



# Taxonomic reassignment of the Paleolithic human navicular from Cueva de los Torrejones (Guadalajara, Spain)

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**Abstract** Evidence of human activity and hominin remains are very scarce inland on the Iberian Peninsula. This fact raises the issue of the scarcity of evidence that Paleolithic *Homo sapiens* occupied this area outside of the littoral margins (Atlantic, Cantabrian, and Mediterranean coasts). Here, we comparatively describe a human right adult navicular bone recovered in the Cueva de los Torrejones site, located in the village of Tamajón (Guadalajara, Spain). This fossil was preliminarily established as belonging to *Homo cf. neanderthalensis*, due to the late Pleistocene faunal association, mainly because of the presence of *Crocuta crocuta* and *Panthera pardus*. The metrical and morphological study of the navicular T93-S3.27 from Cueva de los Torrejones clearly differentiates it from Neandertals and their ancestors, the hominins from Sima de los Huesos, allowing for this fossil to be taxonomically assigned with confidence as *H. sapiens*. The navicular from the Cueva de los Torrejones is absolutely

and relatively medio-laterally narrow with a low wedging index as those of fossil and modern *H. sapiens*, and clearly different of Neandertals. The increased discoveries and publications of new naviculars belonging to genus *Homo*, together with the findings of *P. pardus* and *C. crocuta* in more recent chronologies in the Iberian Peninsula, are compatible with this reevaluation. We propose a probable chronology for this fossil between 12 and 15 ka and ca. 25 ka, based on the biostratigraphy and the oldest presence of *H. sapiens* in the Iberian Peninsula. This work confirms the human presence within the Iberian Peninsula during the Upper Paleolithic and reopens the question of the peopling of the inner Peninsula during this period.

**Keywords** Feet · Navicular · Neandertals · Upper Paleolithic · modern humans · Late Pleistocene · Iberian Peninsula

## Introduction

Human fossils from the Middle and Upper Paleolithic in the Iberian Peninsula are mainly found in the Cantabrian Range, the Mediterranean, and the Atlantic coasts (Basabe 1973a; Trinkaus 1984; Daura et al. 2005; Rosas et al. 2006; Arsuaga et al. 2007; Walker et al. 2011; Arsuaga et al. 2012b; Willman et al. 2012). Recent and intensive studies over the past few years have provided evidence of human presence in the interior of the Iberian Peninsula during the Middle and Upper Paleolithic (Estrada García et al. 1992; López Recio et al. 2007; Mingo Álvarez et al. 2007; Arsuaga et al. 2012a; Lorenzo et al. 2012; Alcaraz-Castaño et al. 2013, 2015b, 2017; Yravedra et al. 2016; Álvarez-Alonso et al. 2017). However, there are just a few Paleolithic sites with human remains. Los Casares, Pinilla del Valle sites, San Isidro, Jarama VI, and Los Torrejones are the only sites containing hominin remains in the Sistema Central

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mountain range region. Taking into account the Late Pleistocene chronologies, the fossils are identified as belonging to Neandertals in all cases (Basabe 1973b; Gracia et al. 2009; Arsuaga et al. 2012a; Lorenzo et al. 2012). In other words, to date, no *Homo sapiens* remains have been identified in inland Iberia for the Upper Paleolithic.

Most of the human fossils recovered in the Late Pleistocene sites in the Iberian Peninsula correspond to craniodental remains (Basabe 1973a; Garralda et al. 1992; Daura et al. 2005; Gracia et al. 2009; Arsuaga et al. 2012a, b; Willman et al. 2012). In some occasions, the craniodental remains appear associated with some postcranial remains, making taxonomic identification of the latter possible based on the former (Lorenzo and Montes 2001; Quam et al. 2001; Rosas et al. 2006; Arsuaga et al. 2007; Walker et al. 2011; Arsuaga et al. 2015). When isolated postcranial remains appear in the sites, the taxonomic proposals are mostly based on chronological, biostratigraphical, and lithic associations (Basabe 1973b; Arribas et al. 1997; Lorenzo et al. 2012). This is the case for Cueva de los Torrejones (Guadalajara, Spain) in which an isolated navicular bone was discovered in the 1990s and interpreted as a Neandertal bone.

Trinkaus (1975, 1983) established that there were no essential morphological differences between the postcranial bones of Neandertals and modern humans. The main differences observed were those related to robusticity. Regarding the foot, the Neandertal navicular and that of their ancestors, the hominins from Sima de los Huesos (SH), are metrically and morphologically similar, but more broad, with a greater thickness of tuberosity and with lower thickness index, compared with the navicular of Early and modern *H. sapiens* (Trinkaus 1975; Trinkaus 1983; Harvati et al. 2013; Pablos et al. 2017). However, the medio-lateral breadth of the navicular clearly differentiates this bone in the evolutionary line that gave rise to Neandertals from that of Early *H. sapiens* and modern humans (Pablos et al. 2017).

The main objectives of this study are to metrically characterize the supposed Neandertal navicular found in the Late Pleistocene levels of Cueva de los Torrejones, and try to establish a clear taxonomic assignation for this fossil. This work will broaden our knowledge regarding the time frame of human occupations within the Iberian Peninsula during the Middle and Upper Paleolithic.

## The Cueva de los Torrejones site

The Cueva de los Torrejones is located in Tamajón (Guadalajara, Spain), in the Sistema Central mountain range region of the Iberian Peninsula (Fig. 1). Three main lithostratigraphic units (LU) have been described in this site in a number of sectors (Entrada—Entrance, Sumidero—sink-hole, and Tejones—badgers). These lithostratigraphic units

are mainly divided into two phases in the different areas of the cave: Holocene-disturbed (LU3) and Late Pleistocene (LU1 and LU2) (Arribas et al. 1995, 1997, 2005). The Late Pleistocene chronology of these last units is based on the biostratigraphical association, due to the presence of typical taxa from this period (*Panthera pardus* and *Crocuta crocuta*, among others). Based on the faunal association, a preliminary age of 60–80 ka for the Pleistocene deposits was suggested (Arribas et al. 1995, 1997; Díez Fernández-Lomana et al. 1998; Carrión et al. 2007). Moreover, a few lithic tools preliminarily assigned to the late Middle Paleolithic were recovered in the lower part of the sequence (Arribas et al. 1995; Carrión et al. 2007). Some cutmarks were observed on some tortoise and leopard remains (Arribas 1997; Arribas et al. 1997), but the main origin of the accumulation is due to carnivore action, i.e., a hyena den (Arribas et al. 1997; Díez Fernández-Lomana et al. 1998). The presence of *Testudo* and other botanical taxa in the Pleistocene sediments suggest an environment characterized by an open and warm climate (Arribas et al. 1995; Carrión et al. 2007).

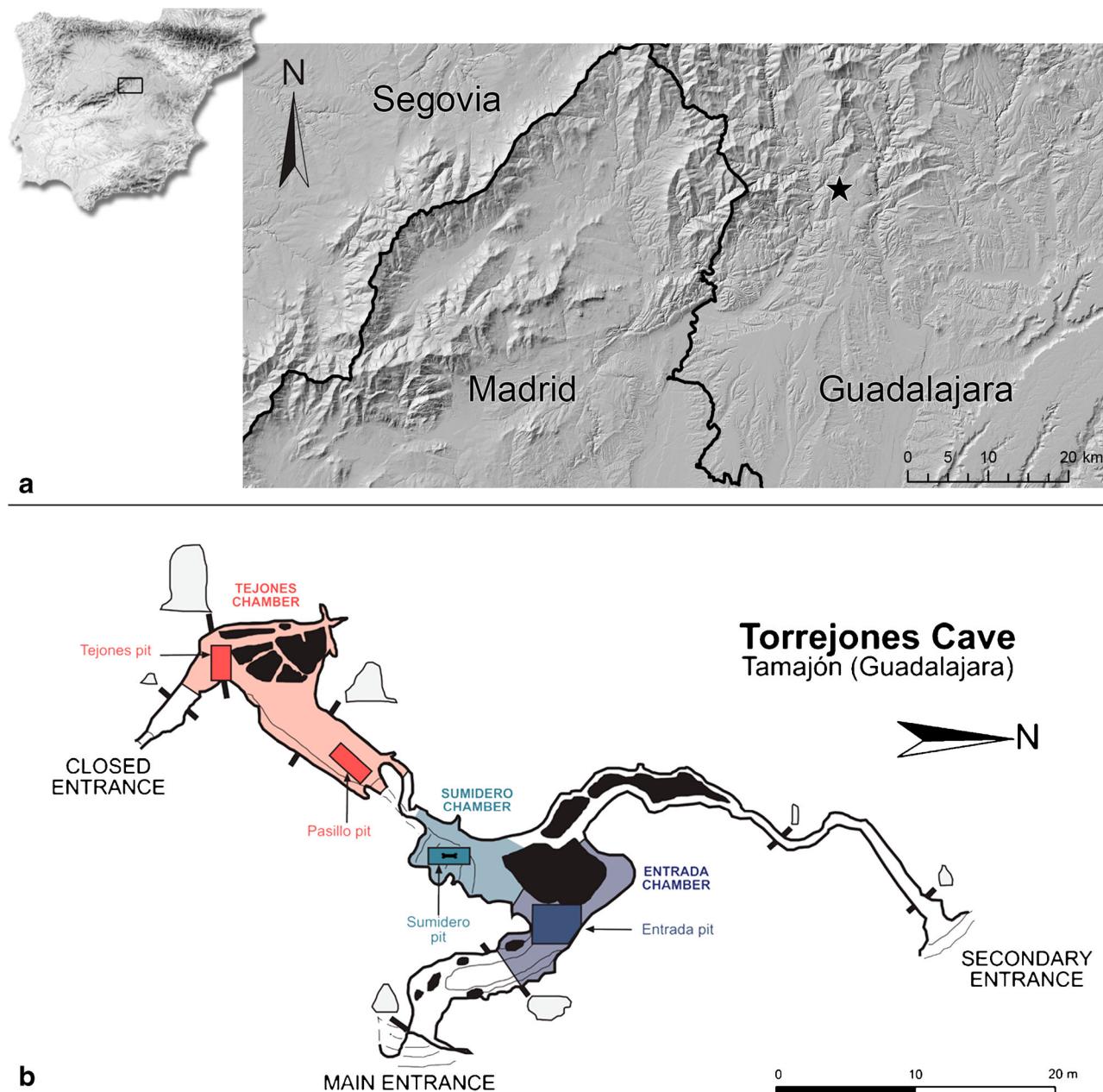
In this cave, several human remains have been recovered (Arribas et al. 1995, 1997), but most of them were found in the disturbed sediments and it was not possible to establish a clear stratigraphical, taxonomic, and chronological context for them. The only human fossil that appeared in the in situ sediments was the right navicular T93-S3-27, found during the 1993 excavation season in level 3 (LU2), around 1 m below the contact with the uppermost level, of the Sumidero sector (Arribas et al. 1995). This navicular was preliminarily ascribed to *Homo cf. neanderthalensis* based on the faunal association of the site, which belonged to the Late Pleistocene (Arribas et al. 1995, 1997).

A reassessment of the navicular from Cueva de los Torrejones is therefore warranted, in light of an increased sample of fossil navicular bones in genus *Homo* (Pearson et al. 2008; Harvati et al. 2013; Sala et al. 2013; Pablos et al. 2014, 2017; Trinkaus et al. 2014). Moreover, the presence of *P. pardus* and *C. crocuta* in more recent sites, such as Praileáitz I (Guipúzcoa) and Cueva de las Ventanas (Granada) in Spain (Carrión et al. 2001; Castaños 2010; Sanchis et al. 2015), extends the chronological range for this faunal association until 12–15 ka in the Iberian Peninsula and provides a new chronological time frame for the Cueva de los Torrejones site.

## Material and methods

### Comparative samples and variables studied

For metric and morphological comparison of the navicular from Cueva de los Torrejones, several *Homo* fossil samples have been used (see Table SI.1 for details). Moreover, three



**Fig. 1** Digital terrain model showing the geographic location of the site (source LiDAR-IGN) (a) and topographic scheme of the plan (b) of the Cueva de los Torrejones (Guadalajara). Modified from Arribas et al. (2005)

modern comparative samples were used for comparative purposes: the Hamann-Todd Osteological Collection from the North-American XX century (Cleveland Museum of Natural History; own data,  $n = 112$ ), the San Pablo Medieval Collection (Universidad de Burgos; own data,  $n = 45$ ), and the unshod Libben Amerindians (Trinkaus (1975) and personal communication;  $n = 40$ ).

The anatomical variables studied in the present work consisted of 15 linear measurements that allow for the description and comparison of the fossil with other *Homo* samples and specimens (Sala et al. 2013; Pablos et al. 2014). These variables are described in Table 1 and depicted in Fig. 2.

#### Statistical and osteometric analysis

A comparative univariate analysis of all of the variables was carried out on the navicular from Cueva de los Torrejones. Z-scores were calculated in order to compare the individual values from this fossil with the averages from the samples, and a value of 1.96 was considered significant ( $p < 0.05$ , Sokal and Rohlf 1979). In order to assess morphological similarities between the navicular from Cueva de los Torrejones and comparative fossils, we used a principal component analysis (PCA) of the raw variables using the correlations matrix because the data are not

**Table 1** Metric standard anthropometric variables (Martin and Saller 1957; Bräuer 1988) studied on the navicular from Cueva de los Torrejones

Name	Description	Source	Figure
Max. breadth—M1	Max. medio-lateral distance of the bone, measured parallel to the long axis of the talar facet.	1	2a
Max. height—M2	Max. dorsoplantar distance from the superior edge of the cuneif. facet to the tip of the plantar extension, measured perpendicular to the long axis of the talar facet.	1	2a
Talar articular length (breadth)—M3 <sup>a</sup>	Max. medio-lateral distance of the talar facet, measured parallel to the long axis of the facet.	1	2a
Talar articular height—M4	Max. dorsoplantar distance of the talar facet, measured perpendicular to the long axis of the facet.	1	2a
Min. thickness (length)—M7 <sup>a</sup>	Min. anteroposterior distance from the edge of the lateral cuneif. facet to the corresponding point in the lateral edge of the talar facet. Measured through the sagittal plane.	1	2c
Sagital thickness (length)—D6 <sup>a</sup>	Anteroposterior distance from the most dorsoproximal point of the talar facet to the most dorsal point of the intermediate cuneif. facet. Measured through the sagittal plane.	2	2c
Max. thickness (length)—M8 <sup>a</sup>	Max. anteroposterior distance from the most medial point of the medial cuneif. facet to the corresponding edge of the talar facet. Measured through the sagittal plane.	1	2c
Max. length (breadth) of cuneif. facets—M6 <sup>a</sup>	Max. distance from the most medial point to the most lateral point of the cuneif. facets.	1	2b
Dorsal breadth of cuneif. I facet—S4	Max. medio-lateral dimension of the medial cuneif. facet.	3	2b
Height of cuneif. I facet—S3	Max. dorsoplantar dimension of the medial cuneif. facet.	3	2b
Dorsal breadth of cuneif. II facet—S5	Max. medio-lateral dimension of the intermediate cuneif. facet.	3	2b
Height of cuneif. II facet—BO17	Max. dorsoplantar dimension of the intermediate cuneif. facet.	4	2b
Dorsal breadth of cuneif. III facet—S8	Max. medio-lateral dimension of the lateral cuneif. facet.	3	2b
Height of cuneif. III facet—S7	Max. dorsoplantar dimension of the lateral cuneif. facet.	3	2b
Tuberosity projection—Mc1	Max. distance from the most medial point of the talar facet to the medial edge of the tuberosity	5	2a

1 = Bräuer (1988); 2 = Deloison (2003); 3 = Sarmiento and Marcus (2000); 4 = Bonch-Osmolovski (1954); 5 = McCown and Keith (1939). See Fig. 2 for a graphic description of each variable

Max. maximum, min. minimum, cuneif. cuneiform

<sup>a</sup> Bräuer (1988) described these variables in non-anatomical terms; the anatomical dimension is shown inside the parentheses

dimensionally homogeneous and the order of magnitude of the variables is not the same (Sokal and Rohlf 1979). Only complete cases with all variables considered in the PCA were used for these analyses. For statistical analysis, we have used Statistica 8.0 (StatSoft Inc. 2007).

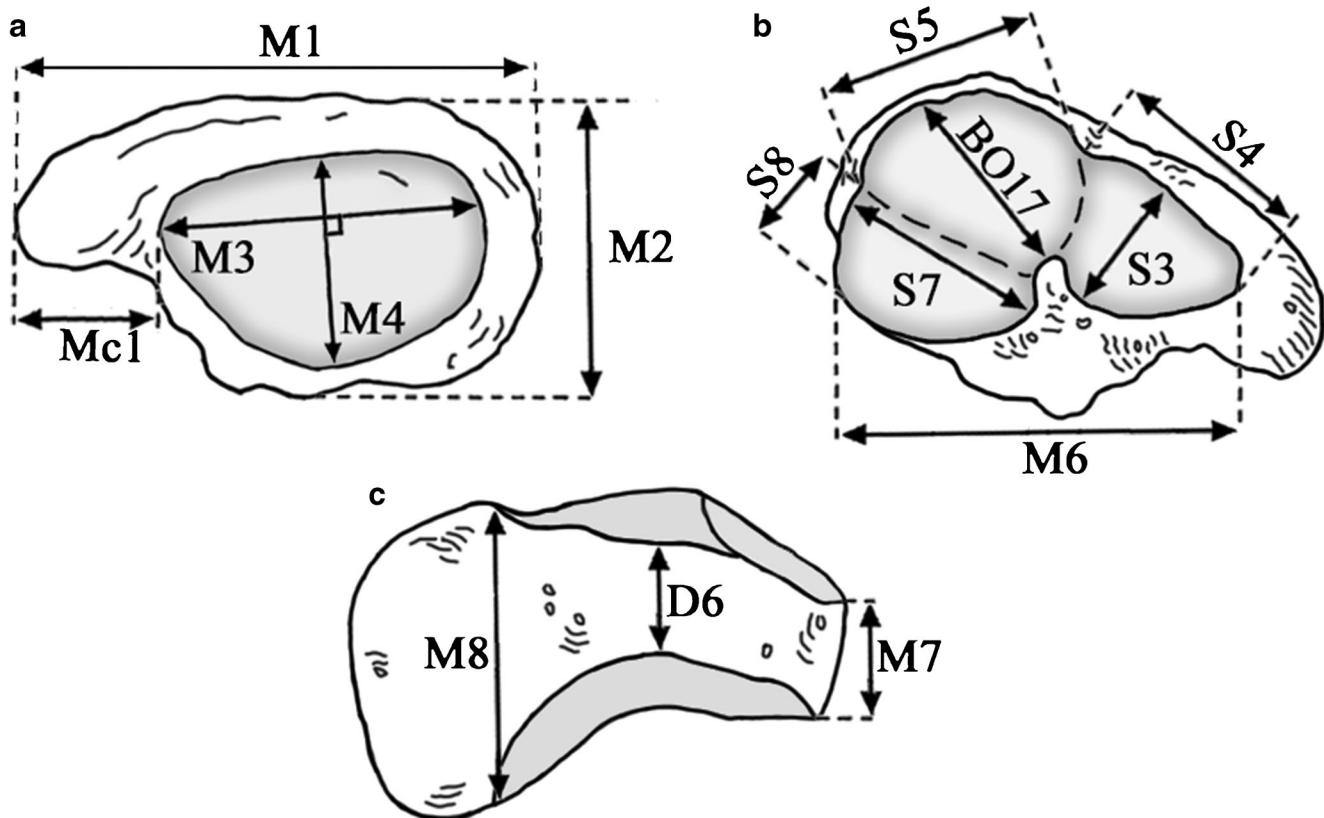
presence of this facet was detected in between 24.0 and 62.0% of cases (Trinkaus et al. 2014). This trait is present in 35.7% of our Neandertal sample ( $n = 14$ ) and in 54.6% of our Late Pleistocene *H. sapiens* sample ( $n = 11$ ). In Fig. 3d, a strong muscular insertion for the tibialis posterior muscle, a plantar flexor of the toes, can be observed.

## Results

The human fossil studied in this work consists of a complete right navicular (T93-S3.27) that probably belonged to an adult individual based on the complete developmental of the bone and the articular facets, and the general aspect of the bone. (Fig. 3). The bone is slightly eroded in the superior area, right next to the articulation with intermediate cuneiform. The presence of the three articular facets for the cuneiforms, together with their arched disposition, indicates the existence of a transversal arch, as well as a full bipedalism in this individual, which is similar to modern humans. The navicular from Cueva de los Torrejones does not display a cuboid subchondral facet, which is a trait present in 58.3 and 66.7% of our recent comparative samples (Hamann-Todd Osteological Collection,  $n = 111$ ; San Pablo Medieval Collection,  $n = 45$ ). In four recent samples, the

## Univariate comparative study

The metrical variables studied in the navicular from Cueva de los Torrejones are detailed in Table 2 in comparison with the comparative samples and other *Homo* fossils. Previously, it was established that there were generally no essential differences between the variables of the navicular of Neandertals and that of Early and modern humans (Trinkaus 1975; Pablos et al. 2017). However, there is one metrical variable—the maximum medio-lateral breadth of the navicular (Pablos et al. 2017)—and two indexes that allow us to differentiate the navicular of Neandertals and that of their ancestors, the hominins from Sima de los Huesos (SH), from that of both modern and Late Pleistocene *H. sapiens*. The Neandertal navicular and that of the hominins from SH are significantly



**Fig. 2** Metric variables studied in the navicular from Cueva de los Torrejones. **a** Proximal view. **b** Distal view. **c** Dorsal view. Abbreviations and description of the variables as in Table 1. Modified from Sala et al. (2013)

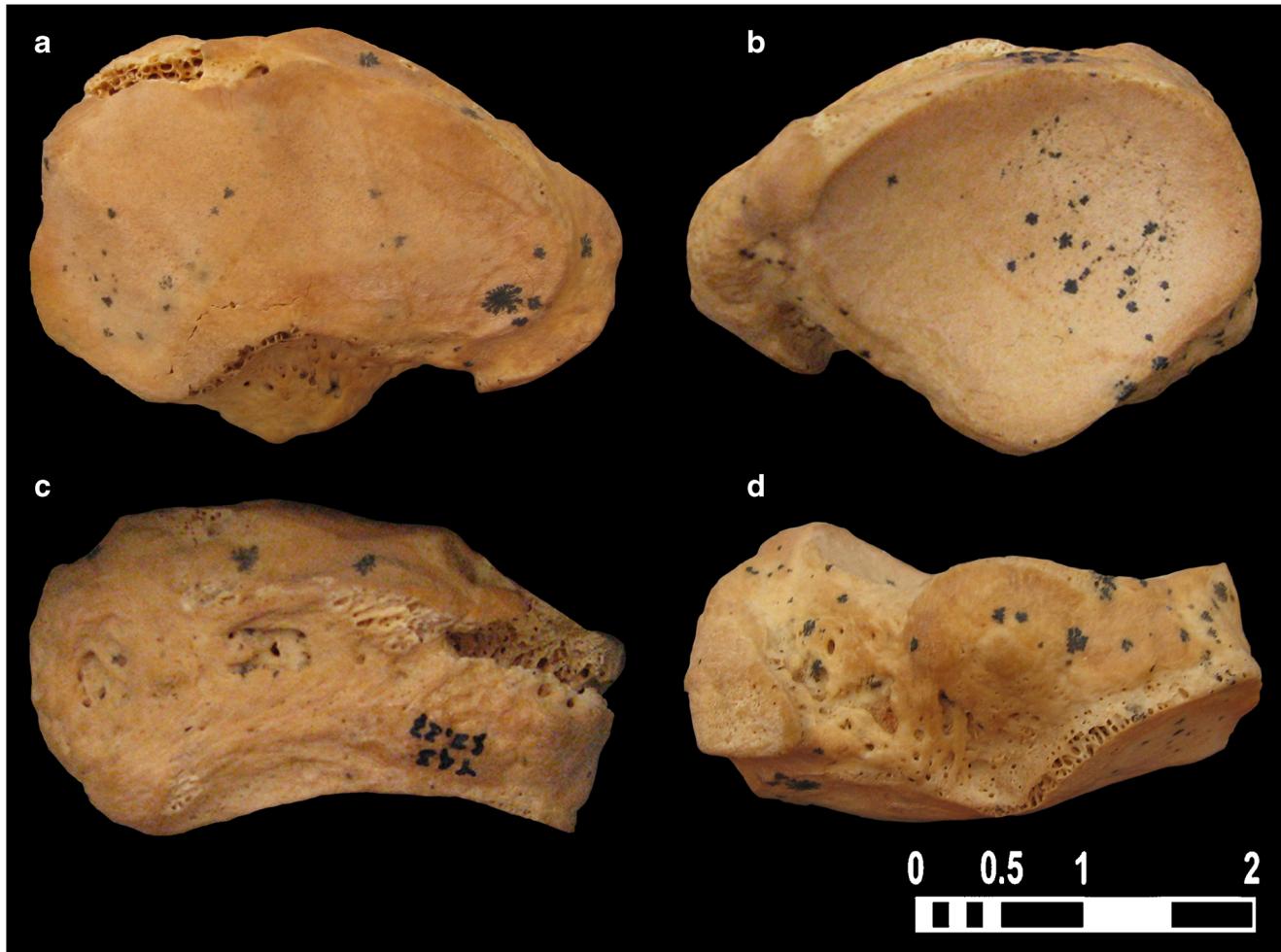
broader ( $p < 0.05$ ) than those of Late Pleistocene and modern *H. sapiens* (Pablos et al. 2017).

The maximum medio-lateral breadth (M1) of the navicular from Cueva de los Torrejones is to more than two standard deviations from Neandertals and their ancestors, the hominins from Sima de los Huesos (Fig. 4a). It is noticeable that the maximum breadth in the navicular from Cueva de los Torrejones is within the range of variation of Late Pleistocene *H. sapiens* and our three modern comparative samples for this variable (maximum medio-lateral breadth—M1). Moreover, the navicular from Cueva de los Torrejones is similar to that of Omo Kibish 1 (Ethiopia), which is considered an early *H. sapiens* despite its chronology of around 195 ka (McDougall et al. 2008; Pearson et al. 2008). Similarly, the navicular breadth of the Middle Pleistocene individual Jinniushan 1 (China) is slightly higher than that of the navicular from Cueva de los Torrejones (Lu et al. 2011). This last statement seems to suggest that a broad navicular represents a Neandertal-derived trait shared by the Neandertals and their ancestors, hominins from Sima de los Huesos (Pablos et al. 2017). Hence, we can rule out that the navicular T93-S3.27 from Cueva de los Torrejones corresponds to a Neandertal, but rather likely belongs to a Late Pleistocene *H. sapiens*.

Regarding the other metrical variables, there are no significant differences between the navicular from Cueva

de los Torrejones and the comparative samples (Table 2). Of importance here is the tuberosity projection (Mc1) that could influence the maximum medio-lateral breadth of the navicular. That variable does not display significant differences among the samples. And the value of the navicular from Cueva de los Torrejones, although lower than the average of Neandertals, is not significantly different from any of the comparative samples. Then, we can discard this variable as mostly affecting the medio-lateral breadth of the navicular.

In order to check if the maximum medio-lateral breadth (M1) of the navicular is proportionally large, we compared this variable with the maximum height (M2). The index that relates the maximum medio-lateral breadth (M1) and the maximum height (M2) in the navicular from Cueva de los Torrejones is more than two standard deviations from our Neandertal sample. When we compare these variables on a bivariate plot (Fig. 4b), we can observe that the fossil T93-S3.27 from Cueva de los Torrejones is well inside the Late Pleistocene *H. sapiens* sample range of variation, and outside of the Neandertal range of variation. This means that the navicular from Cueva de los Torrejones is proportionally narrow (M1) in relation to the maximum height (M2) when compared to Neandertals.



**Fig. 3** Right human navicular from Cueva de los Torrejones in different views. **a** Distal or anterior view. **b** Proximal or posterior view. **c** Dorsal view. **d** Plantar view. Scale = 2 cm

Regarding the wedging index that relates the navicular thicknesses (minimum thickness—M7 and maximum thickness—M8), the Neandertals display a significantly higher wedging index when compared to Late Pleistocene *H. sapiens* and to our modern comparative samples (Trinkaus 1975; Trinkaus 1983; Harvati et al. 2013; and own data). The navicular from Cueva de los Torrejones does not display significant differences with the comparative samples in this index. However, in the bivariate plot that relates these two variables, we can observe that the navicular from Cueva de los Torrejones is well inside of the variation for Late Pleistocene *H. sapiens* and clearly outside of the range of variation for our Neandertal sample (Fig. 4c). Therefore, the navicular from Cueva de los Torrejones is slightly less wedged, which is similar to what is observed in the navicular bones of the Late Pleistocene *H. sapiens* and differs from those of Neandertals. This index for Omo Kibish 1 is more than two standard deviations from Neandertals and the Late Pleistocene *H. sapiens*, and it is out of the range of variation for both samples/populations, along with the entire modern

human sample in the bivariate plot (Fig. 4c). This last observation confirms that this fossil from the Middle Pleistocene found at the Omo Kibish site should be considered different from Late Pleistocene *H. sapiens* (Trinkaus 2005; Pearson et al. 2008; Pablos et al. 2012).

#### Multivariate analysis

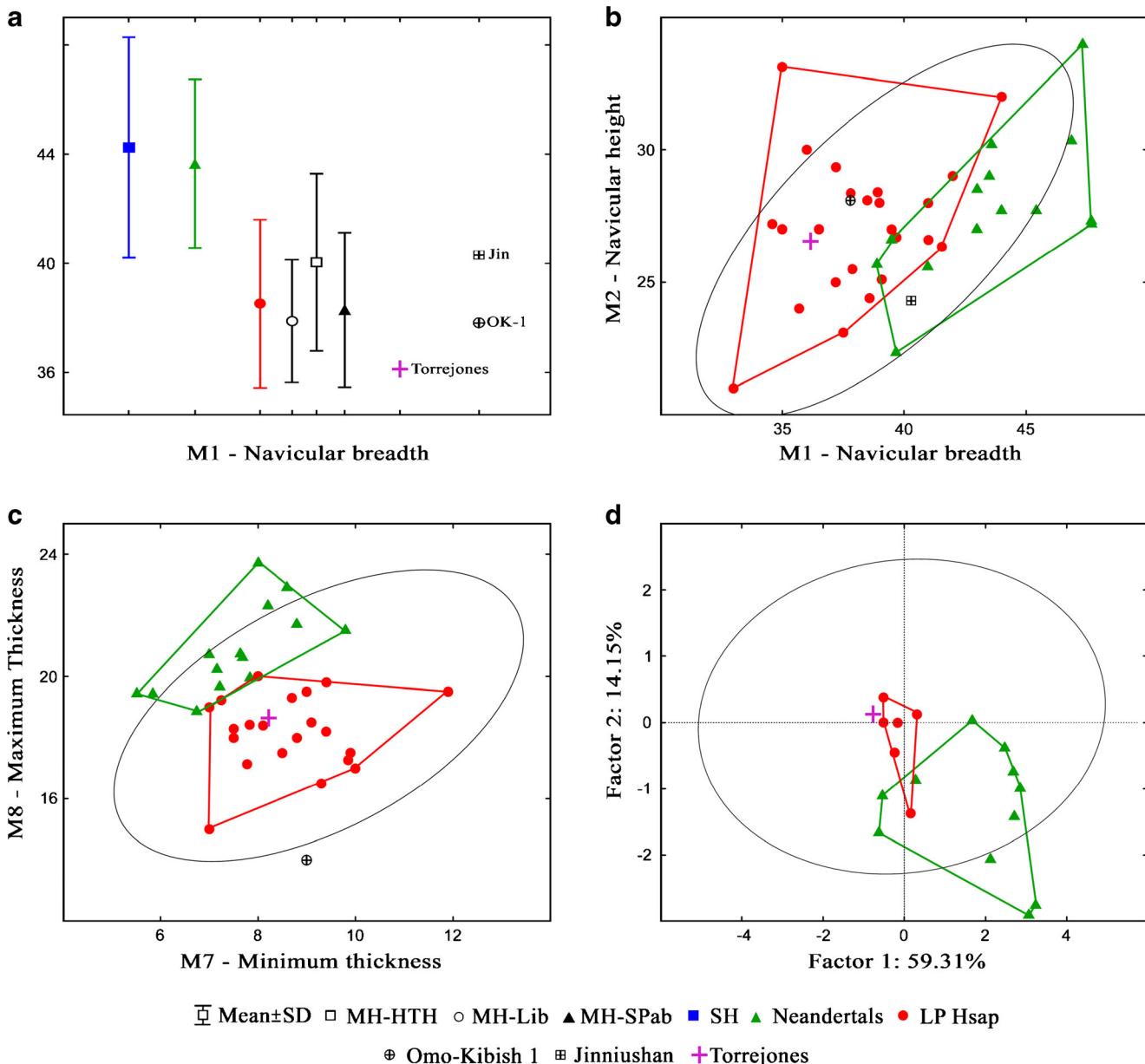
In order to assess the morphological similarities among the samples in the navicular and to determine the position in the morphospace of the navicular from Cueva de los Torrejones, we performed a PCA on the raw variables. Table 3 shows the factor matrix of the PCA and the loadings of the variables on the factors. There are two factors with an eigenvalue greater than or similar to 1, which together account for 73.45% of the total variance.

All of the variables are correlated positively with the first factor, and, except for two cases (minimum thickness—M7 and tuberosity projection—Mc1), all of the variables have a correlation higher than 0.75 with this principal component.

**Table 2** Metrical comparisons (in mm) of the navicular from Cueva de los Torrejones (T93–S3.27)

Variable	T93-S3.27	Omo Kibish 1	Jinniushan 1	Neandertals	LP <i>H. sapiens</i>	MH-HTH	MH-Lib	MH-Spab
Maximum breadth—M1	36.2	37.8	40.3	43.7 ± 3.1 [38.9–47.7] (n = 14)	38.5 ± 3.0 [33.0–46.7] (n = 26)	40.0 ± 3.2 [32.4–46.4] (n = 111)	37.9 ± 2.3 [31.8–41.2] (n = 40)	38.3 ± 2.9 [32.9–43.6] (n = 41)
Maximum height—M2	26.6	28.1	24.3	27.9 ± 2.9 [22.4–34.0] (n = 16)	27.1 ± 2.6 [21.0–33.1] (n = 26)	27.4 ± 3.1 [20.4–38.0] (n = 112)	26.2 ± 1.8 [23.4–31.1] (n = 40)	26.6 ± 2.5 [21.8–34.1] (n = 44)
Talar articular length (breadth)—M3	26.7	28.5	—	29.4 ± 2.7 [22.8–33.3] (n = 17)	26.5 ± 2.6 [21.0–30.0] (n = 25)	28.3 ± 2.4 [22.5–33.9] (n = 112)	26.7 ± 2.0 [22.8–31.1] (n = 40)	27.5 ± 2.2 [23.4–32.1] (n = 45)
Talar articular height—M4	22.0	21.5	—	21.8 ± 1.9 [19.0–25.9] (n = 17)	21.4 ± 2.0 [17.0–26.0] (n = 25)	21.6 ± 2.2 [15.4–28.7] (n = 112)	20.6 ± 1.5 [17.0–25.5] (n = 40)	21.1 ± 2.1 [17.6–25.7] (n = 44)
Minimum thickness (length)—M7	8.2	9.0	—	8.9 ± 1.2 [7.0–11.9] (n = 19)	9.4 ± 1.8 [5.3–15.6] (n = 27)	8.8 ± 1.1 [7.0–11.4] (n = 40)	8.8 ± 1.1 [4.6–13.3] (n = 44)	9.3 ± 1.8 [4.6–13.3] (n = 44)
Sagittal thickness (length)—D6	12.5	—	—	13.2 ± 1.4 [11.5–15.1] (n = 8)	13.4 ± 1.3 [12.3–15.2] (n = 4)	13.6 ± 1.8 [10.1–19.5] (n = 112)	—	13.6 ± 1.6 [10.6–17.1] (n = 45)
Maximum thickness (length)—M8	18.7	14.0	—	21.0 ± 1.5 [18.9–23.7] (n = 15)	18.2 ± 1.2 [15.0–20.0] (n = 21)	18.8 ± 2.1 [13.7–26.6] (n = 112)	18.8 ± 1.3 [15.6–21.0] (n = 40)	18.5 ± 1.8 [14.0–21.9] (n = 45)
Maximum length (breadth) of cuneiform facets—M6	33.6	36.7	—	35.9 ± 4.5 [29.1–43.6] (n = 9)	34.3 ± 1.9 [30.2–37.0] (n = 11)	34.3 ± 2.7 [28.2–40.7] (n = 112)	—	33.3 ± 2.3 [29.8–38.7] (n = 44)
Dorsal breadth of cuneiform I facet—S4	18.1	—	—	22.2 ± 2.6 [18.3–25.7] (n = 7)	19.8 ± 2.8 [17.3–23.3] (n = 4)	22.6 ± 2.8 [16.6–29.4] (n = 112)	—	20.1 ± 2.5 [14.7–24.7] (n = 44)
Height of cuneiform I facet—S3	15.0	—	—	19.6 ± 3.8 [14.0–23.5] (n = 7)	17.8 ± 2.0 [16.3–21.1] (n = 5)	16.5 ± 1.7 [10.6–21.5] (n = 112)	—	16.1 ± 2.0 [13.4–21.1] (n = 45)
Dorsal breadth of cuneiform II facet—S5	15.2	—	—	15.8 ± 2.2 [12.7–18.5] (n = 5)	16.3 ± 2.0 [12.9–18.2] (n = 5)	16.2 ± 1.7 [12.2–20.4] (n = 112)	—	15.0 ± 1.5 [12.4–19.8] (n = 45)
Height of cuneiform II facet—BO17	17.0	—	—	19.0 ± 4.3 [14.2–24.1] (n = 6)	18.4 ± 1.5 [17.1–20.7] (n = 5)	18.0 ± 1.9 [14.0–23.6] (n = 112)	—	16.2 ± 1.5 [13.3–20.4] (n = 45)
Dorsal breadth of cuneiform III facet—S8	11.4	—	—	13.2 ± 1.9 [10.6–16.0] (n = 8)	13.3 ± 0.9 [11.9–14.1] (n = 5)	12.5 ± 1.6 [9.0–16.4] (n = 112)	—	11.8 ± 1.0 [8.9–14.0] (n = 45)
Height of cuneiform III facet—S7	15.3	—	—	15.6 ± 3.3 [10.7–19.6] (n = 7)	14.9 ± 1.3 [14.1–17.3] (n = 5)	14.7 ± 1.9 [10.4–19.1] (n = 112)	—	14.1 ± 1.9 [9.5–18.2] (n = 45)
Tuberosity projection—Mc1	9.9	—	13.1	11.6 ± 1.3 [10.0–14.4] (n = 12)	9.7 ± 2.2 [5.2–12.9] (n = 8)	10.5 ± 2.0 [5.4–15.9] (n = 111)	9.3 ± 1.7 [3.8–13.2] (n = 40)	10.3 ± 1.9 [4.5–13.4] (n = 45)
M2 × 100 / M1 index	73.5	74.3	60.3	63.7 ± 4.7 [56.3–71.8] (n = 14)	68.4 ± 5.5 [58.0–85.8] (n = 16)	69.2 ± 4.5 [59.0–78.5] (n = 111)	69.6 ± 5.2 [61.7–83.5] (n = 44)	—
M7 × 100 / M8 index	44.0	64.3	—	36.3 ± 4.2 [28.4–45.6] (n = 14)	50.1 ± 8.2 [27.7–68.1] (n = 14)	46.9 ± 5.7 [37.6–60.4] (n = 112)	50.1 ± 8.1 [33.2–69.5] (n = 44)	—

Mean ± standard deviation, range [], and sample size (n) are shown. Abbreviations and definition of variables as in Table 1, taken from Trinkaus (1975) and Sala et al. (2013). LP *H. sapiens* Late Pleistocene *Homo sapiens*, MH modern humans, HTH modern humans, Lib Libben Amerindians from Trinkaus (1975), Spab San Pablo Medieval Collection



**Fig. 4** **a** Univariate analysis of the maximum medio-lateral breadth (M1) of the navicular from Cueva de los Torrejones and the comparative samples. The mean and standard deviation (mean  $\pm$  SD) are indicated. Modified from Pablos et al. (2017). **b** Bivariate plot of maximum breadth (M1) and maximum height (M2). **c** Bivariate plot of minimum thickness (M7) and maximum thickness (M8). **d** Scatter diagram based on principal component analyses (PCA) of navicular variables. The x- and y-axis show the factors and their percentage of variance. The solid line indicates the 95% equiprobability ellipse of modern human variation ( $n = 189$ ). Highlighted is the polygon of variation of Neandertals and Late

Pleistocene *Homo sapiens*. MH-HTH = modern humans from the Hamann-Todd Osteological Collection. MH-Lib = modern humans from the Amerindians unshod from Libben Collection (Data from Trinkaus (1975)). MH-SPab = San Pablo Medieval Collection (Burgos, Spain). SH = hominins from the Middle Pleistocene site of Sima de los Huesos (Arsuaga et al. 2014, 2015; Pablos et al. 2017). LP Hsap = Late Pleistocene *Homo sapiens*. Data of Omo Kibish 1 and Jinniushan 1 from Pearson et al. (2008) and Lu et al. (2011), respectively. See Supplementary Table 1 for the composition of the samples

The first factor accounts for 59.31% of the variance and could be considered a factor representing the general size of the navicular. Therefore, the largest naviculars will have high positive values for this factor, and small bones will have more negative values.

The second factor is particularly correlated with the variables that display the least correlation with the first factor: positively with the minimum thickness (M7) and negatively with the tuberosity projection (Mc1). This second factor could be considered a factor representing shape, in which naviculars

**Table 3** Principal component analysis of the variables of the navicular from Cueva de los Torrejones

	Factor 1	Factor 2
Eigenvalue	4.15	0.99
% Variance	59.31	14.14
% Cumulative variance	59.31	73.45
Maximum breadth—M1	<b>0.899</b>	-0.302
Maximum height—M2	<b>0.845</b>	0.158
Talar articular length (breadth)—M3	<b>0.815</b>	0.001
Talar articular height—M4	<b>0.857</b>	0.246
Minimum thickness (length)—M7	0.519	<b>0.628</b>
Maximum thickness (length)—M8	<b>0.789</b>	-0.028
Tuberosity projection—Mc1	0.584	<b>-0.647</b>

Variables designated as in Table 1. Loadings above 0.6 (absolute value) are highlighted in bold in the PCA.

with high values of minimum thickness and with small tuberosities will have high positive values.

Several interesting conclusions can be drawn from the PCA when the first principal component is plotted against the second (Fig. 4d). Most of the fossils show values that fall within the range of variation of modern humans. It is notable that nearly all of the fossils show negative values for the second factor, which place them among the naviculars with low values of minimum thickness and with large tuberosities from the modern human sample.

In general, the naviculars of the Neandertals tend to display positive values in the first factor and they are shifted slightly toward more positive values. We compared the coordinates of this first factor in Neandertals with the other comparative samples (Fig. 4d and Supplementary Table SI.2). For the values of the first factor of the PCA, we observed significant differences among Neandertals and modern humans (altogether and with the three subsamples separated). This indicates that, in general terms, the Neandertals display large naviculars. In this first factor, it is not possible to clearly assign the navicular from Cueva de los Torrejones to Neandertals or Late Pleistocene *H. sapiens* because it falls within the limit of variation of these two samples/populations.

The second factor of the PCA also has some taxonomic value. Nearly all of the fossils have negative values for this second factor, whereas modern humans display positive and negative values regardless of their a priori sex assignation. We compared the coordinates of the second factor among the different populations, and there are significant differences between Neandertals and both modern humans and Late Pleistocene *H. sapiens* (see Fig. 4d and Supplementary Table SI.2). Thus, the Neandertal naviculars display lower values of minimum thickness and larger tuberosities than in modern humans and Late Pleistocene *H. sapiens*. The navicular from Cueva de los Torrejones is well within the range of

variation of Late Pleistocene *H. sapiens* and, although not significantly, is outside of the range of variation of Neandertals for this second factor of the PCA.

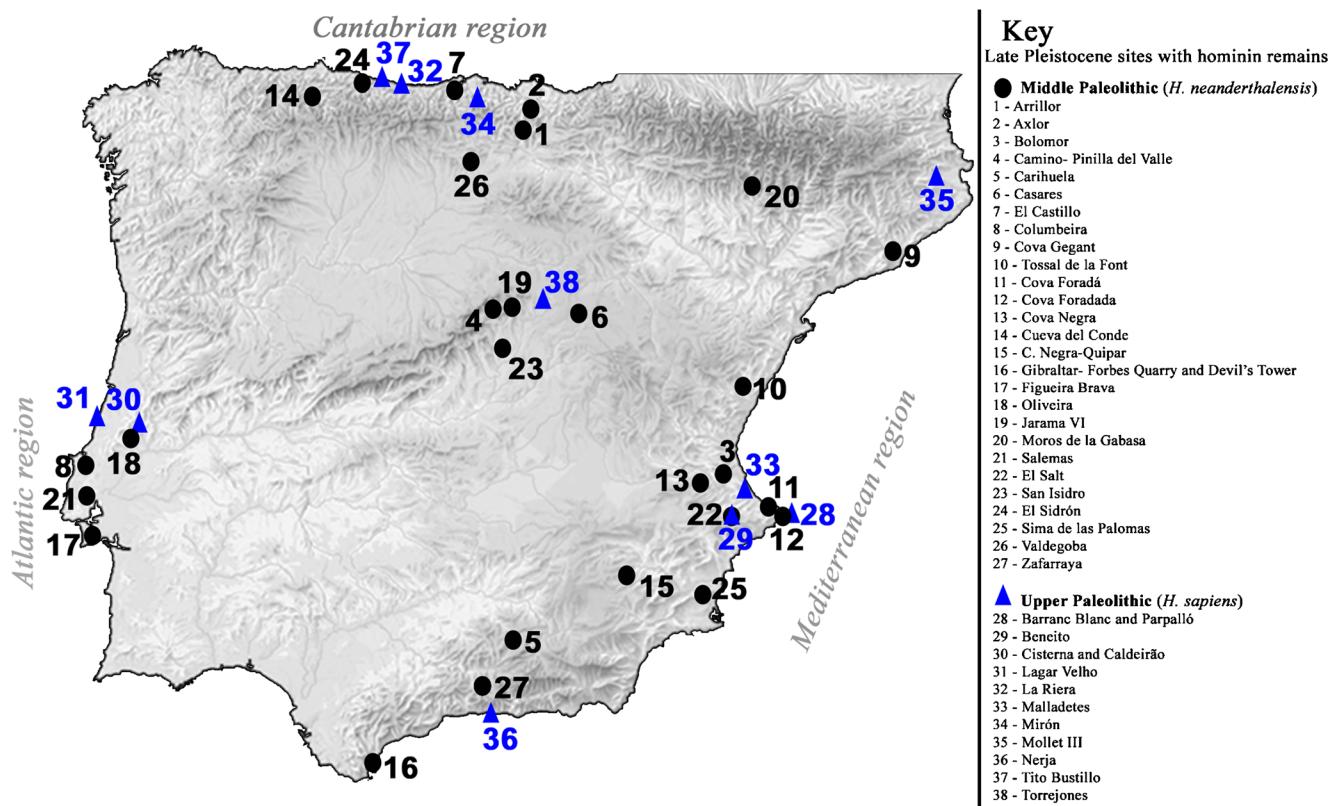
## Discussion and conclusions

The navicular T93-S3.27 from Cueva de los Torrejones is absolutely and relatively narrow medio-laterally, which differentiates it from Neandertals and their ancestors, the hominins from Sima de los Huesos. Moreover, the wedging index indicates that the navicular from Cueva de los Torrejones is a low wedged navicular, similar to that of late Pleistocene and modern *H. sapiens* and different from that of Neandertals.

This specimen likely corresponds to a fossil *H. sapiens*, instead of a Neandertal as was previously proposed (Arribas et al. 1995). This study, together with newly discovered dates from other Pleistocene sites with leopard and hyena close to 10–12 ka (Carrión et al. 2001; Castaños 2010), encourages us to carry out a biochronological review in the interior of the Iberian Peninsula in order to pinpoint the chronological time frame of the navicular from Cueva de los Torrejones.

In a recent paper, Sanchis et al. (2015) conducted a review of leopards (*P. pardus*) in the Iberian Peninsula and established a chronological range for this species in the Iberian Peninsula between 234 ka from level VI of Lezetxiki (Falgúeres et al. 2005) and 115–150 ka from levels 3, 4, and D of Arlanpe (Rios-Garaizar et al. 2015) as the first appearances of this species in the Iberian Peninsula, and 15.4 ka from Praileaitz (Castaños 2010; Peñalver et al. 2017) as the last instant of persistence of the leopard in the Iberian Peninsula. The first appearance of *C. crocuta* in the Iberian record corresponds to the fossils from levels TD3–4 of Gran Dolina (Atapuerca), with a chronology of more than 900 ka (García and Arsuaga 1999; Berger et al. 2008; Rodríguez et al. 2011; Moreno et al. 2015). Similarly to the leopards, the hyenas disappeared from the Iberian Peninsula at around 10.7–12.7 ka in Cueva de las Ventanas (Carrión et al. 2001).

Regarding the human fossil record during the late Pleistocene in the Iberian Peninsula, most of the human record is restricted to the coastal areas (Fig. 5), and there is a scarcity of human fossils within the Iberian Peninsula (Basabe 1973b; Quam et al. 2001; Arsuaga et al. 2012a; Lorenzo et al. 2012). The oldest human fossils clearly assigned to *H. sapiens* in the Iberian Peninsula are represented by the child from Lagar Velho (Portugal) and the occipital bone from Malladetes (Valencia, Spain), with a chronology of around 25 ka (Duarte et al. 1999; Arsuaga et al. 2002). Hence, based on the biostratigraphy of the Cueva de los Torrejones and, due to the presence of *P. pardus* and *C. crocuta*, together with the oldest presence of Upper Paleolithic humans in the Iberian Peninsula, we can preliminarily establish a chronology between 25 and 12 ka, or even as young as 10.7 ka, for the



**Fig. 5** Map of the Iberian Peninsula showing some of the main sites with human fossils belonging to Late Pleistocene *Homo sapiens* and Neandertals. Sites: 1 Arrillor (Bermúdez de Castro and Sáenz de Buruaga 1999). 2 Axlor (Basabe 1973a). 3 Bolomor (Arsuaga et al. 2012b). 4 Pinilla del Valle sites (Arsuaga et al. 2012a; Baquedano et al. 2014). 5 Carihuella (García-Sánchez et al. 1994). 6 Casares (Basabe 1973b). 7 El Castillo (Garralda et al. 1992). 8 Columbeira (Antunes et al. 2000). 9 Cova del Gegant (Quam et al. 2015). 10 Cova del Tossal de la Font (Arsuaga and Bermúdez de Castro 1984; Arsuaga et al. 2001). 11 Cova Foradá (Oliva) (Lozano et al. 2013). 12 Cova Foradada (Javea) (Arsuaga et al. 2001). 13 Cova Negra (Arsuaga et al. 2007). 14 Cueva del Conde (Arbizu et al. 2010). 15 Cueva Negra del estrecho del río Quipar (Walker et al. 1999). 16 Gibraltar sites (Buxton 1928; Trinkaus 1984). 17 Figueira Brava (Antunes and Cardoso 2000). 18 Gruta da Oliveira

(Willman et al. 2012). 19 Jarama VI (Lorenzo et al. 2012). 20 Gruta de Moros de la Gabasa (Lorenzo and Montes 2001). 21 Salemas (Antunes et al. 2000). 22 El Salt (Garralda et al. 2014). 23 San Isidro (Gracia et al. 2009). 24 El Sidrón (Rosas et al. 2006). 25 Sima de las Palomas (Walker et al. 2011). 26 Valdegoba (Quam et al. 2001). 27 Zafarraya (Barroso Ruiz 2003). 28 Barranc Blanc and Parpalló (Arsuaga et al. 2001). 29 Beneito 1 (Iturbe et al. 1993). 30 Galeria da Cisterna and Gruta do Caldeirao (Trinkaus et al. 2001; Trinkaus et al. 2011). 31 Lagar Velho (Duarte et al. 1999). 32 La Riera (Garralda 1986). 33 Malladetes (Arsuaga et al. 2002). 34 Mirón (Carretero et al. 2015; Straus et al. 2015). 35 Mollet III (Soler et al. 2013). 36 Nerja (Solutrean levels) (Turbón et al. 1994; Lalueza Fox 1995). 37 Tito Bustillo (Garralda 1976). 38 Cueva de los Torrejones (Arribas et al. 1995)

navicular from Cueva de los Torrejones. The late Neandertal or Mousterian survival evidence southern to the Ebro River in the Iberian Peninsula well-dated by the ultrafiltration method ends more than 40–42 ka ago (Kehl et al. 2013; Wood et al. 2013; Higham et al. 2014), and the oldest evidence of Upper Paleolithic sites (Gravettian) inside the Iberian Peninsula is around 25–26 ka in Peña Capón (Guadalajara, Spain) site (Alcaraz-Castaño et al. 2013, 2017; Alcaraz-Castaño 2015), which could indicate a long period with no evidence of human presence inland on the Iberian Peninsula. All of these reasons make this navicular from Cueva de los Torrejones the only Paleolithic *H. sapiens* fossil found in the inner Iberian Peninsula known to date.

Due to the scarcity of the archeological record for the Upper Paleolithic inland Iberia, any data about the peopling

of the inner Iberian Peninsula during the Upper Paleolithic by *H. sapiens* offers a very good opportunity to ascertain and understand the peopling of South Europe peninsulas and the dynamics of these hunter-gatherer populations from the Late Pleistocene.

The presence of hominin remains within Iberian Peninsula, especially in the South and North Plateaus and the Sistema Central mountain range region, is quite infrequent (Fig. 5), consisting of a few fragmentary Neandertal remains, which are usually accumulated by carnivores (Basabe 1973b; Quam et al. 2001; Arsuaga et al. 2012a). Although there are a few Upper Paleolithic sites inland on the Iberian Peninsula (Estrada García et al. 1992; Alcolea González et al. 1995; Alcaraz-Castaño 2015; Alcaraz-Castaño et al. 2013, 2015a; Trivedra et al. 2016; Alcaraz-Castaño et al. 2017), Upper

Paleolithic hominin remains in this region were absent up to now. It is noticeable that in the Cueva del Turismo, also in the village of Tamajón (Guadalajara), several Paleolithic paintings have been discovered (Alcolea González et al. 1995), which confirms the presence of Upper Paleolithic humans in this area. This new anthropological revision of the navicular from Cueva de los Torrejones has allowed us to identify the first *H. sapiens* fossil that is found far from the coast in this South European Peninsula. This question reopens the debate regarding whether the scarcity of Upper Paleolithic human fossils outside of coastal margins is due to the absence of occupation of this region and its causes (paleoecological, climatic, etc.) or if the shortage of archeological record is due to the scarcity of archeological research studies in the region.

On the other hand, it is remarkable that proper burials are very rare in the Iberian Peninsula for both Neandertals and modern humans. There are only two well-documented cases for *H. sapiens*: the Magdalenian burial from El Mirón (Geiling and Marín-Arroyo 2015; Marín-Arroyo 2015; Straus et al. 2015) and the Gravettian Burial of Lagar Velho (Duarte et al. 1999). The Torrejones navicular does not show evidence of carnivore activity, and the origin of its deposition is an incognita. The new perspective provided by the Torrejones cave fossil offers a hopeful panorama of new findings and, hopefully, mortuary practices that could allow for a better understanding of the occupations of inland Iberia during the Upper Paleolithic.

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