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A New Society Emerges in Anatolia: Bioarcheological Perspectives on the Late Neolithic and Early Chalcolithic Population of the Gökhöyük (GH)

Elçin Şener | Ali Taş | Ahmet Cem Erkman

Department of Anthropology, Faculty of Science and Literature, Kırsehir Ahi Evran University, Kırsehir, Turkey

Correspondence: Elçin Şener (elcinn.sener@gmail.com)

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ABSTRACT

Gökhöyük (GH), dates to the Late Neolithic and Early Chalcolithic periods, is situated in proximity to other significant tells, such as Çatalhöyük (CH), which holds a prominent place in global archaeological discourse. This study provides a crucial glimpse into the lives of GH's earliest inhabitants through the analysis of their skeletal remains. The research was structured around three primary objectives. First, it aimed to conduct a qualitative assessment of pathologies present in the GH population based on paleopathological findings. Second, it sought to uncover aspects of daily life within the settlement and offer insights into its subsistence economy. Lastly, the study endeavored to contribute to the development of bioarcheological methodologies and comparative analyses of contemporaneous Late Neolithic and Early Chalcolithic settlements in Anatolia. The minimum number of individuals identified within the community was established at 37. The presence of various degenerative joint disorders, metabolic conditions, and periostitis was documented. Findings suggest that the GH population subsisted primarily on a carbohydrate-rich diet, intricately linked to a socioeconomic framework dominated by pastoralism and agricultural activities.

1 | Introduction

The Neolithic period is widely regarded as one of the most pivotal periods in human history, marking the transition from a hunter–gatherer existence to a sedentary lifestyle. This transformation, which fundamentally reshaped human societies, is frequently discussed in academic discourse for two primary reasons. First, it represents the onset of permanent settlements, as communities abandoned nomadic patterns of subsistence in favor of a more sedentary existence. Second, it witnessed the revolutionary shift toward agriculture, as humans began domesticating wild plants and animals, thereby laying the foundation for complex societies.

The Neolithic culture of Anatolia, which played a crucial role in this transition, gradually diffused into neighboring regions (Özdoğan 2018; Braidwood (1960) highlighted that early food production efforts were particularly successful in the fertile, grassy, and forested plateaus of the Fertile Crescent, where food gatherers possessed extensive knowledge of wild wheat, barley, and other native flora, as well as the domestication of wild canids.

Renowned for its fertility, Anatolia has been home to countless civilizations, contributing to its unique historical richness. One such settlement is Gökhöyük (GH), which serves as the focus of this study. As part of a broader bioarcheological initiative in Anatolia, this research seeks to examine the physiological stressors and overall health status of the GH population during the Late Neolithic and Early Chalcolithic periods. The study aims to qualitatively assess the diseases affecting the community and explore their etiology. Additionally, it aspires to contribute to the development of theoretical frameworks and methodological approaches that will illuminate the previously unexamined aspects of GH's inhabitants, whose skeletal remains provide a critical window into their lived experiences.

As with all living organisms, the physiological stress encountered by individuals in their daily struggle for survival leaves tangible imprints on the body. Analyzing how these stressors manifest offers invaluable data for bioarcheologists investigating the interplay between human ecology, pathogen interactions, and long-term health trends (Buikstra 2019; Larsen 2002).

2 | Materials and Methods

2.1 | Archaeological Context

GH was first identified during the construction of the Beyşehir-Suğla Lake Canal in the Gökhüyük neighborhood of the Seydişehir district, Konya province (Figure 1). Following its discovery, it was classified as an archaeological site and subjected to a rescue excavation by the Konya Archaeological Museum Directorate in 2002. GH comprises four distinct archaeological building phases. The earliest and most extensive of these layers dates back to the Late Neolithic period (Figure 1a,b). Following the Late Neolithic and Early Chalcolithic layers, three additional cultural phases corresponding to the Early, Middle, and Late Chalcolithic periods have been identified (Akgün 2019). Pottery findings, which Mellaart identified as corresponding to layers VII–IV/III and Hodder (2014) to layers M-P at Çatalhöyük (CH) (6700/6600–6400/6300 BC), were reported at GH (Akgün 2019). Furthermore, it was noted that a new source of imported volcanic clay and technology, which gradually appears starting from layer VIII in CH (Doherty and Tarkan-Özbudak 2013), was also found in GH (Akgün 2019).

The settlement is strategically positioned 80 km southwest of CH, a site of global archaeological significance (Figure 1). CH and the architectural layout and interior decorative elements of the houses at GH exhibit similarities to those found at CH (Akgün 2019; Gündüz 2021). This resemblance has been interpreted as evidence of population movement, suggesting that certain inhabitants of CH may have migrated to this region (Czerniak and Marciniak 2022).

2.2 | Material

The human skeletal assemblage recovered from the rescue excavations conducted by the Konya Museum Directorate between 2002 and 2005 was transferred to the Paleoanthropology Laboratory in 2018. Unfortunately, due to the absence of a systematic collection protocol during the excavations, the bones were stored in boxes without proper documentation. Moreover, their prolonged exposure to environmental conditions in the museum's garden for 13 years resulted in significant deterioration, further complicating their analysis. As a consequence of these preservation challenges, the scope of the paleodemographic study was restricted to an assessment of the number and type of bones present. To establish the minimum number of individuals (MNI), all bone fragments were meticulously classified and quantified. The femur emerged as the most frequently represented skeletal element, leading to an estimated MNI of 37 (Table 1).

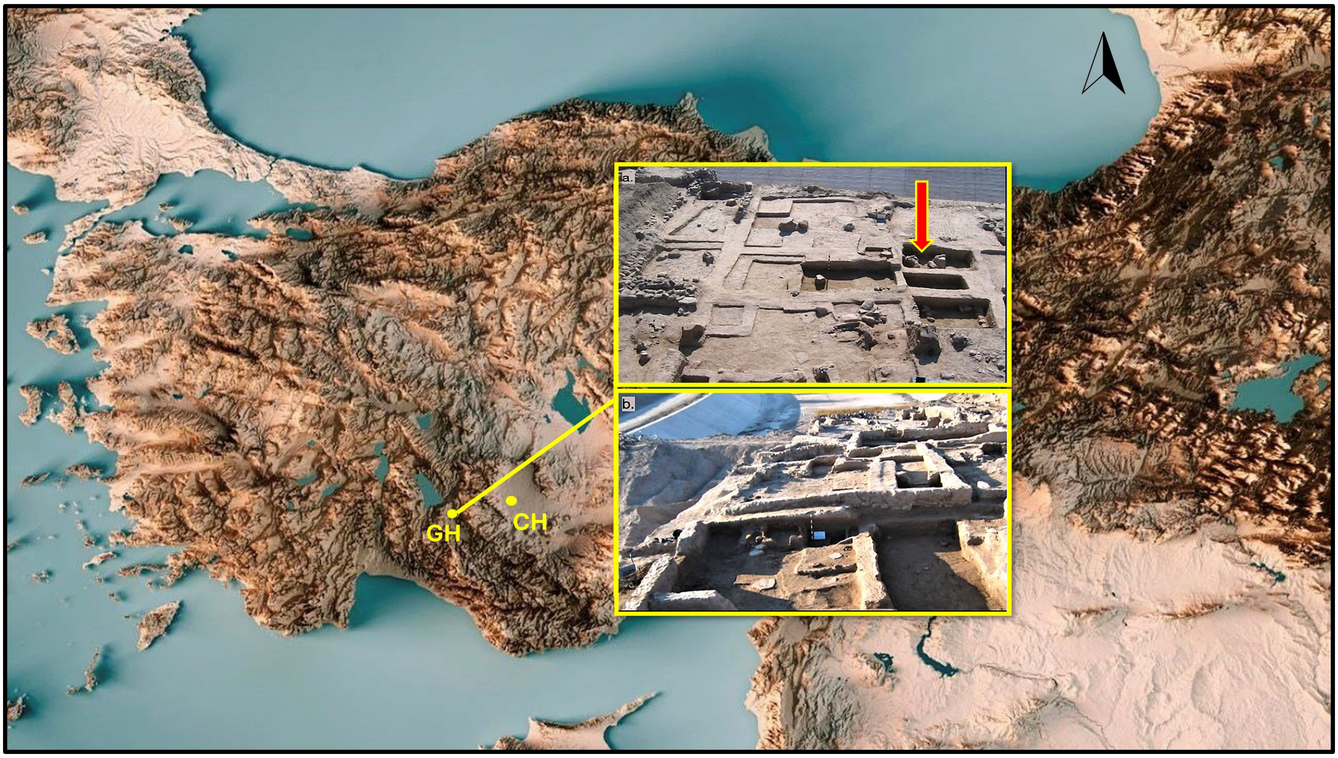

FIGURE 1 | Location of the GH illustrated on the map (CH: Çatalhöyük). (a) Trenches 17/E, D; Granary of Neolithic Construction Stage I. (b) Trenches 15/E-F of Neolithic Construction Stage III (Akgün 2019). [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 | Number and type of bones.

Bone	Section	Left	Right	Total
Cranium		—	—	22
Clavicula		14	8	22
Scapula		5	9	14
Humerus	p:8, c:35, d:24	33	34	67
Radius	p:10, c:27, d:18	22	33	55
Ulna	p:11, c:28, d:18	28	29	57
Vertebrae		—	—	120
Cervical				30
Torokal				47
Lumbar				43
Os coxae		21	22	43
Femur	p:6, c:46, d:21	36	**37**	73
Patella		10	10	20
Tibia	p:14, c:24, d:21	25	34	59
Fibula		16	14	30
Talus		13	18	31
Calcaneus		15	13	28
Sacrum		—	—	6
Phalanges		—	—	268

Note: Bold indicates the minimum number of individuals.
Abbreviations: c, corpus; d, distal; p, proximal.

2.3 | Method

This study aims to reconstruct the health status and lifestyle of the GH community through a bioarcheological analysis of pathological markers and physiological stress indicators present in the skeletal and dental remains. By integrating multiple lines of bioarcheological evidence, insights into the subsistence economy and daily life of the population can be obtained. The skeletal series was analyzed in the Paleoanthropology laboratory. The paleopathological analysis of the skeletal remains followed established methodologies and classification systems, including those proposed by Waldron (2020), Mann and Hunt (2012), Ortner (2003), Aufderheide et al. (1998), Roberts and Manchester (2012), and Brickley (2018). Indicators such as cribra orbitalia (CO), porotic hyperostosis (PH), and periosteal reactions (P) were classified according to the criteria outlined by Steckel et al. (2018). The methods proposed Brothwell (1981), Hillson (2005), and Bouville et al. (1983) were used in the findings of dental pathologies.

Despite the GH assemblage's strong archaeological association with the Late Neolithic, radiocarbon (14C) dating conducted by the TUBITAK Marmara Research Center on a randomly selected bone sample yielded an age of 4462 ± 32 years before present (BP), with a 95.4% probability range corresponding to 3339–3207 BCE (Figure 2). This result provides definitive evidence that GH was occupied during the Late Neolithic and Early Chalcolithic periods. The initial stratigraphic classification of the GH settlement into two distinct cultural layers Chalcolithic (1a) and Neolithic (1b) suggests (Figure 1a,b) that the radiocarbon sample may have originated from a context in which these two phases were stratigraphically intermixed.

3 | Results

3.1 | Pathological Results

3.1.1 | Degenerative Diseases

The primary paleopathological observation in individuals from the GH assemblage is osteoarthritis (OA) (Figure 3a–c), a degenerative joint disease characterized by the deterioration of cartilage within joint cavities. OA is one of the most common lifelong pathological conditions, primarily developing due to mechanical stress on mobile skeletal structures, particularly the joints and defined as a natural process occurring as a result of aging (Waldron 2020; Rogers et al. 1987).

In the GH population, OA was most frequently observed in the ulna %14.03 (8/57), in the distal joint 3/11 (%27.2), and in the proximal join 5/18 (%27.7) Also, it was detected in femur 5.48% (4/73), distal joint 2/21 (%9.5), and proximal joint 2/6 (%33.3) (Tables 1 and 2). Similar findings were reported in CH, where activities such as carrying, gathering, and processing crops placed considerable strain on the hips, knees, upper extremities, and feet, leading to a higher prevalence of OA; additionally, the prolonged use of grinding stones and other tools was linked to stress-induced bone changes (Sadvari et al. 2017). Given that Akgün (2019) identified the presence of grinding stones in GH, a comparable pattern of skeletal stress can be inferred.

Another prevalent pathological feature observed in GH individuals was the formation of osteophytes, defined as bony outgrowths that develop during bone remodeling. The distribution of osteophytes within the GH population was highest in the lumbar (34.88%), thoracic (12.76%), and cervical (3.33%) vertebrae (Figure 3d).

Degenerative condition identified in the GH vertebrae was Schmorl's nodes (SN) (Figure 3e), which occur as a result of intervertebral disc herniation into the vertebral body. This process, often linked to age-related degeneration, is exacerbated by intense physical exertion and mechanical strain (Roberts and Manchester 2012; Mann and Hunt 2012; Dar et al. 2009). Due to the high degree of fragmentation in the GH vertebral remains, SN was most frequently detected in the thoracic (10.63%) and lumbar (4.65%) vertebrae.

Additionally, the skeletal remains exhibited evidence of enthesophytes, bony projections that form at tendon and ligament attachment sites due to repetitive muscle strain and mechanical loading (Mann and Hunt 2012). While this condition is considered a normal physiological response, its prevalence varies based on the intensity of physical labor. Enthesophytes were most commonly observed in the femur (31.50%), patella (30%), and calcaneus (17.85%) (Figure 3f). Notably, the presence of enthesophytes in the calcaneus suggests that the lower limbs

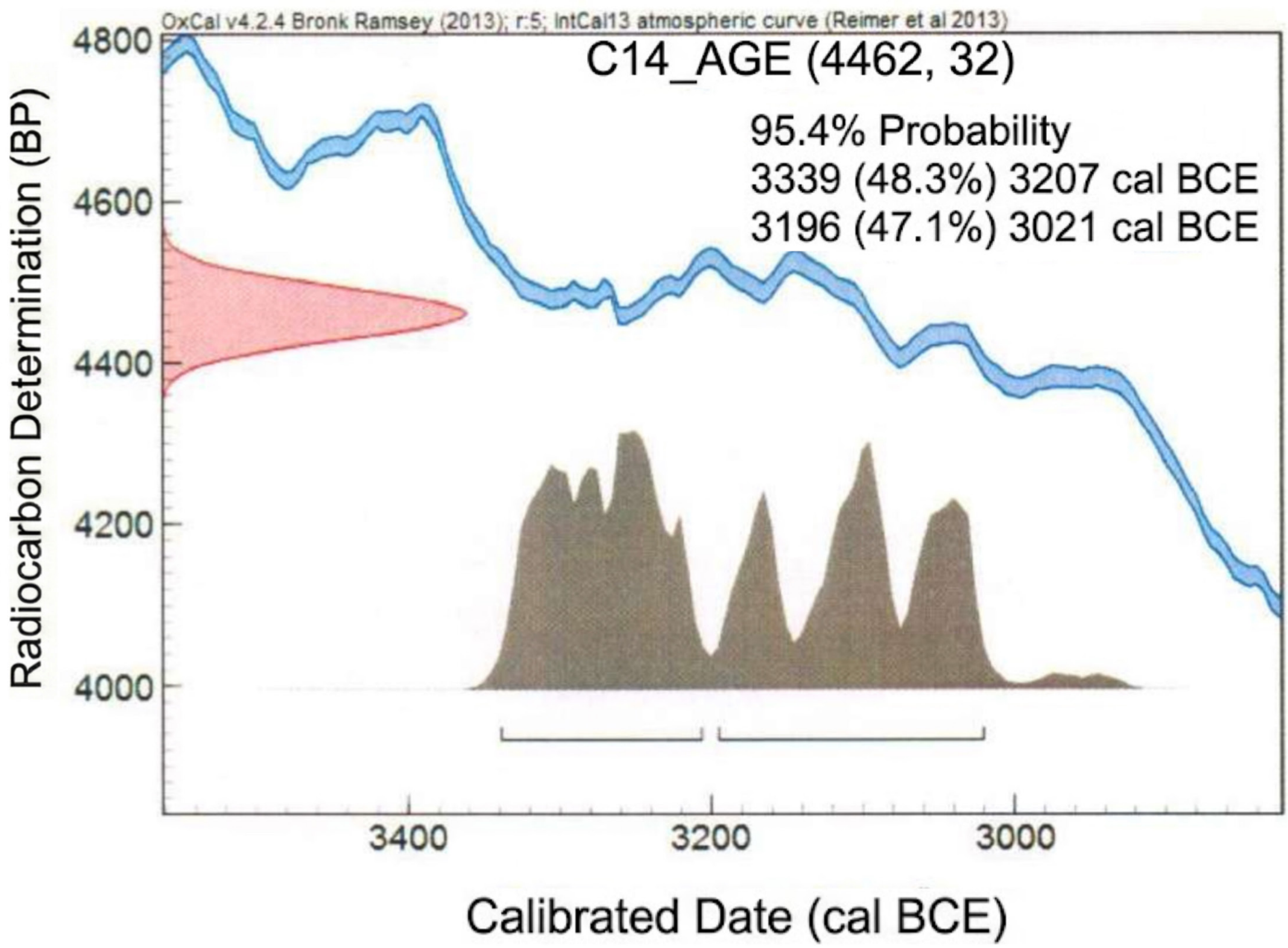

FIGURE 2 | Radiocarbon (14C) dating conducted by the TUBITAK Marmara Research Center. [Colour figure can be viewed at wileyonlinelibrary.com]

endured considerable biomechanical stress, possibly exceeding the body's adaptive capacity.

Anatomical feature observed in GH individuals was the rhomboid fossa (RF), identified in two out of 22 clavicles (9.09%) (Figure 3g). While RF is generally regarded as a normal anatomical variant, some studies have proposed associations with muscle mass, biological sex, and habitual upper limb activity (Mann and Hunt 2012; Rogers et al. 2000; Jit and Kaur 1986) (Table 2). However, due to ongoing debate regarding the etiology of RF, its functional significance remains controversial.

3.1.2 | Trauma

The analysis of trauma provides valuable insights into the social dynamics and daily life of past populations (Roberts and Manchester 2012). Previous studies have shown that cranial injuries can result from accidents (e.g., falls), interpersonal violence, or culturally motivated practices (Lovell 2008).

In the GH population, traumatic lesions were identified in three out of 22 crania (13.63%) (Figure 4a,b,d,e). Typological classification of these injuries revealed two cases of depressed fractures (Figure 4a,b) and one instance of trauma caused by a sharp object (Figure 4d,e). It is known from the literature that both blunt and penetrating objects were used to inflict skull trauma at CH. This also provides clues about the presence of different objects or the circumstances (Knüsel, Glencross, et al. 2021). Notably, in GH, the cranial injury caused by a sharp object (Figure 4d,e) suggests that violent encounters, possibly interpersonal conflicts, took place within this community. Additionally, evidence of a healed ulna fracture was observed (Figure 4c), indicating that the individual survived the injury long enough for bone remodeling to occur. The presence of healing confirms that these injuries were antemortem (Sauer 1998). The paired rotational fracture, observed in ulna (Figure 4c), can be identified by the formation of a transverse line in both the ulna and radius bones. This pathological phenomenon is usually the result of an indirect force such as a fall on the outstretched hand (Judd 2008).

3.1.3 | Metabolic Diseases

CO and PH are morphological syndromes that develop as a physiological response to specific stressors affecting the body (Klaus 2020). While iron deficiency anemia is frequently cited as a primary cause, other contributing factors include

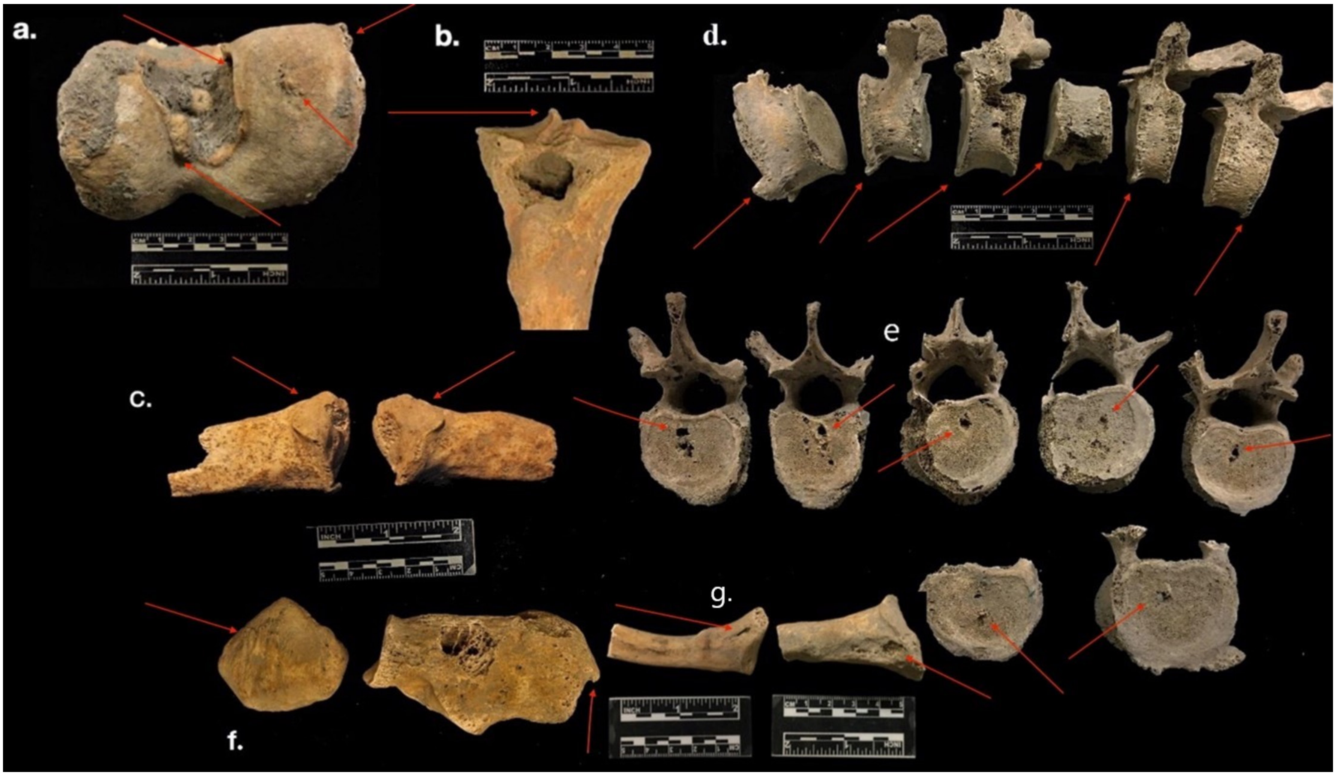

FIGURE 3 | (a) Osteoarthritis in the distal part of the femur. (b) Entheseal change of tibial spine attachment of medial meniscus. (c) Osteoarthritis in the right and left clavicle. (d) Vertebral osteophytes. (e) Schmorl's nodules in the thoracic and lumbar vertebrae. (f) Entheosopathy of the calcaneus (right) and patella (left). (g) Right and left clavicle rhomboid fossa. [Colour figure can be viewed at wileyonlinelibrary.com]

nutrient depletion, vitamin deficiencies, and parasitic infections (Walker 1986; Mann and Hunt 2012).

Among the 22 skull fragments preserved from the GH community, only 13 retained portions of the orbital region, and CO was observed in two cases (15.38%) (Figure 4f). Additionally, PH was identified in four out of 22 skulls (18.18%) (Figure 4g). These findings, which have been prevalent in populations since the Neolithic period, align with high mortality rates among younger individuals, suggesting that nutritional stress and inadequate health conditions were persistent challenges within the GH community.

3.1.4 | Periostitis

Periostitis is characterized by inflammation of the periosteum, which can arise from various causes, including trauma, infection, inflammatory diseases (Aufderheide et al. 1998). In the GH population, periostitis was most frequently observed in the femur (34.24%), followed by the tibia (20.33%). Additionally, periostitis was noted in the fibula (13.3%) (Figure 5a). Although periostitis, CO, and PH have distinct etiological origins, they share numerous common risk factors and pathophysiological interactions. Infections, nutritional deficiencies, and inflammatory conditions play a particularly significant role in their development. Therefore, a comprehensive examination of these conditions is crucial for understanding both individual health status and broader patterns of disease within the GH population.

3.1.5 | Pronator Teres Syndrome (PTS)

PTS occurs when the median nerve is compressed by the pronator teres muscle in the forearm (Dididze et al. 2025). This compression can result from activities such as rapid and repetitive grasping or prolonged hammering. PTS is a condition that can easily be overlooked, and research has shown that it is more prevalent in men (Asheghan et al. 2016). PTS was observed in one of the radius bones (Figure 5b).

3.2 | Dental Disease and Nutrition

Dental remains provide crucial insights into dietary habits, food preparation techniques, and socioeconomic conditions. Additionally, they serve as key indicators of physiological stress, reflecting nutritional deficiencies, disease, and overall health status within past populations (Lukacs 1989).

Despite their durability and resistance to postmortem degradation, teeth are among the most susceptible structures to caries and erosion throughout an individual's lifetime. Dental caries, a common pathological condition, serves as a key indicator of this process. In the GH population, caries were identified in 9.9% of permanent teeth ($n = 231$) (Table 3; Figure 6a). The development of dental caries is closely linked to dietary habits, particularly the type and frequency of carbohydrate consumption. Existing literature consistently demonstrates that high-carbohydrate diets are associated with increased caries prevalence in agricultural

TABLE 2 | Distribution of pathological diseases (O, observed; E, examined).

	Femur	**Tibia**	**Fibula**	**Radius**	**Ulna**	**Humerus**	**Clavicle**	**Cervical**	**Thoracic**	**Lumbar**	**Patella**	**Calcaneus**	**Cranium**	**Orbital region**
	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E	O/E
Lifestyle diseases														
Osteoarthritis (OA)	4/73	1/59	1/30	3/55	8/57		3/22							
Osteophyte	3/73	1/59	1/30	1/55	5/57	1/67	1/22	1/30	6/47	15/43				
Schmorl's nodule (SN)								0/30	5/47	2/43				
Enthesophytes	23/73	7/59	4/30		2/57	10/67	1/22				6/20	5/28		
Trauma					1/57								3/22	
Rhomboid fossa (RF)							2/22							
Metabolic diseases														
Cribra orbitalia (CO)														2/13
Porotic hyperostosis (PH)													4/22	
Periostitis (P)	25/73	12/59	4/30											

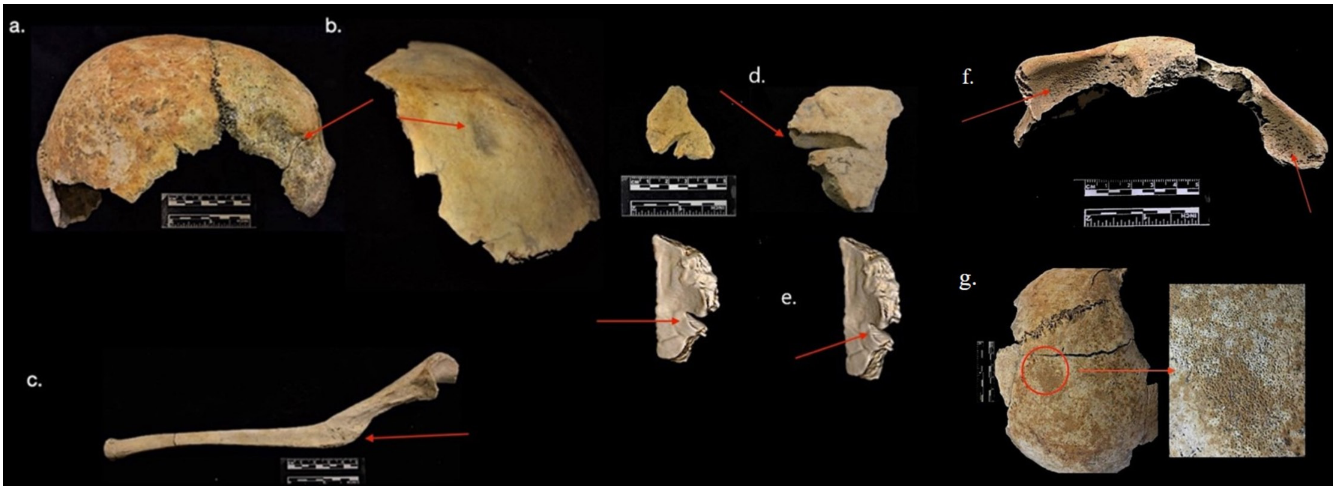

FIGURE 4 | (a–b) A cranial specimen of a head trauma. (c) Specimen of a fracture of the ulnar bone. CT scan (e) and normal (d) image of a cranial fragment trauma caused by a sharp object. (f) CO sample seen in the orbital region. (g) PH sample seen on cranial vault. [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 5 | (a) GH1-2 coded sample of periostitis seen in the Tibia. (b) M. Pronator Teres Sample Observed in a radius. [Colour figure can be viewed at wileyonlinelibrary.com]

populations (Brothwell 1981; Mays 1998; Hillson 2005; Roberts and Manchester 2012).

The relatively higher prevalence of dental caries in the GH population, compared with other contemporary groups, suggests a significant reliance on carbohydrate-rich foods (Figure 7). This finding supports the hypothesis that agricultural products formed a substantial component of the diet, contributing to the observed caries prevalence.

The formation of a dental abscess begins with the infection of the dental pulp, often as a result of progressive caries, severe abrasion, or traumatic factors (Roberts and Manchester 2012). In the GH population, abscess lesions were identified in 12 (3.71%) of the 323 alveoli examined (Table 3), with the maxilla being the most frequently affected region (Figure 6c).

Dental calculus is the mineralized accumulation of bacterial plaque that adheres to the crown or root surface due to inadequate oral hygiene (Ortner and Putschar 1981; Lukacs 1989; Peretz and Smith 2004). In the GH population, calculus deposits were observed in 138 (59.74%) of 231 permanent teeth (Table 3; Figure 6b).

Tooth wear refers to the progressive loss of enamel due to chewing and other mechanical processes, leading to significant tissue depletion, especially on occlusal surfaces (Hillson 2005; Lukacs and Pastor 1988). An analysis of 231 permanent teeth revealed that 176 (76.19%) exhibited signs of wear (Table 3; Figure 6d). Based on Bouville et al.'s (1983) classification scale, the degree of wear in GH falls within the moderate to high range, indicating a diet characteristic of an agricultural society.

Antemortem tooth loss (AMTL), a condition that progressively increases with age, can result from alveolar resorption, trauma, genetics, caries, or abscesses (Lukacs 1989; Roberts and Manchester 2012). In the GH population, AMTL was recorded in 18 of 323 alveoli (5.5%) (Table 3; Figure 6f).

Periodontal diseases are inflammatory conditions of mesodermal origin affecting the gingival tissues surrounding the teeth (Griffin 2014; Hillson 2008; Ogden 2008; Roberts and Manchester 2012). Alveolar loss was observed in 24 of 28 jaws (85.7%), with moderate gingival recession being the most prevalent form (Table 3; Figure 6d).

Enamel hypoplasia, a defect caused by physiological disruptions in amelogenesis, is a widely recognized indicator of developmental stress (Hillson 2008; Roberts and Manchester 2012; Goodman and Armelagos 1985; Goodman and Rose 1990; Ogden 2008). In the GH population, hypoplasia was observed in 6.49% of individuals (Table 3; Figure 6e).

4 | Discussion

Among the pathological disorders observed in the GH population, physical working conditions played a significant role. One of the most relevant conditions in this context is OA, a

FIGURE 6 | (a) Caries. (b) Calculus. (c) Abscess. (d) Tooth wear and alveolar loss. (e) Hypoplasia. (f) AMTL. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 | Distribution of permanent teeth and distribution of dental pathologies.

Pathologies	**E**	**O**	**%**
Caries	231	23	9,9
*Periapical lesions (abscess)	323	12	3,71
Dental calculus	231	138	59,74
Tooth wear (abrasion)	231	176	76,19
*Antemortem tooth loss (AMTL)	323	18	5,57
*Alveolar loss	28	24	85,71
Hypoplasia	231	15	6,49

E, examined; O, observed

*Abscess and *AMTL pathologies were calculated according to the number of dental alveolar.

*Alveolar loss was calculated according to jaw numbers.

	M3	**M2**	**M1**	**PM2**	**PM1**	**C**	**I2**	**I1**	
Upper	2	12	25	12	14	10	16	8	99
Lower	14	26	28	12	17	13	13	9	132
Total	16	38	53	24	31	23	29	17	**231**

Note: Bold indicates the total number of teeth.

joint disorder commonly associated with daily physical activity. The overall prevalence of OA in GH skeletons was 6.75% (20/296). This figure is notably lower than those reported for other Neolithic sites, such as Aşıklı Höyük (90.2%) and Çayönü (71.8%) (Büyükkarakaya and Erdal 2006). Similarly, in the Late Neolithic community of Bademağacı, OA was observed in 62.5% of vertebral joints and 33.3% of long bones (Erdal 2009). In Hakemi Use, 26% of vertebrae and 32.1% of long bones exhibited signs of OA (Erdal 2013). Likewise, Neolithic skeletons from Tepecik-Çiftlik showed OA in 66.6% of vertebrae and 50% of long bones, aligning with patterns commonly seen in agrarian societies (Büyükkarakaya et al. 2009).

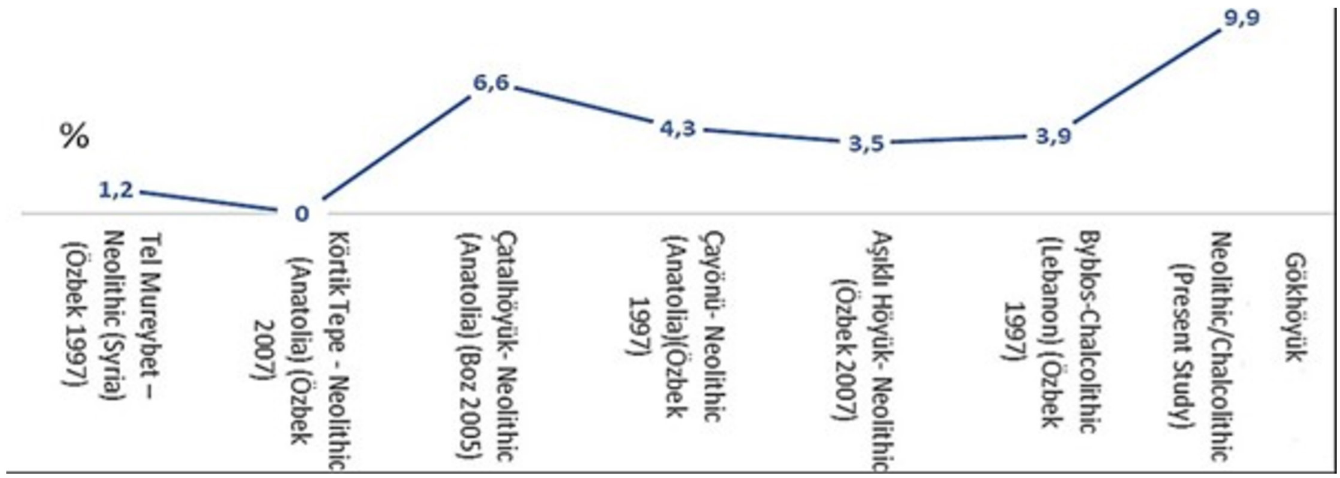

FIGURE 7 | Rates of caries in Neolithic and Chalcolithic period societies. [Colour figure can be viewed at wileyonlinelibrary.com]

The presence of OA in the upper extremities of the GH population suggests that repetitive harvesting activities contributed to joint degeneration, a pattern previously documented at CH, where grinding stones and grain processing played a crucial role (Sadvari et al. 2017). Additionally, the presence of sling stones and animal bones within the GH community, coupled with arthritis findings in the upper extremities, suggests that hunting may have been practiced alongside agriculture.

Repetitive movements over time lead to irregular bony protrusions, known as enthesophytes, which indicate chronic biomechanical stress. In the GH population, enthesophytes were observed in 16.29% (58/356) of individuals, while reactive force (RF) changes in the clavicle were noted in 9.09% (2/22). Enthesophyte development is typically associated with age, physical activity, obesity, and occupational factors and is more common in males (Mann and Hunt 2012). Similar skeletal changes were observed in Aktopraklık, a contemporary Neolithic site, further supporting these findings (Roodenberg and Songül 2011).

In the GH population, trauma was primarily characterized by depressed fractures and sharp-force injuries. Comparatively, in Körtik Tepe, trauma was observed in two out of 10 individuals (Özbek 2005), while in the Çayönü Neolithic population ($n = 605$), nine individuals exhibited cranial trauma (Özbek 1997). In Hakemi Use, four out of 43 individuals presented with cranial trauma, findings similar to depressive trauma in GH (Erdal 2013). The pertinent literature clarified that majority of blunt injuries at CH were caused by blunt force (Knüsel, Glencross, et al. 2021). At GH, the existence of nominal obsidian projectile evidences was documented, same as in ÇH. Clay balls, commonly found at CH, are also present at GH, which interpreted the clay balls found at CH as slingshot ammunition (Knüsel, Glencross, et al. 2021; Larsen et al. 2015).

As noted by Angel (1971), PH and CO were widespread in CH, affecting 41% of the population due to chronic anemia (Wiesenfeld 1967). Angel (1971) initially attributed PH to malaria, though later studies have highlighted additional factors, such as iron deficiency, malabsorption, and parasitic infections (Walker et al. 2009). Recent studies suggest that the parasite profile at CH is dominated by fecal–oral transmitted parasites (Knüsel, Milella, et al. 2021; Walker et al. 2009). The possibility of animal communities influence on parasite taxa as in CH is worth to mention. The prevalence of PH and CO in women and children suggests that factors beyond iron deficiency such as malaria and infectious diseases likely played a role. This hypothesis is supported by the proximity of swampy areas, a known breeding ground for malaria vectors (Alpaslan-Roodenberg 2008). Given the presence of livestock in GH, CH, and Ilıpınar, it is reasonable to infer that protein sources were accessible, meaning metabolic disorders may have stemmed from disease-related iron malabsorption rather than dietary deficiency alone. However, the precise mechanisms underlying these conditions remain unclear.

Periostitis, a nonspecific inflammatory condition, is commonly associated with infection, trauma, and metabolic stress. In conjunction with high rates of metabolic disorders, periostitis findings in GH suggest suboptimal living conditions. The variability in prevalence rates is influenced by preservation conditions of skeletal remains. Notably, the high frequency of skeletal remains from young individuals underscores public health challenges leading to increased premature mortality.

Dental hypoplasia, a developmental stress marker, was observed in 6.49% of GH individuals, indicating moderate physiological stress during growth. This rate suggests that nutritional deficiencies or episodic stressors were present, but not severe enough to indicate extreme hardship. The subsistence economy of a community can be inferred from dental pathologies, particularly caries rates. In the Late Neolithic/Early Chalcolithic GH population, the caries rate was 9.9%, aligning with rates observed in other Anatolian agricultural societies (Erdal 2009). Generally, a caries rate of 10% is indicative of an agricultural diet, rich in carbohydrates (Table 4).

Another critical marker of dietary habits is tooth wear, which occurs due to chewing unprocessed or coarse foods. The tooth wear rate in GH is consistent with that of Neolithic agricultural societies. The presence of grinding stones in archaeological contexts further confirms that grain processing and agriculture were integral to daily life. In contrast, zooarchaeological

TABLE 4 | Data on the dental pathology of Ancient Anatolian societies.

Population	Researcher	Period	Caries %	Periapical Lesion %	Calculus %	Wear	AMTL%	Alveolar loss %	Hypoplasia %
Gökhöyük	This study	Late Neolithic-Early Calcolithic	9,9	3,71	Slight	4 and 4+	5,50	'Medium'	6,49
Aşıklı Höyük	Özbek (1997); Büyükkarakaya and Erdal (2006)	Neolithic	4,1	25	—	4	—	"Slight -Medium"	8,02
Çayönü	Özbek (1997) Büyükkarakaya and Erdal (2006)	Neolithic	4,3	20,2	—	5 and 5++	27,8	—	45,92
Çatalhöyük	Molleson et al. (2005); Boz (2005)	Neolithic	6,6	4,4	—	5	10,4	"Medium"	13
Bademağacı	Erdal (2009)	Neolithic	11,6	—	—	5 and 6	—	—	42,10
Hakemi Use	Erdal (2013)	Neolithic	3,5	—	—	Medium-considerable	—	—	—
Tepecik Çiftlik	Büyükkarakaya (2014)	Neolithic	9,3	—	—	—	—	—	32
Aktopraklık	Roodenberg and Songül (2011)	Late Neolithic-Early Calcolithic	12,23	3,93	Slight	—	6,33	"Medium-considerable"	—
Menteşe Höyük	Alpaslan-Roodenberg and Maat (1999)	Late Neolithic-Early Calcolithic	18,1	9,20	—	—	—	—	—
Musular	Özbek (1997)	Neolithic	0	—	—	3 and 4	—	—	—

evidence, including animal bones, suggests that protein intake from animal husbandry and hunting supplemented the diet.

The advent of harvesting and agriculture marked a decisive shift in Neolithic hunter–gatherer societies, introducing a new economic paradigm in which carbohydrates became predominant while protein intake declined. This dietary transformation reduced nutritional diversity and significantly altered the carbohydrate–protein balance, ultimately affecting physical resilience. Moreover, the increased physical demands associated with early agricultural practices contributed to a decline in overall health and an increase in physiological stress. Concurrently, the shift to sedentary agricultural life led to higher population densities, facilitating the emergence and spread of pathogens. The close cohabitation of humans and domesticated animals further exacerbated disease transmission, leading to a rise in skeletal and immune system pathologies. Compounding this issue was the lack of awareness regarding the presence and transmission of pathogens an aspect widely discussed in the literature (Eshed et al. 2010; Cohen and Armelagos 1984).

The GH population provides a valuable case study for understanding the health impacts of early agricultural societies. The low OA rate, presence of animal remains, and dietary diversity indicate a mixed subsistence strategy that included both agriculture and hunting. However, metabolic disorders, periostitis, and dental health indicators highlight the challenges of early farming societies, including nutritional deficiencies, pathogen exposure, and physical stress. Overall, the skeletal evidence reflects a dynamic interaction between diet, labor, and disease, shaping the biological profile of the GH community.

5 | Limitations of the Study

Since the GH excavation was a short-term project, the limited number of poorly preserved skeletal remains and the small sample sizes studied may not provide a comprehensive representation of the overall findings. Additionally, the mixed bones that remained in the museum garden for up to 13 years made accurate age and sex estimation difficult. Not all pathologies leave traces on the skeleton, so our assessments were based solely on those observed in individuals who reached adulthood. The irreversible loss of the Late Neolithic layer also significantly limited our ability to analyze it. Future research is vital to reconstructing the life histories and dietary habits of these individuals.

6 | Conclusion

The archaeological evidence from GH indicates that the site dates to the Late Neolithic to Early Chalcolithic period, a time marked by the emergence of private property and the family unit, coinciding with population expansion. This period witnessed a transition from cohesive residential structures typical of the Neolithic to more urbanized settlements, often classified as "towns" or "cities." The presence of obsidian within the mound suggests an exchange of raw materials with the Cappadocia region during the Neolithic and Chalcolithic periods (Akgün 2019), underscoring the significance of cultural interaction. Success of this settlement may have depended on continued settled agriculture. Despite advancements in settlement structures and economic activities, the period was characterized by significant health challenges. The close living conditions within these communities contributed to the rapid spread of diseases, with skeletal remains from GH revealing high rates of metabolic and infectious diseases. Poor hygiene and suboptimal living conditions likely exacerbated these health issues. Furthermore, degenerative diseases provide insights into the physical demands of daily life, highlighting the intensive labor associated with agriculture and pastoralism. Trauma analysis suggests that many injuries were linked to physically demanding tasks, challenging working conditions, and, in some cases, interpersonal conflicts. A holistic evaluation of the bioarcheological data indicates that agriculture and animal husbandry were the dominant subsistence strategies at GH. The population's carbohydrate-rich diet may have played a role in mitigating the effects of epidemics, infectious diseases, and seasonal food shortages.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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