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Intragroup variation in the Pre-Columbian Cuba population: A perspective from cranial morphology

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Abstract: The paper aims to study intragroup variation inside the two pre-Columbian Cuban populations: the aceramic Archaic and the ceramic Taino groups, based on their cranial morphology. The latter applied artificial cranial deformation to all its members, so the groups are referred to as "non-deformed" and "deformed" samples here. Studies across different disciplines suggest evidence of cultural and biological diversity inside the non-deformed group, while local variations of applying the deforming device can be responsible for shape variation across the deformed group. Cranial metrics and non-metric cranial traits of the 92 crania of Cuban origin were analyzed, although the sample size varied between the analyses due to the incompleteness of the crania. Geometric morphometrics was applied to the deformed crania to study the shape variation across the sample. Three deformed crania from the Dominican Republic were analyzed together with the deformed Cuban sample to test the variability of the practice between the islands. Principal component analysis and the Mantel test did not reveal any geographic differences in the cranial metric traits. No morphological differences associated with the antiquity of materials could be seen either based on the available data. The principal component analysis of the Procrustes coordinates of the cranial vault outline in the lateral norm revealed continuous variability of cranial shapes from the ones with more flattened frontal and occipital bones to the more curved outlines, which is probably explained by individual variation. Non-metric traits variation revealed bilateral asymmetry in the expression of the occipito-mastoidal ossicles among the deformed crania. In conclusion, the study did not support assumptions about morphological diversity inside the studied samples or proved the impossibility of available craniological data to reflect possible intragroup differentiation at the moment.

Key words: biological anthropology, cranial metrics, non-metric traits, geometric morphometrics, anthropology of Cuba, artificial cranial deformation, The Greater Antilles

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Introduction

Prior to European arrival, Cuba is known to have been inhabited by an indigenous population, which is generally divided into two groups: the aceramic Archaic population, which is believed to have arrived around 5000 years ago (Napolitano et al. 2019:7–8) and the ceramic agricultural Taino population, which inhabited the island since approximately 500 AD (Torres Etayo 2006:35–36) until decimation by the newcomers from the Old World.

There has been much variation in the ways the aboriginal population of Cuba is referred to. To avoid confusion caused by changing perspectives due to new archaeological, linguistic and biological evidence, we will stick to strictly morphological criteria of "non-deformed" and "deformed" crania, which are associated with the aceramic (Archaic) and ceramic (Taino) population groups respectively.

This study focuses on the intragroup variation of the Cuban pre-Columbian population basing on cranial morphology of the deformed and non-deformed samples. Between-group variation is not being addressed, and the samples are analyzed separately for two reasons. First, there has been extensive evidence that the two groups did not have recent common genetic ancestry, so comparing their cranial morphologies would not yield new information. Second, a large body of evidence suggests that artificial cranial deformation affects facial and basal areas of the cranium (Antón 1989; Cheverud et al. 1992; Friess and Baylac 2003), so the direct comparison of deformed and non-deformed crania of different populations would have produced spurious results. Detection of the regions that stay unaffected by the deformation of a particular type requires both deformed and non-deformed crania from the same population, and the results are only valid for the population in question (Rhode and Arriaza 2006). Possible intragroup variation can be explained by multiple origins, microevolutionary processes, different lifestyles for the non-deformed sample and by local traditions in applying the deforming apparatus for the deformed sample. Apart from the spatial dimension, there is a temporal one, which could reflect possible changes throughout the long history of the island population. The assumption that these factors might have impacted the morphology of the studied groups follows from the results of numerous studies across different disciplines.

Two recent genetic studies of the pre-contact Caribbean populations, including the Cuban ones (Nägele et al. 2020; Fernandes et al. 2021), confirmed a single genetic profile for Ceramic-age (referred to as "deformed" in this study) individuals, which suggests a single migration or successive migrations from the same region for this group. However, the studies produced different results considering the homogeneity of the Archaic ("non-deformed") population. This inconsistency is most likely explained by different sampling: the Cueva del Perico individual, shown to have different (presumably North American) ancestry by the work of Nägele et al., was not included in the second genetic study, neither was it available for the present work.

An extensive odothological study has identified two migratory waves that led to populating the Circum-Caribbean region, one connected with the aceramic Archaic groups, the other one bringing the ceramic Taíno population (Coppa et al. 2008). The deformed Cuban sample in the study was represented by the sample coming from a single cemetery, Chorro de Maíta, while the non-deformed samples came from multiple sites and still clustered together according to their dental morphology. This finding is especially remarkable as one of the samples analyzed by Coppa et al. came from Cueva del Perico, an outlier in the genetic study discussed above.

Archaeological data suggest complex population interconnections within the island at different periods (Cooper 2007; Chinique de Armas et al. 2020), while, on the other hand, some sites stayed isolated from the surrounding groups throughout long periods. For example, Canímar Abajo in Matanzas (populated by the non-deformed group) bears evidence of long-standing cultural traditions not present at other contemporaneous Cuban sites (Alarie and Rocksandic 2016). This long isolation could have formed the basis for possible microevolutionary processes within some communities, which might have affected their cranial morphology.

Previously the non-deformed group was often divided into two archaeological complexes (Herrera Fritot 1964; Pospisil and Rivero de la Calle 1964; Tabio and Rey 1966): Complex I and Complex II (sometimes called as Guayabo Blanco and Cayo Redondo or Guanahatabey and Siboney). The division was based on mortuary practices registered at two different sites, but some researchers tended to see two biologically distinct populations behind them (Alonso Alonso 1995:99). Later a more profound consideration of ancient cultures made for understanding that the interplay between the groups that occupied different sites was more complex than a simple dichotomy of two cultural variants, which led to a more differentiated approach to the diversity of pre-Columbian communities in Cuba.

Archaeological data also suggested a possible division of the non-deformed population into two periods: hunter-gathering and protoagricultural (actual names may vary from author to author), the latter one characterized by the evidence of simple agriculture and crude ceramics at the corresponding sites (Tabío 1988:64–65; Guarch Delmonte 1990; Pérez Carratalá 2014:78–80). It has also been shown based on stable isotope analysis that subsistence strategies differed throughout the territory of the island even between contemporaneous communities: groups inhabiting Canímar Abajo site have been shown to rely on horticulture while Cueva Calero and Cueva del Perico inhabitants apparently relied on hunting-fishing-gathering strategy (Chinique de Armas et al. 2018).

Classification of the archaeological and skeletal materials is also an essential issue for discussing the groups' homo- or heterogeneity. Cooper (2007:232) noted that ceramic vessel fragments had been found at some sites classified as pre-agricultural in the Western part of the island, and the cultural attribution relied upon the absence of artificial cranial deformation in the human remains. He argues that it challenges the whole system of classification of the findings, which automatically considers any non-deformed crania belonging to the pre-agricultural population. This, in turn, means that one has no reason to assume that all non-deformed crania belonged to a morphologically, genetically, or culturally uniform population.

As far as the deformed sample is concerned, Herrera Fritot (1964:105) noted that the deformed crania could be divided into two groups: those with moderate deformation concentrated mainly in the frontal and basal occipital areas and those with more pronounced deformation which affected the whole vault and in most cases produced a bilobate shape. He deduced that there must have existed different designs of deforming devices, some of them having a sagittal band in addition to the transverse ones.

The results of all the studies mentioned above suggest grounds for expecting a certain degree of heterogeneity both inside the deformed and non-deformed samples. There is evidence that some local non-deformed groups relied upon different subsistence strategies, were culturally diverse and had lived in isolation for a long time (Chinique de Armas and Rocksandic 2019). Considering that they had been inhabiting the island for several millennia, these factors might have led to significant differences between the local or temporal groups. Given that the non-deformed sample can include individuals with different ancestry and that there is no certainty about them being a single group, a study of intragroup morphological variability can provide insights into the anthropological structure of the island's early population. While not much genetic-based intragroup morphological variation can be expected for the deformed sample, little is known about the deforming practice itself and whether it was performed in the same manner throughout the whole island. The objective of the present study is to analyze the intragroup variation in cranial morphology of the two pre-Columbian Cuban samples and see whether individual differentiation inside them correlates with territorial, cultural, or temporal factors.

Cranial samples from Cuba available for this study suffer from several problems: most of them lack contextual information, zone of origin is often known approximately, secure dating is only available for several sites. Moreover, the humid climate does not favor the long conservation of the bone remains, so their state of preservation is often far from perfect. With that in mind, this article addresses the following questions: (1) Did possible multiple origins or microevolutionary processes contribute to morphologically detectable intragroup differentiation inside the non-deformed sample? (2) Did local differences in artificial cranial deformation contribute to intragroup differentiation inside the deformed sample? and (3) Can analysis of the available craniological data contribute to our understanding of the relationships between different groups that inhabited the island before European colonization?

Cranial morphology is widely used to address prehistorical issues due to the conservative nature of its variation, its underlying genetic component, and strong geographic patterning (Bunak 1959; Howells 1989; Pietrusewsky 2014). Metric and non-metric cranial traits were used in this study to explore the variability of cranial morphology in each sample. For the deformed group, two-dimensional geometric morphometrics was applied to study and visualize the shape variation across the sample. 2D shape analysis is a robust tool for studying morphological variation but must be used with caution with 3D objects due to the so-called "three-to-two-dimension error" (Cardini 2014; Buser et al. 2018), and its performance has been shown to deteriorate when applied to small samples belonging to one taxon (Cardini and Chiapelli

2020). However, it has been proven effective for the studies of artificial cranial deformation (Perez 2007; Gonzalez et al. 2011) and thus will be only applied to the deformed group in this paper.

A review of previous cranial studies of the Cuban pre-Columbian population

Various scholars attempted to study the internal structure of the Cuban pre-Columbian population basing on cranial data, which has always been scarce. The first scholar to study ancient human remains was Luis Montané Dardé, who studied the non-deformed crania from the site of Boca del Purial and noted their anthropological heterogeneity (Montané 1908 cited in Hernández Godoy 2003:192). Later studies were conducted by Rivero de la Calle, who examined the deformed crania and identified this type of deformation as "tabular oblique" according to Dembo and Imbelloni's classification (1938) and detected one cranium that had "tabular erect" type, which he explained as a possible defect of application of the deforming device (1949 cited in Herrera Fritot 1964:82–83).

One of the first works summarizing all the known cranial data was made by René Herrera Fritot (1964), who developed the craniotrigonometric method and applied it to the study of Cuban aboriginal crania. He investigated them through the prism of archaeological classification of the three archaeological "complexes"– Complex I or Guayabo Blanco (non-deformed), Complex II or Cayo Redondo (non-deformed), and Complex III or Taíno (deformed), and saw individuals from the respective sites as characteristic for these "types". Pospisil and Rivero de la Calle (1964) questioned this idea: according to them, it was difficult to separate the first two complexes both by archaeological and anthropological data. A direct comparison between the crania did not reveal any differences, so it was suggested that the preceding authors might have come to an opposite conclusion due to the inclusion of both male and female crania in their samples.

Soviet anthropologist V. Ginzburg, whose measurements of the Cuban crania were included in the present paper, concluded that the non-deformed and deformed groups were not directly related, although both must have had South-American biological affinities. He also suggested two morphological subtypes of the non-deformed crania, one being wider- and lower-faced than the other (Ginzburg 1967:189). His conclusions were disputed by V. Alexeev, who suggested that the differences between the groups could be entirely explained by the effect of cranial deformation (Alexeev 1986:20). By studying the variation of non-metric traits in the two populations, Rivero de la Calle (2009:179–180) concluded that their divergence is greater than the one between comparative samples from distant locations of the American continent (like Peru and British Columbia). Recent genetic studies reaffirmed that both groups had securely different origins (Lalueza-Fox et al. 2003; Nägele et al. 2020; Fernandes et al. 2021).

After that, the focus of major archaeological and anthropological works based on Cuban pre-Columbian materials shifted from studying the population in general to studying local cultural, ecological, nutritional, health, and other issues (Crespo-Torres et al. 2013:437–439). This turned to be a promising approach;

biological anthropology managed to shed new light on mortuary (La Rosa Corzo 2003), weaning (Chiniqie de Armas 2017) and cultural practices (Alarie and Roksandic 2016), subsistence strategies (Chinique de Armas et al. 2015), nature of co-existence with the Europeans at the later sites (Valcárcel Rojas 2016), pathologies (Armstrong et al. 2013).

Some recent attempts to approach intragroup diversity based on morphological data were proposed by students of The University of Havana. Bolufé Torres (2015) found differences in the orbital breadth and stature between non-deformed individuals from different locations in the West of the island. Although the author concluded that the results might indicate the different origin of the individuals, they should be treated with caution due to the small sample sizes available. Valdés Pi (2009) managed to compose a comparatively large sample of both non-deformed and deformed crania. A set of cluster analyses based on facial craniometric variables identified possible sub-clusters both inside the non-deformed and deformed groups, but no patterns (geographical, cultural, chronological) that could explain the identified division were suggested. García Méndez carried out a geometric morphometric analysis of the outlines characterizing the cranial shapes in the frontal and lateral norms in a sample of non-deformed individuals from the East and the West of the country. She concluded there were no significant differences between them (García 2018; García et al. in press). Finally, preliminary analyses of the metric data studied here have been previously published in Russian by the first author (Syutkina 2017; 2018).

This paper is the first attempt to analyze a comprehensive cranial sample of the pre-Columbian Cuban population using a multimethodological approach and taking into account findings reported in recent studies from other disciplines and new perspectives on the complex relations of the groups inhabiting the island.

Material and methods

Data acquisition. The total craniometric sample consists of 95 crania: 92 male and female crania of Cuban origin and three deformed male crania from the Dominican Republic to test the variability of cranial morphology between the islands (see Table 1 for more information on the sites and Supplement Table 1 for the full composition of the samples). The Cuban sample is comprised of the 57 non-deformed (male = 40, female = 17) and 39 deformed (male = 27, female = 12) crania. However, not all of them could be included in all the multivariate analyses due to their incompleteness. The sample size for each analysis is reported separately in this section. Cranial measurements have been standardized by both the Biometrika school and Martin and Saller (1957) in the version applied in Soviet/Russian craniometry (Alexeev and Debets 1964). The craniometric sample is composed of two parts: crania measured by Vulf Ginzburg (n = 18) in 1964 (Ginzburg 1967) and crania measured by one of the authors (TS) in 2017 following the same methodology (n = 77). Ginzburg's sample consists of the crania that could not be found or accessed in 2017 and only contains craniometric variables. Non-metric traits were observed by TS and MGP for the same 77 individuals that were measured by TS. The traits used in the study are a combined list of traits described in Berry and Berry (1967), Krenzer (2006), and

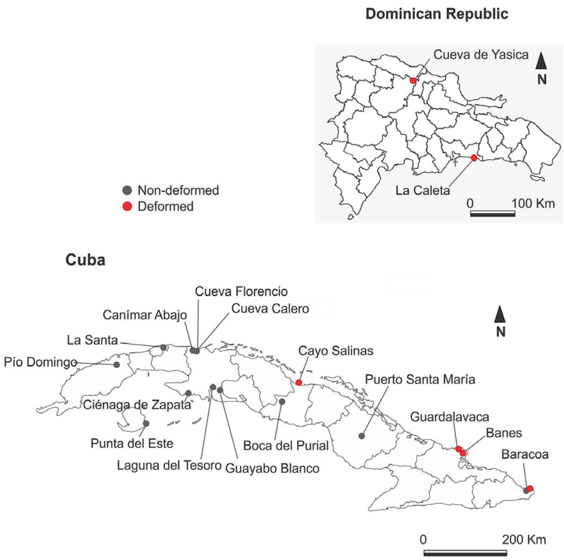

Fig. 1. Map showing location of the sites discussed in the article. Generated with the use of raster package in R (Hijmans 2021). The sites from the zone of Baracoa are represented as a single point, more information on exact origins is available in the Supplement Table 1

Table 1. Cranial samples from Cuba and Dominican Republic

	Site	Male	Female	Total
Non-deformed	Unknown	2	0	2
	Baracoa	16	7	23
	Punta del Este	1	0	1
	Pinar del Río	1	0	1
	Cueva Calero, Matanzas	0	3	3
	Boca del Purial, Sancti Spíritus	1	3	4
	Canímar Abajo (Younger Cemetery), Matanzas	10	1	11
	La Santa, Habana	0	1	1
	Cueva Florencio, Matanzas	1	0	1
	Ciénaga de Zapata, Matanzas	2	0	2
	Guayabo Blanco, Matanzas	2	0	2
	Puerto de Santa María, Camagüey	3	1	4
	Laguna del Tesoro, Matanzas	0	1	1
	Total non-deformed	39	17	56
Deformed	Unknown	3	3	6
	Baracoa	18	6	24
	Guardalavaca	1	0	1
	Cayo Salinas, Sancti Spíritus	2	1	3
	Banes	0	2	2
	Cueva de Yasica, Dominican Republic	1	0	1
	La Caleta, Dominican Republic	2	0	2
	Total deformed	27	12	39

Movsesyan (2005) (see Table 2 for the full list and references). All traits were registered per side to study the symmetry of their expression and per cranium to calculate their frequencies in each group (Czarnetzki 1971). Only adult crania were included (based on the fusion of the spheno-occipital synchondrosis). Sex and age for the 77 crania were estimated according to general methodological guidelines (Buikstra and Ubelaker 1994).

The shape of the deformed crania in the lateral norm was studied using two-dimensional geometric morphometrics, following standard procedures (Bookstein 1991; Zelditch and Swiderski 2018; Vasiliev et al. 2018). Images were taken with a Nikon Coolpix P100 camera, skulls placed in lateral view, camera positioned at 30 cm from the auriculare point. Two landmarks (the deepest point on the frontal bone after glabella and the intersection of the line continuing the direction of the zygomatic process of the temporal bone with the outline of the skull in its posterior part) and 23 semilandmarks between them were placed along the sagittal curve (Figure 2). These landmarks were chosen to analyze the outline avoiding the glabella and mastoid regions, which would otherwise add undesirable sex-related variation. The landmarks were placed, and their coordinates were obtained using tpsDIG2 2.31 software (Rohlf 2015). The semilandmarks were then slid according to the minimum

Table 2. Non-metric traits used in the study and their frequencies in the non-deformed and deformed samples

Trait	Reference	Non-deformed n (N)	Deformed n (N)
Metopism	Berry and Berry 1967	0 (40)	0 (33)
Saggital ossicles	Krenzer 2006	0 (29)	0.129 (31)
Ossicle at the lambda	Berry and Berry 1967	0.071 (28)	0.188 (32)
Inca bone	Krenzer 2006	0 (28)	0.125 (32)
Palatine torus	Berry and Berry 1967	0 (33)	0.103 (29)
Supraorbital foramen	Krenzer 2006	0.538 (39)	0.406 (32)
Supraorbital notch	Krenzer 2006	0.795 (39)	0.906 (32)
Accessory infraorbital foramen	Berry and Berry 1967	0.216 (37)	0.133 (30)
Infraorbital suture	Krenzer 2006	0.649 (37)	0.600 (30)
Trochlear spine	Movsesyan 2005	0.091 (33)	0.000 (28)
Multiple zygomatic foramina	Krenzer 2006	0.784 (37)	0.607 (28)
Stellate pterion	Movsesyan 2005, Murphy 1956	0.029 (35)	0.034 (29)
Fronto-temporal articulation	Berry and Berry 1967	0.000 (35)	0.034 (29)
Epipteric bone	Berry and Berry 1967	0.000 (35)	0.207 (29)
Coronal ossicles	Berry and Berry 1967	0.057 (35)	0.032 (31)
Lambdoid ossicles	Berry and Berry 1967	0.148 (27)	0.533 (30)
Occipito-mastoidal ossicles	Krenzer 2006	0.348 (23)	0.533 (30)
Ossicle at the asterion	Berry and Berry 1967	0.074 (27)	0.367 (30)
Squamoparietal ossicles	Krenzer 2006	0.032 (31)	0.414 (29)
Parietal foramen	Berry and Berry 1967	0.767 (30)	0.793 (29)
Foramen of Huschke	Berry and Berry 1967	0.414 (24)	0.310 (29)
Posterior condylar canal	Berry and Berry 1967	0.962 (26)	0.880 (25)
Condylar facet double	Berry and Berry 1967	0.188 (16)	0 (20)

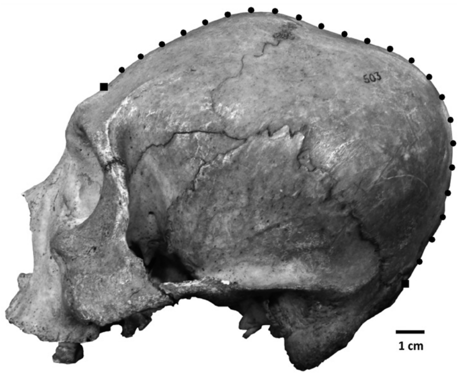

Fig. 2. Landmarks (squares) and semilandmarks (circles) used in the study

bending energy criterion, and both landmarks and semilandmarks were aligned using a generalized Procrustes analysis (Bookstein 1991).

Statistical analyses

All craniometric values were compared with the worldwide variation of the studied traits and categorized as "very small", "small", "medium', "large", "very large" (Alexeev and Debets 1964:114–22). The data were tested for outliers using boxplots (not presented). For the non-deformed crania, descriptive statistics were calculated with and without outliers. In the deformed sample, the outlying values cannot be regarded as random deviations, and the variability should be considered the result of artificial deformation. Only individual number 1047, which is believed to have a different type of deformation, was excluded prior to the repeated calculation to check whether it was responsible for extreme variability of some traits in the male sample.

Sexual size dimorphism (SSD) for all the traits was calculated as the difference between the mean value of a trait in the male and female samples and compared with average world figures (Alekseev and Debets 1964:123–25) where available. SSD was only calculated for traits that could be measured in no less than ten individuals in the smaller female sample (Evteev 2008:9).

Principal component analysis was performed to study the patterns of morphological variation within each sample. Metric variables were used for the non-deformed sample: the set of variables to be included was composed in a manner that would allow maximizing the sample size and cumulative proportion of the variance explained by the first two PCs. For the same reason, neurocranial and facial variables were studied separately for the non-deformed sample, as combining them led to a drastic decrease of the sample size to a very small number of individuals. Seven facial measurements, summarizing overall facial, nasal, and orbital dimensions (FMB, ZMB, UFH, NLB, NLH, OBH, OBB) and ten measurements describing cranial vault (GOL, XCB, BBH, AUB, FRA, PAA, OCA, FRC, PAC, OCC) were included in the principal component analysis. Only the male sample was analyzed to prevent sexual dimorphism from affecting the result, and the female sample was too small to be analyzed independently. 24 and 14 individuals could be analyzed in the facial and neurocranial analyses, respectively.

The deformed crania were analyzed using Procrustes coordinates to study the shape variation across the sample; male and female samples were pooled for this analysis. It included 34 crania with preserved cranial vaults. Individual number 1047 from Baracoa was considered an outlier and excluded from the sample for this analysis for its markedly different type of deformation.

Additionally, a two-way Mantel test (Mantel 1967; Sokal and Rohlf 1995) was used to test the association between the matrices of Euclidean craniometric and geographical distances for the male part of the non-deformed sample. As in previous analyses, morphological variables were divided into two subsets to avoid a drastic reduction of the sample. The neurocranial subset consisted of six variables (GOL, XCB, WFB, XFB, AUB, ASB) and 20 individuals, while the facial subset – of seven variables (FMB, ZMB, UFH, OBB, OBH, NLB, NLH) and 23 individuals.

All calculations were performed in R version 4.0.3 (R Core Team 2020) with RStudio interface version 1.4.1103 (RStudio Team 2020). The Mantel test was carried out in R Studio using the function mantel.rtest from package ade4 (Thioulouse et al. 2018), the number of permutations was set at 5000. The geographic distances calculations were performed in R using the haversine method from the package “geodist” (Padgham and Sumner 2021). The geometric morphometric analysis was carried out by means of geomorph package in R (Adams et al. 2021).

Results

Metric variation

Summary statistics
Non-deformed sample

Both male and female non-deformed crania (Table 3) are characterized by medium-small facial and neurocranial dimensions on a worldwide scale (Alekseev and Debets 1964:114–122), including zygomaxillary and nasomalar facial angles, thus suggesting limited expression of cranial metric traits usually associated with Asian ancestry. The standard deviation of most variables in the male sample falls within average standard deviations for given morphological traits except WFB, XFB, ASB, ALL, ALB, FCD and ALA. In the female sample, these are ASB, ZMA, XFB, FCD, ALL and ALB. However, after identifying and excluding outliers (one for each variable), only FCD and alveolar arch dimensions stayed highly variable within both samples.

Despite the female’s sample higher variability and lower representativeness, all the values fall in the same general categories (small/medium) as in the male sample. The sexual size dimorphism was found to be low among the non-deformed crania: only five traits (XFB, PAA, ZMB, WNB and FCD) proved to have higher than average rates of SSD in the sample.

Deformed sample

In general, both male and female crania from the deformed sample (Table 4) have short, very low, and very wide vaults; the frontal bone is flat and wide, it is steeply inclined and often bears a mark left by the deforming device. Forehead profile angles values are far beyond the lowest average limits for physiologically normal crania. All neurocranial and facial widths are very large, so are orbital and facial dimensions (although orbital and nasal widths tend to be smaller in the female sample compared to female worldwide average values). Horizontal profiling of the face is moderate both at nasomalar and zygomaxillary levels.

The male sample proved to be very heterogeneous: standard deviations of more than a third of variables exceed the world average: XCB, BBH, BPL, XFB, PAA, OCA, FRC, PAC, OCC, UFH, ALL, FCD, FAN and FAG. Testing for outliers revealed numerous outlying values for the same cranium, 1047, which is believed to be the only one having "tabular erect" deformation type (Rivero de la Calle 1949 cited in Herrera Fritot 1964:82–83). Standard deviations decreased after removing it from the sample at this step but stayed over the world average for the same variables as before except XFB and

Table 3. Summary statistics for the non-deformed sample

Abbreviation	Measurement	Male			Female		
		n	Mean	sd	n	Mean	sd
GOL	Glabello-occipital length	31	172.7	6.5	14	167.2	5.5
XCB	Maximum cranial breadth	27	135.3	3.8	15	130.9	5.1
BBH	Basion-bregma height	18	133.9	5.2	10	128.2	4.4
BNL	Basion-nasion length	18	97.3	3.8	10	93.5	2.8
BPL	Basion-prosthion length	14	93.6	2.8	9	92.1	3.6
WFB	Minimum frontal breadth	32	92.8	5.0	14	87.7	4.2
XFB	Maximum frontal breadth	28	111.9	5.6	14	108.6	4.8
AUB	Biauricular breadth	26	124.0	4.9	14	116.4	4.4
ASB	Biasterionic breadth	25	106.0	5.4	13	103.2	4.7
FRA	Frontal arc	26	119.0	5.7	9	116.2	4.7
PAA	Parietal arc	22	125.3	5.8	10	119.7	4.7
OCA	Occipital arc	20	109.9	7.4	6	108.7	2.5
FRC	Frontal chord	27	106.7	4.7	10	104.0	2.9
PAC	Parietal chord	22	110.1	4.4	10	105.8	4.7
OCC	Occipital chord	20	94.5	3.9	6	93.5	2.4
FMB	Bifrontal breadth	33	104.3	3.0	13	98.7	3.2
ZYB	Bizygomatic breadth	23	132.9	4.2	12	124.5	6.1
ZMB	Bimaxillary breadth	28	95.7	3.9	16	90.8	4.8
UFH	Upper facial height (n-alv)	30	63.1	3.6	14	61.6	1.8
OBB	Orbital breadth from maxilofrontale	33	41.3	1.8	17	40.0	1.8
OBH	Orbital height	34	33.1	1.3	17	33.1	1.5
NLB	Nasal breadth	32	23.5	1.7	16	22.9	0.9
NLH	Nasal height	32	49.3	3.2	17	47.4	2.3
ALL	Alveolar length	14	49.8	3.6	5	49.3	3.9
ALB	Alveolar breadth	15	59.2	4.6	5	56.5	3.4
SIS	Simotic subtense	31	2.7	0.7	14	2.3	0.4
WNB	Simotic chord	31	8.6	1.5	14	7.5	2.0
MFS	Maxillofrontal subtense	30	5.7	1.2	14	5.0	1.0
MFC	Maxillofrontal chord	30	19.3	2.2	15	17.2	2.0
FCD	Fossa canina depth	29	3.8	2.0	15	3.8	2.2
FAN	Forehead profile angle from nasion	19	82.0	3.8	13	84.5	2.8
FAG	Forehead profile angle from glabella	19	76.2	3.5	13	78.2	3.2
GFA	General facial angle	18	83.1	2.3	13	82.4	2.9
ALA	Alveolar angle	14	65.9	6.5	9	65.5	6.0
NPA	Nasal protrusion angle	20	21.2	6.6	13	16.9	4.1
NMA	Nasomalar angle	29	144.0	4.4	12	144.4	4.1
ZMA	Zygomaxillary angle	24	127.2	4.8	13	127.7	6.8

FRC. Female crania seem to be considerably more uniform than the male sample: standard deviations exceed the world average for traits XCB, XFB, PAA, FCD and frontal/facial vertical angles (FAN, FAG, GFA, ALA). SSD in the deformed sample is not high in terms of metric traits (observed index in the sample was high-

Table 4. Summary statistics for the deformed sample

Abbreviation	Measurement	Male			Female		
		n	mean	sd	n	mean	sd
GOL	Glabello-occipital length	23	172.0	5.6	12	160.6	4.2
XCB	Maximum cranial breadth	22	154.5	5.5	12	148.0	5.4
BBH	Basion-bregma height	17	125.6	5.4	9	122.3	3.2
BNL	Basion-nasion length	17	97.2	4.3	9	91.0	2.1
BPL	Basion-prosthion length	16	99.0	5.9	9	92.8	3.1
WFB	Minimum frontal breadth	20	96.8	2.6	12	94.2	4.4
XFB	Maximum frontal breadth	20	122.5	6.2	10	118.4	5.7
AUB	Biauricular breadth	21	136.2	4.2	10	130.0	3.5
ASB	Biasterionic breadth	20	112.5	3.4	12	109.1	4.4
FRA	Frontal arc	23	117.9	6.1	10	113.0	2.9
PAA	Parietal arc	23	107.6	9.7	11	103.4	8.2
OCA	Occipital arc	18	113.5	11.7	11	108.5	6.9
FRC	Frontal chord	23	110.0	5.4	10	104.8	3.4
PAC	Parietal chord	23	95.8	7.0	11	92.5	4.8
OCC	Occipital chord	18	97.4	7.6	11	92.5	4.2
FMB	Bifrontal breadth	21	109.6	3.3	12	104.8	2.3
ZYB	Bizygomatic breadth	17	142.5	4.6	10	132.2	3.7
ZMB	Bimaxillary breadth	20	102.1	4.5	11	98.9	2.5
UFH	Upper facial height (n-alv)	21	70.4	5.1	11	67.4	2.2
OBB	Orbital breadth from maxilofrontale	22	43.3	1.9	11	41.3	1.8
OBH	Orbital height	22	36.1	1.4	11	35.8	0.9
NLB	Nasal breadth	22	26.2	1.6	11	25.0	1.6
NLH	Nasal height	22	53.8	3.1	11	51.8	1.8
ALL	Alveolar length	15	52.4	4.0	7	49.6	2.7
ALB	Alveolar breadth	15	64.3	4.1	8	61.2	2.9
SIS	Simotic subtense	21	3.6	0.8	11	3.1	0.6
WNB	Simotic chord	21	10.4	1.6	11	10.1	1.0
MFS	Maxillofrontal subtense	22	6.1	1.2	10	5.8	0.6
MFC	Maxillofrontal chord	22	19.4	1.7	10	18.4	2.5
FCD	Fossa canina depth	22	3.4	1.4	11	3.1	1.3
FAN	Forehead profile angle from nasion	16	66.2	5.2	10	67.2	5.9
FAG	Forehead profile angle from glabella	16	56.4	5.4	10	58.8	5.8
GFA	General facial angle	15	81.1	2.9	11	80.5	3.3
ALA	Alveolar angle	15	69.8	5.0	11	68.7	6.5
NPA	Nasal protrusion angle	16	21.6	4.6	10	18.0	3.0
NMA	Nasomalar angle	21	141.2	4.5	11	143.0	3.4
ZMA	Zygomaxillary angle	20	127.5	4.2	11	126.5	3.9

er than average maximum only for GOL, XCB, OCA, OCC and WNB), but male and female crania are well distinguishable visually.

PCA
Non-deformed sample

Facial variables. The details about the percentage of variance explained and loadings are plotted in Figure 3. As the loading plots indicate, both PCs summarize differences in facial dimensions and nasal height, with nasal breadth and orbital dimensions being the least significant. The results of the PCA do not reveal any territorial differences in the non-deformed sample. Crania from the largest territorial groups – Canímar Abajo and Baracoa (which is not a "group" in a strict sense) are found in all parts of the plot; moreover, pairs of morphologically similar representatives of both groups are not infrequent (e.g., individuals number 18 and 42, 5 and 24, 13 and 25). We can also note the central position of the island individual from Punta del Este, the marginal position of an individual with unknown, but presumably Cuban aboriginal origin, the relative proximity of two crania which come from the same cave in Baracoa (individuals number 39 and 14).

Neurocranial variables. The first two PCs account for 78% of the total variation of the sample based on neurocranial metric traits (Figure 4). The first PC explains 49% of the variation and is a size variable as it is negatively correlated with all the variables, length and height of the vault and occipital arc being the most significant ones. The second PC explains

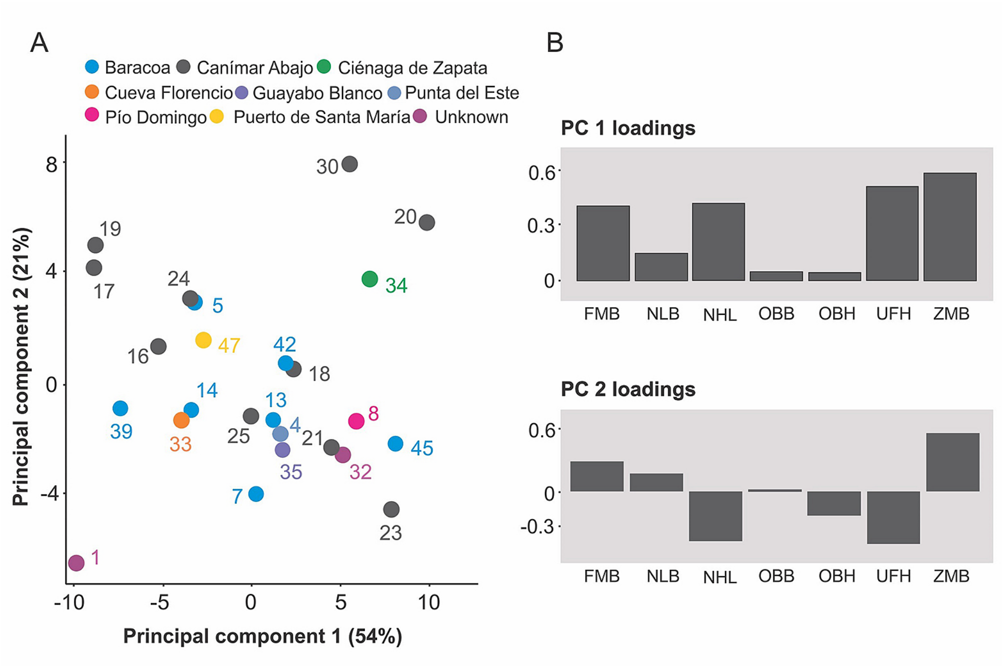

Fig. 3. PCA score plot (A) and loadings (B) of seven facial variables. Non-deformed sample. Numeration as in Supplement Table 1

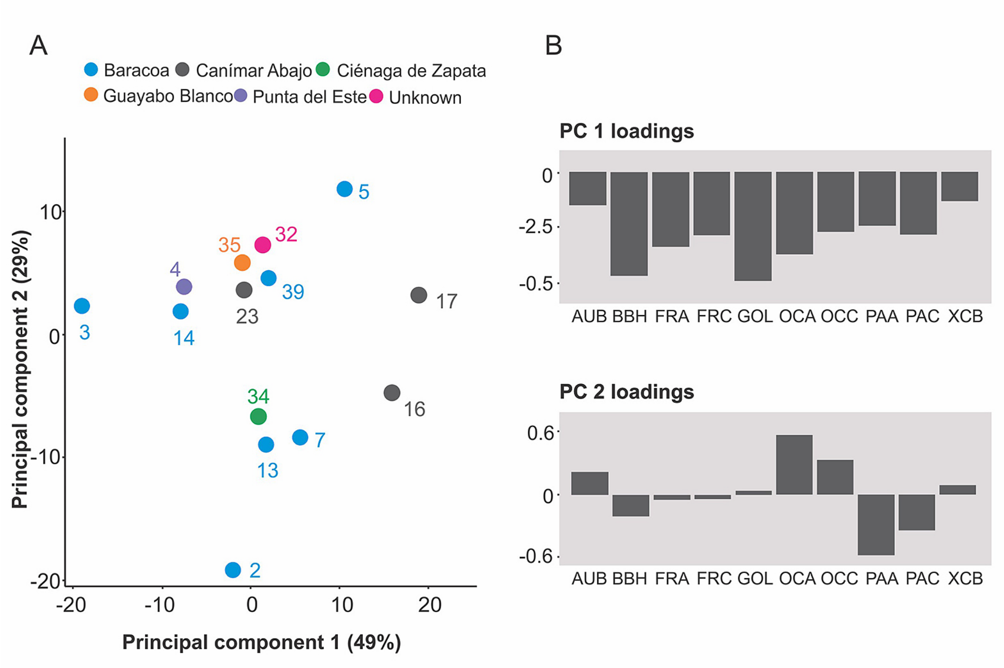

Fig. 4. PCA score plot (A) and loadings (B) of ten neurocranial variables. Non-deformed sample. Numeration as in Supplement Table 1

29% of the variation and is mainly correlated with PAA (negatively) and OCA (positively). Although the number of individuals analyzed has decreased drastically due to poorer preservation of cranial vault in the sample, it is interesting to notice that some trends revealed by the PCA for the facial variables could also be observed for the neurocranial data. For example, individuals from Cueva Fría (Baracoa) maintain their proximity to each other despite being tightly clustered with four individuals from four different locations. So do individuals number 13 and 7 also from Maisí (more detailed location is unknown), individuals number 16 and 17 from Canímar Abajo. Punta del Este individual maintains its central position, while individuals number 3 and 2 now hold the most marginal positions in terms of the first PC and the second PC, respectively, both being from the zone of Baracoa. The PCA based on indices rather than metric variables yielded very similar results and is not presented here. Individuals from different geographical locations appear to be randomly distributed in these plots, thus not suggesting any morphological pattern connected with geography in the non-deformed group.

Mantel test

To further explore whether there is an association between morphology and location of the studied crania from the non-deformed sample, the Mantel test was employed over the matrix of Euclidean distances between the morphological variables and the matrix of geographical distances between all the sites. No correlation was found between the matrices of neurocranial variables and geographical distances (r = 0.04, p = 0.3). This set of variables (GOL, XCB, WFB, XFB, AUB, ASB) accounted for the length and width dimensions of the crania, but not their height, due to generally poor preservation of the bases of the crania. Inclusion of the cranial height in the subset reduced the sample to 12 individuals, and although such an analysis cannot be considered reliable, it was carried out to ensure that a possible association was not overlooked. The correlation remained negligible and insignificant, though (r = 0.03, p = 0.3). Finally, the Mantel test on the facial variables yielded a similar result: r = −0.1, p = 0.9. Thus, the Mantel test did not reveal any connection between the craniometric data and geographic distances for the non-deformed sample.

Deformed sample

Shape change analysis

Figure 5 shows shape variation for the first two components. Most specimens in the deformed sample come from the same zone of Baracoa, several come from other Cuban locations, five are of unknown but presumably Cuban origin, and three crania come from two sites in the Dominican Republic. The latter do not appear to cluster together and are

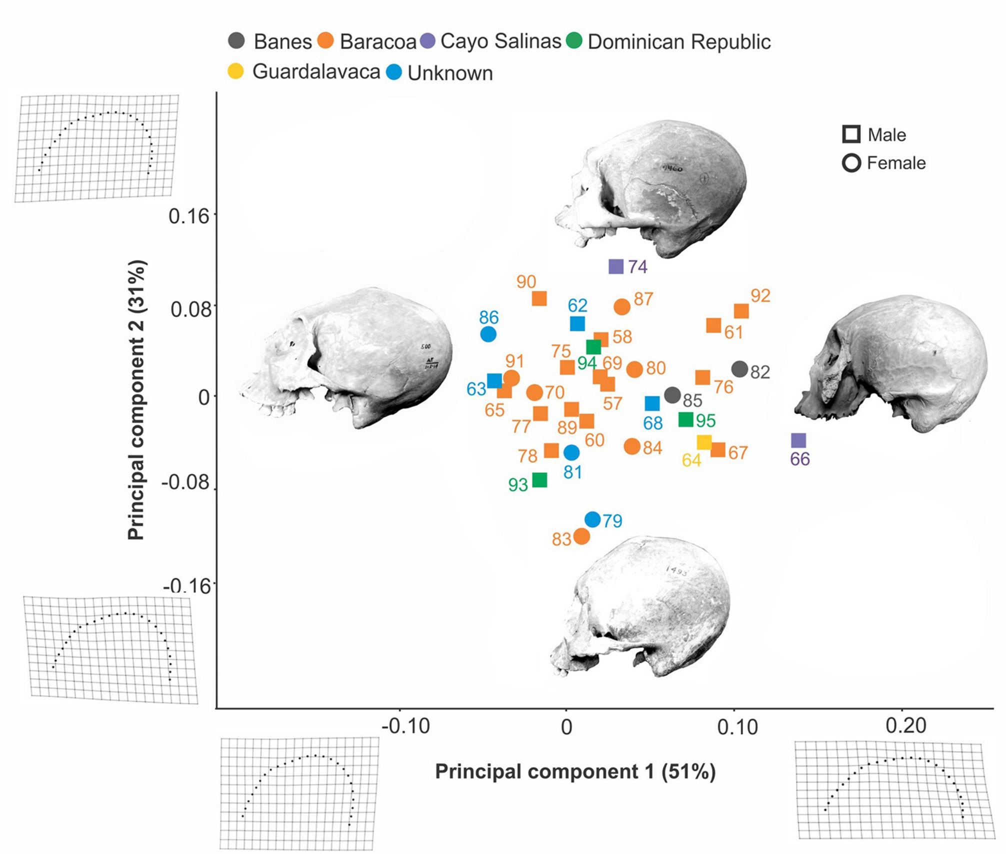

Fig. 5. Shape variation of the deformed crania in the lateral view. Numeration as in Supplement Table 1

scattered across the main cloud of observations.

The plot shows a continuous variation of the deformed crania between the shapes at the extremes of the PC1 and PC2 axes, depicted at the sides of the plot. PC1, which accounts for 51% of the variation, marks the direction of change from a more severely affected vault with flattened frontal and occipital bones and a marked depression after the coronal suture on the left to a more rounded and close to physiological norm vault on the right. The crania of both sexes are distributed randomly across the plot.

Non-metric traits variation

Frequencies of the non-metric traits are shown in Table 2. Both groups have zero frequencies of the metopic suture, low or zero frequencies of sagittal and coronal ossicles, ossicles at lambda, Inca bone, palatine tori, pterion types other than sphenoparietal (although epipteric bones occur in the 20% of the deformed individuals), trochlear spine, double condylar facet. Both groups also have high rates of the supraorbital notch, multiple zygomatic foramina, parietal foramina, posterior condylar canals, and infraorbital sutures. At the same time, there is a marked contrast in the frequencies of lambdoid, occipito-mastoidal, squamoparietal ossicles, and ossicles at the asterion between the two groups: all of these traits are very common in the deformed group and rather rare in the non-deformed one.

No significant differences between sexes were found in the frequency of non-metric traits in both samples. When symmetry was considered, the only significant difference was seen in wormian bones in the masto-occipital suture in the deformed sample: they were significantly ($p = 0,04$) more frequent on the right side.

Discussion and conclusions

The goal of the present paper was to see whether we could expand our understanding of the morphological variation of the Cuban pre-Columbian population on the intragroup level by applying various methods of studying cranial morphology.

We acknowledge that the skeletal material available for the present study has not become substantially larger since the early papers reviewed above. While estimates of the total number of individuals from archaeologically excavated sites often numbers into hundreds (Valcárcel Rojas 2016; Rodríguez Hernández 1998; Chinique de Armas and Rodríguez Suarez 2012), the remains themselves are usually very fragmentary. The present study could not cover all existing collections for various reasons, but much more representative samples than existing at the moment would be needed for more objective conclusions. Relethford (2002) has shown that more than 80% of the total craniometric variation is found within local populations, i.e., among individuals. According to Kozintsev (2016:3), more than 120 specimens in a sample are required to trace its composite nature. At the same time, if morphological patterns are parallelized by some independent criteria, e.g., varying archaeological context, the antiquity of the burials etc., it is justified to suggest a really existing intragroup differentiation.

How right are we to pool all non-deformed crania in one sample? On the one hand, our analysis did not reveal any evident clustering of the individuals in the pooled sample, and we do not possess any certain information about them representing different populations. On the other hand, the opposite is also true: there is no evidence of them being a single population. Some scholars (Ulloa Hung and Valcárcel Rojas 2019, González Herrera 2008) have argued that "Archaic" or "Siboney" in the Caribbean is a historical and archaeological construct, based on first European written sources and supported by the need for classification and systematization of accumulated archaeological materials and cultures, while in fact this concept masks the actual diversity of groups that form this artificial "community".

In this study, the non-deformed crania proved to be rather homogeneous, with the alveolar region being the most variable one. Principal component analysis and Mantel test did not reveal any territorial differences in the cranial metric traits. No patterns resulting from time differences among the samples could be seen either based on the data available for the study (see Table 5 for available dates). For the non-deformed sample, individuals from the single site of Canímar Abajo were found scattered throughout the PCA plot, while the individual coming from Guayabo Blanco, the oldest site among the ones that could be included in the analysis, was found in the middle of the distribution next to the one from Cave 4 in Punta del Este, a much younger site. Similarly, the absence of clear patterns of clustering and scarcity of materials does not allow a comparison between sites with different archaeological settings. Bolufé Torres (2015) attempted to study morphological patterns among skeletal remains from four sites situated in the western part of the island and found significant differences in the orbital breadth between Guayabo Blanco individuals on the one hand and Canímar Abajo and Cueva Calero – on the other. A geometric morphometric analysis revealed variation in the cranial shape among the three samples. Although the author concludes that the results might indicate the different origin of the individuals, the results should be treated with caution due to the small sample sizes (1–8 individuals in each sample). The present study, based on multivariate analyses of cranial metrics, does not support this conclusion.

The deformed sample is significantly more variable, especially its male part. The principal component analysis of the Procrustes coordinates of the cranial vault outline in the lateral norm revealed continuous variability of cranial shapes from the ones with more flattened frontal and occipital bones to the more curved outlines. In our study, most of the deformed crania come from the

Table 5. Radiocarbon dates for some of the sites where the materials of the study come from. All dates are in calibrated years BP

Site	Culture	Date	Reference
Canímar Abajo (Younger cemetery)	Archaic	1570–720	Nägele et al. 2020
Guayabo Blanco	Archaic	2530–1700	Nägele et al. 2020
Cueva Calero	Archaic	1500–1100	Nägele et al. 2020
La Caleta (Dominican Republic)	Ceramic	1307–332	Fernandez et al. 2021
Punta del Este, Cueva 4	Archaic	969–675	Ernesto Tabio, Estudio de las culturas Antiguas en Cuba
El Purial	Archaic	3644–2780	Cooper 2007

same region of Baracoa (in many cases without any additional information), and three individuals from the Dominican Republic do not tend to cluster together, so geography cannot account for this variation of the deformed shapes. Moreover, a highly specific individual number 1047 with the deformation type that has been described as "tabular erect" instead of "tabular oblique" comes from the same zone of Baracoa. Sexual differences do not explain the variation either, which contradicts the conclusion of Ginzburg (1964:202), who reported more moderate deformation of the female crania. Thus, it can be assumed that there were no differences in the application of the deforming device to male and female babies. The lack of contextual information and radiocarbon dates for the deformed sample make it impossible to test whether the variation of the deformed cranial shapes is due to changes of the tradition over time. Our results do not support Herrera Fritot's theory of deforming devices of two types: if this were the case, we would expect to see two separate clusters of crania rather than continuous variation. Therefore, the most reasonable explanation for the observed trend is an individual variation of the resulting shapes.

Variation of non-metric traits in each sample found in this study is totally in accordance with earlier works (Rivero de la Calle 1983:180–181). The high frequency of sutural ossicles in the deformed sample can be both due to the effect of deformation or manifestation of a particular genetic complex – a non-deformed sample of the same origin would be required to make a definite conclusion. An interesting result is an asymmetry seen in the expression of wormian bones in the mastoid-occipital suture inside the deformed sample. The only available written evidence of the deforming apparatus in the Caribbean (although a long time after the contact and not directly in Cuba) is provided by Leblond, who evidenced the practice in the late 18th century (1813 cited in van Duijvenbode 2017:80) and describes a procedure of placing two wooden boards at the front and the back of the skull of a baby. The asymmetry found in our study might result from more pressure applied to the right side of the deforming bandage when a right-handed person fixes it.

Thus, the study revealed relative homogeneity of both non-deformed and deformed samples and the absence of systematic differences inside each sample or proved the impossibility of available craniological data to reflect possible intragroup differentiation. In other words, by now, there are no grounds for identifying sub-groups inside the non-deformed and deformed samples based on cranial morphology.

Studies of skeletal remains are inevitably limited to dealing with samples that do not necessarily reflect the properties of the population it represents, but the more numerous the sample is and the more information about it is available, the more credible the conclusions can be. It is probable that as the pool of materials increases, the trends identified in the present study will be proved erroneous, and new patterns not evident in the analysis of such limited material will be revealed instead. We hope that this paper will serve as a reference point for future studies that will confirm or refute the preliminary conclusions offered here and continue to explore relations between different groups populating the island throughout its pre-Columbian history.

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The Authors' contribution

TS: organization of work, writing the draft and final version, measurements and statistical analyses; MJGP: writing the draft and final manuscript, data acquisition, performing of the data visualization; STHG: writing final version of the work, data acquisition and data curator; CAA: co-author of the final version, work and data curator; ARR: co-author of the final version of the work and data curator.

Conflict of interest

The authors declare that there is no conflict of interest.

Supplementary materials available on request from the authors due to privacy/ethical restrictions.

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