comparison of urban individuals from Isola Sacra (Rome) with a rural sample of slaves and war veterans from Lucis Feroniae (Rome) found that the prevalence rates of enamel hypoplastic defects were comparable (81 and 82 per cent respectively).

[102] Roberts 2002, 32. Living conditions are also risk factors in tuberculosis; unfortunately, bioarchaeological data concerning living conditions and sanitation in both periods are very poorly understood, and no samples exist for Dorset. Existing environmental samples from England are not complete enough to investigate indicator groups, and are dominated by military and urban samples from York and London (Keeley 1987; Bryant 1990; Hurst 1999).

[103] Harcourt 1979; Roberts and Buikstra 2003, 76–82, 119.

[104] Chen 1988; Roberts and Buikstra 2003, 60.

[105] Existing stable isotope assessment of migration in Iron Age England is very limited, and the available data suggest that individuals were local to their place of burial (Richards *et al.* 1998; Budd *et al.* 2003; Montgomery *et al.* 2005). The Dorset population are currently being studied for diet and migration by the author and C. Hamlin.

[106] Groube and Bowden 1982, 48; Woodward 1993, 365–6.

small number of individuals, new routes of transmission can be formed which will affect the wider community.[107] This is an important risk factor for populations undergoing colonisation. Therefore, the forced or 'natural' migration of individuals, such as the short-term presence of Roman troops drawn from a range of ethnic groups and previous postings, may have created new modes of transmission in Dorset, both in response to greater contact with the Empire before the Claudian invasion and increasing cultural transformation post-Conquest, for example, the use of public baths.[108] The transmission of tuberculosis due to travel would have also increased; the Roman state depended upon the travel of many different kinds of people, including military personnel, civil servants, couriers, and envoys. Beyond these groups, travel was also undertaken by merchants, farmers, tourists, and pilgrims — at Poundbury Camp cemetery, two females and a child have been identified as migrants from the Mediterranean.[109] In Roman Dorset, the foundation of *Durnovaria* would have created a larger and perhaps more static community than previously known, which included individuals from elsewhere in the Empire, living in a densely settled community whose economic activity was based upon agriculture — all factors necessary to the spread of tuberculosis in a population.

EVIDENCE FOR REGIONAL HETEROGENEITY

In both periods, dental health showed the most evidence for regional heterogeneity. The lack of statistical significance between the mid-to-late Iron Age and the Romano-British period in Dorset contrasts to the preliminary findings of Peck's comparison of dental health between a late Iron Age cemetery (Danes Graves, Yorkshire), and an urban and military Romano-British cemetery at Trentholme Drive (York).[110] However, differences between these two cemeteries are more likely to be found statistically significant, as York was a military base and there is no continuity in mortuary tradition in the late Iron Age to early Romano-British period. In comparison to mid-to-late Iron Age samples from east Yorkshire (N = 252),[111] Dorset has a higher prevalence rate of carious lesions and ante-mortem tooth loss (Tables 2 and 6), despite stable isotope work indicating that both communities consumed a similar terrestrial diet.[112] The data suggest they practised different food-ways, particularly in consumption of foods high in sugars and carbohydrates.[113] At the national level, the prevalence rate of carious lesions, enamel hypoplastic defects, and ante-mortem tooth loss increases substantially in the Romano-British period (Table 6); however in Dorset, only carious lesions conformed to this trend and the pooled enamel hypoplastic defect rate only shows a small increase (Table 2).

Investigating inter-regional differences in stature was highly problematic, as few publications included femoral length data with which to calculate stature (Table 7). Mid-to-late Iron Age individuals from east Yorkshire were found to be an average of 1 cm taller than those from Dorset and in the Romano-British period, Dorset males and females are shorter than people in London.[114] These results show that the evidence for regional heterogeneity increases in the Romano-British

107 Alland 1966, 48.

108 Bathing was recommended as a cure for tuberculosis in Greek and Roman medical texts (Pease 1940, 387). See also Jackson 1999.

109 Adkins and Adkins 1998, 169; Richards *et al.* 1998, 1251; Roberts and Buikstra 2003, 64, 68; Whittaker 2004.

110 Peck 2007.

111 Stead 1991, 126–39. The burials date from the fourth to second centuries B.C., therefore are not wholly contemporaneous with the Dorset samples.

112 Richards *et al*. 1998; Jay and Richards 2006.

113 Hillson 1998, 260–9.

114 Stead 1991, 129; WORD database (Western cemeteries only).

TABLE 6. MID-TO-LATE IRON AGE (LIA) AND ROMANO-BRITISH PERIOD (RBP) PREVALENCE RATES OF DENTAL HEALTH VARIABLES*

Period	Sample	Sex	Prevalence rate	Carious lesions	AMTL	EHD
MLIA	east Yorkshire (Stead 1991)	Male	Per tooth	1.3% (29)	-	-
			Per dental position	-	2.5% (63)	-
		Female	Per tooth	2.4% (58)	-	-
			Per dental position	-	2% (50)	-
		Pooled	Per tooth	1.9% (87)	-	-
	National data[1] (Roberts and Cox 2003)	All data	Per dental position	-	9.6% (54)	-
			Per tooth	2.3% (186)	-	7.1% (2)
RBP	National data[1] (Roberts and Cox 2003)	All data	Per dental position	-	14.3% (5012)	-
			Per tooth	7.5% (2179)	-	9.1% (437)

* ATML, ante-mortem tooth loss; EHD, enamel hypoplastic defect. Values in parentheses indicate absolute values of teeth or dental positions observed.
[1] Data excludes Dorset samples.

TABLE 7. MEAN STATURE OF MID-TO-LATE IRON AGE AND ROMAN SAMPLES FROM ENGLAND AND FRANCE

Period	Location	Sample	Sex	Mean Stature (cm)	Element used to calculate stature
Mid-to-late Iron Age	England	east Yorkshire (Stead 1991)	Male	170.6	Femur
			Female	157.8	Femur
	France	Champagne (Stead 2006)	Male	170.6	Femur
			Female	157.3	Femur
Romano-British Period	England	London (west) (Word database)	Male	186.9	Femur
			Female	165.8	Femur
Gallo-Roman Period	France	Champagne (Stead 2006)	Male	173.2	Femur
			Female	162.0	Femur

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period — a trend that is most likely to be related to greater population variation, emphasised by the London results, as this urban centre was established by traders and the military.[115]

Dorset is, on present data, the only location where prehistoric evidence for tuberculosis has been recognised. It is also where the majority of Romano-British cases have been identified.[116] Therefore, the results from Dorset suggest that inter-regional differences may have existed in both periods, but more work is needed to verify whether this is a real finding or caused by biases such as the greater number of Romano-British cemeteries excavated in the county. Tuberculosis has also been identified in Roman Italy, Gaul and Spain, indicating that the disease was present throughout the Western Empire; this supports the observation in Roman texts that tuberculosis was a very common disease.[117]

At present only Stead has compared French Iron Age and Gallo-Roman health, based upon her analysis of 40 Iron Age and 55 Gallo-Roman inhumations from cemeteries in the Champagne region.[118] The study demonstrated that mean stature increased after the Roman conquest (Table 7), and the prevalence of carious lesions increased in the Gallo-Roman period. The results of the Champagne and Dorset studies show that the adoption of Romanized life-ways adversely affected dental health.

CONCLUSIONS

The first bioarchaeological analysis of the Roman impact on Britain has shown that what is often considered a cultural process did have a biological dimension, and directly affected the health of the existing and migrant communities of Britain. The results of this regional analysis have demonstrated that life in Roman Dorset cannot be understood without reference to Iron Age communities, as comparison between the two populations showed that environmental and cultural changes directly affected stature, demography, and the prevalence of tuberculosis. The osteological data from Dorset also exhibit regional heterogeneity, supporting existing archaeological evidence for the continuity of inter-regional differences and diverse adaptations to life under Roman rule.

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115 Merrifield 1983.

116 Roberts and Cox 2003, 120. The crude prevalence rate refers to the number of individuals affected in a population, rather than the true prevalence rate which is calculated using the number of bones affected.

117 Roberts and Buikstra 2003, 161–79, 215. See also Jackson 2000, 180–2.

118 Stead 2006. Cemeteries date from 450 B.C. to the fifth century A.D., therefore are not wholly contemporaneous with the Dorset sample (Stead *et al.* 2006).

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