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RADIOCARBON DATES AND STABLE ISOTOPE DATA FROM THE EARLY BRONZE AGE BURIALS IN RIIGIKÜLA I AND KIVISAARE SETTLEMENT SITES, ESTONIA

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ABSTRACT. Four inhumations from Kivisaare and Riigiküla I settlement and burial sites were dated in the course of a project about hunter-gatherer mortuary practices in Estonia, as they were believed to belong to the Stone Age. However, these burials appear to be Early Bronze Age inhumations instead, and thus are discussed separately in the present article. These burials are the first evidence in Estonia of a long-lasting tradition of inhumations without any visible aboveground structures. As the archaeology of the Early Bronze Age in Estonia is poorly known, these four inhumations contribute immensely to our understanding about this time period. Moreover, stable isotope values show that these people had a more terrestrial subsistence strategy than Stone Age hunter-gatherers. Nevertheless, aquatic resources were probably still significant components of their diet, particularly at Kivisaare, and the radiocarbon dates could therefore be subject to significant freshwater reservoir effects. This creates ambiguity in the chronological relationship of these four individuals to burials in stone-cist graves, which are attributed to the Late Bronze Age and which appear to be associated with fully agricultural communities.

INTRODUCTION

This article presents new radiocarbon dates from four inhumations at prehistoric sites at Kivisaare (central Estonia) and Riigiküla I (also referred to as Narva Riigiküla; northeastern Estonia) (Figure 1). These burials were thought to be contemporaneous with the Mesolithic–Neolithic settlement layers at both sites. Recently, in the course of a project about hunter-gatherer mortuary practices in Estonia (M Tõrv, unpublished data), bone collagen samples from a large number of prehistoric human remains have been dated, mainly to the early 3rd millennium cal BC or earlier as expected based on previous research (see e.g. Kriiska et al. 2007). Unexpectedly, however, four inhumations from Kivisaare and Riigiküla I apparently date to the Early Bronze Age.

The Early Bronze Age in Estonia (1800–1100 cal BC)[3] has not attracted the attention of researchers. However, the few finds and in particular comparison of preceding Late Neolithic (2800–1800 cal BC) and subsequent Late Bronze Age (1100–500 cal BC) cultures have allowed some ideas about the intervening period to be developed. Valter Lang has characterized the period as an *Epineolithic culturelessness* (Lang 2007:36), for which very few traces of material culture are available. Only a dozen bronze artifacts are known. Most tools must still have been made of stone or organic materials; among these, the most numerous are stray finds of stone shaft-hole axes. In contrast to the succeeding Late Bronze Age, the absence of a distinct Early Bronze Age material culture is notable. People continued to live at the places used during the Late Neolithic, or established small-size and short-term settlements. This was the period in which the economic, cultural, and social changes manifested in the Late Bronze Age material culture began (Lang 2007). No burials are known in Estonia that can be attributed to the Early Bronze Age from archaeological evidence, so mortuary practices in this period may not be recognizable. In Estonia, aboveground stone graves, i.e. stone-cist graves, emerged during the transition to the Late Bronze Age (Lang 2007:147).

In this paper, we discuss the new dates and stable carbon and nitrogen isotope data with the focus on freshwater reservoir effect (FRE) correction and in the context of early stone-cist graves from the start of the Late Bronze Age.

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3. The periodization of the Bronze Age in Estonia is in correspondence with Nordic Bronze Age (Lang 2007:14); the reasoning behind the periodization is given in Lang and Kriiska (2001:94–9).

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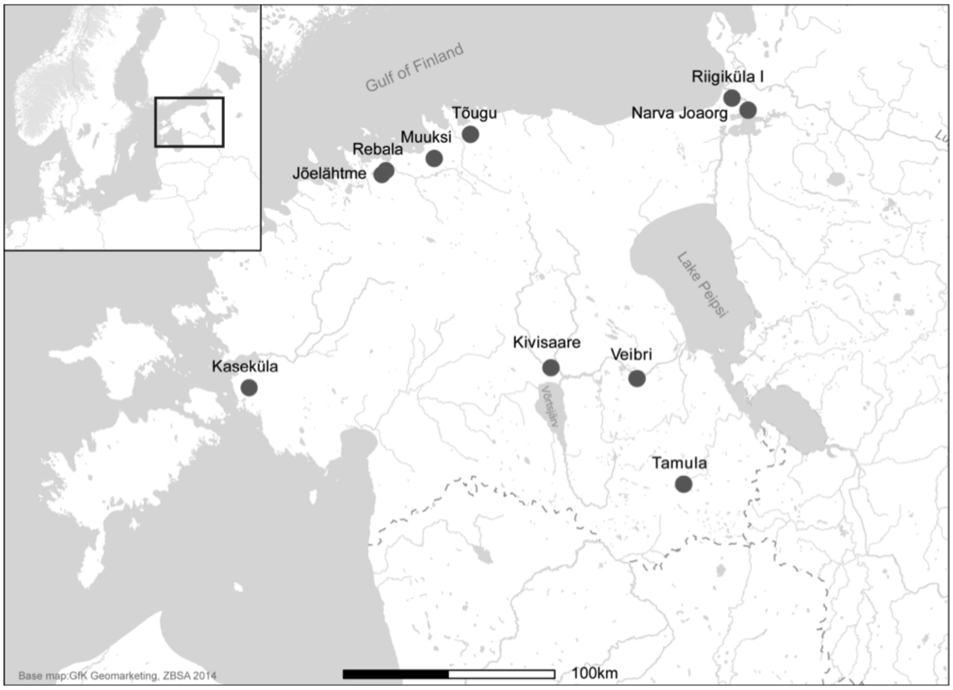

Figure 1 Sites mentioned in the text

Riigiküla I Settlement Site

The following description is based on publications by the excavator, Nina Gurina (1955, 1967). Altogether, 388 m^2 were excavated in 1951–1952, more than half of the entire settlement area. The deep cultural layer, over 1 m thick in places, contained abundant freshwater mussel (*Unio* sp.) shells. Two semi-subterranean houses were situated on a line parallel to the Narva River. A hearth without stone packing was recorded in each house, but to our knowledge charcoal was not collected and thus there are no radiocarbon dates for these hearths. A largely complete skeleton was found in each house, and disarticulated human bones were recorded in the cultural layer.

The accepted site chronology is based on the abundant finds of Narva-type pottery (n = 2752), Typical (n = 5590) and Late (n = 1944) Combed Ware, and Corded Ware (n = 6) (Gurina 1967:4). These pottery types have been dated to 4900–4200, 4200–3600, 3600–1800, and 2800–1800 cal BC, respectively (Kriiska 2009). The stone and bone tool complex, and the diverse faunal assemblage (Paaver 1965:437–8), support the Stone Age dating of the site.

Kivisaare Settlement and Burial Site

In terms of research history, Kivisaare has been regarded as a cemetery; only recently has the presence and importance of the settlement site become clear. The site was discovered during gravel mining in the late 19th century. During several field seasons by amateurs (1882, 1903, and 1908–1910) and professional archaeologists (1913, 1921, 1931, 1962, 1965, 2002–2004) (Bolz 1914; Ottow 1911; Tallgren 1921; Indreko 1931; Jaanits 1965; Kriiska and Johanson 2003; Kriiska et al. 2004), the remains of 27 more-or-less articulated individuals and a considerable amount of loose human bone has been documented.

Although both the burials and occupation deposits had been disturbed by ploughing and gravel extraction, the lower part of the cultural layer was intact (Kriiska et al. 2004:29; Kriiska and Lõhmus 2005:31), but no substantial structures have been found. The vast majority of the finds are of stone, mostly poor-quality local flint (Kriiska et al. 2004:29–30). Only a few pot shards have been found, the majority too small for type determination. A few belong to Corded Ware (Kriiska and Lõhmus 2005:39) and Narva-type vessels (Kriiska and Johanson 2003:50). Based on the finds, it can be said that the site was inhabited from the Mesolithic to Late Neolithic Corded Ware phase (Kriiska and Johanson 2003). As Richard Indreko (1931:4) noted, the site must have also been inhabited during the Bronze Age, due to the find of a bronze sickle. The lack of absolute dates and of culturally specific grave goods have led to debates on the chronology of the cemetery, which has been dated to the Mesolithic (Tallgren 1922:49), the Neolithic[4] (Bolz 1914:15; Indreko 1935a:220–2), and also to the Neolithic and the Bronze Age (Indreko 1935b:10).

The Newly Dated Burials

Gurina initially identified three relatively complete burials during the 1951 and 1952 field seasons at Riigiküla I. These belonged to a 25- to 35-yr-old female(?)(Ia)[5], an adult (6098–2 in MAE RAS[6]), and a 3- to 5-yr-old child (Ib)[7], and were interred in the occupation layers filling the semi-subterranean houses. The female(?) without any grave goods was placed in the southwestern corner of the larger house, 30–40 cm above the floor (Gurina 1955:161, 1967:22). The child was found in the middle of the smaller house, 20–25 cm above the floor (Gurina 1955:161, 1967:29). Gurina (1967:29) identified shards from a Combed Ware vessel at the foot of the child burial and a flint scraper next to one hand as possible grave goods. The second adult was found in the same house, to the south of the child, at the same level (Gurina 1967:30), together with several animal bones but, as with the first adult, without any grave goods (Gurina 1955:161). Although the grave cuts could not be distinguished from the occupation layers filling the houses, Gurina (1967:29) argued based on the stratigraphy that these burials took place during the final, i.e. Neolithic, usage of the houses.

Most of the human bones that have been found at Kivisaare are unfortunately not preserved in archives. The two inhumations discussed here were excavated by Lembit Jaanits in 1962 (Jaanits 1965). These were only partly preserved and belonged to a 5- to 9-yr-old child (I)[8] and an adult (II). The skeletons were found in the southeastern part of the drumlin, 30 cm below the topsoil. They were placed side-by-side. Jaanits assumed that skeleton I must have lain on its back with extended extremities. A flint flake was found on the lateral right side of the skeleton, but this item has been lost. The absence of the majority of skeleton II did not allow any substantial conclusions about the burial position. Jaanits (1965:3–4) argued that these individuals must have been deposited in one grave, with their feet on the same line, during a single burial event. Based on the flint flake and the record of other Stone Age burials on the drumlin, it was assumed to be Mesolithic or Neolithic.

MATERIALS AND METHODS

Human bones (Table 1) were sampled so as not to impede metric and other analyses potentially needed for future osteological studies. Samples were processed at the Kiel Leibniz-Laboratory for Radiometric Dating and Isotope Research (KIA), Germany, and ^{14}CHRONO Centre in Queen's University Belfast (UBA), United Kingdom.

4. During the first decades of 20th century, the Stone Age chronology was two-period: Paleolithic and Neolithic. Bolz himself gave no narrower dates for the cemetery in Kivisaare.
5. Age and sex of the adult were determined based on the characteristics on cranium and pelvis (Buikstra and Ubelaker 1994).
6. Museum of Anthropology and Ethnography, Russian Academy of Sciences.
7. The age of the child was determined by M Tõrv based on the fusion of thoracic vertebrae (Schaefer et al. 2009:341) and the length of femur and tibia (Schaefer et al. 2009:267, 286).
8. The age of the child was determined by the tooth growth (Moorees et al. 1963).

At Kiel, infrared spectroscopy was used to check for potential contamination with conservation agents; none was detected. Crushed bone fragments were then cleaned with acetone, rinsed in deionized water, and demineralized in 1% HCl. The insoluble residue was treated with 1% NaOH (20°C, 1 hr) to extract mobile humic acids, and again with 1% HCl (20°C, 1 hr) to remove any carbonates that may have precipitated during NaOH treatment. The residue was dissolved in a pH 2.7 solution overnight at 85°C, and filtered using a 0.45-µm-pore silver filter to remove insoluble particles. The gelatinized collagen was freeze-dried and an aliquot was sent for elemental analysis-isotope ratio mass spectrometry (EA-IRMS) at the School of Life Sciences, University of Bradford, UK, where carbon and nitrogen concentrations (%C, %N), and $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios ($\delta^{13}C$ and $\delta^{15}N$) were measured using a Thermo Flash 1112 elemental analyzer coupled to a Thermo Delta plus XL mass spectrometer. Laboratory and international standards were analyzed simultaneously, and gave acceptable results. Typical measurement errors of ±0.2‰ are quoted for both $\delta^{13}C$ and $\delta^{15}N$ in both samples and standards. Consistent duplicate results were obtained for each sample and only their averages are reported here. Two aliquots of each extract from the Riigiküla samples were sealed for combustion, graphitization, and accelerator mass spectroscopy (AMS) measurement on the 3MV HVEE Tandetron 4130 AMS in Kiel, following Nadeau et al. (1998). AMS results from each pair of graphite targets were statistically consistent; we have therefore reported only their weighted means. It is noteworthy that the AMS $\delta^{13}C$ measurements were also consistent between target pairs, and almost identical to those obtained by IRMS.

For scheduling reasons, freeze-dried collagen extracted from the Kivisaare samples in Kiel was sent to Queen's University Belfast for EA-IRMS and AMS measurement. For AMS dating, collagen was weighed into precombusted quartz tubes and combusted at 850°C with silver and copper oxide. Carbon dioxide was reduced and graphitized with an iron catalyst for up to 4 hr at 560°C. Graphite targets were measured in a 0.5MV NEC compact accelerator (Remier et al. 2015). Elemental concentrations and stable isotope values were measured using a Thermo Scientific EA-IRMS, to a precision of better than 0.1‰ for both $\delta^{15}N$ and $\delta^{13}C$.

RESULTS

Detailed results are presented in Table 1. The four dates were much younger than expected, in the framework of Late Mesolithic–Early Neolithic hunter-gatherer mortuary practices. The Kivisaare burials, apparently dating to the 16th or 15th centuries cal BC, appear to be slightly earlier than the Riigiküla I inhumations, which probably date to the 14th or 13th centuries.

Table 1 Radiocarbon dates and stable isotope measurements of the human bones of the Early Bronze Age burials from Kivisaare and Riigiküla I settlement sites. Calibration after OxCal v 4.2.4 (Bronk Ramsey and Lee 2013) and InCal13 atmospheric curve (Reimer et al. 2013).

Burial nr	Collection nr	Sample material	Lab nr	Coll. yield (%wt)	Conv. ^{14}C age (^{14}C yr BP)	AMS $\delta^{13}C$ (‰)	Calibrated date 2σ (cal BC)	IRMS $\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N ratio
Kivisaare I (1962)	AI 4379	Fragment of right mandible	UBA-25991/ KIA-50293	8.4	3161 ± 38	–22.0	1510–1370 (88%); 1350–1300 (7%)	–22.0	11.7	3.37
Kivisaare II (1962)	AI 4379	Fragment of midshaft left femur	UBA-25992/ KIA-50294	7.0	3274 ± 32	–22.2	1630–1450 (95%)	–22.2	11.8	3.42
Riigiküla 6098–1 (Ia)	6098 in MAE RAS	Left head of mandible	KIA-48835	2.4	3113 ± 20	–21.2	1435–1370 (59%); 1355–1300 (36%)	–21.2	10.6	3.49
Riigiküla 6098–3 (Ib)	6098 in MAE RAS	A rib	KIA-48836	19.3	3013 ± 19	–22.0	1380–1350 (7%); 1305–1195 (88%)	–21.9	10.7	3.44

The available record clearly suggests that the four burials discussed here should belong to the Stone Age. Then, how can one explain their Early Bronze Age dates? Collagen yields and C:N ratios indicate satisfactory collagen preservation in all four samples (DeNiro 1985; Dobberstein et al. 2009). Having carefully checked the records, we can discount the possibility that the ^{14}C results are from different individuals to those recorded during the excavations (i.e. that the bones were mixed up in the archive, or that samples were swapped or contaminated at some stage of the dating process; further details will be published elsewhere). The reliability of these dates and how they correspond to our present understanding of the Early Bronze Age in Estonia will be discussed in the following sections.

DISCUSSION

The newly dated burials are currently the only known pit-graves from the Early Bronze Age in what is now Estonia. They demonstrate the continuation of the tradition of inhumations in pit-graves without any aboveground structures, which can be dated back to the transition from Early to Late Mesolithic in Estonia (Tõrv, unpublished data) and to the Middle Mesolithic in Latvia (Zagorska 2006). Based on the find material, the Riigiküla I settlement site is dated to the Neolithic; no later occupation episodes were observed in the field. The most recent excavation reveals that the Kivisaare site—graves and settlement layer—was attributed to the Mesolithic and Neolithic (Kriiska and Tvauri 2002:35; Kriiska and Johanson 2003; Kriiska et al. 2004; Kriiska and Lõhmus 2005). It was probably used as a burial ground during several periods. In addition to the burials presented here, two graves from Kivisaare are ^{14}C dated to the Early Neolithic (Kriiska et al. 2007; Tõrv, unpublished data).

Based on the ^{14}C dates from Rebala I–III stone-cist graves, Lang (2007:161–2) cautiously proposed that stone-cist graves were introduced during the Middle Bronze Age.[9] His hypothesis has since been confirmed by a series of ^{14}C dates from stone-cist graves at Sondlamägi at Muuksi, Tõugu, and Jõelähtme, which show that the earliest stone-cist graves date back to 1200–1000 cal BC (Laneman and Lang 2013:102). At face value, both the pit-graves at Kivisaare and the Riigiküla I inhumations predate the stone-cist graves (Figure 2). The stable isotope data, however, suggest a trend from Kivisaare I and II, via Riigiküla Ia and Ib, to the Muuksi and Kaseküla burials, suggesting that people were moving towards a fully terrestrial diet in the late 2nd millennium (see below). An alternative reading of the isotopic evidence, therefore, is that these were contemporaneous communities with different burial practices and subsistence strategies, whose apparent date order is simply a reflection of differences in FRE.

Mixed Diets of Early Bronze Age People

The new stable isotope data are presented in Table 1. For context, these data are juxtaposed with isotope values from inland Late Mesolithic and Neolithic hunter-gatherers (Tõrv and Eriksson, unpublished data) and the Late Bronze Age populations of the Muuksi Sondlamägi and Kaseküla stone-cist graves (Laneman 2012; Laneman and Lang 2013). Moreover, six individuals from Kivisaare and three from Riigiküla I and III settlement site are included (Tõrv, unpublished data; Figure 3).

Lidén and Nelson (1994) reported δ^{13}C values of –16.29 to –14.25‰ for individuals from coastal sites with marine-based diets, and proposed a δ^{13}C range for bone collagen from humans with fully

9. The presently accepted Bronze Age chronology for Estonia is divided into two periods: Early (1800–1100 cal BC) and Late Bronze Age (1100–500 cal BC). New ^{14}C dates from several stone-cist graves indicate that the social, economic, and cultural changes assigned to Late Bronze Age might have started several hundreds of years earlier than hitherto thought. Thus, Lang has proposed that it might be useful to characterize the Bronze Age with a tripartite chronological division: Early (1800–1300 cal BC), Middle (1300–900 cal BC), and Late Bronze Age (900–500 cal BC) (Lang 2007:14).

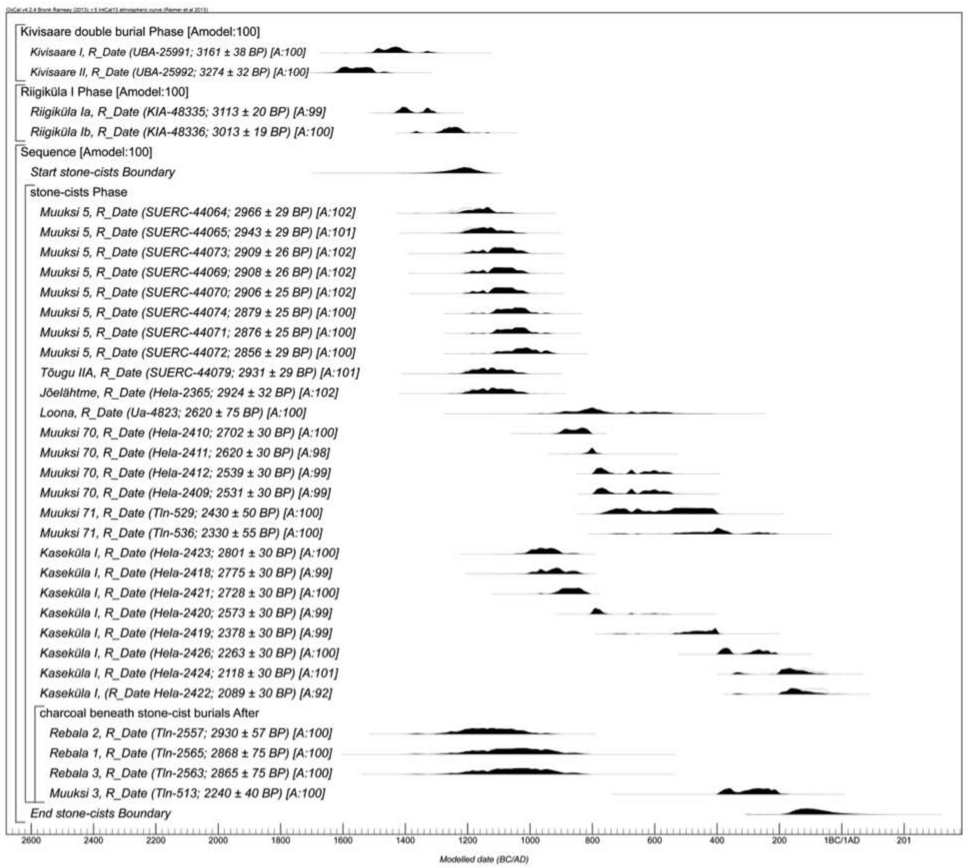

Figure 2 Radiocarbon dates from Kivisaare I and II (1962) and Riigiküla Ia and Ib inhumations plotted against the dates from stone-cist graves (Sondlamägi at Muuksi, Jõelähtme, Tõugu, Rebala, and Kaseküla) (Lang 1996; Lõugas et al. 1996; Lang and Kriiska 2001:96, Table 2; Laneman 2012; Laneman and Lang 2013:102, Table 1). The ^{14}C dates have been calibrated using OxCal v 4.2.4 (Bronk Ramsey and Lee 2013) and the IntCal13 calibration data (Reimer et al. 2013). All dates were obtained from human bone collagen, except Tõugu IIA (SUERC-44079), from calcinated bone, and Rebala 1–3 and Muuksi 3, which were from charcoal found under the stone-cists (Lang 2007:162). Charcoal dates are used as *termini post quos* for the dates of these burials (OxCal function After). The charcoal dates from Tõugu IIA stone-cist grave (Lang 2000) are not used here as their exact relationship to the stone-cist grave is ambiguous (V Lang, personal communication, 12 February 2015). Results from stone-cist graves are included in a Bayesian chronological model, which assumes that the dates of these burials are randomly distributed between the start and end of this form of burial, allowing OxCal to estimate the beginning (Start stone-cists Boundary) and end (End stone-cists Boundary) of the stone-cist tradition in Estonia. For further details, see online supplementary information.

terrestrial diets in the Baltic area during the Neolithic of –20‰ to –21‰. The $\delta^{13}C$ values from the four inhumations discussed in this paper are slightly more depleted, and the suspicion that this may be due to consumption of freshwater fish is supported by their relatively high $\delta^{15}N$ values. Fernandes et al. (2014a) found that collagen $\delta^{15}N$ in terrestrial herbivores from Late Mesolithic and Neolithic sites in northern Europe was 5.9 ± 1.4‰, compared to 8.8 ± 1.5‰ for fishes. Previously, it has been argued that a significant intake of aquatic resources is indicated when the human collagen $\delta^{15}N$ is ≥12‰, but significant reservoir offsets have also been reported with lower values of $\delta^{15}N$ in human collagen (Fernandes et al. 2014a).

The stable isotope values for Kivisaare I and II burial are almost identical; intrasite variances are also negligible for the inhumations at Riigiküla I. Intersite variances can be observed; these are more marked in the case of $\delta^{15}N$ values (differences of 1–1.2‰). The absence of local baseline isotope data for potential foods in this period means that we cannot be certain that the Kivisaare and Riigiküla individuals ate different amounts of fish. However, comparison with stable isotope data from prehistoric humans in Estonia places all four between Stone Age diets dominated by aquatic resources and the basically terrestrial Late Bronze Age diets at Muuksi and Kaseküla (Figure 3).

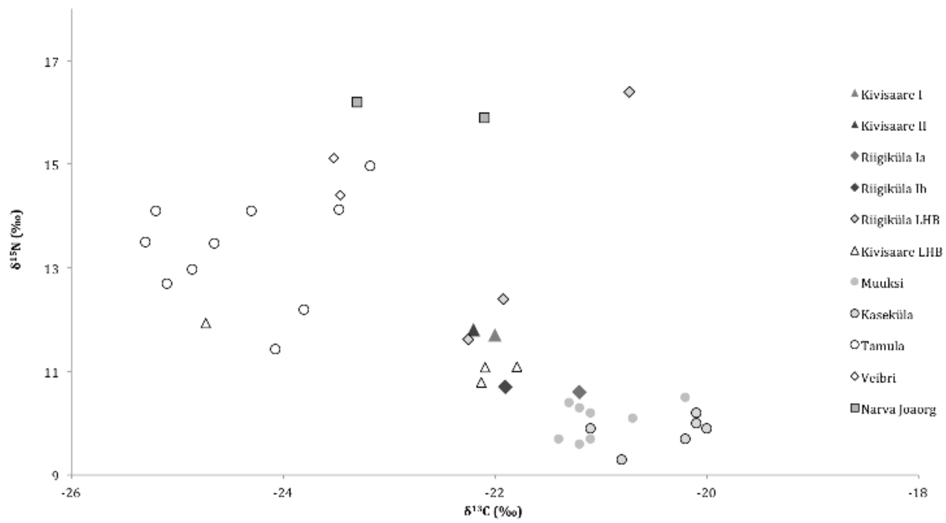

Figure 3 Stable isotope data from Kivisaare I, II and Riigiküla Ia, Ib burials plotted against hunter-gatherer values and values of loose human bones from these two sites (Tõrv, unpublished data; Tõrv and Eriksson, unpublished data) and values from the Bronze Age stone-cist graves in Sondlamägi, Muuksi (Laneman and Lang 2013) and Kaseküla (Laneman 2012). Data from young children omitted.

To quantify the consumption of freshwater food resources by the four individuals discussed in this paper, we have used the Bayesian statistical package FRUITS (Fernandes et al. 2014b). In the absence of detailed local information about baseline isotope values in potential food groups, we have assumed that $\delta^{13}C$ and $\delta^{15}N$ values from mid-Holocene freshwater fish and terrestrial herbivores from around Lake Burtnieks in northern Latvia, ~80 km southwest of Kivisaare (Eriksson 2006; Schmölke et al. 2015), are reasonable approximations. Kivisaare is located on the northern shore of Lake Võrtsjärv and on the River Põltsamaa. The two lakes are located in the same hydrogeological province (UNESCO 1981) and have similar geological settings (Saarse 1990; Eberhards 2006). Like Lake Burtnieks, Lake Võrtsjärv is shallow and moderately alkaline; $\delta^{13}C$ values in dissolved organic matter (DOM) at the outflow of the lake are consistently depleted and the dissolved inorganic carbon (DIC) $\delta^{13}C$ values are similar to that in a modern water sample from the River Salaca at the outflow of Lake Burtnieks (Toming et al. 2013; Meadows et al. 2014). Thus, it would be surprising if the isotopic baselines in prehistoric freshwater resources from the two lakes were very different. The situation at Riigiküla is less straightforward, as the bedrock geology is different. Although on a river, the site is close to the Baltic coast, a setting more comparable to that at Muuksi. The isotope values for the Early Bronze Age individuals from Riigiküla are practically within the range of the Muuksi Late Bronze Age population, but slightly higher in $\delta^{15}N$ and slightly more depleted in $\delta^{13}C$ compared to the expected range for fully terrestrial diets. If they consumed significant amounts of freshwater fish, it may have had similar isotopic values to that consumed at Kivisaare. Terrestrial resources presumably had similar isotopic signatures at both sites, but currently we only have the human isotope data to support this conclusion.

Figure 4 shows the estimated contributions to each individual's overall diet of plant, terrestrial animal, and aquatic foods derived from the FRUITS model. We have not included a marine food group, as there is no indication in the human isotope results that marine resources were important. The model output shows that all four could have consumed a significant amount of freshwater fish, although the freshwater component in Riigiküla Ia's diet may have been minimal. If the Riigiküla diets included a significant marine component, the freshwater component must have been higher than indicated by the FRUITS output, to offset the increase in $\delta^{13}C$ caused by the consumption of marine products.

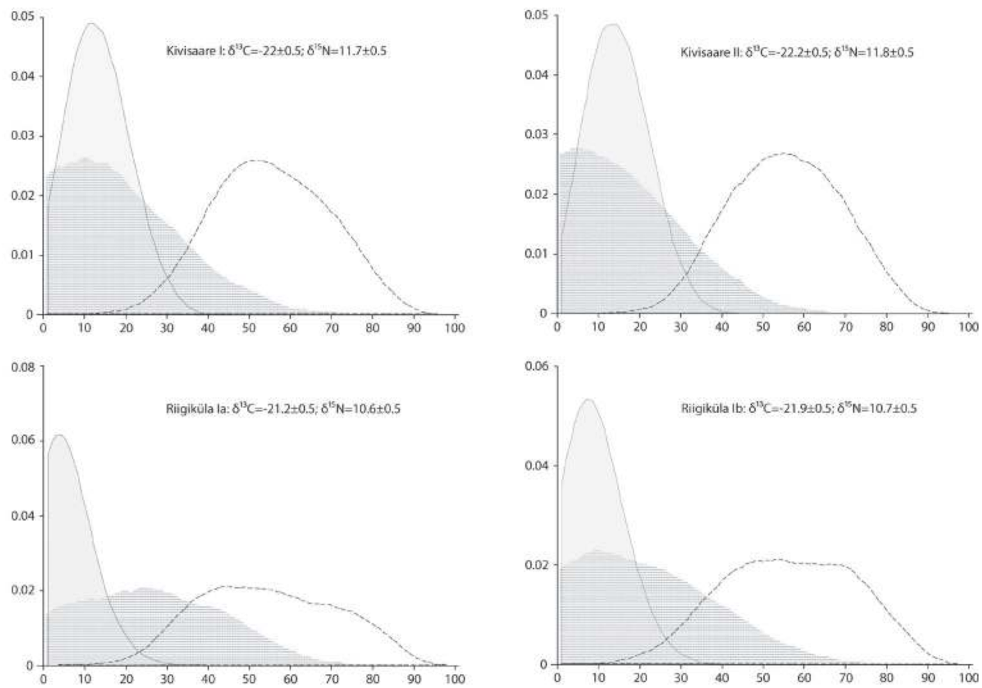

Figure 4 FRUITS model output, estimated probability distributions for the contribution to overall diet of plant foods (dashed line), terrestrial fauna (patchwork), and freshwater fishes (light gray). The same parameter values (isotopic baseline values and macronutrient concentrations for different food groups, diet-collagen isotopic offsets) have been used for all four individuals. For further details, see online supplementary information.

Local Freshwater Reservoir Effect in Kivisaare and Riigiküla I

The appropriate reservoir effect in aquatic resources at either site during the Early Bronze Age cannot be estimated from available data, and in fact we cannot be certain that there was any reservoir effect in freshwater species at these sites. It appears unlikely that freshwater reservoir effects were negligible, however, given the calcareous bedrock and drift geology in Estonia, and there are indications from modern and paleolimnological studies that in some hardwater lakes the reservoir effects may be large (e.g. Olsson and Kaup 2001; Poska and Saarse 2002; Veski et al. 2005; Alliksaar and Heinsalu 2012). Poska and Saarse (2002) found differences of ~500 yr between bulk gyttja and terrestrial plant macrofossil ^{14}C ages. Veski et al. (2005) estimated an offset of 600–700 yr in the ^{14}C age of bulk organic matter from Medieval varve-dated sediment. Alliksaar and Heinsalu (2012) found that bulk organic matter from lake sediment independently dated to the last century gave ^{14}C ages of up to 2000 yr. As the bulk organic matter must include some terrestrial material, the FRE in fully aquatic organisms in these cases must be even greater.

The calibrated dates shown in Figure 2 must therefore be regarded only as maximum ages for these burials. The important archaeological question is whether the real dates of the burials may have overlapped with those from stone-cist graves, now attributed to the Late Bronze Age. A second issue is whether a diet including freshwater fish could account for the difference between the ^{14}C results for the two Kivisaare individuals, who were reported to have been found in a single grave.

The FRUITS model output includes an estimate of the contribution of each food group to each isotopic value in the consumer, and the aquatic carbon contribution to the ^{14}C age must be the same as to δ^{13}C. Using OxCal's *Mix_Curves* function, the dates can be calibrated using the IntCal13 curve for the terrestrial contribution to the ^{14}C age, and IntCal13 with a reservoir equivalent to the estimated local FRE for the aquatic component (Figure 5). Using even a moderate estimate of the local freshwater reservoir effect, it is possible to synchronize the two Kivisaare burial dates, and if the same value is applied at Riigiküla it would appear quite likely that the second burial, Riigiküla Ib, was contemporaneous with at least some of the stone-cist burials at Muuksi.

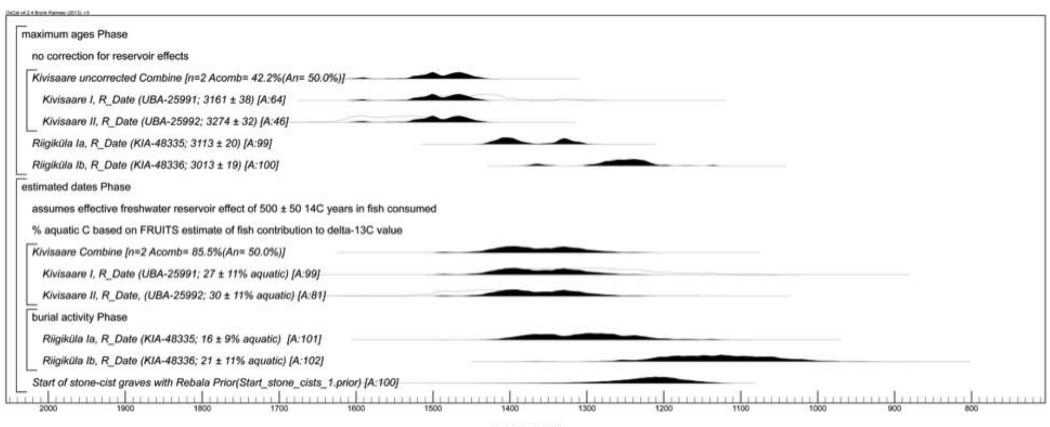

Figure 5 Calibration of the new ^{14}C results, assuming no dietary reservoir effects (above), and "corrected" using the estimated percentage of aquatic carbon in collagen based on FRUITS model output (Figure 4), and a freshwater reservoir effect of 500 ± 50 yr in the aquatic carbon. The OxCal Combine function calculates a single date for the two Kivisaare individuals, which were supposed to be from a double burial, showing that the "corrected" dates are consistent with this assumption, whereas the uncorrected dates are not ($A_{comb} < A_n$). The distribution Prior Start_stone_cists_1 is derived from the model shown in Figure 2, and represents the estimated start of stone-cist burial practice in Estonia. For further details, see online supplementary information.

CONCLUSIONS

The four burials from Kivisaare and Riigiküla demonstrate clearly that graves with no datable inventory should not be assigned to a certain archaeological period without ^{14}C dates. Contrary to expectations, four of the pit-grave inhumations sampled as part of a study of Stone Age burial practices in Estonia were dated to the Bronze Age. It appears that they are the first burials in Estonia that can be attributed to the Early Bronze Age, and the dates therefore provide a valuable insight into cultural practices in this little-known period. In Estonian archaeological material, isolated and unfurnished inhumations do not occur often; it is therefore unsurprising that these are the first to be dated to the Early Bronze Age. While additional burials of this type may be dated to the Early Bronze Age in future, we do not assume that the unfurnished inhumation was the only form of burial practice of that time.

At the moment, we are able to distinguish a single burial event in Kivisaare and two burial episodes at Riigiküla during Early Bronze Age. Moreover, stable isotope results provide the first real evidence of dietary preferences in this period, suggesting a gradual decline in the use of freshwater resources. Nevertheless, the potential for significant freshwater reservoir effects, revealed by the stable isotope results, means that we cannot be certain that all, or indeed any, of these four individuals really predate the appearance of stone-cist burials at sites such as Muuksi, whose diets were apparently fully terrestrial, and presumably based primarily on agriculture.

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