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SEXUAL DIMORPHISM OF A MUDEJAR NECROPOLIS OF SANTA CLARA (CUÉLLAR, SEGOVIA, S. XIV AND S. XV)

ABSTRACT: The objective is to analyze sexual dimorphism in 67 adults from the Santa Clara necropolis. The Sexual Dimorphism Index, t-student and Mann's U tests were calculated to estimate differences between sexes. The number of variables was reduced by principal component and discriminant analysis. The crania are larger in males, but in shape there are differences only in the typology of the orbits and the face width respect to face height. Postcranial dimorphism is less than in cranium. The robustness in the arms is less dimorphic while in the legs it is higher. This could indicate similar manipulation activities in both sexes. The difference between the cranial and postcranial dimorphism, and the low index obtained for stature, places in a scenario of hard living conditions, high workload for both sexes and distribution of tasks related to ambulation, performed mostly by men, and domestic tasks closely related to manipulation, performed by women.

KEY WORDS: Morphological Variability – Mudejares – Osteology

INTRODUCTION

Sexual Dimorphism (SDI) is defined as the somatic differences that appear between individuals of different sexes. It is a biological characteristic whose origin must be sought in secondary sexual characteristics, which affect regions of the body not directly related to fertilization. In the skeleton, it makes the measurements, robustness, and shapes of bones different between men and women. Although genetically regulated, there is no doubt that the environment influences SDI (Loth, Henneberg 2001). Many researchers have tried to assess its importance on the final differences between men and women within a population. Thus, Eveleth (1975) indicates that in populations that suffer a high degree of environmental stress, sexual dimorphism will be lower. For Frayer (1980), SDI is closely related to the sexual

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division of tasks in each social group. He therefore believes that SDI decreases when a task is common or very similar for men and women and increases when the usual occupations are different as it reflects the adaptations of each sex to certain loads in specific anatomical areas. Several authors indicate that sexual dimorphism decreases with age (Meindl *et al.* 1985, Walker 1995) due to morphological changes typical of maturity.

OBJECTIVES

The aim of the study is to establish the degree of sexual dimorphism of the cranium and postcranial skeleton in adult individuals from the necropolis of Saint Clara and to compare this degree of dimorphism with that of other historical Spanish populations.

MATERIALS AND METHODS

The study is carried out on 67 adult individuals (41 male, 26 female) from the population of exhumed individuals in the Saint Clara necropolis. Sex determination was made using the pelvis by the method of Brůžek (2002) and Ferembarch *et al.* (1979). When the coxal bones were not preserved and also to confirm the determination made in the pelvis, the cranium was used (Ferembach *et al.* 1979).

Male sex was estimated in 29 individuals using the coxal. In all of them, the diagnosis coincided except in one individual, which was determined as male by the method of Bruzek (2002) and allophyseal (S = +0.75) by Ferembach *et al.* (1979) method. Twenty-one of these individuals preserved coxal and cranium, with total coincidence in the three diagnoses in 17 cases. In the other four, sex was determined as male in the coxal and allophyseal in the cranium (+0.2, +0.6, +0.8 and +0.9). The rest of the individuals were classified as male, based on the cranium. Twenty-two individuals that preserved their coxal bones were classified as female, with total coincidence between the methods. Except for one individual, all of them also conserved the cranium, the sex determination coincided in 20 individuals, and only in one the sex determination was female according to the coxal, and allophyseal (-0.8) according to the cranium (Ferembach *et al.* 1979). The rest of the subjects were classified as female by cranial morphology.

The necropolis studied (*Figure 1*) is in Cuéllar, in the province of Segovia (Castilla y León). The coordinates of the town are 41° 24'10" North latitude, and 0° 38' 30" West longitude; the altitude of the municipality is 900 m above sea level. The necropolis occupies an area of 1000 m^2 (Vega, 1989). The disposition of the inhumed was right lateral decubitus, with legs and arms slightly flexed, placed next to the south side of the tomb, with orientation West-East (head-foot), some Northwest-Southeast (head-foot). Once deposited in this position, the north side of the grave was filled in to avoid a change in the position of the individual over time. Once the deceased was deposited, the pit was covered with poplar wood, placed transversally in the tomb, occupying part of the pre-pit, which, in some cases, has been preserved. The construction of the tombs follows the juridical-religious doctrine of Malic Ben Anas (Navarro 1985).

The necropolis has been dated to the end of the 15^{th} century based on a jewel and a small part of another jewel located in tomb 2 (Vega 1989). The location is adapted to the Muslim custom of urban necropolis, and is located outside the town, in the south, next to the St. Pedro's Gate. According to Olmos 1998, the Muslim community settled in that period was made up of farmers, shepherds and artisans.

The SDI of the cranial variables and indexes studied in a previous publication are used (Herrerín, Carmenate 2020): those corresponding to the long bones of the upper and lower extremities and the estimation of height. Among the many SDI indexes that have been used to describe the differences between the sexes in each variable, this study follows that established by Borgognini and Repetto (1986): SDI=[MM/FM] *100. MM = Male mean; MF = Female mean.

This SDI value is greater than 100 when the average male value is greater than the female value for a given variable, and it is less than 100 when the opposite is true. To complete the analysis, the difference between means was also calculated (DIF=Male Mean-Female Mean). The total dimorphism of each bone (SDI-total) has been estimated, calculated as the average of the SDI of all the variables and indexes of the specific bone. Likewise, to estimate the most dimorphic bone, the absolute value of the difference between the SDI and the value 100 (which represents a null SDI) has been calculated for all measurements and indexes for each bone. Subsequently, the average of all the differences

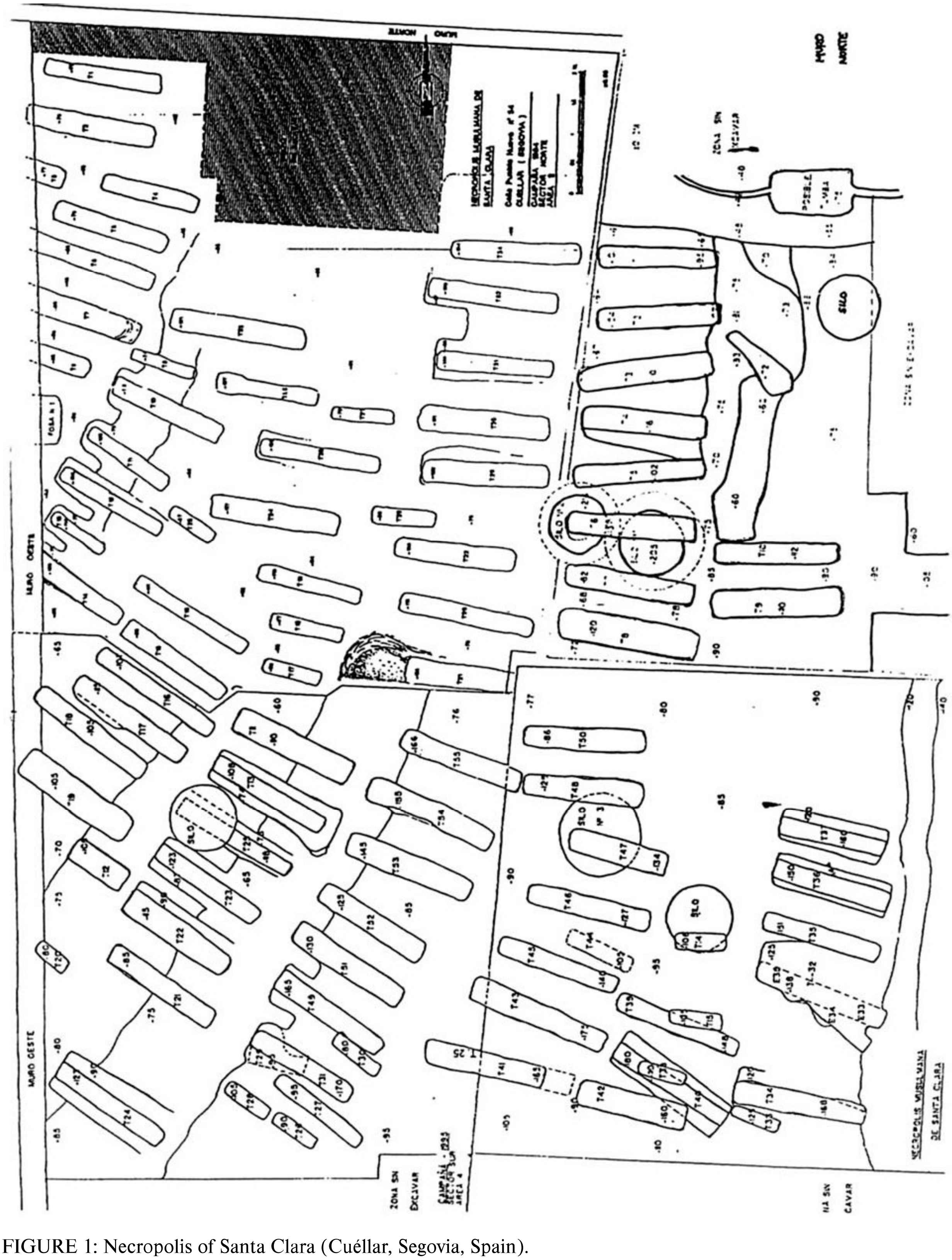

FIGURE 1: Necropolis of Santa Clara (Cuéllar, Segovia, Spain).

TABLE 1: Mean values and sexual dimorphism of cranial and mandible variables. SD: Standard Deviation. *p<0.05; ** p<0.01; ***p<0.001. DIF: difference between means. SDI: Sexual Dimorphism Index.

VARIABLES (mm)	Male			Female			t-Student/U Mann-Whitney	SDI
	N	Mean	SD	N	Mean	SD		
Maximum cranial length (LGMX1)	31	190.55	5.23	25	182.84	5.10	5.45**	104.22
Glabella-inion length (GLIN2)	29	181.14	6.69	25	172.48	5.96	615***	105.02
Glabella-lambda length (GLLA3)	29	185.86	5.17	21	178.38	5.02	5.01**	104.19
Length nasion-basion (NABA5)	7	101.71	7.48	10	95.90	4.63	1.85	106.06
Length basion-opisthion (FMAG7)	6	36.00	1.41	10	34.90	2.18	1.03	103.15
Maximum cranial breadth (LMAX8)	29	139.48	4.46	24	135.25	3.97	3.54*	103.13
Minimum frontal breadth (FMI9)	28	98.43	4.89	26	96.00	4.03	1.95	102.53
Maximum frontal breadth (FMX10)	30	119.23	5.05	25	117.32	4.78	1.40	101.63
Biasterionic breadth (BIAST12)	27	111.70	5.65	22	107.55	6.52	2.34*	103.86
Bimastoid breadth (BIMST13)	23	100.61	5.90	16	96.44	5.51	2.17*	104.32
Foramen magnum breadth (FMAG16)	6	30.33	2.07	9	28.89	2.37	1.13	104.98
Basi-bregmatic height (BABR17)	7	136.86	4.63	11	129.64	4.37	3.15*	105.57
Porion-bregma height (POBR20)	29	114.97	5.49	22	112.77	4.80	1.47	101.95
Horizontal perimeter (PERH23)	29	532.62	11.86	24	512.13	11.66	6.19**	104.00
Transverse arc (ARC24D)	20	315.30	12.74	18	305.11	8.19	2.82*	103.34
Total sagital arc (ARCS25)	17	382.12	23.53	13	368.00	9.30	42*	103.84
Frontal arc (ARCF26)	29	132.52	6.83	24	126.93	6.19	3.03*	104.40
Parietal arc (ARCP27)	32	132.03	7.98	25	127.52	7.53	2.13*	103.54
Occipital arc (ARCO28)	22	118.77	7.96	15	112.93	6.66	2.27*	105.17
Frontal chord (CORF29)	29	115.00	4.60	24	111.92	5.99	213*	102.75
Parietal chord (CORP30)	32	118.50	5.93	25	115.20	5.73	2.08*	102.86
Occipital chord (CORO31)	22	96.82	4.91	15	93.84	4.97	1.75	103.18
Basi-alveolar length (LGTO40)	6	94.67	4.63	9	89.44	7.16	1.47	105.85
Biorbital breadth (BIOR44)	25	95.68	3.25	23	93.04	4.05	424**	102.84
Bizygomatic breadth (BIZG45)	17	127.65	4.06	14	120.57	3.23	5.12**	105.87
Bi-jugale breadth (BJ45-1)	17	111.53	3.26	12	105.25	3.67	4.68*	105.97
Bi-zigomaxillar breadth (BIZM46)	20	91.80	4.01	13	88.92	4.01	1.95	103.24
Upper facial length (HSUP48)	20	71.05	4.90	16	69.13	2.99	1.34	102.78
Naso-spinal-prosthion height (NSPR48-1)	23	17.30	2.51	16	17.13	2.87	0.19	100.99
Interorbital breadth (LOR50)	21	20.76	2.51	20	21.65	2.48	240	95.89
Orbital breadth right (OR51D)	21	41.00	1.82	17	39.47	1.77	251*	103.88
Orbital breadth left (OR51G)	19	40.79	1.81	15	39.33	1.99	99.5	103.71
Orbital breadth (OR51)	40	40.90	1.79	32	39.41	1.85	869**	103.78
Orbital height right (OR52D)	22	33.95	2.06	18	34.11	2.65	0.21	99.53
Orbital height left (OR52G)	19	34.42	2.06	15	34.07	2.34	0.45	101.03
Orbital height (OR52)	41	34.17	2.05	33	34.09	2.48	0.15	100.23
Nasal breadth (NEZ54)	21	24.62	1.83	15	23.00	1.81	238**	107.04
Nasal height (NEZ55)	20	54.35	5.25	15	51.73	1.62	107	105.06
Nasal bone length (NAS56)	22	24.82	3.16	16	24.00	2.00	0.89	103.42
Minimum width of nasal bones (NAMI57)	21	11.05	2.18	18	11.83	2.04	239	93.41
Maximum width of nasal bones (NA57-1)	20	16.30	2.43	14	16.29	1.94	0.01	100.06
Maxilo-alveolar length (PRAV60)	19	54.89	2.69	14	52.43	3.96	2.06*	104.69
Maxilo-alveolar width (BIEM61)	19	60.68	5.09	14	58.21	5.03	1.34	104.24

TABLE 1: Continued.

Palatal length (PAL62)	18	45.44	2.75	14	43.14	4.70	1.68	105.33
Palatal breadth (PAL63)	20	38.85	3.94	13	38.62	3.95	0.16	100.60
Biauricular breadth (BIAU)	25	119.52	5.72	21	112.19	5.70	436***	106.53
Weisbach's facial angle (ANFA)	5	77.00	4.80	9	73.33	4.53	1.32	105.00
Biporion breadth (BI-PO)	29	112.90	5.16	22	106.64	5.01	500***	105.87
Mastoid width (SMAST)	30	46.77	4.34	26	44.00	3.12	235*	106.30
Mastoid height (HMAST)	31	31.45	3.40	26	28.54	3.08	3.30*	110.20
Indices								
Cranial index (8/1)	29	73.13	2.65	24	74.05	2.46	1.27	98.76
Fronto- parietal Transversal Index (9/8)	26	70.99	4.74	24	74.10	3.01	2.69*	95.80
Fronto-transversal Index (9/10)	28	82.69	4.77	25	81.99	3.36	0.60	100.85
Transversal Index (17/8)	7	97.06	4.01	11	95.03	3.48	1.07	102.14
Vertical Index (17/1)	7	71.02	2.48	11	71.25	2.39	0.18	99.68
Basion heigth Index (17/1+8)	7	81.99	2.54	11	81.43	2.69	0.41	100.69
Porion transversal Index (20/8)	27	82.37	4.01	22	83.10	3.11	0.69	99.12
Porion vertical Index (20/1)	28	60.11	2.71	22	61.67	2.82	211	97.47
Cranial height index in the porion (20/1+8)	27	69.50	3.00	22	70.78	2.79	1.50	98.19
Frontal-sagittal Index (29/26)	29	86.85	1.87	24	88.42	6.51	384	98.22
Parietal-sagittal Index (30/27)	32	89.82	1.83	25	90.47	4.32	429	99.28
Occipital-sagittal Index (31/28)	22	81.65	3.17	15	83.15	1.43	1.67	98.20
Foramen magnum Index (16/7)	6	81.29	5.27	9	83.58	10.87	24.5	97.26
Fronto-sagittal arc Index (26/25)	16	34.80	1.12	13	34.53	1.16	0.61	100.78
Parietal-sagittal arc Index (27/25)	17	34.95	2.50	13	35.20	1.52	87	99.29
Occipital-sagittal arc Index (28/25)	17	31.43	2.98	13	30.45	1.40	128	103.22
Perimeter heigth Index (17/23)	7	25.42	1.00	11	25.40	0.82	0.04	100.08
Jugo-frontal Index (9/45)	16	77.29	4.27	14	79.74	1.70	1.94	96.93
Facial superior Index (48/45)	15	55.01	3.07	13	57.45	2.78	2.11*	95.75
Superior malar Index (48/46)	19	77.56	4.84	13	78.35	4.98	0.43	98.99
Nasal Index (54/55)	19	45.24	5.13	14	44.94	4.01	0.18	100.67
Transverse naso-facial Index (54/45)	14	19.10	1.25	12	19.45	1.61	0.60	98.20
Naso-facial vertical Index (55/48)	20	76.57	6.45	15	74.76	2.57	102	102.42
Palate Index (63/62)	18	85.52	8.48	12	89.92	11.98	1.14	95.11
Cranio-facial transverse Index (45/8)	17	91.69	3.32	14	89.25	2.66	2.15*	102.73
Jugo-malar Index (46/45)	14	71.96	2.19	12	73.58	2.62	117.5	97.80
Interorbital Index (50/44)	21	21.65	2.40	19	23.45	2.41	128	92.32
Palato-facial transversal Index (61/45)	13	47.09	3.21	12	49.06	4.10	1.29	95.98
Gnathic Index (40/5)	5	91.13	4.21	9	93.28	5.99	0.66	97.70
Orbital Index left (52/51G)	19	84.44	4.50	15	86.78	6.85	1.16	97.30
Orbital Index rigth (52/51D)	21	82.88	4.98	17	86.91	5.65	2.27*	95.36
Orbital Index (52/51)	40	83.62	4.76	32	86.85	6.14	2.48*	96.28
Orbito-facial transverse Index (right) (51D/45)	15	31.70	1.20	13	32.93	1.12	2.69*	96.26
Orbito-facial transverse Index (left) (51G/45)	14	31.71	1.03	12	32.57	1.29	1.81	97.36
Orbito facial transverse Index (51/45)	29	31.70	1.10	25	32.76	1.43	3.02*	96.76
Orbito-facial vertical Index (rigth) (52D/48)	20	48.09	2.69	15	49.90	4.47	1.44	96.37
Orbito-facial vertical Index (left) (52G/48)	18	48.35	2.66	14	49.69	4.00	1.10	97.30
Orbito-facial vertical Index (52/48)	38	48.21	2.65	29	49.80	4.18	1.87	96.81
Maxillo-alveolar Index (61/60)	19	110.59	8.10	13	112.04	11.40	0.41	98.71

was calculated and the resulting number is a measure of its deviation from a null SDI. Calculating the total SDI does not reflect the most dimorphic bone: a variable with a high SDI (for example 120) due to a large difference in favor of the male average and another with a low SDI (for example 80) due to a large dimorphism with values higher than the female average in the same bone would result in a total-SDI = 100, a null SDI, which is not intended estimation. For example, the coxal bone, which is very dimorphic, includes variables in which women have higher values (pubic length, for example, will have a value of SDI<100) and others where the male value is greater (for example, the total height, with a SDI > 100).

Therefore, a new way of calculating the SDI, the SDI-100 ABS, which calculates the difference (in absolute value) between the SDI for a given variable and the value 100 (null SDI), was added. This prevents values above 100 from being counteracted with values below 100, which would distort the total SDI count of the bone.

The Green test (Green, 1898) was applied to make comparisons between the SDI of the study population and other historical populations. Height was calculated using the methods of Pearson (1899), Troter and Gleseer (1958) and Olivier *et al.* (1978). Cranial capacities were calculated using the Olivier's method (Olivier *et al.* 1978), the Lee and Pearson's method and the Schmitd Module.

The distribution of the variables was analyzed: when they followed a normal distribution, the t-student test was applied to identify differences between means and when they did not follow this distribution, the Mann-Whitney U test was used. To reduce the number of initial variables, a principal component analysis (PCA) was applied, and subsequently a discriminant analysis was used.

RESULTS

The analysis of metric characters in the skull (*Table 1*) indicated a statistically significant SDI in 50% of them. Except for the interorbital width (LOR50) and the minimum width of the nasal bones (NAMI57), the value of the male series is always higher. The degree of SDI of the variables, significant or not, ranges from 110.20 (height of the mastoid process, HMAST) to 93.41 (minimum width of the nasal bones, NAMI57). The maximum width of the nasal bones represents the lowest SDI. When calculating the total SDI for the metric variables of the crania, a value of 103.54 and an SDI-100 ABS of 3.99 are obtained.

Only 20.5% of the 39 indexes analyzed have significant SDI: the frontal-parietal transverse index (9/8), the upper facial (48/45), the cranio-facial transverse (45/8), the interorbital (50/44), the right orbital (52/51D), the orbital of both sides together (52/51) and the right and total 51/45. The total SDI for all indexes of the crania is 98.26; while the SDI-100 ABS is 2.44.

With respect to cranial capacities (*Table 2*), there are differences between the sexes in all methods applied. The value is high in the four cases, always with greater capacities in men, with differences between 98.30 and 177.20 cm^3 depending on the estimation method used. The male cranial capacity is between 7.11 and 8.90% higher than in women and is again method dependent.

The mean values by sex of the measurements taken on the long bones are shown in *Table 3*. Almost all variables of the humerus, ulna and radius have differences between sexes, with greater means in the male sex (SDI> 100 and DIF> 0). In the humerus, the highest values of SDI are for the vertical diameter of the head and the width of the distal epiphysis. In the ulna, the greatest SDI is found in the medial-lateral and

TABLE 2: Cranial capacities according to sex and sexual dimorphism. CC: Cranial Capacity, SD: Standard Deviation. *p < 0.05; ** p < 0.01. DIF: difference between means. SDI: Sexual Dimorphism Index.

VARIABLES	Male			Female			t-Student	SDI
	N	Mean (cm^3)	SD	N	Mean (cm^3)	SD		
CC (Lee & Pearson, 1901)	27	1480.86	91.87	22	1382.56	76.28	3.9331*	107.11
CC (Lee & Pearson, 1901)	7	1515.20	61.62	11	1381.69	55.67	4.4843*	109.66
CC (Olivier *et al.*, 1978)	27	1480.08	90.20	22	1359.13	82.56	4.7486**	108.90
CC (Olivier *et al.*, 1978)	7	1533.28	84.49	11	1356.08	79.13	4.2524*	113.07
SCHMITD Module	7	156.90	2.88	11	149.36	3.26	4.7159**	105.05

in the radius, the greatest SDI is in the sagittal diameter at midshaft half. As for the robustness indexes, only that of the humerus is different between the sexes. The most dimorphic bone, when all variables are analyzed, is the humerus (SDI-total = 112.09) and the least dimorphic is the radius (SDI-total = 110.74), although the three bones show a similar and high-valued SDI (SDI-total ulna = 111.11).

Almost all the metric variables of the femur, tibia and fibula have differences between the sexes, with greater means in the male sex (SDI> 100 and DIF> 0). In the femur, the largest SDI is found in the sagittal midshaft diameter in half; in the tibia, in the sagittal diameter at the nutrient foramen; and in the fibula in the minimum diameter at midshaft.

When analyzing the SDI of the indexes, it can be verified that the robustness indexes of the three bones show differences. The most dimorphic bone when all variables are analyzed, regardless of the index, is the fibula (SDI-total = 111.63) and the smallest is the femur (SDI-total = 110.33), although the three bones show similar, high-value SDI (tibia SDI-total = 111.49). The average SDI for the variables of the three long bones of the arm together is 111.40 and for the three long bones of the leg is 111.17.

The SDI analysis in height (*Table 4*) shows that there are differences between the sexes in all cases, regardless of the method used in the estimation. The highest SDI is found when applying the Trotter and Glesser method (1958) and the lowest when Olivier *et al.* (1978) is employed.

The *Table 5* shows the comparison between the SDI obtained in the study sample and those of other historical populations (Prevosti 1951, Garralda 1974, Rodríguez-Hernandorena 1981, Souich 1980, Pérez *et al.* 1981, Galera 1989, Hernández y Turbón 1991, Herrerín 2008). Only the results aquired using the Green test (1989) indicated significant differences. The comparison in the post-cranial skeleton indicates that the SDI of the sample for the maximum length of the humerus is statistically smaller than that obtained in the Neolithic (NEOL), Visigoth (VISI), La Torrecilla (TORR) and Sepúlveda (SEPU) groups. For the minimum diameter of the humerus, the differences are found with TORR and with respect to the robustness index, the population's SDI is greater than OSMA (El Burgo de Osma).

Differences in the SDI of the maximum length of the ulna are observed, with Santa María de Hito (HITO), VISI, TORR, Montjuich (MJUI) and La Olmeda (OLME) groups, all presenting higher values than Santa Clara sample. For the minimum diameter, the differences are with VISI and San Nicolás sample (NICO), both of which also have higher values. The robustness index of the sample has the lowest SDI (except for that obtained in OSMA sample) and is statistically different from VISI, NICO and OLME groups. Differences in maximum length of the radius are found with MJUI and OLME. The assessment of the lower extremities (*Table* 5) indicates that the maximum length of the femur has a statistically lower SDI in relation to HITO, VISI, TORR, MJUI and SEPU. The robustness index of the femur is significantly higher than OSMA and the platymeric index rate of that of NICO. The SDI of the maximum length of the tibia is less than VISI and SEPU, and in the transverse diameter at the nutrient foramen with SEPU and OSMA. The robustness index has a SDI greater than SEPU and OSMA, and the platymeric index is greater than OSMA.

With respect to the crania, the SDI values of the sample are similar to those calculated for the rest of the populations; differences have only been found in the crania maximum length, the upper facial height and the bizigomatic width. The maximum length of the crania has a SDI different from that of the Neolithic population, the only one in which women have a higher average than men. For the upper facial height, the Neolithic population is the only one with sexual dimorphism, although in this case, with higher values in men. As for the bizigomatic width, there are differences with the sample of Santa Eulalia. The differences in SDI capacity between the sample and 12 historical populations are shown in *Table 6* (*Figure 2*). The value of SDI in the Santa Clara sample is high, slightly lower than presented in SEPU group and higher than all others. The cranial capacity of the study sample is very high in men (only higher in HITO), and medium to small in women.

The comparison of the height SDI with other historical Spanish populations (*Table 7, Figure 3*) shows that the men of Santa Clara are in the group of smaller stature, while the women are among the tallest. The average male height only exceeds the Jews of Montjuich, Santa Eulalia, the population of Romans and El Burgo de Osma. In women, however, only the Cantabrians of Santa María de Hito and the women of La Olmeda are taller. The most important differences in men are found with the Visigoth sample (4.47 cm taller than the study sample), and in women with the Montjuich Jews (-6.19 cm). As for the height SDI, the population of Santa Clara has a very low value, only

TABLE 3: Sexual dimorphism in variables of the postcranial skeleton. SD: Standard deviation; t-Student/U-MannWhitney = (* p < 0.05; ** p < 0.001). SDI = Sexual Dimorphism Index.

VARIABLE	Male			Female			t-Student/U	
	N	Mean	SD	N	Mean	SD	MannWhitney	SDI
Humerus								
Maximum length HUMLGMX1 (mm)	46	320.26	12.96	36	298.92	14.42	6.95*	107.14
Minimum perimeter HUMPMIN7 (mm)	65	65.29	4.23	45	57.53	3.79	10.06*	113.49
HUMPMIN6(mm)	47	18.04	1.41	36	15.89	1.39	1402**	113.53
HUMPMAX5 (mm)	47	23.26	1.8	36	20.92	1.56	290**	111.19
Vertical head diameter HUMDTT10 (mm)	44	45.11	2.52	39	39.51	2.17	10.88*	114.17
Distal epiphysis width HUMLDIST (mm)	51	62.18	3.3	32	54.09	2.44	12.80*	114.96
HUMLART (mm)	51	28.49	1.96	28	25.86	1.86	5.90*	110.17
Robusticity Index HUM7/1	46	20.47	1.5	36	19.3	1.26	3.84*	106.06
Diaphysial Index HUM6/5	47	77.74	5.13	36	75.77	5.24	1.71	102.60
Ulna								
Maximun length CUBLGMX1(mm)	50	263.34	10.51	29	239.59	12.26	8.98*	109.91
Physiological length CUBLPHY2 (mm)	49	234.65	9.04	29	211.41	11.68	9.69*	110.99
Minimum perimeter CUBPMIN3 (mm)	59	38.47	3.16	34	35.24	3.77	4.21*	109.17
Transverse diameter in half CUBDTR13 (mm)	54	24.59	2.9	38	21.68	2.82	1639**	113.42
Sagittal sub-sigmoid diameter CUBDSA14(mm)	54	27.52	2.51	38	24.53	2.3	367*	112.19
Sagittal diameter at half CUBDSMC (mm)	50	12.92	1.01	30	11.7	1.78	1241**	110.43
Transverse diameter at half CUBDTMC (mm)	50	17.16	1.8	30	15.37	2.06	292*	111.65
Robusticity Index CUB3/1	50	14.76	1.05	29	14.85	1.67	0.29	99.39
Platolenic Index CUB13/14	54	89.53	9.08	38	88.21	6.75	0.80	101.50
CUB S/T	50	76.15	11.6	30	76.19	5.29	0.02	99.95
Radio								
Maximun length RADLMIX1 (mm)	45	240.67	13.42	34	220.18	10.82	7.51*	109.31
Minimum perimeter RADPMIN3 (mm)	58	43.38	3.3	44	38.91	2.7	7.52*	111.49
Sagittal diameter at half RADDSMR (mm)	48	11.96	1.17	34	10.62	0.65	1386**	112.62
Transverse diameter at half RADDTMR (mm)	48	16.4	1.59	34	14.97	1.42	402*	109.55
Robusticity Index RAD3/1	44	18.32	1.32	33	17.77	1.1	896	103.10
RADS/T	48	137.49	10.59	33	141.35	13.12	900.5	97.27
Femur								
Length FEMLGPO2 (mm)	42	440.1	17.14	34	414.59	18.4	6.16*	106.15
Maximum length FEMLGMX1 (mm)	42	443.4	16.95	34	419.06	18.44	5.93*	105.81
Minimum perimeter FEMPER8 (mm)	43	88.98	6.38	34	78.71	5.02	7.91*	113.05
Sagittal mid-shaft diameter FEMDIAS6 (mm)	45	29.64	2.86	34	25.94	2.15	6.56*	114.26
Transverse diameter of the mid-shaft FEMDIAT7 (mm)	45	26.87	2.63	34	24.24	1.91	5.15*	110.85
Subtrochanteric sagittal diameter FEMTRS10 (mm)	57	27.32	2.73	42	24.17	1.82	416*	113.03
Subtrochanteric transverse diameter FEMTRT9 (mm)	57	31.75	2.72	42	29.83	2	3.83*	106.44
Sagittal head diameter FEMTET18 (mm)	41	46.56	2.36	33	41.67	1.91	830*	111.74
Maximum head diameter FEMDIMX (mm)	41	46.56	2.36	33	41.73	1.88	9.80*	111.57
Distal epiphysis width FEMDIS21 (mm)	53	79.26	3.89	34	71.82	2.76	10.42*	110.36
Robusticity Index FEM8/2	42	20.25	1.41	34	19	1.11	4.32*	106.58
Pilastric Index FEM6/7	45	111.34	14.58	34	107.4	9.19	911	103.67
Platymeric Index FEM10/9	57	86.55	10.64	42	81.22	6.65	2.83*	106.56
Robustness index with the diameter FEM6+7/2	42	12.86	0.91	34	12.11	0.77	3.77*	106.19
FEM7/21	38	33.61	3	29	34.13	1.83	481	98.48

TABLE 3: Continued.

Tibia								
Maximun length TIBLGMX1 (mm)	65	361.52	15.18	39	339.28	15.46	2156**	106.56
Minimum perimeter TIB10b (mm)	70	75.27	4.48	46	67.39	4.31	295.5*	111.69
Sagittal diameter at the height of the nutrient hole TIBDS8a (mm)	71	33.25	2.34	48	28.96	2.26	3078**	114.81
Transverse diameter at the heigth of the nutrient hole TIBDT9a (mm)	71	24.13	1.87	48	21.69	1.9	637**	111.25
Perimeter at the height of the nutrient hole TIBFMN (mm)	71	92.54	6.13	48	81.81	6.04	362.5*	113.12
Robusticity Index TIB10/1	65	20.89	1.04	39	19.82	1.14	4.79*	105.40
Platymeric Index TIB9a/8a	71	72.7	5.24	48	75.02	5.31	1250*	96.91
Fibula								
Maximum length PERLGMX1 (mm)	37	358.19	14.18	20	334.15	14.63	620**	107.19
Perimeter at half diaphysis PERPER4a (mm)	37	46.08	4.26	20	40.75	3.11	645**	113.08
Maximum diameter at half diaphysis PERDMAX2 (mm)	37	15.32	1.6	20	13.65	1.23	585**	112.23
Minimum diameter in half PERDIMIN3 (mm)	37	12.03	1.09	20	10.55	1	118.5*	114.03
Robusticity Index PER4a/1	37	12.88	1.21	20	12.2	0.84	2.20*	105.57
Diaphysial index PER3/2	37	78.94	7.79	20	77.81	9.32	0.48	101.45

TABLE 4: Sexual dimorphism in height. SD: Standard Deviation. *p < 0.05. DIF: difference between means. SDI: Sexual Dimorphism Index.

Stature	Male			Female					
	N	Mean (cm)	SD	N	Mean (cm)	SD	t-Student	DIF.	SDI
Pearson (1899) Method	40	163.24	3.93	26	155.29	3.62	8.1546 *	7.50	105.12
Trotter y Gleser (1958) Method	40	168.66	4.41	26	159.88	4.85	7.4799 *	8.78	105.49
Olivier *et al.* (1978) Method	40	165.80	4.86	26	159.27	4.60	5.3633 *	6.53	104.10

slightly higher than La Olmeda, with the population of Visigoths showing the highest SDI.

The result of the application of the ACP reduced the number of initial variables to 11 components that explained 89.60% of the sample variance. These components were used in the discriminant analysis that resulted in a Wilks Lambda value of 0.381 (F= 4.326; p <0.001). Two of the discriminant variables were significant at a level p <0.001 and explained 67.6% and 22.4% of the total variance; the first variable represented by the length and capacity of the skull, length of the femur and tibia and width of the distal epiphysis of the femur; the second variable with a greater contribution of the basio-bregma height, porion-bregma height, porion-bregma-porion transverse arch, nasion-bregma frontal cord, diameter at the level of the tibial nutritional foramen, transverse diameter at midshaft of the femur and subtrochanteric transverse diameter. The differences between pairs of groups were estimated using the Mahalanobis distance value (D^2) and the values in all cases were significant (p <0.001). The functions obtained adequately classified 75.60% of the male cases and 76.92% of the female cases.

DISCUSSION

The greatest differences found in the crania were found in areas considered very dimorphic, while the lowest values of SDI were observed in splacnocranial variables. SDI values are significant for the skull shape (defined by the indexes), the eyes shape of the eyes (more rounded orbits in women) and the width of the face (narrower and elongated in women).

TABLE 5: Results of the comparison of the SDI with different historical populations. Green Test = * p<0.05; ** p<0.001; SD: Standard deviation; SDI = Sexual Dimorphism Index. NEOL: Neolithic (Garralda 1974), EULA: Sta Eulalia (Rodríguez-Hernandorena 1981), VISI (Visigoth Sites), TORR: La Torrecilla (Souich 1980), SEPU: Sepúlveda (Pérez *et al*. 1981), HITO: Sta Mª de Hito (Galera 1996), MJUI: Montjuich jews (Prevosti 1951), OLME: La Olmeda (Hernández y Turbón 1991), OSMA: El Burgo de Osma (Herrerín 2008), STCL: Santa Clara.

Poblaciones	Male		Female		SDI	GREEN Test	Sexual dimorphism difference
	N	Mean; SD	N	Mean; SD			
			Maximum cranial length (LGMX1) (mm)				
STCL	31	190.55; 5.23	25	182.84; 5.10	104.22		5.25
NEOL	36	187.28; 6.10	29	189.24; 5.92	98.96	4.6705 *	
			Bizygomatic breadth (BIZG45) (mm)				
STCL	17	127.65; 4.06	14	120.57; 3.23	105.87		4.43
EULA	12	127.41; 1.28	6	125.60; 4.27	101.44	2.5422 *	
			Upper facial length (HSUP48) (mm)				
STCL	20	71.05; 4.90	16	69.13; 2.99	102.76		-7.16
NEOL	23	69.17; 3.95	12	62.92; 2.64	109.93	2.2795 *	
			Humerus length (HUMLGMX1) (mm)				
STCL	46	320.26; 12.96	36	298.92; 14.42	107.14		
NEOL	20	308.94; 19.04	13	275.29; 12.45	112.22	2.0105 *	-5.08
VISI	40	328.46;11.50	51	299.23; 12.01	109.77	2.0269 *	-2.63
TORR	52	317.83; 17.85	42	283.31; 14.21	112.18	2.8637 *	-5.05
SEPU	23	326.82; 12.69	18	291.43; 3.07	112.14	2.9206 *	-5.00
			Minimum perimeter of the humerus (HUMPMIN7) (mm)				
STCL	65	65.29; 4.23	45	57.53; 3.79	113.49		-7.13
TORR	89	62.48; 4.01	91	51.80; 2.88	120.62	3.2168 *	
			Maximum femur length (FEMLGMX1) (mm)				
STCL	42	443.40; 16.95	34	419.06; 18.44	105.81		
HITO	58	457.64; 20.43	30	421.05; 14.03	108.69	2.0991 *	-2.88
VISI	69	461.20; 19.14	69	421.29; 18.04	109.47	2.9735 *	-3.67
TORR	64	446.16; 22.39	50	398.82; 18.64	111.87	3.9326 *	-6.06
MJUI	31	433.50; 32.10	18	387.80; 23.90	111.78	2.4804 *	-5.98
SEPU	89	440.34; 20.52	83	395.26; 18.40	111.41	3.9525 *	-5.60
			Maximum ulna length (CUBLGMX1) (mm)				
STCL	50	263.34; 10.51	29	239.59; 12.26	109.91		
HITO	43	326.88; 17.91	14	245.40; 10.87	133.20	10.9427 *	-23.29
VISI	40	328.47; 11.50	22	246.91; 10.27	133.03	14.6849 *	-23.12
TORR	52	317.83; 17.85	21	238.19; 10.83	133.44	11.6205 *	-23.52
MJUI	25	309.60; 18.90	5	224.00; 10.20	138.21	8.5611 *	-28.30
OLME	62	313.67; 16.96	34	249.08; 13.09	125.93	9.3208 *	-16.02
			Minimum perimeter of the ulna (CUBPMIN3) (mm)				
STCL	59	38.47; 3.16	34	35.24; 3.77	109.17		
VISI	16	40.25; 3.13	17	33.65; 1.83	119.61	2.5723 *	-10.45
NICO	172	36.59; 3.25	103	31.56; 2.34	115.94	2.3631 *	-6.77
			Maximum radius length (RADLGMX1) (mm)				
STCL	45	240.67; 13.42	34	220.18; 10.82	109.31		
MJUI	24	240.00; 26.80	13	205.40; 13.90	116.85	2.0682 *	-7.54
OLME	51	240.45; 13.27	48	229.60; 11.52	104.73	2.5584 *	4.58

TABLE 5: Continued.

Maximum tibia length (TIBLGMX1) (mm)							
STCL	65	361.52; 15.18	39	339.28; 15.46	106.56		
VISI	104	376.90; 18.95	91	341.12; 14.07	110.49	3.3406 *	-3.93
SEPU	59	369.66; 16.71	41	326.83; 14.29	113.10	4.6218 *	-6.55
Transverse diameter at the height of the tibia nutrient hole (TIBDT9a) (mm)							
STCL	71	24.13; 1.87	48	21.69; 1.90	111.25		
SEPU	60	24.73; 1.93	45	20.97; 1.92	117.93	2.5537 *	-6.68
OSMA	23	22.09; 2.41	22	21.14; 1.49	104.49	2.2070 *	6.76
Humerus Robusticity Index (HUM7/1)							
STCL	46	20.47; 1.50	36	19.30; 1.26	106.06		5.81
OSMA	28	19.61; 1.06	24	19.56; 1.39	100.26	2.3556*	
Ulna Robusticity Index (CUB3/1)							
STCL	50	14.76; 1.05	29	14.85; 1.67	99.39		
VISI	16	15.28; 1.37	16	13.65; 0.49	111.94	3.2807 *	-12.55
NICO	134	13.64; 1.12	66	12.99; 1.07	105.00	2.2872 *	-5.61
OLME	43	14.66; 1.05	33	13.57; 1.09	108.03	2.9985 *	-8.64
Femur Robusticity Index (FEM8/2)							
STCL	42	20.25; 1.41	34	19.00; 1.11	106.58		7.56
OSMA	20	19.26; 1.36	23	19.45; 1.24	99.02	2.9162*	
Femur Platymeric Index (FEM10/9)							
STCL	57	86.55; 10.64	42	81.22; 6.65	106.55		6.31
NICO	197	80.69; 7.26	112	80.49; 7.42	100.25	2.7944 *	
Tibia Robusticity Index TIB10b/1							
STCL	65	20.89; 1.04	39	19.82; 1.14	105.40		
SEPU	54	20.26; 1.24	41	19.87; 1.30	101.96	2.0032 *	3.44
OSMA	20	20.08; 1.25	22	20.65; 1.46	97.24	3.8072 *	8.16
Tibia Platymeric Index (TIB9a/8^{a})							
STCL	71	72.70; 5.24	48	75.02; 5.31	96.91		5.40
OSMA	23	69.53; 7.06	22	75.98; 6.47	91.51	2.0540 *	
Brachiale Index							
STCL	32	75.15; 1.93	28	72.82; 1.89	103.20		
MJUI	14	75.50; 3.53	8	76.50; 1.58	98.69	2.9053 *	4.52
OLME	42	78.53; 2.56	31	77.86; 2.51	100.86	2.0897 *	2.35
OSMA	16	73.82; 2.06	18	73.75; 3.86	100.09	2.1770 *	3.12
Crural Index							
STCL	41	82.88; 2.25	30	81.79; 2.07	101.33		2.15
OLME	45	82.65; 2.49	36	83.33; 2.08	99.18	2.3940*	

It can be concluded that the skull is larger in men (with a cranial capacity greater between 8.9 and 13.07%, depending on the method used). However, regarding the shape there are only differences between sexes in the typology of the orbits and in the width of the face in relation to its height.

Analysis of the postcranial skeleton indicated that almost all variables of the six long bones show dimorphism, with higher values in men. These high SDI values contrast with the low SDI values of the robustness index. The maximum SDI is observed in the robustness of the femur, and the minimum in that of the ulna (this shows greater robustness in women). The general SDI of the postcranial skeleton is significantly less than that found in the skull.

In the upper extremities, the data reveals that the arm bones would be larger in size in men than in women, but the robustness, strongly influenced by daily work and reflecting the muscular activity to which they are subjected, would not be as different. The

TABLE 6: Sexual dimorphism in cranial capacity, comparison with male and female series from historical populations of the Iberian Peninsula. HITO: Sta Mª de Hito (Galera 1996), NEOL: Neolithic (Garralda 1974), EULA: Sta Eulalia (Rodríguez-Hernandorena 1981), ORDO: Ordoñana (Fernández de Prado 1978), CATA (Catalonia and neighboring regions (Vives, 1987), MJUI: Montjuich Jews (Prevosti 1951), TORR: La Torrecilla (Souich 1980), VISI: Visigoth Sites (Varela 1974), SEPU: Santiago Church, Sepúlveda (Pérez, Bellón y Arzuaga 1981), VALE: Sta Catalina de Valeria (Pérez, Bellón y Arsuaga, 1981), OSMA: El Burgo de Osma (Herrerín, 2008), PISC: Sta Mª de la Piscina (Souich y Martín 1982), BERL: San Baudelio de Berlanga (Herrerín 2003), GARA: San Juan de Garai (Arenal y de la Rua 1988), LAST: Lastra's Castros (Arenal y de la Rua 1988), SUSO: Suso Monastery (Martin y Souch, 1981), STCL: Santa Clara. SDI: Sexual Dimorphism Index.

Populations	Male Mean (cm^3)	Female Mean (cm^3)	Male/ STCL	Female/ STCL	SDI	Sexual dimorphism difference
HITO	1544.46	1412.58	11.18	56.50	109.34	-3.73
NEOL	1446.59	1373.19	-86.69	17.11	105.35	-7.72
EULA	1480.56	1362.93	-52.72	6.85	108.63	-4.44
ORDO	1511.89	1431.57	-21.39	75.49	105.61	-7.46
CATA	1479.66	1360.95	-53.62	4.87	108.72	-4.35
MJUI	1454.75	1277.22	-78.53	-78.86	118.78	5.71
TORR	1396.82	1263.39	-136.46	-92.69	110.56	-2.51
VISI	1508.40	1356.33	-24.88	0.25	111.21	-1.86
SEPU	1364.32	1205.52	-168.96	-150.56	113.17	0.10
VALE	1486.26	1376.08	-47.02	20.00	108.01	-5.06
OSMA	1370.01	1238.66	-163.27	-117.42	110.60	-2.47
PISC	1505.55		-27.73			
BERL	1447.78		-85.50			
GARA	1517.61		-15.67			
LAST	1487.45		-45.83			
SUSO	1517.08		-16.20			
STCL	1533.28	1356.08	0.00	0.00	113.07	0.00

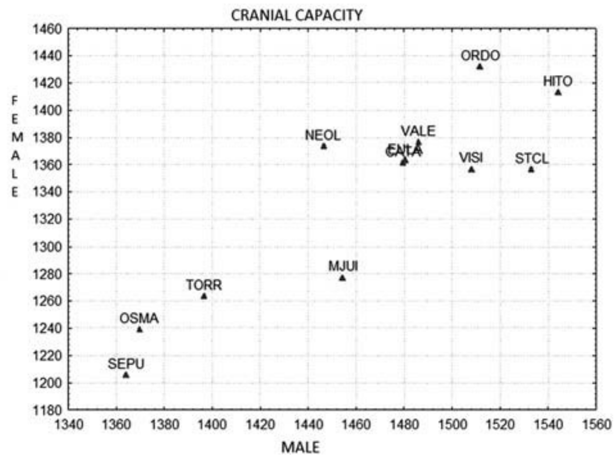

FIGURE 2: Cranial capacity. Comparison with other historical populations of the Iberian Peninsula.

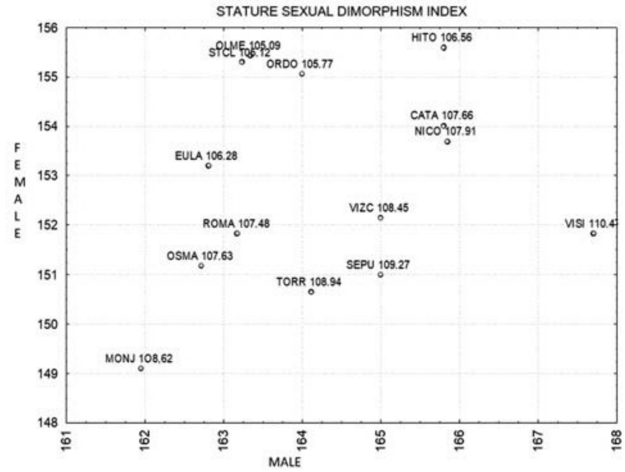

FIGURE 3: Comparison of the sexual dimorphism index of stature between the sample and other historical populations. Pearson's method.

TABLE 7: Differences between mean height values of historical populations with the population of Santa Clara and sexual dimorphism for height. HITO: Sta Mª de Hito (Galera 1996), EULA: Sta Eulalia (Rodríguez-Hernandorena 1981), ORDO: Ordoñana (Arenal y de la Rua 1988), CATA (Catalonia and neighboring regions (Vives 1987), MJUI: Montjuich jews (Prevosti 1951), TORR: La Torrecilla (Souich 1980), VISI (Visigothic Sites), SEPU: Sepúlveda (Pérez *et al.* 1981), OSMA: El Burgo de Osma (Herrerín 2008), OLME: La Olmeda (Hernández y Turbón 1991), ROMA: Hispanic-Romans, NICO: San Nicolás (Robles 1997), STCL: Santa Clara. SDI: Sexual Dimorphism Index.

	Male Mean (cm)	Female Mean (cm)	Male STCL	Female STCL	Dif. Between sexes	SDI	Sexual dimorphism difference
HITO	165.80	155.59	2.56	0.30	10.21	106.56	1.44
EULA	162.81	153.19	-0.43	-2.10	9.62	106.28	1.16
ORDO	164.00	155.05	0.76	-0.24	8.95	105.77	0.65
CATA	165.80	154.01	2.56	-1.28	11.79	107.66	2.54
MJUI	161.95	149.10	-1.29	-6.19	12.85	108.62	3.50
TORR	164.12	150.65	0.88	-4.64	13.47	108.94	3.82
VISI	167.71	151.82	4.47	-3.47	15.89	110.47	5.35
SEPU	165.00	151.00	1.76	-4.29	14.00	109.27	4.15
OSMA	162.72	151.18	-0.52	-4.11	11.54	107.63	2.51
VIZC	165.00	152.14	1.76	-3.15	12.86	108.45	3.33
OLME	163.34	155.43	0.10	0.14	7.91	105.09	-0.03
ROMA	163.18	151.82	-0.06	-3.47	11.36	107.48	2.36
NICO	165.85	153.69	2.61	-1.60	12.16	107.91	2.79
STCL	163.24	155.29	-	-	7.95	105.12	-

dimorphism of the robustness indexes of the arms in the studied population is low (only statistically different in the humerus), while the SDI of the robustness indexes of the legs is higher, with statistical differences in the robustness of the three long bones. This could indicate similar manipulation activities in both sexes, while moving heavy loads would have been undertaken more often by men. Women are suggested to have carried out more sedentary activities but with a similar requirement regarding the use of arms in their daily tasks. It is important to remember that SDI decreases in populations that suffer a high degree of environmental stress, where both sexes are subject to great physical demands and to common or similar tasks between the sexes.

When an analysis of main components was performed, it was found that the size of the skull and its length and the variables of the femur and tibia were those with the greatest weight in the explanation of the variability. The skull SDI (very genetically controlled and with little environmental influence) is important but does not provide enough weight to explain the total SDI calculated. The rest of the total weight of the SDI is provided by variables of the lower extremities. This analysis reinforces the SDI of the inhabitants of Santa Clara above as it focuses on the cranial size and lower extremities. It is known that the SDI of the postcranial skeleton, especially about robustness, is more affected by environmental conditions, although it also has a clear genetic basis.

The low SDI value of the stature in the sample (smaller than that calculated for other populations) would be more related to environmental conditions than to genetic aspects. This low stature dimorphism would indicate shared tasks, which would be very demanding for both sexes, and a similar diet, which would result in a difference of average height of less than 8 cm between sexes. Although short stature in men was observed when compared to other Spanish populations, the height of the women of Santa Clara is high, only surpassed by the women from two of the populations used in the comparison. Studies of cohorts born at the end of the twentieth century in non-marginal environments (Cámara 2018) found that the average of the differences between male and female statures was 13.69 cm, much greater than the cohorts born during the nineteenth century, which were abnormally low especially during periods of worsening living conditions. Obviously, height is not a health indicator per se given the genetic implications that exist behind it, but it does constitute an accurate indicator of one of the basic components of health: nutrition (Spijker *et al.* 2015). Recognizing that the maximum biological growth potential of a person is established by their genes, their actual final height is the result of the interaction of environmental variables of different types. Therefore, among large and genetically similar populations, differences in height can be expected to respond to these variables.

Finally, when the data of the SDI of the individuals of Santa Clara has been compared with the rest of the populations used in the study, it can be seen that the SDI of the skull is similar to most series; it differs only slightly from the Neolithic population, the only series with greater skull length in women and with a very high face in men and very low in female individuals, and Santa Eulalia, in which the width of the face is similar in both sexes. However, with regards to size, the male skulls of Santa Clara are very large compared to the other series, and the females are of medium size. The few differences between the SDI of the cranial indexes of the individuals of Santa Clara with the rest of the populations would indicate a very similar genetic dimorphism. Christian, Muslim and Jewish populations are found within this set of samples so similarities can be thought of in the genetic heritage; the data indicates a high homogeneity in the populations compared.

Establishing the degree of SDI of the skull and postcranial skeleton in adult individuals from the Santa Clara necropolis and comparing the data obtained with that of other Spanish historical populations has served to increase the knowledge about the way of life and occupations of the men and women who lived in this community, as well as to better understand the differences between them and other populations. The study population was a minority community of Muslims within a Christian majority who retained their beliefs and customs. This was respected by the community of Cuellar during the fourteenth and fifteenth centuries as evidenced by the funeral rites used and the documents from the time. Without a doubt, these facts should have influenced the data obtained from the population's SDI, offering a very interesting study opportunity on the distribution of tasks and the living conditions of this group.

The difference between cranial and postcranial SDI, as well as the low SDI obtained for height, places us in a scenario of harsh living conditions, with a large workload for both sexes and a distribution of tasks related to wandering, which would be carried out mostly by men, and household tasks closely related to manipulation, mostly carried out by women.

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