



McDONALD INSTITUTE MONOGRAPHS

Temple people

Bioarchaeology, resilience and culture in prehistoric Malta

By Simon Stoddart, Ronika K. Power, Jess E. Thompson,
Bernardette Mercieca-Spiteri, Rowan McLaughlin,
Éoin W. Parkinson, Anthony Pace & Caroline Malone



Volume 3 of Fragility and Sustainability – Studies on Early Malta,
the ERC-funded FRAGSUS Project

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On the cover: *Stick figures from the Circle.*

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In memoriam George Mann

Caroline Malone

The re-discovery of the Xagħra Brochtorff Circle (1987–94) and the retrieval of prehistoric burials from the site represents the material that is the subject of this volume. Here we reassess and delve deeper into the detail of the excavated remains of a large prehistoric population and other prehistoric burials known from Malta and Gozo. The original Xagħra fieldwork was intense, hot and hard, and it took place mostly at the height of summer, during university vacations. Such work was not for the faint-hearted; early morning routines and 6-day weeks, crowded communal conditions – these were the standard experience for the young team of students and professional archaeologists who participated. It was an exciting learning experience for the ‘young ones’. For two much older men, retired from their careers, to choose to participate in this frenetic and noisy environment was unexpected, but enormously significant and supportive to what was then a major and pioneering undertaking. These gentlemen, Dr George Mann (a

retired ENT consultant from Addenbrookes Hospital in Cambridge with a Masters in biological anthropology), and Kenneth Stoddart (just retired from a life of city commuting and business), brought maturity, wisdom, humour, compassion and humanity, as well as a vital breath of civilization to each annual season of work. We dedicated the 2009 volume to the memory of Kenneth Stoddart. This volume appropriately is dedicated to the memory of George Mann.

Dr George Edgar Mann (1923–2019) participated in the Gozo Project between 1990 and the completion of osteological study in 1996. Initially George, fresh from a post-retirement study of bioanthropology at Cambridge, came to assist Corinne Duhig who prepared the initial rock-cut tomb report. Professionally he had been a specialist consultant in otolaryngology at Addenbrookes Hospital in Cambridge, and had done his retirement MPhil dissertation on bony exostoses in the outer meatus of the ear, caused by swim-



Figure 0.1. *George and Sheila Mann at work in the kitchen of the dig house, systematically recording a skeleton 1994.*



Figure 0.2. *George Mann at work on the roof-top of the dig house in Gozo in 1994.*

ming in cold water. The Gozo assemblage demanded a rapid revision of his knowledge of the post cranial skeleton, but soon up to speed, George then came every year to participate in each field season and post-excavation study season. He worked tirelessly with his wife Sheila, processing the excavated bones, separating out the animal bones for study by Geraldine Barber, and identifying the human remains himself with his team. He cheerfully accepted the



Figure 0.3. *Sheila Mann cleaning bones for George in the dig house 1994.*

spartan and crowded living conditions where he spent much time at the kitchen table or on the roof of rented holiday flats, sorting endless sacks of bone fragments into coherent identified catalogues. He measured, studied and quantified as he went and ensured every fragment was recorded. Towards the end of the fieldwork, some osteological material was transported to Britain, and George continued to log, measure, examine and interpret the human material in preparation for the 2009 report. His systematic and painstaking recording work of the entire assemblage was of great importance, as the following pages reveal. Even with the ERC *FRAGSUS Project* resources, which provided funding at a level unimaginable in the earlier excavation years, it has been possible only to re-examine a sample of the vast osteological archive. George managed to ensure that we have the fundamental knowledge of the scope of the assemblage, and this is listed in the first report (see Malone *et al.* 2009d) and it forms the base for ongoing research of these remarkable ancient people and the Xaghra site. The record was written by hand, and the hundreds of sheets of record remain in the archives of the National Museum of Archaeology, ready for future studies, and whilst the original digital database of those handwritten records becomes ever more antiquated, George's immense work remains a vital archive even as technology advances. All the teams, past and present, are delighted to dedicate this volume to George's memory and his tremendous contribution to Maltese and osteological scholarship.

Another key contributor to the work of the original Gozo Project was Ann Monsarrat, who lived on Gozo, and supported the project and its team with generosity and warmth over the many years of work and study.

In memoriam Ann Monsarrat

Anthony Pace

Ann Monsarrat (1937–2020) made her home on Gozo, where she moved in 1968 with her husband Nicholas, the author of many novels about Malta and the sea. Gozo was a special place for Ann, a home with people that she truly loved, respected and admired. Ann was a remarkable person. She was welcomed and felt at home in the small village of San Lawrenz, where she lived for more than four decades. Her house was forever busy with people dropping in and sharing news, experiences, aspirations, the changing fortunes of Malta and Gozo and, of course, the difficulties of writing and the literary world. But beyond these and many other conversations, Ann was particularly interested in landscape – Gozo’s in particular – where archaeology, history and legends carved meaning out of a small island full of hills, valleys, majestic cliffs and skylines marked by parish church cupolas rising above quiet village houses.

FRAGSUS owes a great deal to Ann. For, unbeknown to her, several good friends – all archaeologists – whom she supported and entertained annually during the excavation of the Xagħra Brochtorff Circle between 1987 and 1994, came together again to deliver another important project. Ann would have certainly been happy and excited with the results of *FRAGSUS*. A career journalist and a distinguished author in her own right, with works such as *And the Bride wore*; *Thackeray: An Uneasy Victorian*; *Gozo: island of oblivion, a graphic literary itinerary*, Ann was particularly interested in the archaeology of Malta and Gozo. She was always keen to follow research developments and new discoveries, and was eager to see young scholars, budding archaeologists, photographers, historians, artists, writers, journalists, and so many others making headway in areas that she understood to be important in promoting Maltese cultural identity. Ann was in fact a formidable advocate of Maltese arts, culture and cultural heritage. Her work on the governing board of Saint James Cavalier

Centre for Creativity in Valletta, and her continuous presence in Gozitan cultural circles, as well as her various contributions to numerous publication projects reflected an enthusiasm and positiveness which was contagious and encouraging. Ann’s enthusiasm shone every time she visited the Xagħra Brochtorff Circle excavations, during our long walks along the ta’ Ċenċ promontory, during visits to the Cittadella, or when listening to the sounds rumbling from the depths of blocked shafts at the legendary clock-maker’s salt-works on the north coast of Gozo. These were real places with real stories, some illustrated in prints, others silently waiting to be teased out from



Figure 0.4. Anne Monsarrat (with kind permission of her family).

stone monuments, field terraces and beautiful natural spots. Perhaps these were places whose biographies could best be understood by visiting and experiencing them in person.

One of the last places Ann and I visited together was the archaeological site at Ras il-Wardija on Gozo's western coast. The site is not an easy one to interpret, but from a spot rising several metres above the surrounding area, we shared an almost bird's-eye view

of Dwejra with the distant Azur Window below us, and we chatted about the meaning of the site and its links to the sea: seascapes, ancient mariners, people lost at sea, shipwrecks; and also of builders who constructed beautiful places and made beautiful art, making the Maltese Islands their home for at least seven thousand years.

In these pages, the *FRAGSUS* team pays tribute to Ann Monsarrat.

Acknowledgements

The *FRAGSUS Project* 2013–18 is indebted to numerous individuals and institutions and acknowledges support throughout the course of a long and energetic project. In particular, we thank the European Research Council which awarded an Advanced Research Grant (Advanced Grant no. 323727) to Caroline Malone, as the Principal Investigator of the Project and the extended team in late 2012, enabling the project to take place between May 2013 and April 2018. Without this funding and the trust placed in us by the ERC and the grant assessors, this project could never have taken place. We express our gratitude for this opportunity to expand knowledge of Malta and indeed much else connected with prehistoric societies and their world in the early Mediterranean. The research team also wants to record our indebtedness to the administrators of the grant within our own institutions, since this work required detailed and dedicated attention. In particular we thank Rory Jordan in the Research Support Office (Queen’s University Belfast – QUB), Laura Cousens (Cambridge University – UoC), Glen Farrugia and Cora Magri (University of Malta – UM), the Curatorial, Finance and Designs & Exhibitions Departments in Heritage Malta (HM) and Stephen Borg at the Superintendence of Cultural Heritage (SCH).

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For the preparation of this volume, we thank Dr Rob Barratt, Dr Rowan McLaughlin, Dr Eóin Parkinson, Dr Jess E. Thompson and Olivia Shelton for assisting in

the editing and assembly of this very substantial work. Prof. Simon Stoddart was the overall editor who undertook the major editing of the volume (including the index and glossary), the design of the opening and closing chapters and was in the grant application defined as responsible for the Human Population work group and the Landscape group in Cambridge. Prof. Caroline Malone undertook the preliminary assembly of the text, the checking and setting of tables and images, as well as much proofing and editing. We thank Emma Jarman in the McDonald Institute for her important role in coordinating the submission of material, and Dr James Barrett and Prof. Cyprian Broodbank (when James left Cambridge) for their oversight of the McDonald Monograph series. We thank Dr Matt Davies, the new

Deputy Director and Editor of the Monograph Series, for guiding the volume into its final stages. In particular, we thank Ben Plumridge who undertook the task of production. Ben ‘cut his teeth’ in publication in 2007–9 when he was the principal assistant in the preparation of the 2009 *Mortuary Customs in Prehistoric Malta* (the original site report and the forerunner of the three companion volumes from *FRAGSUS*), making the work of the late Dora Kemp, his McDonald predecessor, as production editor so much easier. The archaeology of the island of Malta has thus continued to benefit from his support after his appointment as Production Editor of the McDonald series by Simon Stoddart when he was acting Deputy Director.

To all those involved, we thank you.

Preface

Caroline Malone and Simon Stoddart

This volume is the third in the *FRAGSUS Project* series. Volume 1: *Temple Landscapes* (edited by Charles French, Chris O. Hunt, Reuben Grima, Rowan McLaughlin, Simon Stoddart & Caroline Malone, 2020) focuses on the changing landscapes of early Malta, and provides the background for the following two volumes. Volume 2: *Temple Places* (edited by Caroline Malone, Reuben Grima, Rowan McLaughlin, Eóin W. Parkinson, Simon Stoddart & Nicholas Vella, 2020), reports on the archaeological studies of six sites through an examination of their chronological sequence, material culture and economic role in the Neolithic world of Malta. These discoveries set the scene against which Volume 3: *Temple People* (edited by Simon Stoddart, Ronika K. Power, Jess E. Thompson, Bernardette Mercieca-Spiteri, Rowan McLaughlin, Eóin W. Parkinson,

Anthony Pace and Caroline Malone, 2022) are reassessed. This volume also has an additional role since it follows on more directly from the 2009 publication: *Mortuary Customs in Prehistoric Malta* (edited by Caroline Malone, Simon Stoddart, Anthony Bonanno & David Trump, 2009). That volume revealed one of the largest prehistoric burial assemblages yet discovered in the Mediterranean, amounting to some 220,000 bones, with a rich assemblage of animal bone, figurative sculpture, symbolic artefacts and architectural remains. The new volume concentrates on the human remains, taking their evidence to a new level. In the light of better understanding of the changing environment and resources of a small island world, the early people of Malta emerge as a remarkable community telling an important tale of prehistoric resilience and survival.

Chapter 7

Physical activity and body size in Temple Period Malta: biomechanical analysis of commingled and fragmentary long bones

Eóin W. Parkinson & Jay T. Stock

7.1. Introduction

The reconstruction of physical activity from the human skeleton provides archaeologists with important insights into past lifestyles and lived experiences. Whilst a range of approaches have been developed to reconstruct activity in archaeological skeletons (Jurmain *et al.* 2012; Larsen 2015; Meyer *et al.* 2011), the application of skeletal biomechanics offers an objective means of quantifying and exploring habitual behaviour in past populations that has benefits over other approaches which rely on activity-related pathology or analysis of muscle attachment sites (Waldron & Rogers 1991; Wallace *et al.* 2017; Wilczak *et al.* 2017). Skeletal biomechanics applies mechanical principles to bone tissue in order to understand its form and function, and has been most widely employed to understand structural adaptation of long bones diaphyses. This particular method models the long bones as structural beams in order to quantify their cross-sectional geometric (henceforth CSG) properties related to bone strength and bending rigidity (Huiskes 1982; Ruff & Hayes 1983a, 1983b), thus making it possible for bioarchaeologists to estimate the degree of mechanical strain associated with habitual activity during life.

Although skeletal morphology is influenced by a wide range of genetic, environmental, hormonal and age related factors (Kini & Nandeesh 2012), experimental studies have demonstrated that bone tissue adapts and remodels in response to *in vivo* mechanical loading (Biewener *et al.* 1983; Lanyon 1984; Lanyon & Baggott 1976; Lanyon *et al.* 1982; Simkin *et al.* 1989), and in a manner consistent with particular patterns of known and inferred habitual behaviour (Macintosh & Stock 2019; Shaw & Stock 2009a, 2009b; Stock & Pfeiffer 2001; Ruff 2019). This process, referred to as ‘bone functional adaptation’ (Ruff *et al.* 2006a), enables bioarchaeologists to reconstruct broad patterns of behaviour from the human skeleton and has been successfully applied to a

variety of archaeological contexts to examine changes in subsistence strategy (Marchi *et al.* 2011), social change (Sparacello *et al.* 2011), patterns of mobility behaviour (Sládek *et al.* 2006b, 2006a), economy and trade (Pomeroy 2013) or genetic and cultural discontinuity (Stock & Macintosh 2016). The analysis of the Xagħra assemblage, presented in this chapter, forms a discrete part of a much larger study that explored spatial and temporal trends in body size and post-cranial robusticity across the longue durée of central Mediterranean prehistory (Parkinson 2019).

A useful by-product of CSG analysis is the acquisition of osteometric data related to body mass and long bone lengths which can be converted into estimates of stature, thus enabling an exploration of body size. The relationship between body size, skeletal growth, physiological stress and life history has been used by bioarchaeologists and economic historians to understand social and economic circumstances in modern (Stock & Migliano 2009; Tyrrell *et al.* 2016) and archaeological populations (Formicola & Holt 2007; Macintosh *et al.* 2016; Niskanen *et al.* 2018). Population history has also been shown to have an important role in understanding body size in archaeological populations, in acknowledgement of the genetic control over final adult height (Cox *et al.* 2019; Martiniano *et al.*, 2017). Estimates of stature heritability have been reported to be as high as 80-90% (Silventoinen *et al.*, 2003), however, final adult stature has also been shown to be influenced by non-genetic factors, such as developmental stress and growth impairment, as well as adaptive life history traits (for reviews see Wells & Stock 2011, 2020). The analysis of estimated stature and body mass at Xagħra therefore provides a means of investigating these themes, which are complementary to palaeopathological analysis presented elsewhere (Chapter 4, Chapter 8).

Another important element of this study was overcoming the considerable methodological challenges that were encountered during the analysis

of the highly commingled and fragmented Xaghra assemblage. The acquisition of reliable and accurate osteometric data is one of the fundamental challenges of working with fragmentary and commingled human bone, and therefore this chapter also introduces the various approaches used in the analysis. The application of 3D surface scanning technology particularly aided in the reconstruction and estimation of bone dimensions that were necessary for the acquisition of CSG properties.

Few studies have attempted to analyse long bone CSG properties from commingled and fragmentary skeletal material because of the difficulties of acquiring the necessary osteometric data. Stock & Willmore (2003) investigated broad patterns of habitual activity through the application of skeletal biomechanics in a large fragmented and commingled Iroquoian burial assemblage, successfully illustrating the validity of such studies. Palaeoanthropological studies have also demonstrated the wealth of information that can be extracted from small samples of fragmented fossil hominin remains (Ruff 2008b; Trinkaus & Ruff 1999; Xing *et al.* 2018), providing a strong methodological framework on which to build. In particular, recent analysis of a large commingled and fragmented assemblage of *Homo naledi* remains (see Marchi *et al.* 2017) has also addressed many of the issues faced in this research.

7.2. Materials

7.2.1. Sampling strategy

The main period of use at the Circle was during the Tarxien phase (c. 2800–2400 cal. bc; Chapter 3), when the site was the setting of an elaborate set of funerary rites, whereby human remains underwent complex and varied processes of disarticulation and dispersal (Malone & Stoddart 2009; Chapter 12 in this volume). The natural cave system was elaborated with megalithic architecture and periodically restructured throughout the Tarxien period, where burial deposits functioned as structural deposits (§3.4.2). The combination of these site formation processes with the funeral rituals performed on site resulted in the formation a large commingled and highly fragmentary skeletal assemblage.

The large size and complexity of the Xaghra assemblage therefore required a targeted sampling strategy aimed at contexts containing high frequencies of long bones as reported in the original study by Malone *et al.* (2009d). Sampling was initially targeted at both the earlier rock-cut tomb (c. 3500–3200 cal. bc) and the main Tarxien phase burial complex (c. 2975–2250 cal. bc), although material from the rock-cut tomb was eventually excluded from the final analysis owing its small sample size and extreme level of fragmentation.

Furthermore, extensive concretion obscured much of the cortical surface of the long bones from the rock-cut tomb, limiting the potential to retrieve accurate CSG properties. Sampling of the Tarxien phase deposits was directed towards three articulated individuals from contexts (799), (960) and (1241), in addition to three large commingled mortuary deposits, Contexts (783), (1206) and (1268). Contexts (1206) and (1268) from the ‘Shrine’ area were specifically targeted for their high frequencies of humeri, femora and tibiae, and because they presented the clearest record of a stratified sequence within the site that spanned the Tarxien phase (Stoddart *et al.* 2009c). The nature of the Xaghra assemblage was such that complete skeletons could not be reconstructed, eliminating the potential to explore sex-based or whole-body trends in skeletal robusticity, and restricting the analysis to an exploration of broad patterns in body size and physical activity.

7.2.2. Comparative sample

Comparative data for Copper Age central Italy from Parkinson (2019) were included in the analysis in order to place the Maltese data within a broader central Mediterranean regional context. The comparative sample consists of 32 individuals from Ponte San Pietro (Latium) and Fontenoce-Recanati (Marche) dated to the Italian early Copper Age (3600–3300 cal. bc) (Dolfini 2010; Silvestrini *et al.* 2004). Both sites are associated with the Rinaldone burial tradition (Cazzella & Moscoloni 2012; Dolfini 2006b, 2006a), and are traditionally considered as agro-pastoralists that navigated the mountainous and hilly terrain of the central Italian Apennines (Cocchi Genick 2009; Manfredini *et al.* 2009; Skeates 1997). The comparative central Italian sample consists almost entirely of fully articulated skeletons, thus enabling a more detailed exploration of patterns across the skeleton. One major benefit of this comparison is the ability of the more detailed results from central Italy to help tease out underlying trends in the Xaghra sample.

7.3. Methods

7.3.1. Long bone cross-sectional geometry

Long bone solid CSG properties were captured at the mid-shaft (50% of bone length) of the femur and tibia, and at the mid-distal (35% of bone length) point of the humeral diaphysis thereby avoiding the morphology of the deltoid muscle attachment (Ruff 2019). Given the relationship between endosteal (internal) and periosteal (external) contours, capturing both internal and external cross-sectional properties is preferred (Larsen 2015; Ruff & Hayes 1983a). However, solid CSG properties based on external contours alone have

Table 7.1. Cross-sectional geometric properties used in the study.

Property	Definition	Biomechanical relevance
TA	Total cross-sectional area	Correlate of compressive strength
J	Polar Second Moments of Area (SMA)	Sum of $I_{max}+I_{min}$, correlate of torsional strength and average bending rigidity
I_x/I_y	Cross-sectional shape ratio	Distribution of bone about the anterior-posterior and medio-lateral axes, indicator of cross-sectional shape and direction of mechanical loading
I_{max}/I_{min}	Cross-sectional shape ratio	Distribution of bone about maximum and minimum axes, indicator of cross-sectional shape

been shown to correlate strongly with true cross-sections and likely reflect the most mechanically relevant bone tissue (Davies *et al.* 2012; Macintosh *et al.* 2013; Stock & Shaw 2007). The solid cross-sectional properties used in this study are total cross-sectional area (TA), a correlate of compressional strength, the Polar Second Moments Area (J), a correlate of bending and torsional rigidity, and the cross-sectional shape ratios I_{max}/I_{min} and I_x/I_y , which give an indication of cross-sectional shape and the direction of mechanical loading (Table 7.1). Solid CSG properties were derived from 3D laser surface scans of individual bones captured with a NextEngine object scanner using AsciiSection v.3.2 (Davies *et al.* 2012). All 3D scans were processed in Rapidform XOR and aligned to standard anatomical axes defined by Ruff (2002). As body size itself constitutes a mechanical force, CSG properties must be body size standardized using a combination of bone length and body mass (Ruff 2000, 2019). Body mass estimations were derived from femoral head diameter using regression equations developed for European Holocene populations (Ruff *et al.* 2012), whereas knee breadth was used to estimate body mass from isolated tibiae (Squyres & Ruff 2015). The bones of the upper limb have also been shown to scale with body mass, and therefore humeral CSG properties must also be standardized for the influence of body size (Pomeroy *et al.* 2018; Ruff 2002; Ruff *et al.* 1993). Upper limb CSG properties are typically standardized using body mass estimates derived from associated femora, however, the commingling of the Maltese sample makes this impossible. Instead, CSG properties for isolated humeri were standardized using powers of bone length, as recommended by Ruff (2019). The recommended power of bone length for standardizing TA is maximum length³, whilst the recommended powers for Second Moments of Area (I and J) are maximum length^{5.33} (Ruff *et al.* 1993).

7.3.2. Approaches to fragmented material

A series of adapted and original approaches were used to overcome the methodological challenges that were posed by the fragmented and commingled Xaghra assemblage. The use of 3D scanning to acquire long bone CSG properties in this study was particularly useful in enabling the application of digital reconstruction techniques to overcome some of the methodological challenges of working with fragmented skeletal material. Specific to this study was the need for estimates of complete bone length and femoral head diameter from fragmentary long bones. Maximum bone length is not only required to establish accurate, standardized cross-section locations along the diaphysis, such as the femoral and tibial mid-shaft (50% of bone length) and mid-distal humerus (35% of bone length from the distal end) (Ruff & Hayes 1983a), but it is also a vital component in size standardization of CSG properties (Ruff *et al.* 1993).

Ruff (2008a, 2019; §7.3.1) recommends the use of estimated bone lengths when working with fragmented and isolated skeletal elements, and estimated bone lengths are widely used in the analysis of fragmentary fossil hominin material (Day & Molleson 1976; Haeusler & McHenry 2004; Korey 1990; Ruff 2008b; Trinkaus & Ruff 1989, 1996; Trinkaus *et al.* 1998). Slight misplacement of cross-section location within 5% of bone length has been shown to have little effect on CSG properties of the femur and humerus (Ruff 2008b; Sládek *et al.* 2010), enabling biomechanical analysis of these elements with confidence. However, CSG properties of the tibia have been shown to be most sensitive to cross-section misplacement because of the irregular and angular morphology of the tibial medial and lateral surfaces (Sládek *et al.* 2010). For this reason, extra care was taken to screen CSG data from tibiae, and only elements that were more than approximately 75% complete were selected for analysis.

7.3.2.1. Estimation of maximum bone length:

3D reconstruction and superimposition

Estimation of maximum bone length was achieved primarily through 3D digital reconstruction and 3D superimposition. Forensic anthropologists have developed a range of methods to estimate complete maximum bone length from fragmented long bones for the purposes of stature estimation (Jacobs 1992; Simmons *et al.* 1990; Steele 1970; Steele & McKern 1969; Wright & Vasquez 2003), but available methods are problematic in that they are often exclusively developed for the lower limb and often calculate stature directly rather than provide an estimate of bone length. Considerable doubt has also been placed over the accuracy and repeatability of current methods for

estimating complete length from fragmented long bones, which are population specific and often rely on highly variable anatomical landmarks (Bidmos 2009).

A major benefit of the 3D scanning approach, however, is the opportunity to manipulate skeletal elements digitally in virtual space, enabling the use of techniques in 3D digital reconstruction and 3D superimposition (Fig. 7.1). Both 3D digital reconstruction and 3D superimposition provide accurate estimates of complete long bone length, which have advantages over traditional visual approaches (Sylvester *et al.* 2008). Long bone reconstruction was performed in Rapidform XOR using the Interactive Alignment function, where individual fragments were aligned and positioned according to anatomical landmarks, estimated anatomical axes and fracture congruence (Benazzi *et al.* 2014; Grine *et al.* 2010; Gunz *et al.* 2009; Senck *et al.* 2015). Once reconstructed, the individual 3D scanned meshes of each fragment were fused to form a single mesh using Rapidform's Combine tool (Fig. 7.1). As with any analysis involving fragmentary skeletal material, digital reconstruction relies on careful documentation during the initial data collection stage and reference to, whenever possible, excavation notes. 3D digital reconstruction also offsets the need to undertake restoration and reconstruction of the

physical skeletal element, which often requires the use of adhesives that can lead to serious long-term conservation issues (Caffell *et al.* 2001; Johnson 1994).

3D digital superimposition was undertaken to estimate complete bone length for incomplete fragmented long bones, such as those without epiphyses. Similar to visual pair matching, which is used widely in forensic (Adams & Byrd 2006; Adams & Konigsberg 2004) and palaeoanthropological (Marchi *et al.* 2017; Trinkaus *et al.* 1998) research, this approach compares the diaphyseal contours and anatomical landmarks of a fragmented skeletal element with a complete element from a reference collection. The combination of the incomplete and complete elements can then be used to make a reliable estimation of complete bone length (Fig. 7.1). Traditional visual comparison methods are more subjective, in that they rely on comparison between two bones positioned next to one-another, whilst 3D digital superimposition allows for clearer and more accurate comparisons to be made *in silico*, thus limiting subjectivity. In a test of this approach, Karell *et al.* (2016) showed that manual 3D superimposition outperformed automated matches and traditional visual comparison methods in 100% of comparisons. The application of 3D digital superimposition has also been effectively employed in analysis of very fragmented fossil hominin material (Xing *et al.* 2018). 3D superimposition was performed in Rapidform XOR by importing a 3D mesh of a complete bone of similar size and morphology, on the basis of approximate length estimations made during initial data collection. Incomplete bones were then positioned and orientated over the complete reference bone, on the basis of a comparable morphology, using the Interactive Alignment and Datum Match functions in Rapidform XOR. Whilst this approach requires experience in handling 3D data, as well as access to specialist software and 3D scanning equipment, 3D superimposition achieves reliable estimations of complete bone length and can be replicated using open-source software alternatives (Fig. 7.1). In the case of fragmentary elements belonging to articulated individuals (i.e., two humeri from the same individual, the left missing a distal epiphysis and the right missing a proximal epiphysis), both sides were scanned and used to create 'hypothetical' reconstructions whereby the individual models were mirrored and superimposed on to the corresponding skeletal element.



Figure 7.1. Examples of digitally reconstructed humeri: a) 3D superimposed humerus; b) 3D digitally reconstructed humerus (E. Parkinson).

7.3.2.2. Estimating femoral head diameter: shape fitting

Femoral head diameter was required for the estimation of body mass (*i.e.*, Ruff *et al.* 1997) and the standardization of CSG properties. Whilst the femur is one of the best surviving elements in archaeological contexts

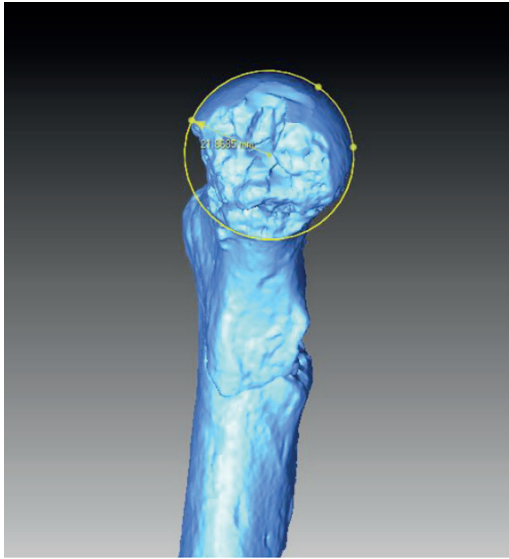


Figure 7.2. Example of shape fitting method applied to fragmented femoral head. The femoral head is modelled as a sphere and the curvature of the surviving surface is then extrapolated to achieve an estimated diameter (E. Parkinson).

(Stojanowski *et al.* 2002; Waldron 1987), long bone epiphyses are often damaged in commingled assemblages (Adams & Byrd 2006). In these cases, shape fitting can be used to estimate the diameter of fragmented femoral heads. By modelling the femoral head as a sphere and extrapolating the curvature of the surviving surface with the Measure Radius tool in Rapidform XOR, it was possible to estimate the complete diameter (Fig. 7.2). The estimated radius was then multiplied by two to achieve an estimated femoral head diameter. Whilst this approach does assume perfect sphericity of the femoral head, clinical and experimental research has shown that the femoral head can be confidently modelled as a sphere (Cereatti *et al.* 2010; Hammond & Charnley 1967; Kim 1989) or partial sphere (Parkinson 2014; Ruff 1990, 2002; Rafferty & Ruff 1994). Similar approaches applied to fossil hominin acetabula have proved an effective means of estimating femoral head size in palaeoanthropological literature (Berger *et al.* 2010; Hammond *et al.* 2013; MacLachy & Bossert 1996; Plavcan *et al.* 2014a, 2014b).

7.3.3. Statistical approach

Independent *t*-tests were used to compare CSG properties between the Xaghra and central Italian Early Copper Age groups and between the left and right humeri from the Xaghra assemblage. Box-and-whisker plots are used here to visualize the data, with the box component depicting the first and third quartiles and

the whiskers representing the maximum and minimum values, with the exception of outliers which are plotted as separate points. The threshold for statistical significance was set as $p < 0.05$ for all analysis and statistical tests were conducted in SPSS 25.

7.4. Results

7.4.1. Upper and lower limb CSG properties

Descriptive statistics and results of the independent *t*-tests comparing solid CSG properties of the humerus, tibia and femur of Xaghra and Italian Copper Age groups are displayed in Table 7.2 and Table 7.3. Box-and-whisker plots comparing the solid CSG properties of the humerus, femur and tibia between the Xaghra and central Italian groups are displayed in Figure 7.3, Figure 7.4 and Figure 7.5 respectively. The results show a significant difference in both *TA* ($p < 0.001$) and *J* ($p = 0.002$) in the humerus between the two groups (Table 7.2), where the Xaghra group has lower average values (Fig. 7.3; Table 7.3). The comparison of humeral cross-sectional shape also shows a significant difference between groups ($p = 0.004$), with the Xaghra group having more elliptically shaped humeral cross-sections, as indicated by average greater I_x/I_y values (Table 7.2). A consideration of the standard deviations (Table 7.3) and box-and-whisker plots (Fig. 7.3), which reflect the degree of variability within a sample, shows constrained variation in both measures of upper limb robusticity and cross-sectional shape among the Xaghra group. The results for the lower limb, however, show a considerably different pattern to that observed in the upper limb in that no statistical difference was observed between both groups in any of the comparisons in CSG properties of the femur and tibia (Table 7.3). The descriptive

Table 7.2. Summary statistics and results of independent *t*-test comparing cross-sectional properties of upper limb (humerus) between Xaghra and Copper Age Italy. ^aSample contains individuals that have determined biological sex, but are included as a pooled-sex sample here. ^bSignificant difference, $p = < 0.05$.

Cross-sectional property	N	Mean	St.D.	<i>t</i> -test <i>p</i> ^b
Humerus TA (35%)				
Xaghra	32	808.56	121.76	<0.001 ^b
Copper Age central Italy ^a	61	917.92	143.99	
Humerus J (35%)				
Xaghra	32	5114.34	1388.71	*0.002 ^b
Copper Age central Italy ^a	61	6335.67	1908.11	
Humerus I _x /I _y (35%)				
Xaghra	32	1.19	0.13	*0.004 ^b
Copper Age central Italy ^a	61	1.09	0.16	

Table 7.3. Summary statistics and results of independent *t*-test comparing cross-sectional properties of lower limb (femur and tibia) between Xaghra and Copper Age Italy. ^aSample contains individuals that have determined biological sex, but are included as a pooled-sex sample here. ^bSignificant difference, $p < 0.05$.

Cross-sectional property	N	Mean	St.D.	<i>t</i> -test <i>p</i> ^b
Femur TA (50%)				
Xaghra	31	882.84	108.56	0.658
Copper Age central Italy ^a	32	871.84	87.06	
Femur <i>I</i> _{max} / <i>I</i> _{min} (50%)				
Xaghra	31	1.31	0.18	0.893
Copper Age central Italy ^a	32	1.31	0.17	
Femur <i>J</i> (50%)				
Xaghra	31	4097.77	958.26	0.508
Copper Age central Italy ^a	32	3947.53	827.85	
Tibia TA (50%)				
Xaghra	27	713.15	106.45	0.866
Copper Age central Italy ^a	32	717.5	90.29	
Tibia <i>J</i> (50%)				
Xaghra	27	4419.78	939.48	0.552
Copper Age central Italy ^a	32	4264.19	1039.61	
Tibia <i>I</i> _{max} / <i>I</i> _{min} (50%)				
Xaghra	27	2.29	0.51	0.269
Copper Age central Italy ^a	32	2.42	0.44	

statistics (Table 7.3) and box-and-whisker plots (Figs 7.4 & 7.5) for the lower limb also display remarkable consistency in CSG properties of the femur between the central Italian and Xaghra groups. In particular, both Xaghra and the central Italian group have identical femoral I_{max}/I_{min} values of 1.31. However, all CSG properties in the tibia, except TA, are numerically greater at Xaghra, and the Xaghra group generally

Table 7.4. Descriptive statistics for CSG properties of the humerus (35%) by side and results of independent samples *t*-test comparing left and right CSG properties of humerus from Xaghra. ^aSignificant difference, $p < 0.05$.

Cross-sectional property	Left (N=11)		Right (N=21)		<i>t</i> -test p^a
	Mean	St.D.	Mean	St.D.	
J	220.19	57.03	249.82	92.97	0.363
TA	786.98	107.44	824.79	161.11	0.507
I_{max}/I_{min}	1.27	0.16	1.26	0.09	0.818
I_x/I_y	1.2	0.17	1.18	0.13	0.628

exhibits greater variation in CSG properties of the lower limb (Table 7.3).

Although it is not possible to examine upper limb bilateral asymmetry within single individuals from Xaghra, comparisons between the left and right humeri were made on a group-wide basis in order to explore broad patterns in hand preference. Summary statistics and results of the independent *t*-tests comparing differences between the CSG properties of the left and right humeri within the Xaghra group are presented in Table 7.4. Figure 7.6 and Figure 7.7 display box-and-whisker plots for the CSG properties of the left and right humerus for the Xaghra sample. No significant difference between the any of the CSG properties of the left and right humeri were observed, although interesting numeric differences are apparent (Table 7.4). In TA and J , right humeri display considerably more variation (Fig. 7.6), whereas the shape ratios (I_{max}/I_{min} and I_x/I_y) show a slightly different pattern. In particular, I_{max}/I_{min} in right humeri exhibits extremely limited variability (Table 7.4; Fig. 7.7). These results suggest different patterns of mechanical loading and habitual behaviour between the left and right upper limb and indicate preference for the right side, at least on a sample wide basis.

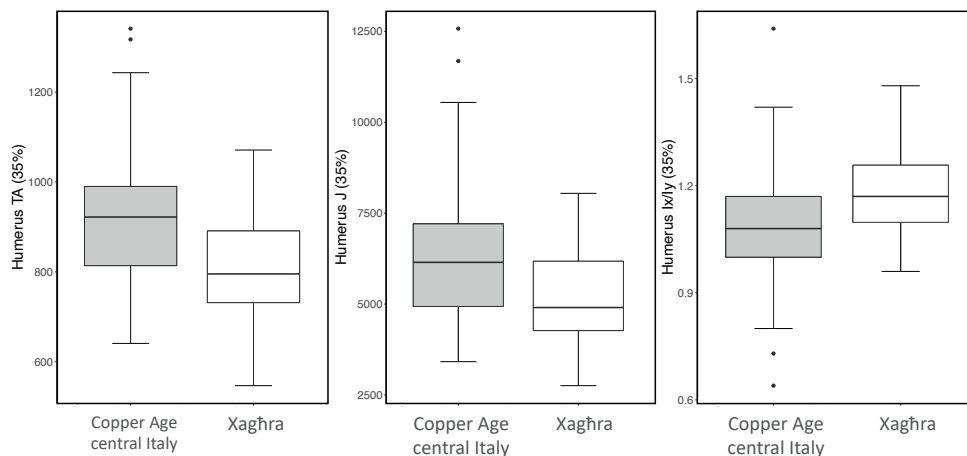


Figure 7.3. Comparison of solid CSG properties of the humerus between Xaghra and central Italy.

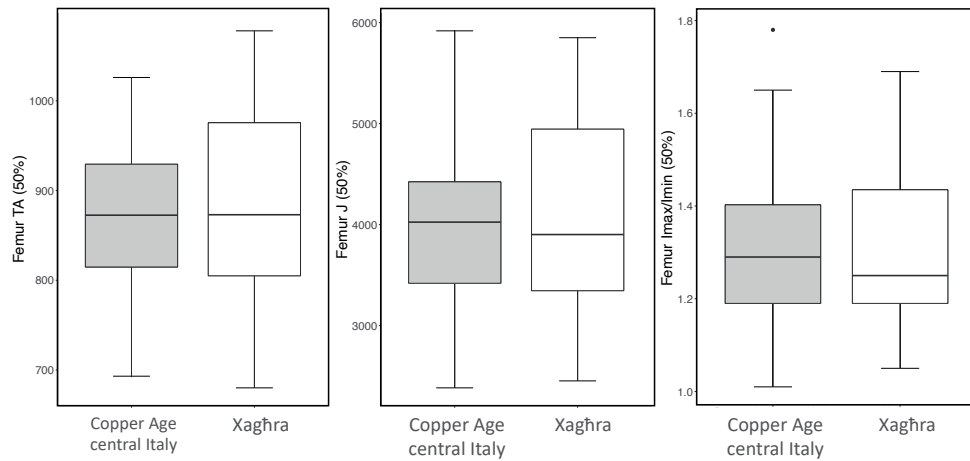


Figure 7.4. Comparison of solid CSG properties of the femur between Xaghra and central Italy.

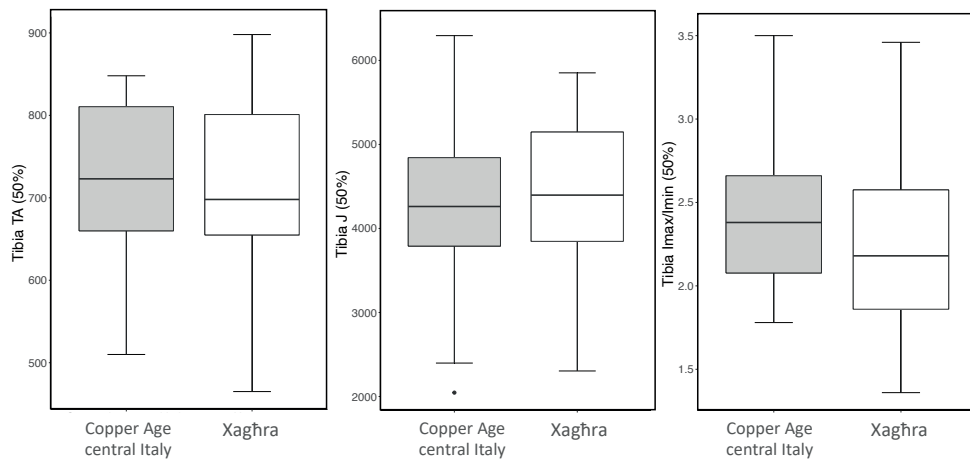


Figure 7.5. Comparison of solid CSG properties of the tibia between Xaghra and central Italy.

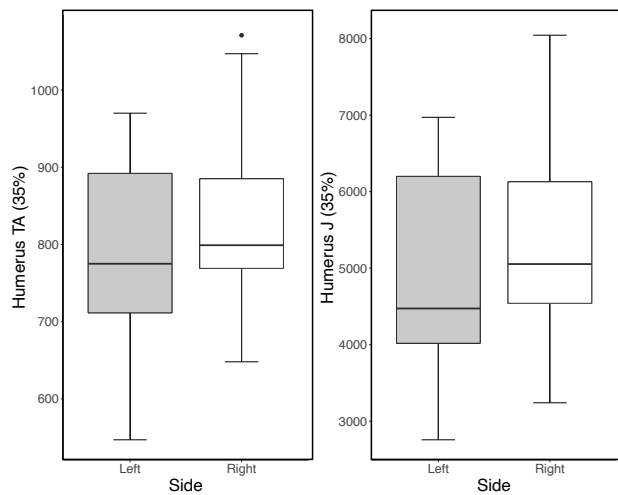


Figure 7.6. Side differences in TA (left) and J (right) of the humerus at Xaghra.

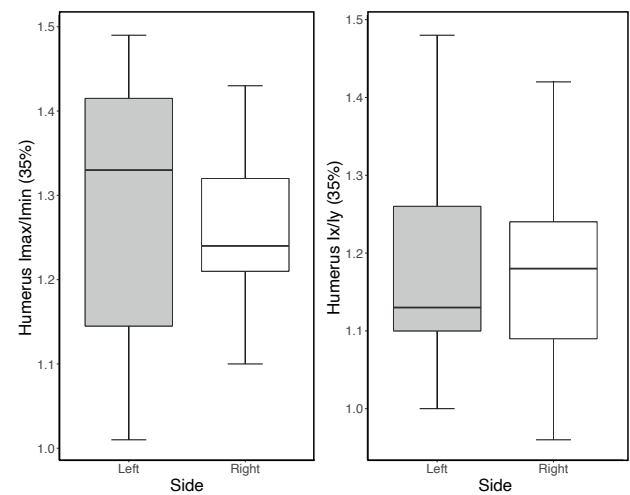


Figure 7.7. Side differences in cross-sectional shape of the humerus (left, I_{max}/I_{min} and right I_x/I_y) at Xaghra.

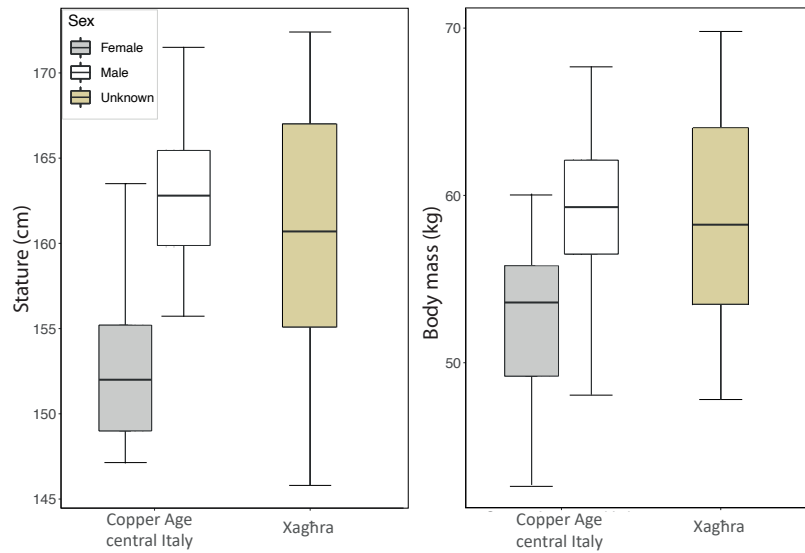


Figure 7.8. Comparisons of estimated stature (cm) and body mass (kg) between Xaghra and central Italy.

7.4.2. Body size

Table 7.5 contains descriptive statistics and independent *t*-test comparisons of estimated stature (cm) and body mass (kg) between the Xaghra and central Italian groups. Box-and-whisker plots showing body size variables for the Xaghra (pooled-sex) and central Italian (by sex) groups are displayed in Figure 7.8. Whilst no significant difference in either stature or body mass is observed, the summary statistics and box-plots indicate that the Xaghra group exhibits greater overall body size. Although the analysis presented here only offers one comparison, the results follow a broader central Mediterranean trend where late Neolithic Malta exhibits larger body size than contemporary and near-contemporary groups (Parkinson 2019). The greater range of variation in body size variables at Xaghra is reflective of this group being a pooled-sex sample, where males and females cannot be identified because of commingling. This is highlighted by the clear body size differences between males and females in the central Italian group, where males have a numerically greater average body size than females.

Table 7.5. Descriptive statistics and results of independent *t*-tests comparing body mass and stature. *Significant difference, $p < 0.05$.

Group	Estimated stature (cm)			Estimated body mass (kg)			<i>t</i> -test p^a
	N	Mean	St.d.	N	Mean	St.d.	
Late Neolithic Malta	22	160.72	7.71	28	58.63	6.76	0.159
Copper Age central Italy	25	158.34	6.85	30	56.19	6.27	0.268

7.5. Discussion

The results of the biomechanical analysis of the humerus, femur and tibia indicate that the late Neolithic population of the Maltese Islands had gracile upper limbs, but that the mechanical profiles of the lower limb were similar to Copper Age populations in central Italy. The results also demonstrate preferential use of the right hand within the Xaghra sample, alongside limited variability in CSG properties of the upper limb in stark contrast to the greater variation observed the lower limb. The data are interpreted here as reflecting evidence for reduced levels of physically demanding manual activity in late Neolithic Malta, relative to near-contemporary groups, in contrast to adaptations in the lower limb to heightened levels of terrestrial logistical mobility around the rugged terrain of Gozo. A further interesting feature of the Xaghra assemblage was the constrained variation of upper limb CSG properties.

Increased I_x/I_y values in humeri indicate an elliptical cross-section shape in the antero-posterior plane and are usually interpreted as evidence for repetitive unidirectional habitual (Ruff 2019; Stock & Pfeiffer 2004) and food processing among early agricultural societies (Larsen 2015; Stock *et al.* 2011). Large numbers of querns are known from late Neolithic Malta (Malone *et al.* 2009a, 264; Trump 1966), and it has been suggested that agriculture intensified during the Tarxien phase under a more controlled system, of which the megalithic Temples formed a focus (Stoddart *et al.* 1993; Trump 1980; Volume 2, Chapter 13). More recent palaeoeconomic models for late Neolithic Malta have

added nuance to this view, suggesting that landscape management practices were increasingly employed during the Tarxien phase to offset the diminution of soil cover and aridification (Volume 2, Chapter 5), causing potential dietary changes (Chapter 10). Furthermore, the proliferation of stone masonry on the Maltese Islands during the Tarxien phase (Trump 2002) could also be argued as a plausible explanation for the high I_x/I_y values among the late Neolithic Maltese sample. Experimental studies have shown that such activities would have involved vigorous and repetitive unidirectional manual activity (Caruso 2016; Larocca 2016).

However, the decreased humeral robusticity and rigidity (TA & J) of the Maltese sample is also important to consider, and an alternative interpretation for the patterning in the data may also be driven by the upper limb gracility of the Maltese sample. Pronounced anterior ridges along the distal humeral diaphysis are an artefact of gracility that may result in a more triangular or elliptical cross-section shape. When viewed alongside the decreased TA and J values, this shape suggests that the results for all three CSG properties could be related and reflective of decreased levels of mechanically demanding manual behaviour in late Neolithic Malta. The evidence for decreased mechanical loading in the upper limb is somewhat supported by the lack of activity-related pathology, specifically degenerative joint disease, on the major joints of the limbs (§8.4.3). However, incidences of pathology in the upper extremities (bones of the hands) are indicative that intensive manual activities were part of the lived experience of late Neolithic Malta (§8.4.2), but that such behaviours could have involved repetitive and strenuous fine-motor skills, rather than significant mechanical loading of the upper appendicular skeleton.

Although analysis of humeral asymmetry was not possible with the Xagħra assemblage, comparisons between the left and right humeri from the site showed that right humeri exhibited greater robusticity, allowing for a broad exploration of handedness in late Neolithic Malta. Comparisons of shape ratios did not, however, reveal any differences between the left and right sides. When interpreting these broad results, it is important to consider the full spectrum of potential behaviours in late Neolithic Malta and analysis of the dentition from Xagħra also shows evidence for the use of the mouth as a 'third hand', likely as part of a variety of craft-working or food processing activities (§5.8). Recorded instances of enamel trauma and wear at Xagħra occur most frequently on the right maxillary premolars and left mandibular molars. Such a distinctive diagonal pattern of dental trauma and wear is consistent with repeated clamping and gripping of abrasive materials extending from the right side of

the mouth. The biomechanical evidence for preferential use of the right hand among the Xagħra group, although typical for modern (McManus 2009; Raymond & Pontier 2004) and prehistoric populations (Sladěk *et al.* 2018), seems to be conducive with the model of habitual activity evidenced through dental wear.

The results of the comparative analysis showed that both the Xagħra central Italian Copper Age groups have similarly robust lower limbs. These results are surprising, given that the Xagħra sample might have been expected to exhibit evidence for decreased terrestrial mobility because of their geographically restricted island context – the Maltese Islands have a combined area of 316 km², of which Gozo is only 67 km² (Schembri *et al.* 2009). Reduced lower limb loading and terrestrial mobility has been observed in Island groups from the Andaman Islands (Stock & Pfeiffer 2001), but in contrast the Xagħra group show lower limb CSG properties that are comparable with those of the Italian Copper Age. A recent comparison between the central Italian Copper Age sample used in this study and a coeval Copper Age sample from the Po Plain, northern Italy, demonstrated increased lower limb robusticity in the central Italian sample, interpreted as reflecting logistical mobility around the hilly terrain of central Italy (Parkinson *et al.* 2018). The influence of terrain and landscape context on lower limb CSG properties has been well studied in Neolithic Liguria, northern Italy, where high levels of lower limb robusticity and greater bending rigidities were also attributed to an adaptation to rugged terrain and high levels of mobility associated with pastoralism (Marchi *et al.* 2006, 2011; Marchi 2008; Sparacello & Marchi 2008). In these studies, the Neolithic Ligurian population displayed levels of lower limb robusticity closer to highly terrestrially mobile Late Upper Palaeolithic or Mesolithic groups (Marchi 2008; Marchi *et al.* 2011), with similar results seen in 'Ötzi' the Alpine Iceman (Ruff 2006b) and Neolithic groups from mountainous regions of southern France (Lambert *et al.* 2013). In spite of their restricted geographical context, the Xagħra population exhibits evidence for undertaking similarly intensive mobility behaviours to central Italian Copper Age groups. The results therefore seem to suggest that the late Neolithic population of Gozo were engaging extensively with their physical landscape, evidently navigating the harsh and irregular terrain of the island. However, the unique and restricted landscape setting of the Maltese case study may also have future implications for how we define, discuss and interpret mobility behaviour in studies of CSG properties in archaeological populations.

The contrasting variability between the CSG properties of upper and lower limb for the Xagħra

sample is also interesting. Understanding the precise relationship between the upper and lower limb at Xaghra is difficult in the absence of a larger sample of articulated individuals, although the results do hint at an opposing relationship between patterns physical manual activity and mobility behaviour. The constrained variation in CSG properties of the humerus within the Xaghra sample, when compared to the Italian Copper Age sample, offers useful insights into the division of labour in late Neolithic Malta. Comparison with the humeral CSG properties of the central Italian sample (Fig. 7.3) illustrates how increased variation – at least within that particular archaeological context – can be driven by sexual dimorphism. Considering the Xaghra sample as a commingled assemblage, composed of a mixture of males, females and adult age categories, the limited variation may suggest there was no sex-based division of manual labour during the Tarxien phase. Various social models have been put-forth for late Neolithic Malta that suggest the megalithic temples formed part of structured or hierarchical chiefdom system (Renfrew 1973; see also Cazzella & Recchia 2015, *contra* Bonanno *et al.* 1990 who suggest internal rivalry). The data from the upper limb, with its relative homogeneity, perhaps suggests a more inclusive and heterarchical society and division of labour. Ultimately, attempting to interpret sex-based differences using only CSG values is problematic, however, since post-cranial robusticity has been shown to be heavily influenced by physiological differences between men and women (Macintosh *et al.* 2017, 2019). Examination of sexual dimorphism in the upper limb therefore requires analysis of bilateral asymmetry, which is independent of the physiological factors affecting post-cranial robusticity, although such analysis is simply not possible with the Xaghra commingled assemblage.

The analysis of body size, which revealed a larger average body mass for late Neolithic Malta relative to near-contemporary groups, also has implications for discussions on skeletal growth, stress and development. The averages for body mass (58.6 kg) and stature (160.72 cm) in late Neolithic Malta are at the higher end of ranges obtained from Neolithic and contemporary Copper Age groups in the central Mediterranean (Parkinson 2019) and wider Europe (Macintosh 2016; Niinasken *et al.* 2018), suggesting that the physiological factors affecting skeletal growth and development were less prevalent in Temple Period Malta. In this respect, the higher body size of the Xaghra assemblage lies in apparent contrast to evidence of skeletal stress suggested before (Stoddart *et al.* 2009a) and strengthened in this volume. In particular, the analysis of dental pathology (Chapter 4) and palaeodiet

(Chapter 10) shows increasingly marked incidences of linear enamel hypoplasia, decreasing incidences of caries and fluctuating ^{13}N throughout the duration of the Tarxien phase, indicative of developmental stress and changes in diet in the final years of the Temple Period. When viewed together, the evidence therefore appears to present an interesting case whereby the late Neolithic population of Xaghra were clearly faced with increased stress and a changing dietary regimen, but not to the extent that there was a major impact on normal skeletal growth and development. The increased average body size from Xaghra is further surprising given the small island context of the site, where smaller body size might be expected (Foster 1964). Insular dwarfism has been documented in modern human populations (Berger *et al.* 2008; Diamond 2004), although socio-economic factors and life histories have also been shown to affect this phenomenon (Stock & Migliano 2009). When considered alongside the broader archaeological, environmental and palaeoeconomical data for the period (Volume 2, Chapter 12), the Tarxien phase appears to have been a time of considerable changes in diet, behaviour and agricultural practices that suggest the late Neolithic population of the Maltese Islands was grappling with the ever changing environmental instability of their island world.

7.6. Conclusion

Few studies have attempted to analyse long bone cross-sectional geometry in large commingled and fragmented burial assemblages because of the methodological issues they pose, however the results presented here show that meaningful insights into past lifestyles and lived experiences can be gained from such challenging material. This is especially true in cases, such as at Xaghra, where CSG properties and body size data are viewed and interpreted alongside studies exploring diet, health and pathology. The gracile upper limbs of the Xaghra group, when compared with the central Italian group, indicate that levels of manual activity in late Neolithic Malta were perhaps less intensive than in contemporary Copper Age societies in the central Mediterranean. By contrast, the surprising evidence for robust lower limbs among the Xaghra group has shown that despite their geographically restricted island context, the late Neolithic inhabitants of Gozo were actively mobile and engaging with their rugged and hilly natural landscape. The broad patterns of side bias in the upper limb also correspond with side biases in identified dental wear elsewhere in the volume, which when integrated provide exciting glimpses into the lived experience of late Neolithic Malta. The results

from the analysis of stature and body mass indicate that average body size among the Xagħra group was greater than that of contemporary groups in the central Mediterranean, suggesting that the physiological factors affecting stature and body mass were perhaps less prevalent in late Neolithic Malta. Interestingly, the body size data presented here shows some contrasts with the palaeodietary and palaeopathological data for Xagħra reported elsewhere, highlighting the complex interplay between skeletal indicators of developmental stress and life history.

Despite the interpretive limitations imposed by the commingling at Xagħra, the broad insights into habitual behaviour derived from the biomechanical analysis presented in this chapter were augmented by the analysis of dentition and palaeopathology presented in Chapters 5 and 8, underscoring the effectiveness of multi-method research programmes in bioarchaeology. However, one particular limitation of this study was that it only considered adult long bones. The evidence from dental wear (Chapter 5) demonstrates that adolescents undertook similar habitual tasks to adults, suggesting a broader division of labour in late Neolithic Malta that integrated younger members of society. It is worth noting, however, that the activity induced bone growth reflected in long bone CSG properties appears to correspond to mechanical loading during adolescence (Haapasalo *et al.* 1996; Kontulainen *et al.* 2002; Pearson & Lieberman 2004). The emphasis on particular contexts also imposes further constraints on the inferences that can be drawn on the data collected here, however; the main contexts that were analysed (from the Shrine, Chapter 3) do offer a representative sample for the entire duration of the Tarxien phase.

The discussions in this chapter also highlight the impact that recent developments in archaeological science have had on the study of complex commingled assemblages, enabling minimal and efficient sampling procedures that provide maximum results. For this study, the application of 3D laser scanning aided the acquisition of osteometric data that would have otherwise been impossible since it enabled a flexible approach whereby study materials could be revisited *in silico*, allowing methodologies to be constantly refined, developed and reapplied.

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Temple people

The ERC-funded *FRAGSUS Project* (*Fragility and sustainability in small island environments: adaptation, culture change and collapse in prehistory, 2013–18*) led by Caroline Malone has focused on the unique Temple Culture of Neolithic Malta and its antecedents. This third volume builds on the achievements of *Mortuary customs in prehistoric Malta*, published by the McDonald Institute in 2009. It seeks to answer many questions posed, but left unanswered, of the more than 200,000 fragments of mainly commingled human remains from the Xaghra Brochtorff Circle on Gozo. The focus is on the interpretation of a substantial, representative subsample of the assemblage, exploring dentition, disease, diet and lifestyle, together with detailed understanding of chronology and the affinity of the ancient population associated with the ‘Temple Culture’ of prehistoric Malta. The first studies of genetic profiling of this population, as well as the results of intra-site GIS and visualization, taphonomy, health and mobility, offer important insights into this complex mortuary site and its ritual.

Remarkable evidence on the bioanthropology of care practised by these populations, together with a relatively low level of interpersonal violence, and examples of longevity, reveal new aspects about the Neolithic Maltese. Detailed case studies employing computerized tomography describe disease such as scurvy and explore dietary issues, whilst physical activity and body size have been assessed through biomechanical analysis, supported by taphonomic study, isotopic analyses, a review of mortuary practices during prehistory and a robust new chronology. The results form a rich contextualized body of material that advances understanding of cultural change within the context of small island insularity, and provides biological comparisons for the graphic figurative art of early Malta. These data and the original assemblage are conserved in the National Museum of Archaeology in Valletta as a resource for future study.

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