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The rise of coastal Middle Bronze Age Levant – A multidisciplinary approach for investigating in Sidon, Lebanon

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Abstract

Objectives: The Levantine Middle Bronze Age (MBA, circa 2000–1500 BCE) marks a period of increased trade and regional interaction, spurred on by technological developments. In light of previous research exhibiting limited mobility in Sidon, further investigation was conducted using biodistance analysis to understand local population history and site development.

Materials and Methods: Dental nonmetric traits, a proxy for genetic information, were explored using ASUDAS on a sub-sample of primary inhumations ($n = 35$). The biodistance matrix was generated using Gower distance measures, and further tested using PERMDISP, PERMANOVA, Mantel test and hierarchical cluster analysis. The data was also contrasted to $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ as well as $\delta^{13}C$ and $\delta^{15}N$ values.

Results: There were no significant diachronic differences in isotopes values, and there was biological continuity ($n = 35$, Mantel test $r = 0.11$, $p = 0.02$, comparing local phases and biodistance). The analysis also suggested of a sub-group of individuals with biological proximity shared a more limited range of mobility and dietary habits.

Conclusions: The isotopes ($^{87}Sr/^{86}Sr$, $\delta^{18}O$, $\delta^{13}C$, $\delta^{15}N$) and biodistance analysis conducted on the Sidon College site skeletal assemblage exhibits stability and continuity of the people, despite the site's increasing role in the maritime network. This continuity may have been a key factor in Sidon's success, allowing it to accumulate wealth and resources for centuries to come.

KEYWORDS

ASUDAS, biodistance analysis, Gower, Mediterranean, Western Asia

1 | INTRODUCTION

The Middle Bronze Age (MBA, circa 2000–1500 BCE) has been regarded as a period of innovation, urbanization and increasing inter-regional trade in the Levant. Viewed as the "dawn of internationalism" (Ilan, 1995), the economic prospects at natural anchorages along the Levantine coast became increasingly realized during the MBA, leading to economic prosperity and urbanization of its towns (Falconer & Savage, 2009). Here, we provide new information from Sidon (Lebanon), a Levantine harbor town that began to grow during the

MBA, securing its role as a major trade hub for centuries to come (Doumet-Serhal, 2013).

Sidon, like Tyre and Beirut, had a natural harbor with partially drowned sandstone islets (Marriner et al., 2014). Already during the Early Bronze Age (EBA, circa 2500–2000 BCE), large vessels were anchoring offshore on the island of Zire and making the rest of the trip to land in smaller boats (Marriner et al., 2014). Though tentative, there is evidence of slight human impact to the harbor topography and infrastructure around 1700–1500 BCE, making it one of the earliest modified harbors in the Levant; most harbors in the region did not experience this change until transitioning to the Late Bronze Age or even Iron Age (Marriner et al., 2014). Active trade reached all the way to Egypt, Cyprus, and Crete (Charaf, 2014; Doumet-Serhal, 2008; Véron et al., 2011), which culminated during the Late Bronze and Iron Age as the site became associated with the seafaring Phoenicians (Edrey, 2019).

Several preliminary reports and stand-alone publications have studied the Sidon skeletal assemblage (Haber et al., 2017; Haber et al., 2020; Kharobi et al., 2021; Ogden & Schutkowski, 2004; Schutkowski & Ogden, 2011; Stantis et al., 2019; Stantis, Maaranen, Kharobi, Nowell, Macpherson, Schutkowski, & Bourke, 2021). Genetic studies of modern and ancient Lebanese have reported an increase in genetic components seen in ancient Anatolian and South-Eastern European populations during the Iron Age (circa 1100–330 BCE), possibly due to the emergence of the Phoenicians (Haber et al., 2020). Overall, however, changes are minimal and suggest continuity from antiquity to the modern Lebanese population (Haber et al., 2017, 2020). An isotope study of the MBA Sidon assemblage indicated minimal mobility at the College Site (Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, 2021); $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ values suggested five potential non-locals were among the 56 sampled for isotope analysis. Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, (2021) noted the challenge in identifying non-locals in this part of the world as the biospheric map of the wider region is not complete, though work appears undergoing (e.g., the biospheric map of Southern Levant by Moffat et al., 2020, the current project led by Durham University, 'A multi-isotope base map for Jordan: a tool for re-examining movement and community in the past', and the joint project by Max Planck and University of Warsaw 'Scales of fragmentation: bioarchaeological evidence of economic and social transformation from the Late Roman to Early Medieval period in the Eastern Mediterranean').

A multi-method approach was taken by combining biological distance (biodistance, henceforth) analysis with the isotope data from Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, (2021). Isotope results have been used in combination with biodistance data before (Maaranen et al., 2021; Sjögren et al., 2020; Sorrentino et al., 2018), primarily focusing on comparing individuals by childhood residence, that is, locals versus non-locals. The objectives were two-fold; (1) to explore diachronic changes using both data types and (2) contrast the biodistance and isotopes data to identify overlaps between biological closeness, mobility and dietary choices. As very few potential non-locals were identified from Sidon, a different approach, cluster analysis, was required to investigate potential groupings.

2 | MATERIALS

The Sidon College Site (Figure 1) rests at the heart of the city. It acquired its name from the Gerard Institute and the Marist College that

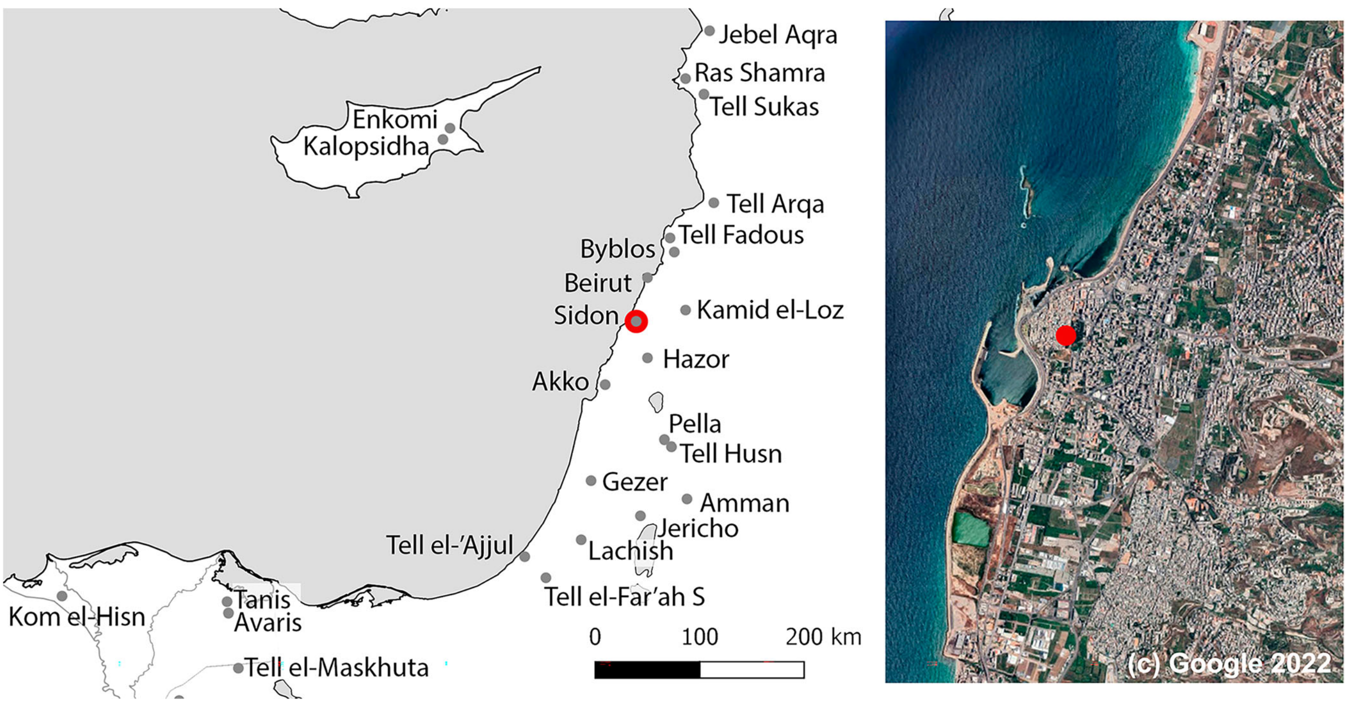

FIGURE 1 Map of eastern Mediterranean with Sidon circled (left) and via Google Maps (right, dot indicates the location of the College site).

operated at the site until demolished in the late 1950s-early 1960s. In 1998, the Lebanese Directorate General of Antiquities, together with the British Museum, initiated large-scale excavations under Dr Claude Doumet-Serhal that have been running for over two decades. A total of 172 burial numbers have been given at the Sidon College site. From this, 158 primary and secondary burials with single and multiple inhumations have been assigned to the MBA. As carbon-dating is currently underway, the burials follow a local a relative chronology, dividing into eight consecutive phases from the beginning to the end of the MBA. From the perspective of funeral practices and the burial context, three phases are of particular interest for the study; phase 1 as the onset, phase 4 and phase 6 (elaborated below).

The earliest phase 1 contains weapon burials, also known as 'warrior burials', where the individual was accompanied by bronze weapons and other artefacts such as metal belts. The custom began in the Early Bronze Age Anatolia and Mesopotamia before spreading across SW Asia and the eastern Mediterranean, creating one of the earliest examples of a regional *koiné* (Burke, 2021; Philip, 1995). Phase 4 marks an increase in interments, likely reflecting a growth in settlement size, and the emergence of a new burial custom, communal burials, which are widely attested from the Western Asia [e.g., Pella (Bourke et al., 2006), Shechem (Clamer, 1977), Jerusalem (Saller, 1965), Hazor (Yadin et al., 1960), Dothan (Cooley & Pratico, 1994) and Gezer (Seger & Lance, 1988)]. In Sidon, they are also associated with ritual feasting in the cemetery (Doumet-Serhal & Shahud, 2013), a well-documented custom from the Levant that was sacred in both institutional and personal spheres (Bergquist, 1993, p. 55). In phase 6, the communal feasting activities appear to have been moved from the burial ground to a monumental building next to the cemetery (Doumet-Serhal & Shahud, 2013). For this study, efforts were focused on individuals with sufficient dental preservation for biodistance analysis. This limited the analysis to individuals from phases 1–6, while isotope data (Stantis et al., 2021) was available from individuals dating to phases 1–7. Both thus capture the site's transformation to a larger trade hub.

3 | METHODS

As the isotope methods and results (pertaining both mobility and dietary data) have been published in Stantis et al. (2021), this section focuses on the recording of dental nonmetric traits and the subsequent statistical techniques used to explore the data. Sex and age-at-death (to categorize adults and subadults) were estimated using standard osteological techniques (AlQahtani et al., 2010; Boldsen et al., 2002; Buikstra & Ubelaker, 1994; Falys & Prangle, 2015; Schaefer et al., 2009; Scheuer & Black, 2000; Walker, 2008).

3.1 | Recording dental nonmetric traits

Dental nonmetric traits were used as a proxy for genetic data; these hereditary features, visible on tooth cusps and roots, have been found to recreate population distances that are similar to DNA studies (Delgado et al., 2019; Hubbard et al., 2015; Rathmann & Reyes-Centeno, 2020). Dental non-metric traits have been used in various biodistance investigations, ranging from global (Hanihara, 2008; Scott & Dahlberg, 1982; Scott & Turner, 1997; Stojanowski & Schillaci, 2006) and regional (Coppa et al., 2007; Irish, 2005, 2006; Irish & Friedman, 2010; Parras, 2004; Ullinger et al., 2005) to intra-site comparisons (Adams et al., 2020; Elias, 2016; Maaranen et al., 2021; Paul et al., 2013; Pilloud & Larsen, 2011; Prevedorou & Stojanowski, 2017; Rathmann et al., 2019; Stantis, Maaranen, Kharobi, Nowell, Macpherson, Schutkowski, & Bourke, 2021; Stojanowski, 2003; Stojanowski & Schillaci, 2006). In comparison, intra-site (i.e., intra-cemetery) analyses are not as common though they have much potential by providing insight into cemetery structures, post-marital residency, biological kinship, temporal microchronology and phenotypic variability (Stojanowski & Schillaci, 2006).

There are several methods for recording dental variation (Alt, 1991; Alt & Türp, 1998; Zubov, 1973), but the Arizona dental anthropology system (ASUDAS) has become the most widely used. The traits in ASUDAS, which also include three oral non-metric traits (palatine and mandibular tori and rocker jaw) have been selected because of their durability, easy identification, good repeatability, heritability and lack of sexual dimorphism (Hanihara, 1992; Hubbard et al., 2015; Scott, 1973; Scott & Turner, 1997; Turner et al., 1991). The traits deemed most useful were first compiled by Turner et al. (1991), including casts for further recording assistance. Further resources, such as more detailed descriptions and photographic atlases (Irish, 2015; Scott & Irish, 2013, 2017), have been produced since then to increase intra- and inter-observer reliability.

Dental and oral traits were recorded following Scott and Irish (2017) (Table 1). Traits were not recorded in cases of moderate to strong dental attrition to avoid under- or over-scoring features. Abbreviations have been used; U = upper, L = lower, I = incisor, C = canine P = premolar and M = molar. For instance, UM2 indicates upper (U) second molar (M2). For the statistical analysis, the key tooth for each trait was selected following Scott and Irish (2017), except for upper molar cusp 5 for which UM2 was selected due to better preservation. LM2 cusp 5 was scored as present/absent (1 indicating 5-cusped LM2). The side with the stronger expression was used and assumed to best express the underlying genotype (Scott & Turner 1997).

Intra-observer error testing indicated good agreement between recording events (Spearman's = 0.98, $p < 0.00$, $n = 216$ observations) (Maaranen et al., 2021). Age-related dependencies (between adults and subadults) were tested using a Kendall tau-b correlation test (Supporting information). No significant correlations were detected between age cohorts, however sample sizes were small even in these wide categories. The number of estimated males and females was too low to allow for meaningful statistical testing (less than 10 in each group); rather than sexes, the analysis pooled individuals by phases.

3.2 | Distance matrix

The distance analysis was conducted using Gower coefficients, as applied in recent studies (Gamble et al., 2001; McClelland, 2003; Paul

TABLE 1 Dental non-metric traits available in ASUDAS (Scott & Irish, 2017; Turner et al., 1991).

Trait	Scale	Range	Used in analysis (tooth)
Winging	Ordinal	0–3	
Labial Curvature	Ordinal	0–5	(UI1)
Palatine Torus	Ordinal	0–4[a]	
Shoveling	Ordinal	0–7	(UI1)
Double-shoveling	Ordinal	0–6	(UI1)
Interruption groove	Present/Absent		(UI2)
Tuberculum dentale	Ordinal	0–6	(UI2)
Pegged of reduced incisor	Present/Absent		
Mesial accessory ridge	Ordinal	0–3	
Distal accessory ridge	Ordinal	0–5	
Premolar accessory ridges	Ordinal	0–4	
Accessory cusps	Present/Absent		
Metacone size	Ordinal	0–5	
Hypocone size	Ordinal	0–6	(UM2)
Bifurcated hypocone	Present/Absent		
Cusp 5	Ordinal	0–5	(UM2)
Marginal ridge tubercles	Present/Absent		
Carabelli cusp	Ordinal	0–7	(UM1)
Parastyle	Ordinal	0–6	
Enamel extensions	Ordinal	0–3	
Upper premolar root number	Count		
Upper molar root number	Count		
M3 congenital absence	Present/Absent		
Odotome	Present/Absent		
Tome's root	Ordinal	0–5	
Lower premolar lingual cusp number	Count	0–3[b]	
Anterior fovea	Ordinal	0–4	(LM1)
Mandibular torus	Ordinal	0–4	
Groove pattern	y		(LM2)
Rocker jaw	Ordinal	0–2	
LM cusp 5 size (hypoconulid)	Present/Absent		(LM2)
LM cusp 6 size	Ordinal	0–5	
LM cusp 7 size	Present/Absent		(LM1)
Deflecting wrinkle	Ordinal	0–3	
C1-C2 crest	Present/Absent		
Protostylid	Ordinal	0–7	(LM1)
Lower canine root number	Count		
Lower molar root number	Count		
Torsomolar angle	Present/Absent		

[a]Modification of the ASUDAS plaques showing range 0–4.
[b]Recommended simplification of Scott's (1973) original scales 0–1 > 0, 2–7 > 2, 8–9 > 3.

et al., 2013; Rathmann et al., 2019; Stantis, Maaranen, Kharobi, Nowell, Macpherson, Schutkowski, & Bourke, 2021). Gower coefficients measure the difference between observations, beginning by computing the distance between pairs and then combining the distances into a single value per record-pair (Gower, 1971). Gower coefficients allow for missing data, an ever-present issue in archeological material, including the Sidon assemblage. The distance matrix was created using the package cluster (Maechler et al., 2019) in R (2020) which scales (standardizes) values to fall between 0 and 1 from identical to maximally dissimilar. Additional transformations can be specified using the *type* argument, such as symmetric and asymmetric binary values; as a default, the function treats the values the way they have been defined, for example, numeric (continuous) or ordered factor (ordinal). Because Gower coefficients require trait independence, the dataset requires checking for inter-trait associations. The Kendall tau-*b* test was selected, recording correlations by base-pair. Traits with little to no variation (palatine and mandibular torus, rocker jaw, UI2 variation, metacone size variation, bifurcated hypocone, parastyle, UP and UM root numbers, enamel extensions, odontome, LC and LM root number) and/or preservation-related low recording rate (winging, UC mesial and distal accessory ridges, UP accessory ridges and cusps, UM1 marginal ridge tubercles, M3 variation, Tome's root, LP lingual cusp number, LM cusp 6, LM1 deflecting wrinkle and C1-C2 crest, torsomolar angle) were excluded; the remaining traits selected for the analysis did not exhibit strong ($b > 0.5$) inter-trait correlation (Supporting information).

Though Gower can accommodate missing data and even create a data matrix with missing data, any missing values in the matrix can hinder further analyses. Some traits and individuals with too high counts of missing values were omitted from further analysis, leaving 35 individuals and 13 traits with 5.1–38.5% (averaging at 20.7%) of missing data (full data set in Supporting information). All remaining traits contributed to variation (Supporting information).

The resulting distance matrix (or, matrices) were further analyzed using permutational analysis of variance (PERMANOVA), isolation-by-distance (IBD) as well as hierarchical cluster analysis (HCA). Results were visualized using R package ggplot2 (Wickham, 2016). Several dimension-reduction techniques are available to bring the biodistance data into a visually observable form. Here, non-metric multidimensional scaling (NMDS) from the package vegan (Oksanen et al., 2019) was used to create a spatial representation in 2 dimensions. NMDS attempts to maintain the best dissimilarity between points by assigning different points for several iterations until the best solution is found.

3.3 | PERMANOVA and PERMDISP

Multivariate analysis of variance from nonparametric distance measurements requires different statistical tools. Here, PERMANOVA and PERMDISP tests, designed for non-Euclidean data, were utilized. PERMANOVA (permutational multivariate analysis of variance) can detect differences in group mean location (or direction) and group dispersion (spread). It is distribution-free, less sensitive to differences in group variances, insensitive to correlation among variables and zeros in the data matrix, and the number of variables (columns) can exceed samples (rows). It does, however, require equal number of datapoints (a balanced design) for the groups under analysis to avoid false positives. PERMDISP (permutational dispersion), on the other hand, measures the multivariate dispersions of the nonparametric distance matrix by comparing within-group and between-group distances using group centroids. PERMDISP only regards spread, not the direction of the values (Anderson, 2006).

A significant PERMANOVA test can result from a difference in the location of the samples (average community composition), dispersion of the samples (variability in community composition) or both. In cases of significance, PERMDISP distinguishes between the options. However, PERMANOVA is not as effective for distinguishing differences in spread as PERMDISP. The package vegan (Oksanen et al., 2019) was employed to conduct PERMANOVA (function adonis) and PERMDISP (betadisper and permutest). If the results of adonis returned significant values, an additional a pairwise test was conducted using package pairwiseAdonis by Martinez Arbizu (2017).

3.4 | Isolation-by-distance

The Mantel (1967) is a correlation test between two matrices. It computes the significance of the correlation through permutations of one of the input matrices, providing a value between -1 and 1. Positive values indicate distances grow together, while negative values indicate an inverse relationship. Values close to 0 indicate no correlation. Statistically significant Mantel correlation indicates the presence of isolation-by-distance. It has previously been used to exhibit the positive correlation between biological and geographic distances between sites (Irish, 2010; Rathmann et al., 2019; Zakrzewski, 2007) and within sites (Konigsberg, 1990). A partial Mantel test has been used to introduce a third matrix into the analysis to control for temporal changes (Konigsberg, 1990; Rathmann et al., 2019). Here, instead of using time as a control, the Mantel test was used to compare distances between individuals in relation to morphology and time. The time matrix was generated from phases/strata using function daisy and the metric gower as the occupation phases can be treated as ordinal variables.

3.5 | Cluster analysis

Cluster analysis is widely used in biodistance analyses to establish groupings based on biological similarity. Hierarchical cluster analyses (HCA) have been used on both metric and non-metric data (e.g., Paul et al., 2013; Pilloud & Larsen, 2011). Each object is assigned to larger and larger clusters in every iteration. The goal of the analysis was to assess phenotypic similarity on a general, not a familial, level. Ward's clustering method was employed to create groups based on an analysis of variance. The HCA dendrogram produces height values indicating where the clades (i.e., groups) fuse, but the height vary by method. Because cluster analysis is exploratory by nature, there are no definitive answers to define the best number of clusters. To assess the best division in the Sidon dataset, the dendrogram, produced using the R base function hclust, was assessed with a scree plot as well as visually observing the clusters on the NMDS plot.

4 | RESULTS

4.1 | Diachronic changes

As the focus of the analysis was diachronic changes, individuals were pooled by phase. The number of males ($n = 8$) and females

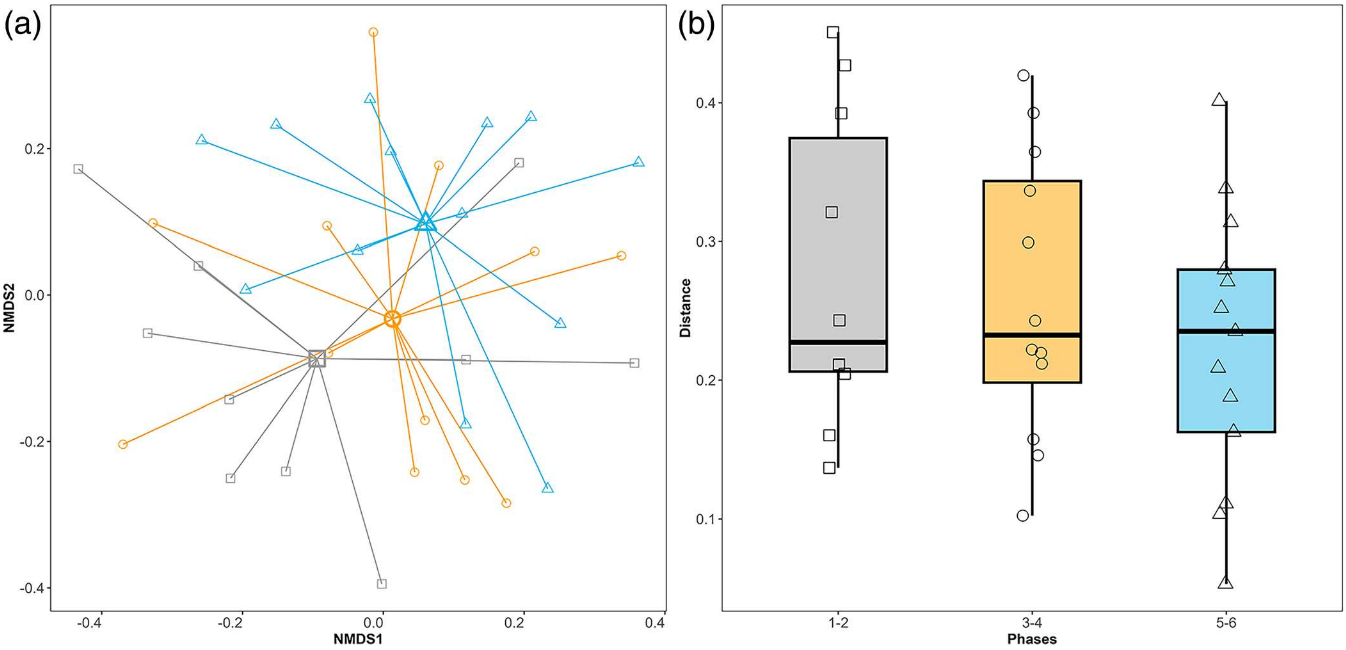

FIGURE 2 NMDS plot of Sidon biodistance data, grouped by phases. Group centroids gradually become more distant by time (a) while distance from group centroids decreases through time (b). Shapes and colors correlate between graphs.

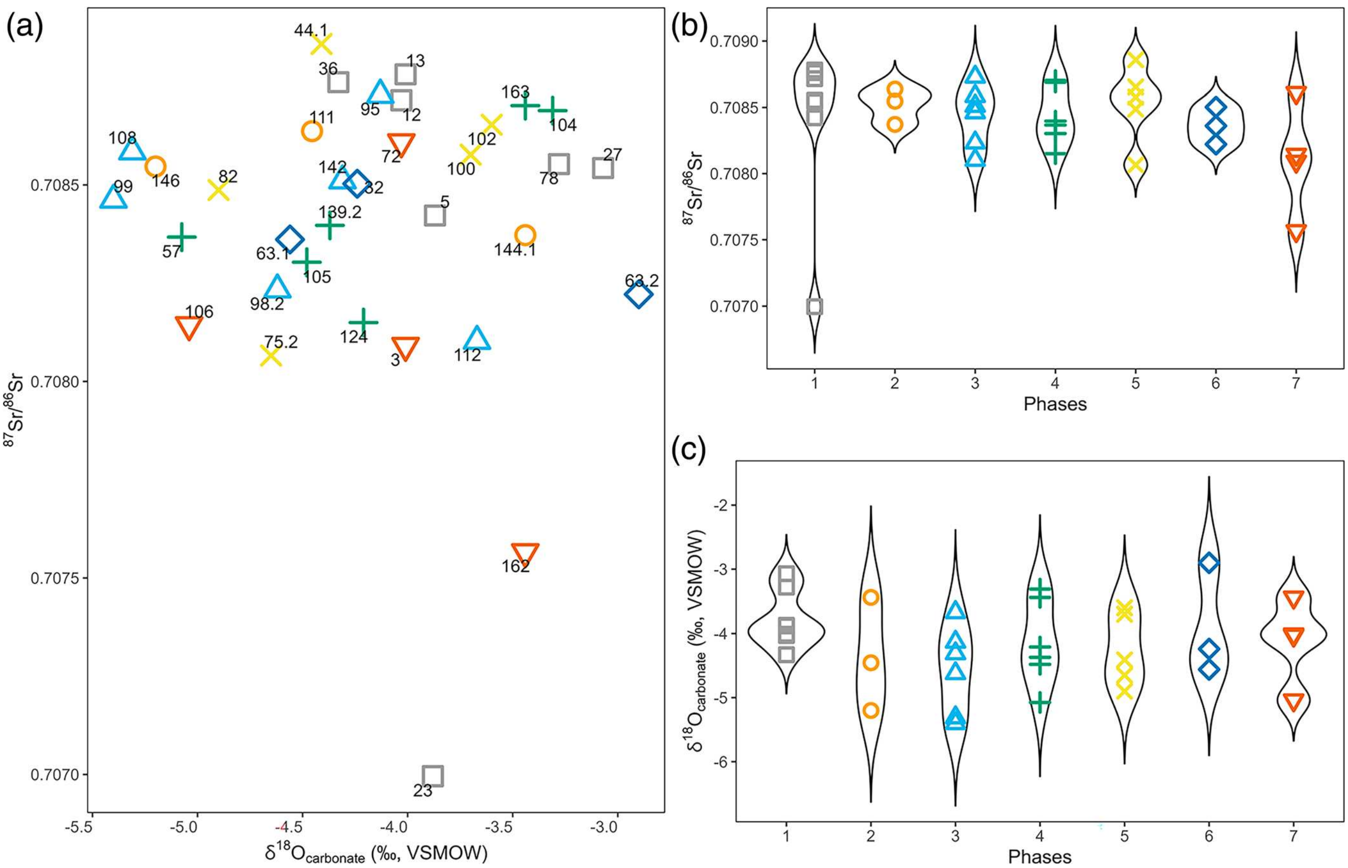

FIGURE 3 Sidon isotope (mobility) data by phase, showing no clear patterns.

($n = 6$) was low in the dataset, not allowing for a meaningful statistical exploration of sex-based differences (e.g., post-marital residence), however both groups had similar dispersions (Supporting information). Similarly, the sample numbers for individual phases was low ($n < 10$), though the distance between phase centroids seemed to generally increase with time

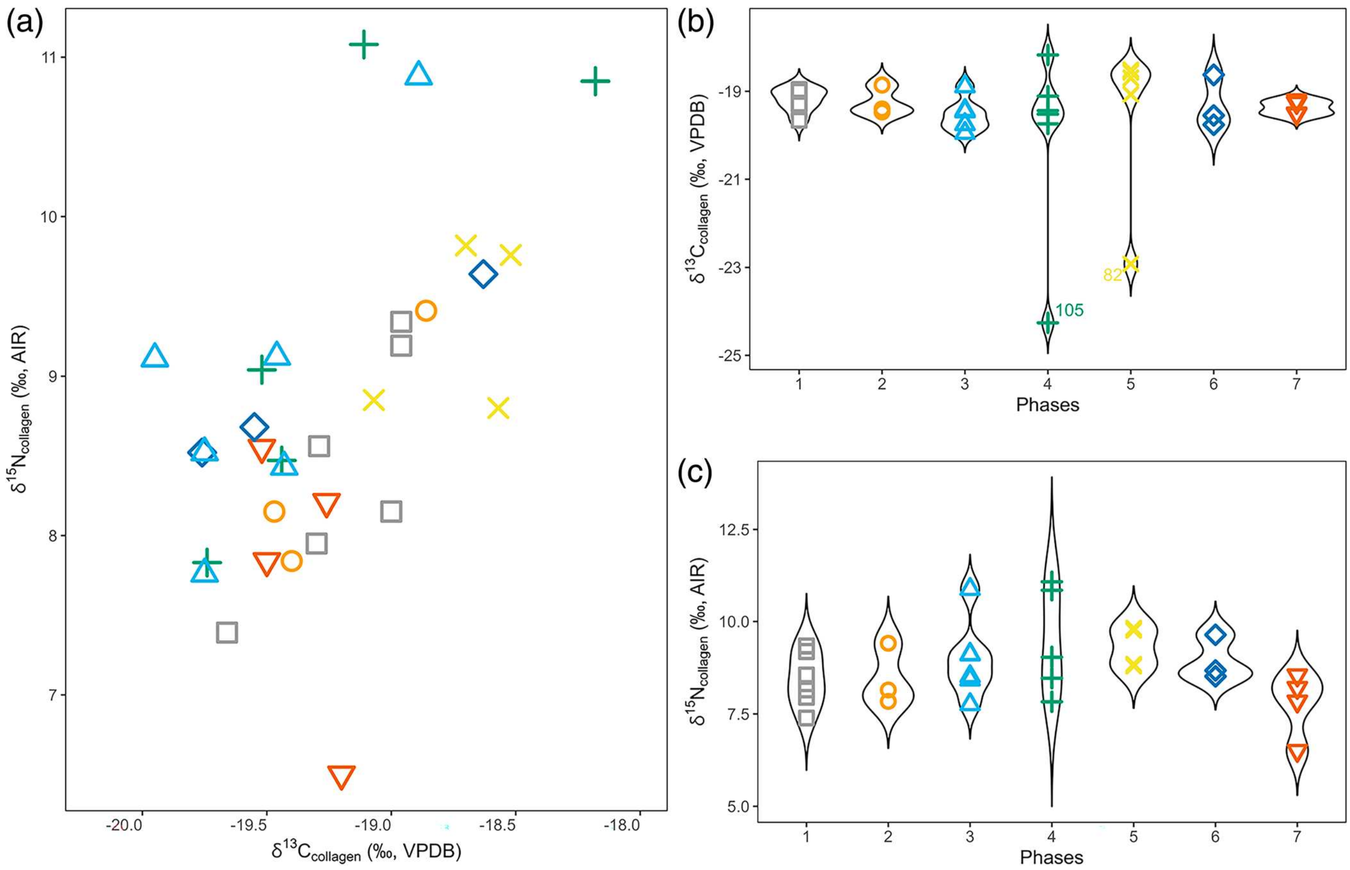

FIGURE 4 Sidon isotope (diet) data by phase. A wider range of $\delta^{15}N$ values was noted during phase 4 and phase 7, however sample numbers by phase are low.

(Supporting information), even more evident when grouped into larger units (Figure 2). The grouped samples were large enough to be considered statistically; Differences were not significant in dispersion (PERMDISP $F(2,32) = 0.81$, $p = 0.48$) or mean location (PERMANOVA $F(2,32) = 1.38$, $R2 = 0.08$, $p = 0.27$). An alternative grouping (1–3, 4–5 and 6) has been provided in Supporting information to assess the effect of grouping; no significant changes were noted. A Mantel test on biodistance and temporal distance indicated positive, though weak, correlation through time ($r = 0.11$, $p = 0.02$).

The isotope data was similarly plotted by phase. $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ plot did not suggest any distinct pattern by phase, though the range of $^{87}Sr/^{86}Sr$ values show a slightly wider spread in phases 3–5 and 7 (excluding the phase 1 outlier, burial 23) (Figure 3b). No great variation is visible in $\delta^{13}C$ or $\delta^{15}N$ either (Figure 4), though $\delta^{15}N$ values were more widely spread during phase 4 (Figure 4c). Difference between phases was tested using non-parametric tools due to non-normal distribution, even after excluding outliers. For comparative purposes, values were grouped similarly to the biodistance data (Figure 2). Kruskal-Wallis *h* test indicated no significant differences between phases for $^{87}Sr/^{86}Sr$ ($X^2 = 2.66$, df = 3, $p = 0.45$), $\delta^{18}O$ ($X^2 = 2.48$, df = 3, $p = 0.48$), $\delta^{13}C$ ($X^2 = 4.05$, df = 3, $p = 0.26$) or $\delta^{15}N$ ($X^2 = 6.77$, df = 3, $p = 0.08$).

4.2 | Cluster analysis

To find the most meaningful morphological division, the distance matrix was analyzed using both clustering and dimension reduction techniques. The scree plot suggests a plateau after three clusters, which were well-defined in a NMDS plot as well (stress-test $S = 0.27$, Supporting information). Each group consists of adults and subadults, and all spread across multiple phases (Figure 5).

The biodistance clusters were plotted against $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ as well as $\delta^{13}C$ and $\delta^{15}N$ values (Figure 6). Phase 1 individuals (5, 13, 23, 27, 36, 78) form not only the largest singular phase with both biodistance and isotope data but the burials are also the richest – these single inhumations had associated weapons and jewelry with sometimes entire animals as meat offerings. Only individual in burial 13 placed in a different morphological cluster (Figure 5). This individual, a subadult circa 4–5 years-of-age, also had an Egyptian jar included in the grave goods. Individual 23, the possible non-local based on their Sr value (Figure 3, see also Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, 2021), was not distinct biologically or according to their diet.

A small morphologically distinct group (Figure 5, burials 95, 99, 108) appears from phase 3 onwards – 99 and 108 have the lowest $\delta^{18}O$ values of the Sidon assemblage. All three adult individuals

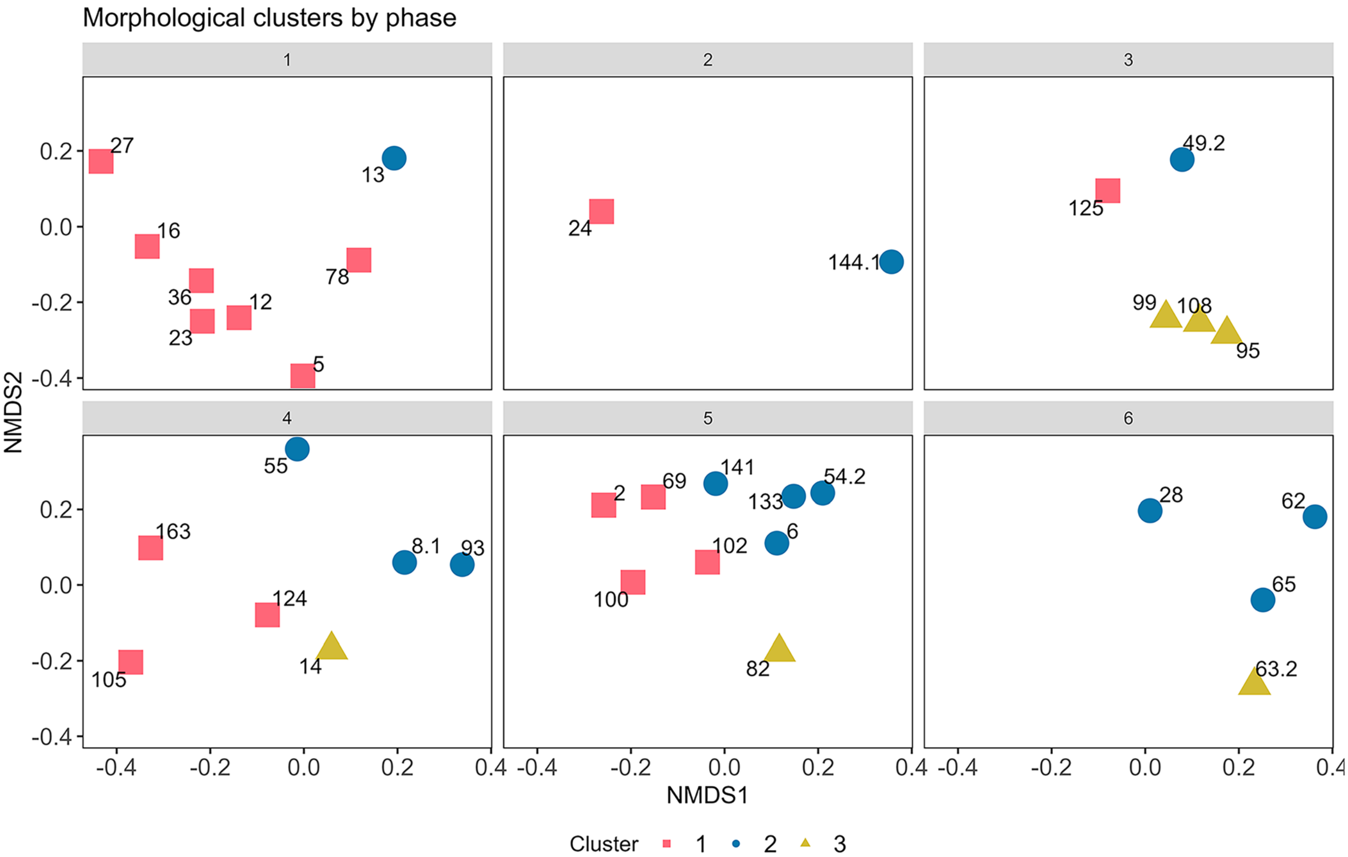

FIGURE 5 NMDS plots of biodistance data, divided by phase and categorized further by morphological cluster. Cluster 3 (triangle) appears in phase 3; these individuals were closely buried. Caution is advised as the sample sizes were limited.

(95, 99, 108) – two males (95, 108) and one female (99) – were buried close to one another. Burial 95, a primary pit burial of a young adult male from the same phase 3, was morphologically similar to 99 and 108 and buried close-by but had a higher δ^{15}N value. No association was observed between 'mobility' data and biodistance.

Further exploratory cluster analyses were applied on the isotopes data as well using k-means clustering techniques; contrasting the diet and mobility data against the biodistance data, namely the NMDS values, supported the observations described above. Diet and mobility cluster were also contrasted against each other; this did not reveal distinct divisions across both data types, though some groupings were more defined in their dispersal. The analysis and results are available in Supporting information.

5 | DISCUSSION

More studies are exploring the impact of trade and interconnectivity to population structures in the Middle Levantine region (Elias, 2016; Haber et al., 2020; Maaranen et al., 2022; Mardini et al., 2023; Nassar, 2019). The Middle Bronze Age led to an increase and intensification within and between regions in the eastern Mediterranean, but responses were varying; some sites have provided evidence of an influx of migrants (Stantis et al., 2020; Stantis, Kharobi, Maaranen, Macpherson, Bietak, Prell, & Schutkowski, 2021), accompanied by the presence of diverse material culture (Bader, 2012), while in others, the expansion of the MBA trade network has not correlated with newcomers (Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, 2021; Stantis, Maaranen, Kharobi, Nowell, Macpherson, Schutkowski, & Bourke, 2021). Due to its continuous occupation and growing importance throughout the Bronze and Iron Age, Sidon provides key insights to the wider development of the region.

Sidon's increasing role on the eastern Mediterranean trade network is visible also in the burial context, both in the material culture and customs. Phase 4 marks the emergence of communal burials, associated with ritual feasting (meal offerings) that were replaced by more centrally performed ritual activities, detached from the burials in phase 6. Lev-Tov and McGeough (2007) have proposed that ritual feasts were used by the higher class not only to demonstrate power and control over circulation of commodities, but also to promote unity. The shift from feasting at the burial ground to feasting at the large monumental building adjacent to the burials suggests the emergence of a top-down process, potentially as a result of an intensified level of administration and urbanization. Though social organization likely experienced remarkable changes, the biodistance and isotopes data suggest the local population remained stable throughout this shift. Dissimilarity incrementally increased between individuals through time while within-group variation decreased (Figure 2b).

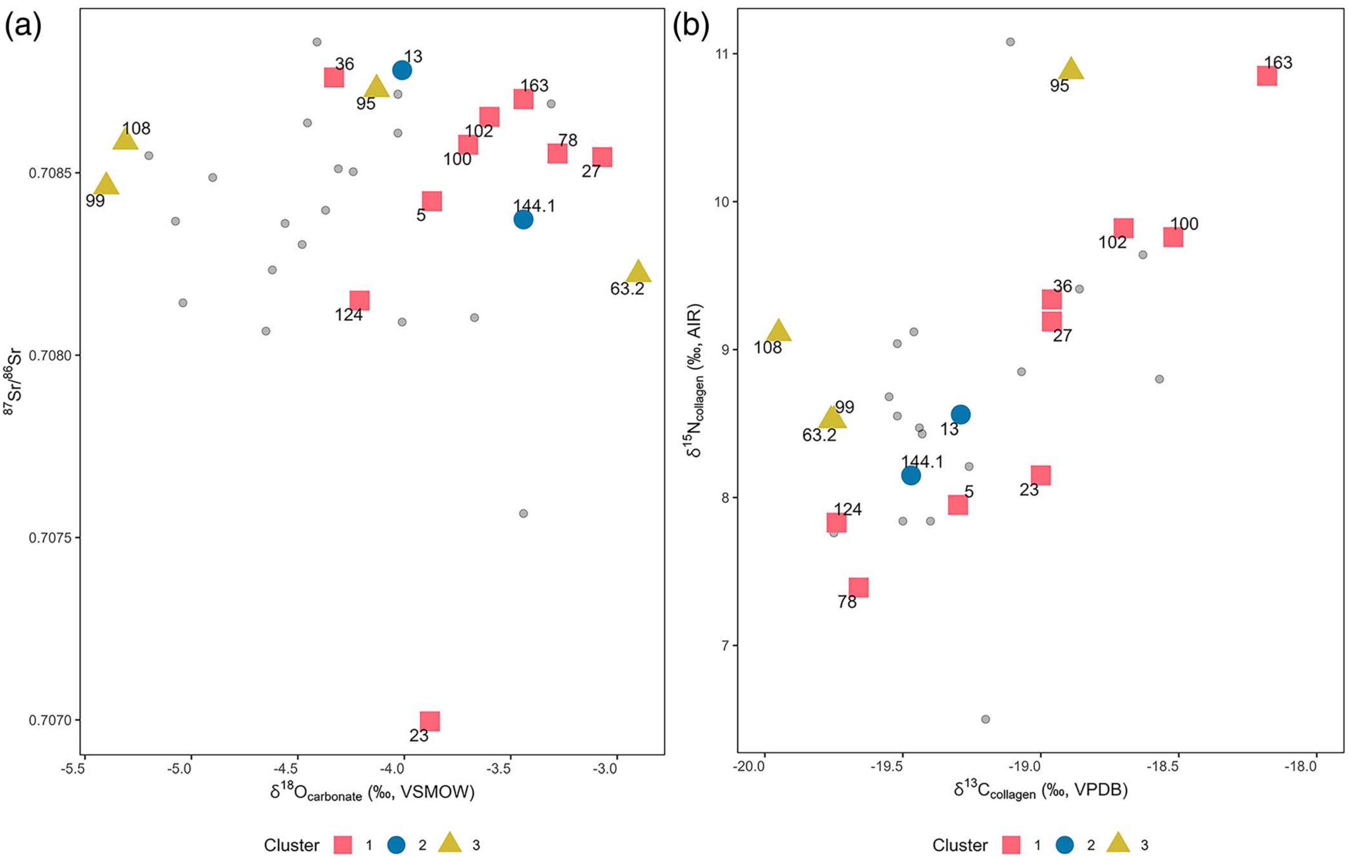

FIGURE 6 Cluster data plotted against non-clustered values; $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values (a) and $\delta^{13}C$ and $\delta^{15}N$ values (b) grouped using morphological clusters.

Together with the $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values (Figures 3 and 4), the results suggest that, despite being a bustling trade hub, there is no marked introduction of newcomers in the Sidon College Site during the MBA.

Why the lack of migration and mobility? The individuals buried at the site may have formed a group of locals overseeing transactions, and thus not been as active in the more direct labor-aspect of trade. Kharobi et al. (2021) noted very few paleopathological conditions, signs of trauma or activity-related stress in a sub-sample of Sidon individuals, suggesting limited labor-intense activities. The burial items, frequent and opulent meal offerings at the cemetery and labor-intense burial constructions (stone- and mudbrick lined tombs) suggest that the College site Sidonians had accumulated wealth. The luxury items, associated not only with adults but also subadults, signal ascribed social status and the importance of concurrent trade connections. This is exemplified by the individual in burial 13 who was circa 4–5 years of age and was buried associated with both gold and silver jewelry, a bronze dagger and an imported Egyptian jar.

There is a tentative relationship between biodistance and dietary data spanning multiple phases (Figure 6). While there were no marked differences in diet across generations, some families might have maintained a diet distinct from others. Overall, there were no marked shifts in $\delta^{13}C$ and $\delta^{15}N$ values between phases (Figure 4), however differences may have existed in the choice of preparation processes rather than ingredients (Stantis, Maaranen, Kharobi, Nowell, Macpherson, Doumet-Serhal, & Schutkowski, 2021). The dynamics of cultural identity and lifestyle related to food choices were better observed in the multi-methods approach in this study and could potentially hint to more differences unobservable from the biochemical data alone.

It must be highlighted that the data points covering both biodistance and diet (or even just one or the other) were limited. The three groups from the hierarchical cluster analysis showed overall good division in the NMDS plot, however some individuals (burials 5 and 78) fell further from their group centroid. It was also noted that while the results generally aligned with previous study (Kharobi et al., 2021), the biodistance analysis did not produce identical results. For instance, individuals in burials 13 and 27 did not place into the same morphologically defined cluster in this study as they had before – though both are equally far away from the other individuals in the cluster. This previous analysis focused on the elite individuals of phase 1 (the so-called warriors) and so trait selection was guided by their preservation status. Furthermore, the data was also clustered and visualized using different methods, partitioning around medoids (PAM) and t-distributed stochastic neighbor embedding, which also did not produce clearly defined groups between clusters. Though the other individuals from phase 1 and the three phase 3 individuals highlighted here remained similar, the slight variation underlines the fact that biodistance analyses on epigenetic traits from fragmentary remains are relational, depending not only on the individuals and the traits but also the methods used when working with smaller (typical archeological) sample sizes. Several studies have shown that biodistance analysis comparing individuals does not currently generate as reliable results as group comparisons (e.g., Delgado et al., 2019; Haber et al., 2017), an issue which was ameliorated here by cross-comparisons and focusing on group-level patterns.

6 | CONCLUSION

Though the multi-methods approach in this paper has limitations for confident interpretation, especially when considering time-based considerations across the phase periods, larger burial assemblages may benefit from this integrated data approach. Nonetheless, some observations can be offered from Sidon. The evidence of harbor modifications, population growth, the slowly emerging new burial and religious practices contrast with the continuity observed in the biological and biochemical results. This stability may have been a prominent factor in Sidon's success. One of the key elements of the eastern Mediterranean Bronze Age was its rapidly growing maritime trade network, and settlements emerged and thrived at locations that offered optimal conditions to engage with it. Sidon prospered as a mediator and a hub of activity, with local groups able to obtain and accumulate generational wealth.

AUTHOR CONTRIBUTIONS

N. Maaranen: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); writing – original draft (lead). **C. Stantis:** Data curation (equal); validation (equal); writing – review and editing (supporting). **A. Kharobi:** Conceptualization (supporting). **S. Zakrzewski:** Methodology (equal); writing – review and editing (equal). **H. Schutkowski:** Conceptualization (equal); funding acquisition (lead); resources (lead). **C. Doumet-Serhal:** Data curation (equal); resources (equal); validation (equal); writing – review and editing (supporting).

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supporting information of this article.

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