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ORIGINAL PAPER

Anthropic resource exploitation and use of the territory at the onset of social complexity in the Neolithic-Chalcolithic Western Pyrenees: a multi-isotope approach

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Abstract

Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope analyses from bone collagen provide information about the dietary protein input, while strontium isotopes ($^{87}Sr/^{86}Sr$) from tooth enamel give us data about provenance and potential territorial mobility of past populations. To date, isotopic results on the prehistory of the Western Pyrenees are scarce. In this article, we report human and faunal values of the mentioned isotopes from the Early-Middle Neolithic site of Fuente Hoz (Anuntzeta) and the Late Neolithic/Early Chalcolithic site of Kurtzebide (Letona, Zigoitia). The main objectives of this work are to analyse the dietary and territorial mobility patterns of these populations. Furthermore, as an additional aim, we will try to discuss social ranking based on the isotope data and existing literature on this topic in the region of study. Our results show that, based on the bioavailable Sr values, both purported local and non-local humans were buried together at the sites. Additionally, they suggest similar resource consumption based on C_3 terrestrial resources (i.e. ovicaprids, bovids, and suids) as the main part of the protein input. Overall, this study sheds light on how individuals from different backgrounds were still buried together and shared the same "dietary lifestyle" at a time in the Prehistory of Iberia when social complexities started to appear.

Keywords Carbon, nitrogen, and strontium isotopes · Diet · Provenance · Territorial mobility · Neolithic · Chalcolithic · Iberian Peninsula

Introduction

Information about different dietary patterns has been widely debated in Northern Iberia, especially focused on the Mesolithic/Neolithic transition (e.g. Arias 2005). However, there is less literature on alimentation at post-Neolithic archaeological sites. One of the main reasons could be the scarcity of faunal remains available at funerary sites dated to those periods (Ontañón 2003). Additionally, other studies, such as those related to the material culture (lithic industries, the presence of materials used in farming, use-wear analyses, etc.), show the important role of plant foods, both in hunter-gatherer and agropastoralist diets. Unfortunately, these types of remains usually appear only in an indirect way (Zapata 2002).

Regarding the mobility of prehistoric groups, the dialectic about the use of megalithic chambered tombs and burial caves related to territorial patterns has been studied in detail (De Carlos-Izquierdo 1988). One of the traditional theories is based on the possibility that people buried of both local and non-local origin were buried together (Edeso-Fito and Mujika-Alustiza 2012). Megalithism is one of the most relevant characteristics of post-Neolithic funerary practices in Western Europe. However, in the last decades, it has been shown that this monumental phenomenon was not exclusive, but individuals in this period

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used other sites for burials, such as caves or rock shelters (Ontañón and Armendariz 2005–2006). This casuistry has caused great interest in an attempt to explain possible differences among the individuals buried in the megalithic monuments and those found in caves or rock shelters. In the case of Northern Iberia, a slight overlap has been observed between the two funerary practices (Fernández-Crespo and Schulting 2017), suggesting a new hypothesis of territoriality and social ranking.

Prehistoric human remains from few archaeological sites have been analysed isotopically so far in Northern Iberia (Fig. 1). The most significant studies have been carried out in J3 (Arias 2005), Ondarre (Fernández-Crespo et al. 2016), Pico Ramos and Santimamiñe (Sarasketa-Gartzia et al. 2017), as well as La Poza l'Egua, Colomba, and Los Canes in Asturias, and Cotero de la Mina and La Garma A in Cantabria (Arias 2005). Elsewhere in Iberia, analyses have been carried out in Atlantic Iberia (e.g. Fontanals-Coll et al. 2016; Guiry et al. 2015; López-Costas et al. 2015), the Ebro Valley (e.g. Fernández-Crespo and Schulting 2017; Villalba-Mouco et al. 2017), Central Iberia (e.g. Alt et al. 2016; Salazar-García et al. 2013), and Mediterranean Iberia (e.g. Fontanals-Coll et al. 2015; Salazar-García et al. 2018).

Within the double aims of this research, firstly, we use isotope ratio analyses of carbon (δ^{13}C) and nitrogen (δ^{15}N) in archaeological bone collagen in order to investigate past human diet (e.g. Le Bras-Goude 2011). Secondly, we use strontium isotope ratios (^{87}Sr/^{86}Sr) from tooth enamel to obtain potential information on where the analysed individuals spent their time during the formation of the specific dental piece studied (e.g. Bentley 2006).

Therefore, our study has three main goals: (1) to evaluate Neolithic and Chalcolithic dietary patterns; (2) to assess territorial mobility in Northern Iberia within a diachronic perspective; and (3) to evaluate possible differences among the individuals buried in caves or rock shelters and those found in megalithic monuments. For this, we have analysed both human and faunal remains from two archaeological sites in the Basque Country in the Western Pyrenees: Fuente Hoz, dated in the Early-Middle Neolithic (Anuntzeta, Araba-Álava), and Kurtzebide, corresponding to the Late Neolithic/Early Chalcolithic (Letona, Zigoitia, Araba-Álava). Finally, the new results from this study, together with other published data, are used to discuss the dialectic proposed by some authors regarding possible social ranking at the end of the Late Neolithic/Early Chalcolithic (Fernández-Crespo and Schulting 2017).

Archaeological site description

Both of the analysed sites are located in the Basque province of Araba. Both consist only of diachronic burial levels, but with a different burial structure. Fuente Hoz is a small funerary cave, and Kurtzebide is a megalithic chambered tomb.

Fuente Hoz

Fuente Hoz is a small cave situated at 620 m.a.s.l. and less than 100 m away from Pobes village (Anuntzeta, Araba). Geographically, the site is located in the basin formed by the Baias River, which rises on the southern slope of Gorbea Mountain and joins the River Ebro at Miranda de Ebro. Fuente Hoz was discovered by F. Murga in 1979. In 1980, some members of the *Instituto Alavés de Arqueología* sifted the sediment from the demolition that affected the site. The first materials obtained were mainly lithic industries, a pottery fragment, and some badly preserved faunal remains (Baldeón 1983). Unfortunately, the extension of the original archaeological site remains unknown due to the mentioned demolition destroying a part of it. Dated to the Early-Middle Neolithic, the site has two levels (I and II).

The first one is divided into two sublayers (Fig. 2): (Ia) characterised by the amount of lithic industry (flint mainly) and two Neolithic burial levels (first level with MNI = 2; second level with MNI = 3) and (Ib) also characterised by the large amount of flint and the third Neolithic burial level (MNI = 1) (Baldeón et al. 1983:45). However, in the anthropological study, a MNI of 9 was determined (Basabe and Bennassar 1983: 78), but without specifying their levels.

The second level yielded a flint assemblage and was attributed to the Neolithic (Baldeón et al. 1983). Besides the human and faunal remains, more than 600 lithic pieces of wide typological variability were found; flint was the main raw material together with a few rock crystal and quartzite pieces. The flint tools include the following: micro burins, bordée micro blades, blacked blades, retouched flakes, triangles, trapeziums, and arrowheads. Some 65 very small potsherds were recovered, making it possible only to reconstruct partially an ovoid open pot. Three pieces of retouched bones were also found: two of them probably spatulas and the other an awl. Finally, a small limestone pendant was recorded (Baldeón et al. 1983). The archaeological assemblages found, together with the three available radiocarbon dates, suggest an Early-Middle Neolithic chronology.

Kurtzebide

Kurtzebide archaeological site is located in Letona, Zigoitia (Araba), on the northeast border of the Arrato mountain range. The megalith, at 570 m.a.s.l., is on the upper right edge of a depression created by the sediments of the Zaia River. F. Murga reported the discovery of the site in 1977 when he realised that there were some slabs forming the tumulus near the road from Vitoria-Gasteiz to Murgia. He collected some materials from among the slabs and deposited them in the

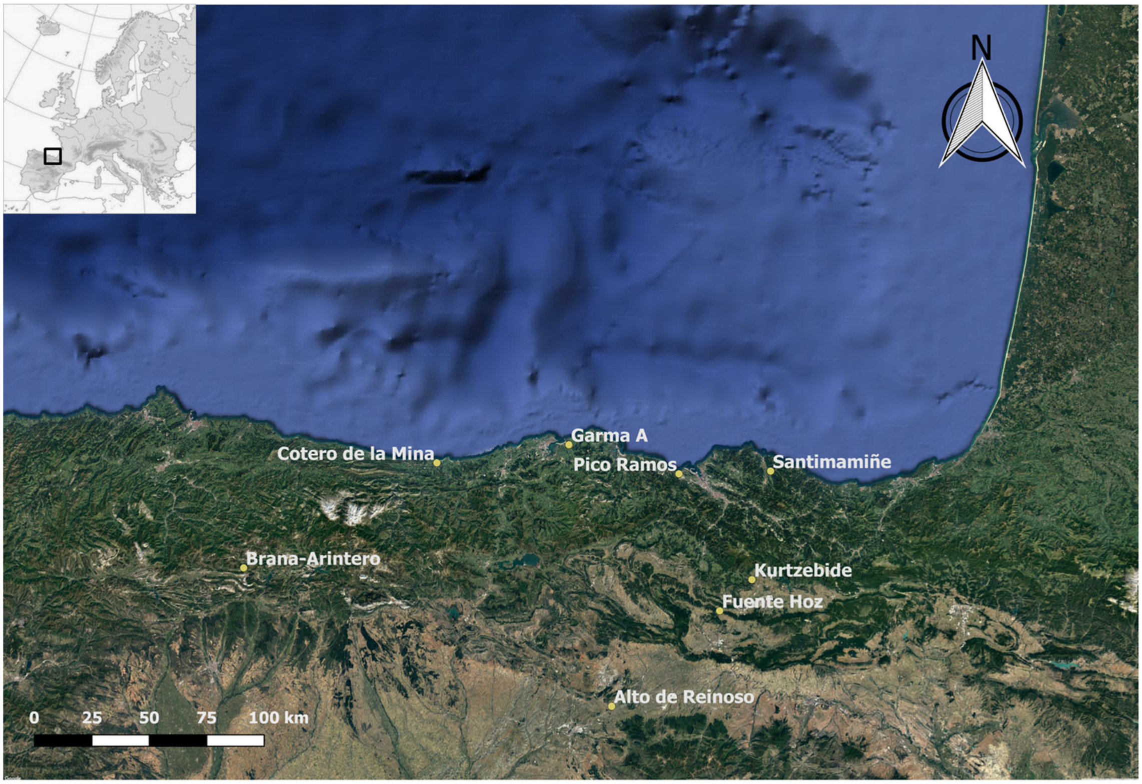

Fig. 1 Location of the archaeological sites analysed and mentioned in the text from the area of study

Museo Provincial de Álava. As a result of the imminent works on the road (A-68), in 1978, an emergency excavation was initiated. The site was divided into four sections according to the cardinal points north-south and east-west. After that, it was seen that what at first had seemed to be bedrock was, actually, a big fallen slab. The sequence consisted of three depositional layers dated to the Late Neolithic/Early-Middle Chalcolithic period (Table 1). The most recent layer was characterised by some rocks without any order. The second layer was defined by loose stones and without archaeological materials. The third layer was the actual archaeological deposit, and it is in this layer that faunal and all the human remains (MNI = 6) were found (Vegas 1981). Apart from the human and faunal remains, which will be explained later, some microfauna and lithic remains were recovered. Out of 117 flint pieces, only 25 were retouched; for example, six triangles, one trapezoid, one arrowhead, and five blades. In the bone assemblage, two pieces of an ovicaprid tibia were associated with an idol typology. Additionally, a green pendant, a total of 111 slate beads, several remains of sandstone, rock crystal, and a perforated and smoothed jet object were found (Vegas 1981). Finally, potsherds came from different parts of the pots: rims, necks, bodies, and bases, including two pieces with impressed decorations. All these materials, together with the radiocarbon date, point to a Late Neolithic/Early-Middle Chalcolithic chronology.

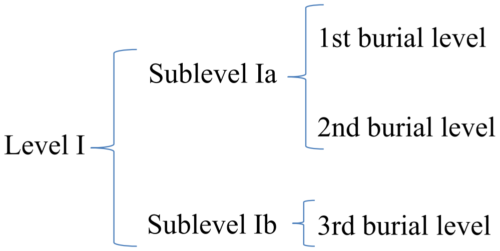

Fig. 2 Organisation of burial levels in Fuente Hoz (modified from Baldeón et al. 1983)

Isotopic studies

Carbon and nitrogen analysis

The stable isotope ratios of carbon and nitrogen have proved to be a useful tool to reconstruct past dietary patterns (e.g. Makarewicz and Sealy 2015). This method is based on the premise that “we are what we eat” (DeNiro and Epstein 1978, 1981; Schoeninger and DeNiro 1984), meaning that the analysed human tissues reflect the values of the consumed resources after a predictable isotopic fractionation (δ^{13}C values vary between ca. 0 and 1‰ and the δ^{15}N values increase between ca. 3 and 5‰ from food to consumer) (Schoeller 1999). Several recent studies, however, suggest the increase of nitrogen stable isotope ratio values through

Table 1 Radiocarbon dates from Kurtzebide and Fuente Hoz archaeological sites. Calibrated using OxCal v4.2.4 (Bronk Ramsey and Lee 2013) and IntCal 13 atmospheric curve (Reimer et al. 2013)

Archaeological site	Level	Lab code	Chronology	^{14}C age BP	CalBP (2σ) data	Material	Reference
Fuente Hoz	II level	I-12,084	Early Neolithic	6120 ± 280	6669–7278	Bone	Baldeón et al. 1983
Fuente Hoz	Ib level (3rd burial level)	I-11,589	Middle Neolithic	5240 ± 110	5908–6167	Bone	Baldeón et al. 1983
Fuente Hoz	Ia level (2nd burial level)	I-11,588	Middle Neolithic	5160 ± 110	5778–6088	Bone	Baldeón et al. 1983
Kurtzebide	3rd level	I-10,826	Late Neolithic-Chalcolithic	4445 ± 95	4939–5247	Bone	Vegas 1981

fractionation could be higher (Hedges and Reynard 2007; O'Connell et al. 2012). Although other skeletal substrates, such as bone apatite (e.g. Tieszen and Fagre 1993) and dental calculus (e.g. Salazar-García et al. 2014b), have been used and evaluated as dietary markers, collagen is still the preferred material for this type of analysis since it allows both isotopes to be studied and has internationally accepted quality controls to evaluate the degree of diagenesis (e.g. Van Klinken 1999).

The $\delta^{13}C$ is related to the carbon bio-geo-chemical cycle, discriminating between C_3 and C_4 plants (Van der Merwe 1982). However, for the chronology and geographical zone of study, C_4 plants were almost non-existent. This is because this type of plant is mainly from tropical ecosystems (Vogel and Van der Merwe 1977). Since the weather in the region is defined as oceanic (López-Davalillo 2014), carbon isotope ratio analysis is mainly useful for discriminating the consumption of terrestrial and marine resources (e.g. Arias 2005). Also, in this context, it must be noted that consumption of brackish and estuarine fish could yield lower $\delta^{13}C$ values than expected as observed in Mediterranean prehistoric sites (Salazar-García et al. 2014a). On the other hand, $\delta^{15}N$ values vary depending on the complexity of the trophic chain (DeNiro and Epstein 1981). Marine ecosystems tend to display more complex trophic level arrangements than terrestrial ones and therefore are related to overall higher levels of $\delta^{15}N$ (Minawaga and Wada 1984).

For a better interpretation of isotopic results, we must take into consideration several issues. Firstly, since carbon and nitrogen values of bone collagen reflect dietary protein input, we must acknowledge that plant consumption is usually masked by meat consumption due to the significant different amount of absorbable proteins in the tissues (Richards et al. 2003). Secondly, in the case of infantile remains, nitrogen values could be higher because of a breast-feeding and weaning effect (Fuller et al. 2004). Finally, stable isotope results on bone collagen reflect diet in the last years of an individual's life, with the average time varying according to the bone element used in the analyses (Hedges et al. 2007).

Strontium isotopes

Strontium isotope ratio analyses of archaeological enamel have provided useful results by characterising past animal migrations (e.g. Britton et al. 2009), human provenance (e.g. Strauss et al. 2015), and territorial mobility patterns (e.g. Goude et al. 2012). Strontium isotope ratio values depend on the isotopic proportions (^{87}Sr to ^{86}Sr) existing in different geological areas (Copeland et al. 2010). The ^{87}Sr in rock is derived from the decomposition of rubidium (^{87}Rb), and more ancient rocks display higher levels of ^{87}Sr as a result of ^{87}Rb decomposition. Taking this process into account, the values of $^{87}Sr/^{86}Sr$ vary in each geological zone on Earth (between 0.700 and 0.750) (Bentley 2006). These ratios are conveyed by the weathering of rock, through the soil, into the food chain and, ultimately, into human tissues (in this case tooth enamel), with minimal isotopic fractionation.

Tooth enamel was used in this study because there is no remodelling once formed, and because it is more resistant to Sr diagenetic incorporation than other skeletal tissues (Bentley and Knipper 2005). This allows the possibility of tracking individual mobility during time, by analysing enamel from different teeth with a well-known development and eruption time pattern (Hillson 1996). Effects such as weathering, sea spray effect, hydrological cycles, biopurification, and diagenesis will also affect the ultimate bioavailable Sr ratio in a specific location and should be thus considered when designing the geological sampling strategy and discussing the interpretation (Bentley 2006; Slovak and Paytan 2012). In the same way, the bioavailable strontium data have been obtained with the aim of determining the strontium isotopic ratio in each area that is directly available for consumption (Price et al. 2002). Thanks to the mentioned incorporation of the bioavailable strontium values in humans during enamel mineralisation, this information can be used to provide evidence about provenance and territorial mobility, based on the idea of matching the isotopic signatures from an individual to the biologically-available signature at a suspected location of origin.

Materials and methods

Archaeological remains from Fuente Hoz and Kurtzebide

Different sampling strategies have been followed according to the different methodologies carried out in this study. For carbon and nitrogen isotope ratio analysis, human bones from Fuente Hoz ($n = 7$) and Kurtzebide ($n = 10$), as well as faunal remains (two *Cervus elaphus* from Fuente Hoz and one Ovicapridae from Kurtzebide) were sampled. For strontium isotope ratio analysis, M2 enamel from human teeth also from these two sites ($n = 7$ and $n = 8$ respectively) was sampled.

At Fuente Hoz, even though there are no complete skeletal pieces due to explosions during the road works, the anthropological study provided more details and was more helpful for designing the sampling strategy (Basabe and Bennassar 1983). A MNI of 9 was established taking into account the most abundant bones (humerus, radius, and femur). However, for this study, and in order to have a secure association of teeth and bones analysed from same individuals, we have only sampled skulls and their associated mandibles (Fig. 3). This way, C, N, and Sr isotope ratio values were obtained for each individual.

In the case of Kurtzebide, the MNI is 6 (Vegas 1981): five adults and one child. Because of the poor preservation of the remains as well as the fact that they were all comingled, it was decided to sample more bones than the 6 MNI from different parts of the tumulus and the cist to potentially avoid as far as possible the duplicity of values from same individuals.

To determine the range of bioavailable strontium from the immediate surroundings of both sites, 20 samples of modern plants and snails (Table 2) were collected. Both modern plants and snail shells (*Helix aspersa*) were analysed to average the local bioavailable strontium from two different materials in order to avoid potential discrepancies (e.g. Evans et al. 2009; Maurer et al. 2012). For Fuente Hoz, we sampled *Quercus ilex*, *Pinaceae*, *Rosaceae*, *Thymus*, and *Poaceae*. At Kurtzebide, the plants taken were *Q. ilex*, *Pinaceae*, *Rosaceae*, *Juniperus*, and *Poaceae*. The selection of herbs, bushes, and trees aimed to determine the real average, due to the different depths of their roots and therefore the different water intake and bedrock perforation.

Fig. 3 Example of Fuente Hoz mandible sample

Bone sample preparation and CN isotope ratio analysis

Bone collagen extraction and analysis were carried out at the isotope-dedicated facilities of the University of Cape Town (South Africa). Firstly, between 300 and 500 mg of bone chunks were sampled and superficial contaminants were removed by mechanical abrasion. After this, collagen extraction proceeded following the Longin method (Longin 1971). This method has been modified by Brown et al. (1988) with an additional ultrafiltration step (Salazar-García et al. 2014a): (1) Each sample was demineralised in 0.5M HCl solution at 5 °C; (2) samples were rinsed with deionised water until pH became neutral; (3) samples were gelatinized using a heater block (FMH instruments, South Africa) at 70 °C during 48 h; (4) samples were filtered with 5-mm Ezee-filters (Elkay, UK) and ultrafiltered using > 30-kDa Amicon ultrafilters (Amicon, Germany) in a centrifuge (Thermo Fisher Megafuge 16, USA) at 2500 rpm; and (5) the solution was frozen and lyophilized. Once the collagen was extracted, ca. 0.5 mg was weighed into tin capsules and run in the mass spectrometers. All samples were analysed in duplicate (standard deviation among duplicate samples for carbon and nitrogen and among the repetitive measurements of in-house and international standards [1σ] < 0.1‰), using a Delta plus XP continuous-flow isotope ratio mass spectrometer (Thermo Fisher Scientific, USA) after being combusted in a Flash EA 1112 elemental analyser that was interfaced with it (Thermo-Finnigan, USA). Repeated analysis of internal and international standards determined an analytical error better than 0.1‰ [1σ] for $\delta^{13}C$ and $\delta^{15}N$. Stable carbon isotope ratios were expressed relative to the VPDB scale (Vienna PeeDee Belemnite), and stable nitrogen isotope ratios were measured relative to the AIR scale (atmospheric N_2), using the delta notation (δ) in parts per thousand (‰).

Enamel and modern sample preparation and Sr isotope ratio analysis

All the samples presented here were prepared and analysed at the isotope-dedicated facilities of the University of Cape Town (South Africa). Depending on the type of material, the sample preparation process was different:

(1) Modern snail shells were manually cleaned (using distilled water and disposable brushes) to remove possible contamination agents, before ultrasonication with Milli-Q water. Then, they were taken in Eppendorf tubes to the specific clean chemistry laboratory for the digestion process: ca. 25–50 mg of each sample was taken and placed in 7-ml Teflon beakers, adding 2 ml of 65% HNO_3. These were left on a hot plate at 140 °C overnight. After that, 1-ml 2-M HNO_3 was added and they were again placed on the hot plate at the same temperature.

Table 2 Carbon and nitrogen isotopes results for Fuente Hoz and Kurtzebide. $\delta^{13}C$ ‰ and $\delta^{15}N$ ‰ mean values and collagen quality parameters (%C, %N, and C:N) of the two measurements analysed for each sample. List of fossil and modern analysed samples from Fuente Hoz and Kurtzebide with $^{87}Sr/^{86}Sr$ results. Concentrations have been only made in fossil samples to check the state of preservation

Archaeological site	Chronology	Bone sample (S-UCT)	Species[b]	Inventory number (bone sample)	Bone type	Corresponding enamel sample (S-UCT)	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰	% C	%N	C:N
Fuente Hoz	Early-Middle Neolithic	18652	Human (male, 20 years)	FH. Skull 1 (Sublayer Ia)	Long bone	18225	− 19.9	8.5	36.4	12.3	3.5
Fuente Hoz	Early-Middle Neolithic	18653	Human (male, 40 years)	FH. N1. Z38. A2. C3 (Sublayer Ia)	Mandible	18219	− 19.6	9.3	35.2	12.1	3.4
Fuente Hoz	Early-Middle Neolithic	18654	Human (possible female, 20 years)	FH. Z7. N1. L3 (Sublayer Ia)	Long bone	18224	− 19.5	9	41.2	14	3.4
Fuente Hoz	Early-Middle Neolithic	18655	Human (male, 40 years)	FH. N1. A2. C4 (Sublayer Ia)	Skull	18221	− 19.8	8.3	40.5	14.1	3.4
Fuente Hoz	Early-Middle Neolithic	18656	Human (male, 40 years)	FH. Z2.N1.L2 (Sublayer Ia)	Rib	18220	− 20	9.4	30	10	3.5
Fuente Hoz	Early-Middle Neolithic	18657	Human (male, 20 years)	FH. Z2.N1.Z50 (Sublayer Ia)	Skull	18223	− 19.5	9.5	43.4	15.1	3.4
Fuente Hoz	Early-Middle Neolithic	18658	Human (male, 20 years)	FH. A2.N1.110. 64 (Sublayer Ib)	Vertebra	18222	− 19.6	9.3	39.8	14.2	3.3
Kurtzebide	Late Neolithic-Chalcolithic	18642	Human (> 20 years)	TBI.15A	Mandible	18228	− 19.9	8.4	38.6	13.5	3.3
Kurtzebide	Late Neolithic- Chalcolithic	18643	Human (> 20 years)	TBI.42B	Mandible	18231	− 19.8	9	40.3	14.3	3.3
Kurtzebide	Late Neolithic- Chalcolithic	18644	Human (> 20 years)	TBI.51	Rib	18232	− 20.3	9.4	40.4	13.9	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18645	Human (> 20 years)	TBI.58	Rib	18233	− 20.1	9.1	42.5	14.8	3.3
Kurtzebide	Late Neolithic- Chalcolithic	18646	Human (> 20 years)	TBI.64	Rib	–	− 20.1	8.7	38.5	13.2	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18647	Human (> 20 years)	TBI.11	Rib	18226	− 20	9	38.1	13.3	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18648	Human (> 20 years)	TBI.18	Rib	18230	− 20	9	40.7	14.4	3.3
Kurtzebide	Late Neolithic- Chalcolithic	18649	Human (> 20 years)	TBI.49	Skull	–	− 20.3	8.6	32.2	11.2	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18650	Human (> 20 years)	TBI.16	Vertebra	18229	− 19.9	9.4	41.3	14.4	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18651	Human (> 20 years)	TBI.14	Skull	18227	− 20	8.7	38.6	13.7	3.3
Fuente Hoz	Early-Middle Neolithic	18659[a]	*Cervus elaphus*	FH. A2.N1.I8.228. L1. 11	Long bone	–	− 20.9	3.6	29.7	9.2	3.8
Fuente Hoz	Early-Middle Neolithic	18660	*Cervus elaphus*	FH. Z2. L8. 616. L1.11	Long bone	–	− 20.3	4.5	40.8	13.9	3.4
Kurtzebide	Late Neolithic- Chalcolithic	18641	Ovicapridae	TBI.54	Mandible	–	− 21.1	2.3	41.6	14.5	3.4

Site	Sample (S-UCT)	Material	$^{87}Sr/^{86}Sr$	Sr concentration (ppm)	$^{84}Sr/^{86}Sr$	Sr (V)
Fuente Hoz	18078	*Quercus ilex*	0.70800	–	0.05654	7.6
Fuente Hoz	18079	*Pinaceae*	0.70878	–	0.05654	7.8
Fuente Hoz	18080	*Rosaceae*	0.70826	–	0.05657	8.1
Fuente Hoz	18081	*Thymus*	0.70816	–	0.05650	8.2
Fuente Hoz	18082	*Poaceae*	0.70801	–	0.05654	8.9
Fuente Hoz	18179	*Helix aspersa*	0.70761	–	0.05661	8
Fuente Hoz	18180	*Helix aspersa*	0.70763	–	0.05659	8.9
Fuente Hoz	18181	*Helix aspersa*	0.70764	–	0.05658	10.1
Fuente Hoz	18182	*Helix aspersa*	0.70768	–	0.05655	9.4
Fuente Hoz	18183	*Helix aspersa*	0.70754	–	0.05655	9.7
Fuente Hoz	18219	*Homo sapiens*-M2	0.71142	96.7	0.05654	6.9

Table 2 (continued)

Fuente Hoz	18220	*Homo sapiens*-M2	0.70787	156.1	0.05656	10.3
Fuente Hoz	18221	*Homo sapiens*-M2	0.71217	123.6	0.05658	8
Fuente Hoz	18222	*Homo sapiens*-M2	0.70830	203.8	0.05653	8
Fuente Hoz	18223	*Homo sapiens*-M2	0.70869	256.4	0.05655	9.1
Fuente Hoz	18224	*Homo sapiens*-M2	0.70829	265.6	0.05655	9.2
Fuente Hoz	18225	*Homo sapiens*-M2	0.71164	89.9	0.05658	8.1
Kurtzebide	18083	*Quercus ilex*	0.70775	–	0.05657	9.7
Kurtzebide	18084	*Pinaceae*	0.70761	–	0.05656	7.5
Kurtzebide	18085	*Rosaceae*	0.70769	–	0.05655	8.2
Kurtzebide	18086	*Juniperus*	0.70773	–	0.05656	7.4
Kurtzebide	18087	*Poaceae*	0.70787	–	0.05647	8.5
Kurtzebide	18184	*Helix aspersa*	0.70755	–	0.05655	8.2
Kurtzebide	18185	*Helix aspersa*	0.70752	–	0.05655	7.8
Kurtzebide	18186	*Helix aspersa*	0.70751	–	0.05651	7.7
Kurtzebide	18187	*Helix aspersa*	0.70749	–	0.05658	6.6
Kurtzebide	18188	*Helix aspersa*	0.70754	–	0.05658	9.4
Kurtzebide	18226	*Homo sapiens*-M2	0.70977	119	0.05658	7.7
Kurtzebide	18227	*Homo sapiens*-M2	0.70824	140.3	0.05658	7.7
Kurtzebide	18228	*Homo sapiens*-M2	0.70844	142.4	0.05654	7.9
Kurtzebide	18229	*Homo sapiens*-M2	0.70831	175.3	0.05658	8.7
Kurtzebide	18230	*Homo sapiens*-M2	0.70899	148.8	0.05657	8.1
Kurtzebide	18231	*Homo sapiens*-M2	0.70887	81.6	0.05656	7.9
Kurtzebide	18232	*Homo sapiens*-M2	0.70836	122.9	0.05656	8
Kurtzebide	18233	*Homo sapiens*-M2	0.70800	124.6	0.05655	6.5

[a] Sample not meeting quality standards

[b] The anthropological information of Kurtzebide was obtained from Vegas (1981). Due to the bad preservation of the remains, it has been concluded that all the samples correspond to individuals of more than 20 years without sex determination, with the exception of an individual of 8–9 years. In the case of Fuente Hoz, human remains have been obtained following the research carried out by Basabe and Bennassar (1983)

Finally, 2-ml 2-M HNO_3 was added and, from this solution, 1.5-ml was centrifuged for 20 min at 4000 rpm in centrifuge tubes. This 1.5-ml sample was the solution used to isolate the strontium, through chemical separation using 0.2 ml of Sr. Spec resin in Bio-Spin Disposable Chromatography Bio-Rad columns according to the method of Pin et al. (1994).

(2) The process to prepare plants was similar. Firstly, they were ashed (e.g. Copeland et al. 2016; Salazar-García 2011; Snoeck et al. 2016); each sample was crushed and placed in ceramic bowls, which were placed in a muffle furnace at 650 °C. Resultant ashes were carried to the previously mentioned clean laboratory, where they were weighed in 7-ml Teflon beakers and dissolved in 2 ml of a 3:1 mixture of 48% HF and 65% HNO_3 for 48 h at 140 °C. After digestion, the solution was dried down and redissolved in 1 ml of 65% HNO_3. The next steps were the same as those followed to process the snail shells, beginning with the overnight evaporation of the acid at 140 °C.

(3) Archaeological human enamel samples were taken after the tooth surface was cleaned using a Dremmel-tool fitted with a diamond-polishing head that was cleaned with Milli-Q water and an ultrasound bath after each use. Then, a diamond saw was used to take ca. 20 mg of enamel chunk from the upside to the downside, in order to sample the average of the mineralisation time of the tooth enamel, removing all dentine attached to it. This was then digested in HNO_3, and the Sr concentration levels were calculated to check for any possible diagenesis contamination. After that, the samples were analysed following the same method as described above (Pin et al. 1994), starting by adding 2 ml of 65% HNO_3.

The separated strontium fraction for each sample was dried down, dissolved in 2-ml 0.2% HNO_3, and diluted to 200-ppb Sr concentrations for isotope analysis using a Nu Instruments NuPlasma HR MC-ICP-MS. Analyses were referenced to bracketing analyses of NIST (National Institute of Standards and Technology, Gaithersburg, MD, USA) SRM987, using an $^{87}Sr/^{86}Sr$ reference value of 0.710255. All strontium isotope data are corrected for isobaric rubidium interference at mass 87 using the measured signal for ^{85}Rb and the natural $^{85}Rb/^{87}Rb$ ratio. Instrumental mass fractionation was corrected using the measured $^{86}Sr/^{88}Sr$ ratio and the exponential law and a true $^{86}Sr/^{88}Sr$ value of 0.1194. Results for repeat analyses of an in-house carbonate standard processed and measured with the batches of unknown samples in this study ($^{87}Sr/^{86}Sr$ 0.70894; 2 sigma 0.00004; $n = 33$) are in agreement with long-term results for this in-house standard ($^{87}Sr/^{86}Sr$ 0.70892; 2 sigma 0.00005; $n = 125$).

Results

Carbon and nitrogen isotope ratio results

The stable isotope ratio analysis results ($\delta^{13}C$, $\delta^{15}N$, %C, %N, C:N) of human and faunal remains from the sites of Fuente Hoz and Kurtzebide are shown in Table 2.

Fuente Hoz

It was possible to analyse the > 30-kDa collagen fraction from all samples ($n = 7$ humans, $n = 2$ faunal remains). Enough good quality collagen was obtained from all human samples to analyse them in duplicate. One faunal remain yielded enough collagen for only one run, but achieved the quality collagen controls mentioned before (Ambrose 1993; Van Klinken 1999). The other faunal remain (S-UCT 18659) did not meet the collagen quality controls and is therefore omitted from the discussion of the results.

The one acceptable faunal remain belongs to a *Cervus elaphus* ($\delta^{13}C$ of − 20.3‰ and $\delta^{15}N$ of 4.5‰). This value portrays a typical terrestrial C_3 environment. Human sample results gave a mean value of $\delta^{13}C$ of − 19.7 ± 0.2 [1σ] ‰ ($n = 7$, min − 20‰, max − 19.5‰) and $\delta^{15}N$ of 9 ± 0.5 [1σ]‰ (min 8.3‰, max 9.5‰). These values show protein consumption based on C_3 terrestrial resources and situate humans on a higher trophic level than herbivores (ca. 5‰ higher). Unfortunately only two faunal remains were available from the site for sampling, from which only one yielded good collagen for analysis, so the faunal background does not allow for more detailed interpretation of the results.

Kurtzebide

The yield of the > 30kDa collagen fraction was enough for analysis in duplicate of all samples ($n = 10$ humans, $n = 1$ faunal remain). Almost all results met the accepted quality controls for %C, %N, and C:N elemental ratio (Ambrose 1993; Van Klinken 1999).

The faunal remain analysed from Kurtzebide is an herbivore (Ovicapridae). Its values are $\delta^{13}C$ of − 21.1‰ and $\delta^{15}N$ of 2.7‰, showing typical values of a C_3 type terrestrial ecosystem at the herbivore level (e.g. Fontanals-Coll et al. 2015; Van der Merwe and Vogel 1978). The human remains gave a mean $\delta^{13}C$ of − 20 ± 0.3 [1σ]‰ ($n = 10$, min − 20.3‰, max − 19.8‰) and $\delta^{15}N$ of 9.1 ± 0.3 [1σ]‰ (min 8.6‰, max 9.5‰). These data are also in agreement with an overall protein consumption of C_3 terrestrial resources (Fig. 4). The human $\delta^{15}N$ values indicate that humans were on a higher trophic level than the analysed fauna (approximately 6‰ higher than the fauna remain analysed).

Strontium results

The strontium isotope analysis results (^{87}Sr/^{86}Sr, Sr concentration (ppm), ^{84}Sr/^{86}Sr, Sr (V)) of human and modern remains from the sites of Fuente Hoz and Kurtzebide are shown in Table 2.

Fuente Hoz

Fuente Hoz is located in an area with a Cenozoic substrate from the Lower Miocene, and the bedrock consists mainly of calcareous conglomerates with occasional intercalations of calcareous sandstones and siltstones. The bioavailable ^{87}Sr/^{86}Sr values of modern plant samples (n = 5) give a mean of 0.70798 ± 0.00019 [1σ] (min 0.70754, max 0.70878), and those of snail shell samples (n = 5) give a mean of 0.70762 ± 0.00005 [1σ]; overall, the bioavailable Sr range is of 0.70776 ± 0.00022 [1σ] (n = 10). As we can see in Table 2, some of the analysed human individuals (n = 7) have values that fall outside the bioavailable ^{87}Sr/^{86}Sr range. Three of the human individuals (S-UCT 18219, 18221, and 18225) show the highest discrepancy compared to the bioavailable ^{87}Sr/^{86}Sr range. When comparing the average of the humans bioavailable range of 0.70977 ± 0.00188; to these, three samples, they fall outside this range (S-UCT 18220, 18221, 18225).

Kurtzebide

Modern plants and snail shells (n = 10) were collected to calculate the range of bioavailable ^{87}Sr/^{86}Sr in the Upper Cretaceous substrate with bedrock formed by limestone and marly limestone in decametric and metric beds on which the archaeological site is located (Fig. 5). The overall values are of 0.70776 ± 0.00012 [1σ] (min 0.70754, max 0.70787), as shown in Fig. 6 (mean of 0.70772 ± 0.00009 [1σ] for plants, and 0.70751 ± 0.00002 [1σ] for snails). Human enamel (n = 8) values show a range of 0.70862 ± 0.00057. One of the ^{87}Sr/^{86}Sr human values (S-UCT 18226) differs significantly from the mentioned bioavailable range with a ^{87}Sr/^{86}Sr value of 0.70977 (Fig. 6). The results from the other human samples display ^{87}Sr/^{86}Sr values ranging between 0.70800 and 0.70899, with a mean value of 0.70846 ± 0.00035 [1σ]. Using the average of the human values (the range is 0.70862 ± 0.00057) sample S-UCT 18233 falls outside the local range, as well as S-UCT 18226.

Discussion

Bearing in mind that because of archaeological limitations the number of samples is low, the discussion of the data must be made with caution. However, data available from previous studies in nearby regions will be compiled and discussed together with the new results presented here.

The isotopic dietary reconstruction from Fuente Hoz and Kurtzebide shows a homogeneous human protein diet based on C$_3$ terrestrial resources despite chronological and cultural differences between the two sites. All humans analysed are placed clearly on a higher food chain trophic level than the few herbivores analysed (ca. 5–6‰ higher in δ^{15}N). Due to the small number of analysed species and samples, this observed offset should be taken with caution. This difference in δ^{15}N values between the fauna and humans could mean that the latter based their protein diet on terrestrial animals. The low fauna sample number makes it impossible to know whether there were domestic or wild animals, even if for similar chronologies high δ^{15}N human values have been sometimes linked to the consumption of domestic herbivores fed by composted fodder (e.g. Fontanals-Coll et al. 2015; Salazar-García 2011; Villalba-Mouco et al. 2017). However, it could also be partially linked to the consumption of foods with higher nitrogen levels such as crops and legumes grown on land fertilised with animal manure or animals that fed on them (Bogaard et al. 2007). Referring to the landscape, the natural vegetation was greatly disturbed by human activities in the study area from the Neolithic onwards, as shown by the pollen

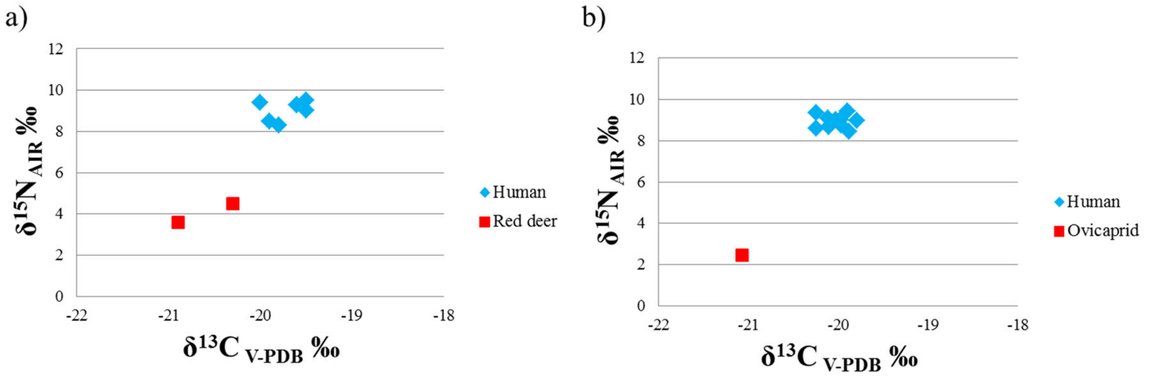

Fig. 4 Plot of carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope ratio values of human and animal remains from (a) Fuente Hoz and (b) Kurtzebide

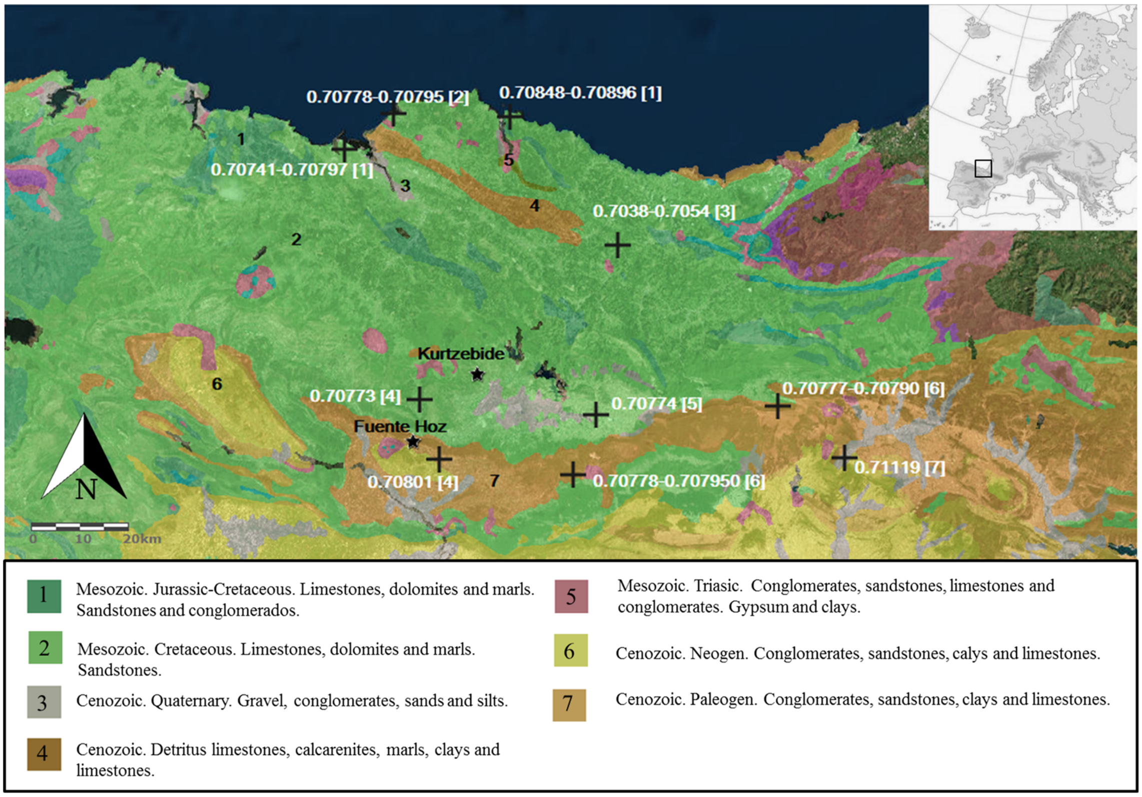

Fig. 5 Geological map of the region of study. The crosses indicate the bioavailable sampling areas, the stars correspond to the archaeological sites of Kurtzebide and Fuente Hoz. (source: mapas.igme.es/gis/services/Cartografia_Geologica)

record (Iriarte-Chiapusso and Zapata 2004). This reflects an open landscape with Mediterranean vegetation (*Quercus* sp. *ilex-coccifera*, *Cupressaceae*, *Oleaceae*) and a progressive fall in humidity, with the presence of the first cultivated species (*Triticum dicoccum* and *Hordeum vulgare*) (Pérez-Obiol et al. 2011).

Zooarchaeology is able to shed a little more light on dietary patterns linked to animal exploitation, as has been done before to complement low numbers of faunal samples in isotope studies (e.g. Fraser et al. 2013). In the case of Fuente Hoz, except for two remains of ovicaprid, all the other faunal remains found in the site were of wild animals. Unfortunately, leaving aside the *Cervus elaphus* sample, all other wild animal remains were burnt and therefore not eligible for the isotope background of the site. Even so, the presence of wild animals suggests that hunting was still important at a time in which

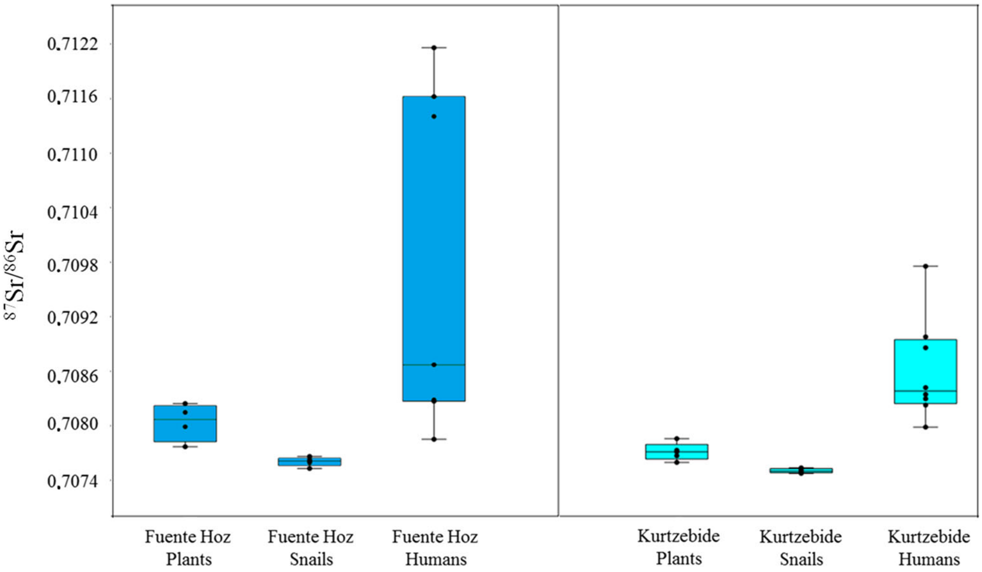

Fig. 6 Plot of strontium isotope ratio (^{87}Sr/^{86}Sr) results for Fuente Hoz and Kurtzebide. Boxes represent median value, 1stand 3rd quartiles; whiskers are 1.5 times the interquartile range

domesticated animals were abundant (Altuna 1980). For Kurtzebide, the situation is not better because only the analysed ovicaprid remain and three *Bos taurus* molars were found at the site (Mariezkurrena 1983; Vegas 1981). Fortunately, in this case, isotopic values of faunal remains are available for the nearby and chronologically contemporary archaeological sites of Los Husos I, Peña Larga, El Sotillo, Alto de la Huesera, and Chabola de la Hechicera. More specifically, results for *Ovis aries*/*Capra hircus* ($n = 11$) (δ^{13}C of -20.6 ± 0.3 [1σ]‰ and δ^{15}N of 5.2 ± 1.3 [1σ]‰), *Bos taurus* ($n = 5$) (δ^{13}C of -20.6 ± 0.5 [1σ]‰ and δ^{15}N of 5.1 ± 1.2 [1σ]), *Cervus elaphus* ($n = 2$) (δ^{13}C of -20.2 ± 0.5 [1σ]‰, and δ^{15}N of 5 ± 2 [1σ]‰), *Sus domesticus* ($n = 4$) (δ^{13}C of -20.6 ± 0.6 [1σ]‰ and δ^{15}N of 5.6 ± 2.5 [1σ]‰), and finally, one *Sus scrofa* sample (δ^{13}C of -20.7‰ and δ^{15}N of 6.7‰) (Fernández-Crespo and Schulting 2017). These results match the δ^{13}C value obtained in the present study, whereas the mean δ^{15}N value of *Ovis aries*/*Capra hircus* is higher than in our study.

Other than roughly discuss diet from a population perspective, little can be said about individual differences among the humans analysed from each site, other than they cluster together quite well. It is not possible to discuss potential slight differences between sexes because of the limited number of sexed individuals (none for Kurtzebide and only a probable female [Basabe and Bennassar 1983] from Fuente Hoz). As regards the age of the individuals, the identified young adults (ca. 20 years) and adults (ca. 40 years) cluster together, although due to the scarce anthropological information further detail is not possible.

Regarding differences between populations at the two sites, non-parametric Mann-Whitney statistical tests show significant differences in δ^{13}C human values between Kurtzebide and Fuente Hoz (p: 0.007), but not in δ^{15}N values (p: 0.567). As these sites are not contemporary to each other, the differences could be a consequence of the different ecosystems in each period rather than the diet, as observed in recent research (Villalba-Mouco et al. 2018). Unfortunately, it is not possible to check this due to the scarce faunal remains. We can only add that the faunal remains at Kurtzebide have lower carbon values, as well as the mean human value (Fig. 4b).

When this new data is compared to previously published data on Neolithic and Chalcolithic humans in Northern Iberia (Fig. 7), it can be observed how they all display a similar isotopic dietary pattern with no evidence of marine protein consumption, as shown in Table 3, even if the sites are close to the Atlantic coast (e.g. Arias 2005; Sarasketa-Gartzia et al. 2017). Likewise, in Atlantic Europe, there is no isotopic evidence of marine resource consumption once the Neolithic period started. The progressive abandonment of marine resources appears even in coastal populations, where there was a marked shift in δ^{13}C to lower values interpreted as a change in dietary pattern, from marine to terrestrial resources, at the onset of the Neolithic (e.g. Bonsall et al. 2002; Schulting and Richards 2002). This trend has been observed in the British Isles (e.g. Richards et al. 2003), Atlantic France (e.g. Le Bras-Goude et al. 2013), Portugal (e.g. Waterman et al. 2016), and Denmark (e.g. Fischer et al. 2007). What has been questioned is whether this shift from Mesolithic to Neolithic diet on the Atlantic seaboard was as sharp and quick as previously thought (Milner et al. 2004).

When combining CN isotope ratio results with Sr isotope results, it is possible to assess archaeological questions other than diet, such as those of provenance. In our case, we can see that some human enamel Sr isotope ratio values differ from most of the studied population and from the immediate bioavailable area around each site. This means that "non-local" individuals spent at least a part of their childhood elsewhere. The geological areas south of the archaeological sites of Kurtzebide and Fuente Hoz correspond to more recent periods, such as the Paleogene, Neogene, and Quaternary (Fig. 5). However, there are older geological areas to the north and west of the sites (Triassic and Jurassic), and we can correlate some of the "non-local" ^{87}Sr/^{86}Sr results (S-UCT 18223, 18229, and 18231) with the bioavailable strontium data obtained previously from the coast of Bizkaia (Sarasketa-Gartzia et al. 2017). On the other hand, it is difficult to specify the possible origins in detail, although the results from the easternmost sampled point show higher strontium values. Additionally, we should take into account the possibility that the number of non-local individuals is higher but undetectable isotopically if they came from regions with the same bioavailable strontium isotope values as those in the immediate surroundings of the site.

The presence of "non-local" individuals, if those with Sr values outside the immediate bioavailable range of the site can be considered "non-local" (Fig. 6), suggests the split of the funerary area from the settlement. This presence of "non-locals" might also mean that several communities living in different settlements shared a common burial space in the Late Neolithic/Chalcolithic (Kurtzebide) and especially in the Early-Middle Neolithic (Fuente Hoz). Whether this was the case or not, the absence of differences in carbon and nitrogen isotope ratio values between "locals" and "non-locals" suggests that there were no main dietary differences and the different communities accessed the same food resources. The burial of non-local individuals together with local people has been a common practice throughout time and space (e.g. Sarasketa-Gartzia et al. 2017; Villalba-Mouco et al. 2017). It is often related to social (e.g. female exogamy; e.g. Schulting 2003) and economic practices (e.g. trade; e.g. Harding and Fokkens 2013), and is not necessarily typical of unstratified or egalitarian societies as seems to be suggested (Fernández-Crespo and Schulting 2017). The interpretation of social hierarchy based only on CN isotope analysis should be considered

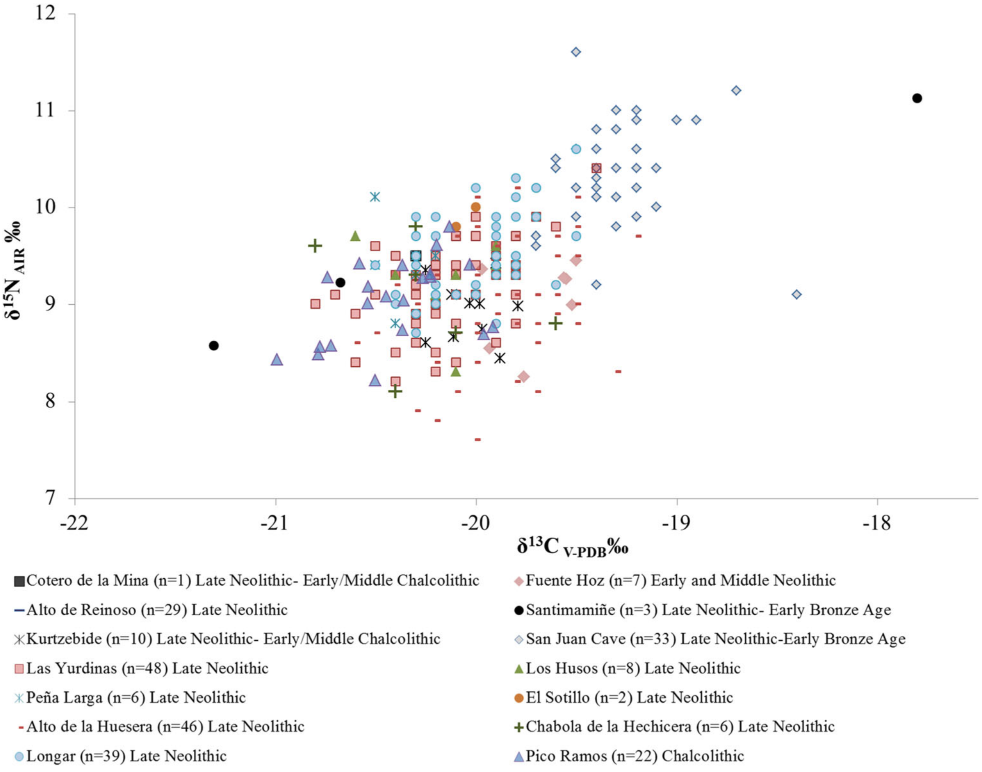

Fig. 7 Plot of carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope ratio values for Northern Iberian archaeological sites (Alt et al. 2016; Arias 2005; Fernández-Crespo and Schulting 2017; Sarasketa-Gartzia et al. 2017; Villalba-Mouco et al. 2017)

with caution, as small differences in the isotopic values could be due to other reasons (different ecosystems, different chronologies, the presence of non-local individuals, etc.) and not necessarily demonstrate social ranking or complexity.

The non-local signatures of these individuals could also be explained by herding practices. Although there is scarce available data for faunal remains and regarding the bioavailable strontium mapping of the region, it is a hypothesis that has to be taken into consideration for further research. For several traditional researchers from the region, such as Pericot (1925) and Barandiaran (1927), nomadic herding, especially transhumance, is as old as domestication itself and started with the origins of the Neolithic in the study area. However, more analyses or methodologies, such as the analysis of the bioavailable strontium and of cattle tooth enamel, and especially of sheep, or the use of Laser Ablation would be of interest to develop this idea (e.g. Copeland et al. 2008; Richards et al. 2008). Another interesting point is the association between herds of cattle and megalithism defended by many researchers and historians in the region (Barandiaran and Manterola 2000). According to Dueso (1987), and taking into account the faunal remains located in Los Husos and Arenaza, herding

Table 3 Carbon and nitrogen human results of Neolithic and Chalcolithic periods in the Northern Iberia region

Archaeological site	Number of samples	δ^{13}C mean value [1σ] ‰	δ^{15}N mean value [1σ] ‰	Reference
Alto Reinoso	29	− 19.6 ± 0.3	9.9 ± 0.4	Alt et al. 2016
Pico Ramos	22	− 20.4 ± 0.3	9 ± 0.4	Sarasketa-Gartzia et al. 2017
Santimamiñe	3	− 19.8 ± 1.5	9.2 ± 1.2	Sarasketa-Gartzia et al. 2017
Cotero de la Mina	1	− 20.3	9.5	Arias 2005
San Juan Cave	33	− 19.3 ± 0.3	10.3 ± 0.6	Villalba-Mouco et al. 2017
Las Yurdinas II	48	− 20.1 ± 0.3	9.2 ± 0.5	Fernández-Crespo and Schulting 2017
Los Husos I	8	− 20.2 ± 0.3	9.2 ± 0.4	Fernández-Crespo and Schulting 2017
Peña Larga	6	− 20.4 ± 0.1	9.4 ± 0.4	Fernández-Crespo and Schulting 2017
El Sotillo	2	− 20 ± 0.1	9.9 ± 0.1	Fernández-Crespo and Schulting 2017
Alto de la Huesera	46	− 19.9 ± 0.3	9 ± 0.6	Fernández-Crespo and Schulting 2017
Chabola de la Hechicera	6	− 20.3 ± 0.4	9.1 ± 0.6	Fernández-Crespo and Schulting 2017
Longar	39	− 20 ± 0.3	9.3 ± 0.6	Fernández-Crespo and Schulting 2017

has existed in the Basque Country, at least, since 2200 B.C. The function of the megalithic monuments has been traditionally linked to mechanisms of topographic mapping to help groups encode the landscape, and it is symbolically indicative of the usufruct of pastures, in connection with the cult of ancestors (Barandiaran 1927). Ethnographic information on herding in the region exists as well as archaeological data (e.g. Barandiaran 1927; Pericot 1925). It is traditionally known that the natural crossing between southern France and Northern Iberia over the Pyrenees was used for transhumance purposes. Some researchers say that the axial zone of the Basque Pyrenees retains in the labyrinth of its valleys some cultural features of a very long tradition (Barandiaran 1953–1957), and that this culture is related to the herding and ranching that was documented in medieval documents regarding the movements of Basque flocks of sheep along the same routes as nowadays (Haristoy 1983). In any case, it is important to emphasise the need to map the region more intensively and carry out serial analyses in faunal teeth to confirm or reject the transhumance hypothesis.

As regards the archaeological implications of this study, the first point that should be taken into account is the regional variability in Iberia that can be observed during the Late Neolithic/Chalcolithic in such aspects as material culture and resource exploitation (Castro et al. 2006; Chapman 1990, 2008; Díaz del Río and García Sanjuan 2006). Some of the most relevant implications are related to the notable demographic growth and agricultural intensification (Delibes 2011; Delibes et al. 1995). While the present text focuses on burial spaces, Late Neolithic settlement sites are virtually unknown in the region. It is currently assumed that groups were quite small and mobile, which would explain the general lack of archaeological evidence of more permanent settlements. However, when they are indeed found, sites are typically defined by clusters of underground features frequently interpreted as storage pits and other domestic facilities (Díaz del Río 2006). In this context, the presence of collective burials is one of the central aspects for understanding social relationships in these societies and the key for interpreting kinship-based societies (Chapman 2008).

Some researchers argue that, during the Chalcolithic, economic intensification and social inequalities emerged and endured for several centuries (e.g. Gilman 1987). Developing the idea of social inequalities, previous studies in the region have suggested the possible existence of a partitioned use of the differential exploitation of the landscape. This differentiation has been based on small differences in δ^{13}C values among the individuals buried in caves and megalithic monuments in the Late Neolithic/Early Chalcolithic (Fernández-Crespo and Schulting 2017). This idea could be related to the theory of a possible higher status of individuals buried in the mentioned megalithic tombs (e.g. Waterman et al. 2016). In the case of Kurtzebide (megalithic burial site) and Fuente Hoz (cave burial site), although they are not coetaneous, they do show significant differences in δ^{13}C but not in δ^{15}N values as seen before. However, although they are still small, bigger differences are observed between the individuals of the same site than between sites. Comparing the Kurtzebide mean values with those from monuments, the δ^{13}C value of $-20.3 \pm 0.2[1\sigma]$‰ and the δ^{15}N value of $8.9 \pm 0.3[1\sigma]$‰ reflect a higher carbon value and a lower nitrogen value than at the monuments in Fernández-Crespo and Schulting (2017). Although Fuente Hoz is not totally contemporaneous, it has a mean value of $-19.7 \pm 0.2[1\sigma]$‰ for δ^{13}C and $9 \pm 0.5[1\sigma]$‰ for δ^{15}N, which is considerably lower than expected in comparison with the later sepulchral caves in the region (Fernández-Crespo and Schulting 2017).

Conclusions

New isotopic evidence shows that humans with both local and non-local strontium signatures were buried together in the Basque Western Pyrenees during both the Early-Middle Neolithic and the Late Neolithic-Chalcolithic. These individuals with different strontium signature all show a similar protein diet based on the consumption of C_3 terrestrial resources. Overall, this study sheds light on how individuals from different backgrounds were still buried together and shared the same “dietary lifestyle” at a time in the prehistory of Iberia when social complexities purportedly started to emerge. However, further analysis is required to characterise better the faunal background and the bioavailable strontium in the region and thus attain a more in-depth vision on the territorial mobility of these Neolithic and Chalcolithic populations. Future analysis at other archaeological sites of the same chronologies will complete these results, and provide a better understanding of prehistoric socioeconomic dynamics in Northern Iberia.

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