THE MULTI-ETHNICITY OF THE 18TH-19TH CENTURY SANTA CRUZ: A PRELIMINARY NON-METRIC TRAIT STUDY ON THE CHURCH BURIALS OF LA CONCEPCIÓN IN SANTA CRUZ DE TENERIFE

Samuel James Cockerill[1], Matilde Arnay de la Rosa[1], and Emilio González Reimers[2]

[1] Departamento de Prehistoria e Historia Antigua, Universidad de La Laguna
38271 La Laguna, Tenerife, Spain
s_cockerill@hotmail.com; Matarnay@ull.es
[2] Departamento de Medicina Interna, Hospital Universitario de Canarias
38320 La Laguna, Tenerife, Spain
egonrey@ull.es

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Abstract. The 18th- 19th century population of Santa Cruz de Tenerife held a great variety of people from different ethnic backgrounds. The origin of various traits is unknown and the aim of this ongoing study is to find more evidence suggesting the influences of the talus and calcaneus facets and Os Trigonum trait in order for them to be used in forensic identification and osteoarchaeological studies. In total, 264 bones were analyzed in this study (126 tali and 138 calcanei) and chi-square tests were completed to determine sex independence of each trait. The results show that the traits are proportionate amongst males and females. Chi-square tests were not significant with the exception of the Os Trigonum trait that appeared to be highly significant. Therefore, the talus inferior facets and calcaneus inferior facets appear to be possibly affected by genetics but the Os Trigonum appears to be highly affected by activity stress.

Keywords. Non-metric traits. Anatomical variants. Osteoarchaeology. Calcaneus. Talus.

1. INTRODUCTION

The calcaneus or "heel bone" is the largest tarsal bone in the foot and it articulates with the talus. The talus bone is the link between the leg and the foot as it supports the tibia and is supported by the calcaneus. The Talus has no muscle attachments but has many ligamentous attachments (Boyan *et al*. 2016). The calcaneus and the talus bone are the main osseous structures within the foot that support the total body weight of a person (Anbumani, Sridharan, and Selvi A 2017). Only in very rare instances have these bones been used in population studies and this is principally because of the unknown origin of the non-metric traits found on them and so authors prefer to use dental and cranial traits due to their reliability (Alt, Rösing, and Teschler-Nicola 1998; Berry and Berry 1967). Cranial and dental traits are also preferred over anatomical variants found in the rest of the skeleton because it is believed that postcranial traits are highly influenced by activity stress (Rodríguez Martín and Martín Oval, 2009). However, there is not much evidence that suggests that all postcranial traits should be discarded from biodistance and kinship studies and more research needs to be completed on postcranial traits to test their reliability and usage in physical and forensic anthropology, as well as osteoarchaeology. Recent studies have found research in postcranial traits to be successful populational and kinship markers but more research is needed (Case, Jones, and Offenbecker 2017).

According to many authors (Voisin 2012; Saunders and Popovich 1978; Katzenberg and Saunders 2007) a trait with age and sex independence suggests that it could have a genetic predisposition. This is because traits with age and sex independence appear to be less affected by environmental factors or activity stress. It is usual to find a sex dependence of a trait if the trait is highly influenced by activity stress due to unequal division of labour between the sexes in modern western societies. It is common to find age dependence in a trait that's caused by trauma or activity stress due to the lack of infant specimens manifesting the trait and the trait mainly appearing at a later age when activity stress and trauma are common. It has been suggested in previous studies that calcanei and tali facets could be used in identifying population groups when DNA analysis is contaminated or too costly (Berry and Berry 1967; Alt *et al*. 2003).

La Concepción Church population is a 18^{th}-19^{th} century population of Santa Cruz Tenerife in the Canary Islands. This population is known for its multiethnicity and heterogeneous activity patterns shown in the church's funerary records (J. M.

Sanz de Magallanes 2002; Pérez Álvarez 2015). The multiethnicity of the population has been explored in previous publications where DNA analysis has been applied to the collection, showing the presence of haplogroups from North Africa, Subsaharian Africa, Europe and America, clearly showing the multiethnicity of the population (Maca-Meyer *et al*. 2005).

The understanding of non-metric traits is the key to gathering information about interpopulation and intrapopulation differences in cases where DNA analysis is impossible. The human skeleton has over several hundred non-metric traits available for identifying kinship, associated groups within a population such as ethnic groups and the identification of migration patterns in the archaeological record but most studies only use the 84 traits in the skull due to the uncertain origin of postcranial traits (Guatelli-Steinberg, Irish, and Lukacs 2001; Schillaci, Irish, and Wood n.d.). This is why the objectives of our study are:

1.- To test whether there is an association between sex and the type of facets and other traits of the talus belonging to this population.
2.- Establish the frequency of the different talus and calcaneal traits and facet types amongst the population buried in La Concepción during the 18th and 19th century.

2. MATERIALS AND METHODS

126 tali and 138 calcanei were analysed and measured following the standard recommendation (Martin and Knussmann 1988). Therefore, in total 264 bones were analysed. Chi-square analysis was used to calculate the sex independence of each facet and trait based on previous studies. Specific Mediterranean population formulas were used to identify the sex of the bones (Alemán Aguilera, Botella López, and Ruíz Rodríguez 1997). The formulas used were the ones with the highest accuracy available. These are: Calcaneus body height (CAT), Maximum length of the trochlea for the tibia (ALMT), Maximum width of the trochlea (AAMT). These three measurements were used for the right and left calcaneus and talus.

The tali were classified into 5 types following the classifications of Cho *et al.* (Cho, Kwak, and Kim 2014). (Fig. 1).

The Os Trigonum trait (OT) was analysed using the classification of Sewell (Sewell 1904) because it appears to offer the most complete categorization avail-

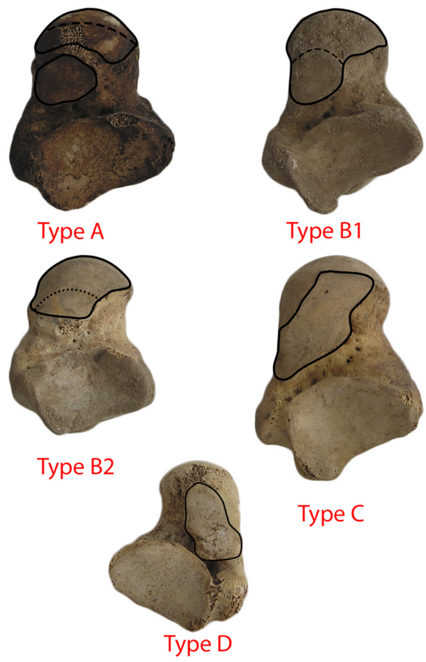

Fig. 1. Talus Inferior Facet types. Type A: Completely separated facet. Type B1: Visible ridge between both facets: the medial facet and the facet that separates the talus' head in two parts. Type B2: Two facets separated by an unclear but palpable ridge. Type C: Two completely fused facets with no visible or palpable ridge. Type D: Only one facet present.

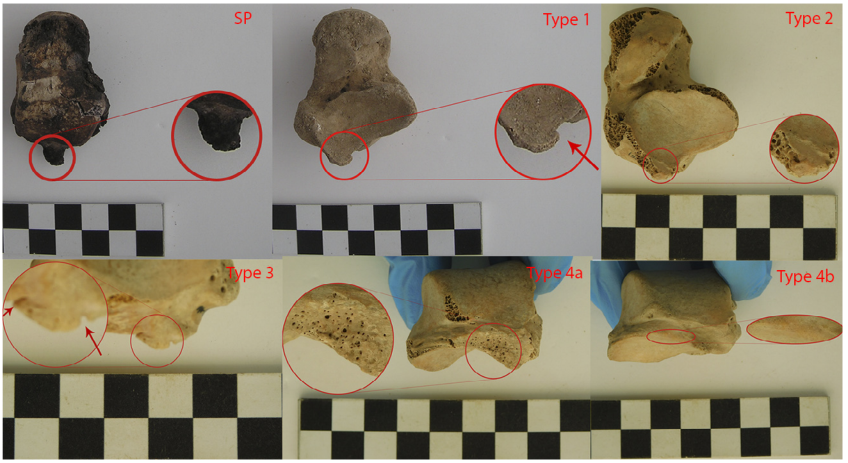

Fig. 2. Traits of the posterior talus. SP=Steida Process. OT Type 1: Completely fused Os Trigonum with sharp notch. OT Type 2: Completely fused Os Trigonum with inferior groove. Type 3: Semi-fused Os Trigonum with a well marked notch. OT Type 4a: Os Trigonum was attached to the talus by a fibrous tissue. OT Type 4b: Os Trigonum was attached and covered with a thin layer of hyaline cartilage and separated by a joint cavity.

Fig. 3. Calcaneal facets included in this study. Type Ia: Fused anterior facets constricted type (top left). Type Ib: Fused anterior facets non-constricted type (top right). Type IIa: Triple facets: <5mm between facets (middle left). Type IIb: Triple facets: 5-10mm between facets (middle right). Type IIc: Triple facets: >10mm between facets (bottom left). Type III: Absence of anterior facet (bottom right).

able in the literature. However, during the chi-square tests, we decided to group together all types as present or absent as previous authors have done (Yilmaz and Baykara 2008). This was in order to avoid diluting the general number of Os Trigonum in La Concepción population. (Fig. 2).

The method used for classification of the calcanei facets was a combined method of various previous authors (Campos and Pellico 1989; Madhavi *et al*. 2008; Kori *et al*. 2016; Saadeh *et al*. 2000) (see Fig. 3).

3. RESULTS

According to the formulas of Alemán Aguilera *et al.* (1997) (see Table 1) at least 94 tali belong to males (72.9%) and 31 belong to females (35.6%). While 35 calcanei belong to males (27.1%) and 56 belong to females (64.4%). The Chi-square results below (see Table 2) show us how the traits are distributed among the sexes in La Concepción population.

Table I. Number (N) and percentage (%) of Non-metric traits in the chi-square test

Non-metric Traits		Est. Of Sex			
		Male		Female	
		N	%	N	%
Descripción	Calcaneus	35	27,1%	56	64,4%
	Talus	94	72,9%	31	35,6%
TalusFacetTypeA	Absent	76	96,2%	25	100,0%
	Present	3	3,8%	0	0,0%
TalusFacetTypeB1	Absent	62	78,5%	20	80,0%
	Present	17	21,5%	5	20,0%
TalusFacetTypeB2	Absent	58	73,4%	19	76,0%
	Present	21	26,6%	6	24,0%
TalusFacetTypeC	Absent	46	58,2%	14	56,0%
	Present	33	41,8%	11	44,0%
TalusFacetTypeD	Absent	74	93,7%	22	88,0%
	Present	5	6,3%	3	12,0%
TalusFacetsFused	Absent	92	97,9%	31	100,0%
	Present	2	2,1%	0	0,0%
MedialFacet	Absent	62	68,9%	21	70,0%
	Present	28	31,1%	9	30,0%
LateralExtension	Absent	38	41,8%	16	51,6%
	Present	53	58,2%	15	48,4%
MedialExtension	Absent	31	34,1%	17	56,7%
	Present	60	65,9%	13	43,3%
SquattingLateralFacet	Absent	28	30,4%	6	19,4%
	Present	64	69,6%	25	80,6%
SteidaProcess	Absent	62	78,5%	22	78,6%
	Present	17	21,5%	6	21,4%
Os Trigonum	Absent	76	83,5%	18	62,1%
	Present	15	16,5%	11	37,9%
FacetTypeIa	Absent	26	83,9%	43	76,8%
	Present	5	16,1%	13	23,2%
FacetTypeIb	Absent	19	61,3%	32	57,1%
	Present	12	38,7%	24	42,9%
FacetTypeIIa	Absent	20	64,5%	44	78,6%
	Present	11	35,5%	12	21,4%
FacetTypeIIb	Absent	28	90,3%	51	91,1%
	Present	3	9,7%	5	8,9%
FacetTypeIIc	Absent	31	100,0%	56	100,0%
	Present	0	0,0%	0	0,0%

Non-metric Traits		Est. Of Sex			
		Male		Female	
		N	%	N	%
FacetTypeIII	Absent	32	97,0%	54	96,4%
	Present	1	3,0%	2	3,6%
FacetTypeIV	Absent	31	100,0%	56	100,0%
	Present	0	0,0%	0	0,0%
FacetTypeV	Absent	31	100,0%	56	100,0%
	Present	0	0,0%	0	0,0%

Table II. Chi-square test sex results between individuals of La Concepción. P=0.05 or <0.05 is significant while P>0.05 is not significant.

PEARSON CHI-SQUARE TESTS

Non-Metric Traits		Est. Of Sex
TalusFacetTypeA	Chi-square	,978
	df	1
	Sig.	,323
TalusFacetTypeB1	Chi-square	,026
	df	1
	Sig.	,871
TalusFacetTypeB2	Chi-square	,066
	df	1
	Sig.	,797
TalusFacetTypeC	Chi-square	,039
	df	1
	Sig.	,844
TalusFacetTypeD	Chi-square	,860
	df	1
	Sig.	,354
TalusFacetsFused	Chi-square	,670
	df	1
	Sig.	,413
MedialFacet	Chi-square	,013
	df	1
	Sig.	,909
LateralExtension	Chi-square	,910
	df	1
	Sig.	,340
MedialExtension	Chi-square	4,815
	df	1
	Sig.	,028*
SquattingLateralFacet	Chi-square	1,423
	df	1
	Sig.	,233

Non-Metric Traits		Est. Of Sex
SteidaProcess	Chi-square	,000
	df	1
	Sig.	,992
Os Trigonum	Chi-square	5,960
	df	1
	Sig.	,015*
FacetTypeIa	Chi-square	,610
	df	1
	Sig.	,435
FacetTypeIb	Chi-square	,142
	df	1
	Sig.	,707
FacetTypeIIa	Chi-square	2,027
	df	1
	Sig.	,155
FacetTypeIIb	Chi-square	,013
	df	1
	Sig.	,908
FacetTypeIIc	Chi-square	.
	df	.
	Sig.	.
FacetTypeIII	Chi-square	,019
	df	1
	Sig.	,891
FacetTypeIV	Chi-square	.
	df	.
	Sig.	.
FacetTypeV	Chi-square	.
	df	.
	Sig.	.

* The Chi-square statistic is significant at the 0.05 level.

Facet type IIc, IV and V could not be calculated because of the low presence of these traits in the La Concepción sample. All the traits that were calculated in Table 2 appear to be non significant and therefore proportionate between the sexes with the exception of medial extension and Os Trigonum. The medial extension appears to be very significant (P=0.02) and this is the case for the Os Trigonum trait that also appears as very significant (P=0.01).

4. DISCUSSION

Previous authors have mentioned that the talus inferior facets could be influenced by genetics and the environment (Namburu, Kaavya, and Reddy 2017; Boyan *et al*. 2016; Dixit, Kaur, and Kakar 2012). Some authors suggest that the talus inferior facets may change in the course of development due to activity stress (Bidmos, Dayal, and Adegboye 2018). Other authors state that these facets could be influenced by genetics or activity stress. Therefore, the origin of the talus inferior facets is unknown (Verna *et al*. 2014). Our study shows that the talus inferior facets are independent of sex in an urban population where there was an unequal distribution of labor between sexes (Pérez Álvarez 2015). Therefore, the talus inferior facets could be influenced by genetics as previous authors suggested.

The squatting facets (medial facet and squatting lateral facet) and the trochlear extensions (medial and lateral extensions) of the talus have been considered by previous authors to be highly influenced by the squatting posture and dorsiflexion of the foot (Oygucu *et al*. 1998). In these studies, the distribution of squatting facets and trochlear extensions appear to show considerable differences (Garg *et al*. 2015; Trinkaus 1975; Oygucu *et al*. 1998; Pandey and Singh 1990). In our study, the medial facet, lateral squatting facet and lateral extension appear to be equally distributed between the sexes. However, the medial extension manifests in a significantly higher frequency among males. This suggests that ankle activity stress was different between males and females as to be expected due to the sexual division of labour in European urban societies of the 18-19th century.

The Os Trigonum trait is known by other authors to be possibly influenced by genetics or microtrauma/activity stress (Silva 2011; Davies, Whitehouse, and Jenkins 2003; McDougall, 1955; Nayak *et al*. 2007; Yilmaz and Baykara 2008). This trait has been studied intensely and anatomical explanations to its many types have been published (Sewell 1904). It has been recommended not to use Os Trigonum in kinship analysis due to its absence in infantile specimens and its common appearance, making it a common trait in many previous population studies (Case, Jones, and Offenbecker 2017). Case *et al.* (2017) observed an age bias. In our study we have not detected an age bias, but our results coincide with Case *et al.* (2017) recommendations against using this trait in kinship analysis. As we have seen in the results (see Table 1 and Table 2) the Os Trigonum trait appeared as significantly more frequent in females than in males. It is to be noted that It appeared as highly significant.

According to Pérez Álvarez (Pérez Álvarez 2015) women of the 19th century Santa Cruz often had to work to survive as it was commonplace for men to emigrate to the Americas to find work. Therefore, large quantities of married women had to make ends meet by cleaning clothes, sewing or selling water. Most resources were usually found far distances away in the mountains, meaning that women would have to walk long distances through mountainous terrain in order to reach the resources they needed to acquire. The English author and traveler Thomas (Thomas 1860) mentions that women were "*used as beasts of burden in transporting these fragile commodities* (olive jars) *across the mountains, and the weight they carry, over roads too steep for wheeled carriages, is astonishing to American eyes*". This would explain the sex bias found in our results and the higher percentage of Os trigonum trait amongst females compared to males.

The calcaneal facets are considered to be highly influenced by genetics (Chavan Satpute, and Wabale 2014; Gupta; Gupta and Arora 1977; Arora *et al*. 1979; Vijay Laxmi 2018). The argument that the calcaneal facets are influenced by genetics is mainly based on the different frequencies found between populations. However, there are also authors who have found evidence that these facets are associated with arthritis (Drayer-Verhagen 1993). Our study coincides with previous research, as they appear to be independent of sex and therefore could be influenced by genetics. The independence of sex is suggested by the equal distribution of the calcaneal facets between the sexes. The calcaneal facet frequencies appear as equal between males and females in a population with a sexual division of labour. This suggests that the calcaneal facets do not represent the different activity patterns of the population. Therefore, these facets could be influenced by genetic and/or environmental factors in the La Concepción population.

5. CONCLUSION

The distributions of the talus and calcaneus trait data show a similar distribution amongst males and females apart from a larger proportion of the Os Trigonum trait and the medial extension in females. In general these results support that most of the traits included in this study could be highly influenced by genetics and/or environmental factors. The exceptions are the trochlear extensions, squatting facets and Os Trigonum trait. As we have seen, many previous studies have shown how the trochlear extensions and squatting facets appear to be highly influenced by posture and certain activities such as squatting and dorsiflexion of the foot. Our results show that the medial extension of the trochlear surface and Os Trigonum appear to be highly influenced by activity stress shown by congruity with the significant proportion difference between males and females in this population marked by a sexual division in labour.

The calcaneal facets have not shown a sex bias in a population characterized by a sexual division of labour. This shows that the calcaneal facets don't appear to be highly affected by activity as they do not follow the same activity pattern of the La Concepción Church population. Future research on other population with different characteristics could shed more light on the main influences of this tarsal trait.

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