Chapter

Anthropological and Paleodietary Analysis of Human Remains: A Case Study from the Teutonic Settlement of Torre Alemanna in Puglia (Cerignola, FG, Italy)

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Abstract

The main object of this paper is to reconstruct the presence of the knights of the Teutonic Order in the archeological site of Torre Alemanna (Foggia, Italy), one of the best preserved Teutonic production sites. This is an interdisciplinary study that includes archeological and anthropological research combined with the paleonutritional results and radiocarbon dating. Specifically, for this study, the area 5 of the complex has been investigated. The cemetery is located in the northwest corner of the complex, and the burials are probably dated at the beginning of the Teutonic settlement. In order to draw conclusions about their presence, attention has been focused primarily on ergonomics activities, injuries, morphological and metric characters, diet, and dating.

Keywords: anthropology, archeology, Teutonic Order, paleodiet, rider syndrome, radiocarbon dating, injuries, Apulia

1. Introduction

This anthropological study has concerned with human bones from the archeological context of Torre Alemanna, and it has allowed to reconstruct a complete biological framework of the skeletons excavated (**Figure 1**). In this research, all the methodologies of surveys necessary to have a complete overview of the archeological site have been used. In general, craniological and craniometric analysis is especially useful for understanding the genetic characterization of populations and possible migration routes. The study of nutritional and occupational stress markers allows to understand the interaction between man and environment and to reconstruct the *modus vivendi*. Through paleonutritional studies, it is possible to reconstruct the type of power supply and the relative subsistence strategies of ancient human groups. In this particular case, the reconstruction of the biological and paleopathological profile of individuals combined with the data of the paleodiet allows to understand their *ante-mortem* status. It is possible to understand if the individuals belonged to a privileged social

Figure 1.
Cemetery area. Individual T1S4.

class and consequently if they had a good diet. The study of occupational stress markers and traumatic injuries let us know if they were warrior monks, through the presence of markers of riding and injuries from interpersonal violence. In addition, it is possible to realize if the individuals came from the north with the study of the skull through the analysis of the ancestry assessment, the shape distance, and PCA.

2. Archeological studies

2.1 The archeological site of Torre Alemanna

Since the Early Middle Ages, many northern European pilgrims had gone to the Holy Land to undertake long and dangerous devotional journeys [1].

In the last years of the third crusade (1182–1190), the Teutonic Order was born in San Giovanni d'Acri, Palestina [2]. Teutonic knights were to be German and from a noble family, they could join the Order after the fourteenth year of age. They were subject to rules, such as observing chastity and poverty. However, in case they wanted to keep their assets, what they obtained from the rents had to be given to the Order, in such a way as to help the poor, the sick, and for hospital assistance. Even the meals were regularized and were preceded by prayer. They could eat meat three times a week, on Friday fish, and the other 3 days dairy and eggs. There were no prohibitions for legumes, vegetables, and fruit. Everything left over from the meals was offered to charity. During the meals, it was necessary to respect the silence and in some established days fast. From the first half of the thirteenth century "baliati," complexes of the goods belonging to the Order were created, particularly in Germany, Bohemia, Moravia, Italy, Greece, Netherlands, and so on. In these places, the Teutons had churches, castles, villages, farms, and mills, but above all, hospitals and hospices were built everywhere.

The presence in Italy of the Teutonic Order should be attested since the end of the twelfth century because the knights have acquired some properties in Apulia and Sicily, for the purpose of providing assistance for Crusaders and Pilgrims who were headed to Holy Land [3].

Torre Alemanna is one of the best preserved Teutonic production sites [4] (**Figure 2** [5]). Since 1226, Teutonic Order settled in that site and in the near *castrum* of Corneto [6]. Corneto was a thriving village with ideal characteristics for the agricultural production. Water was recoverable from the Carapelle and Ofanto rivers and from numerous canals and springs [7]. The proceeds were to join in part the supplies for the Holy Land, the place where the headquarters of the Order was located in the castle of Monfort [8]. The site of Torre Alemanna takes its name from the quadrangular tower, probably having the function of lookout (**Figure 3** [9]). The tower was 24 m tall and 10 × 10 m wide. The knights of the Teutonic Order built the tower, including a preexisting church with interesting paintings. The remains of the thirteenth-century medieval church are the quadrangular choir corresponding to the ground floor of the tower; some precious stone remains evoking a decoration of considerable value; and the frescoes of the late thirteenth to the early fourteenth century. The pictorial decorations show the images of holy bishops and popes, along with episodes of the Passion of Christ and a Tree of the Cross. It is not possible to know if in Torre Alemanna there was a religious community, as happened to St. Leonardo of Siponto (also occupied by the Teutonic Knights), but being

Figure 2.
Monumental complex of Torre Alemanna in the municipality of Cerignola [5].

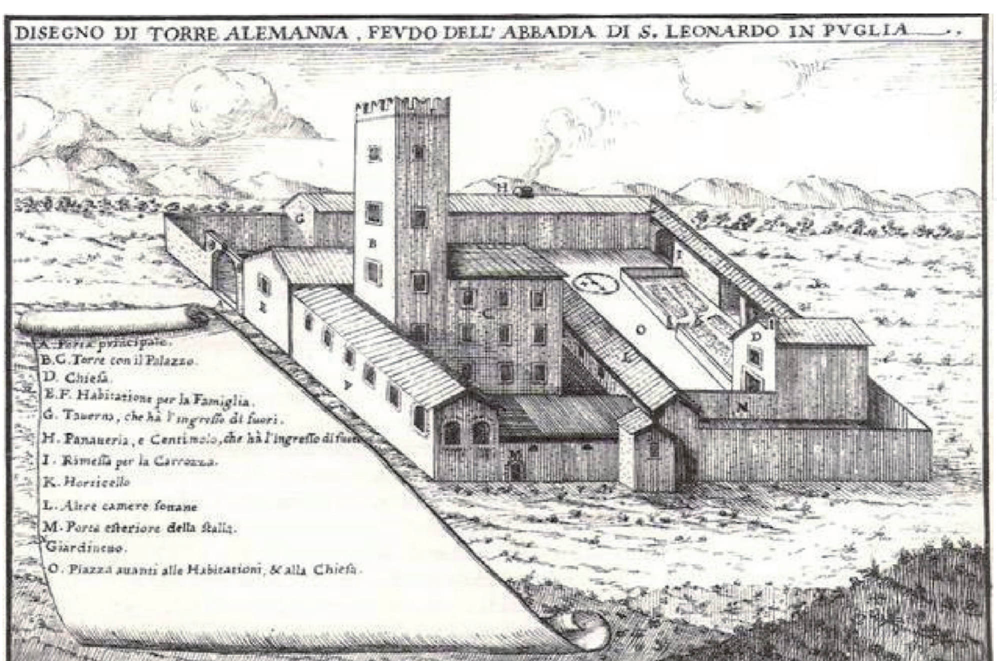

Figure 3.
Torre Alemanna on the seventeenth century manuscript [9].

an important fief with an agricultural-pastoral company, there had to be officers or intermediate ministers in addition to the lowly hand. From 1999 until 2008, archeological research focused on the extension of the investigation in the area of the church and its surrounding space [10]. We know about two other anthropological studies of individuals belonging to Knightly Orders: one archeological site is located in the courtyard of the House of the Teutonic Order of Vipiteno – Deutschordenhaus Sterzing (Bolzano, Italy) [11] and another in the Holy Trinity Church of Konstanz (Germany) where a knight of the Order of San Giovanni has been studied [12].

2.2 The Teutonic cemetery

The burial ground of the area 5 of the complex has been examined under the direction of Dott.ssa Giovanna Pacilio from the "Soprintendenza per i Beni Archeologici della Puglia" in 2007–2008.

The burials are located in the northwest corner of the complex, and it is probably dated at the beginning of the Teutonic settlement [13].

A first layer of sandy deposit was dated from the second half of the thirteenth to the early fourteenth century, on the basis of the material found, in particular on the discovery of proto-majolica ceramics. A second layer of ground coincides with the occupation of the cemetery dated with radiocarbon analysis. The layers, then, have been cut to build the foundations of the original fence wall in the north of the complex. The space inside the wall has been used as a cemetery connected to the church, located to the east.

Certainly, the burial ground follows the construction of the perimeter wall of the complex, and this is confirmed by the discovery of a burial covering the trench of the groundwork, and it leans on the structure of the wall.

The burial ground is therefore attributable to the first phase of the settlement, as well as to the initial phase of the Teutonic occupation.

Later, a part of the area 5 was cut after the construction of a hypogaeum that intercepted a series of burial. In fact, tibias, fibulas, and feet bones were under the wall.

2.3 The emblem of Torre Alemanna

Many ceramics found during the excavation of the site report an emblem characterized by a circumference with, drawn inside, diameter and, perpendicular to it a radius, thus forming the letter Tau "T" [14]. Among the types of ceramics on which the emblem is present, we report not only plates and bowls of majolica, plates and mugs of graffiti, and polychrome slipware pottery but also closed forms. It is also possible to find the same emblem on different stone artifacts and boundary markers. It was probably the symbol of the community of Torre Alemanna attested from the end of the fifteenth to the seventeenth and eighteenth centuries, period immediately following the presence of the Teutonic knights in the site. The oldest testimony dates back to the twelfth century. It is an exemplary stone, now walled inside the tower on the wall overlooking the entrance of the farm, where a bas-relief emblem has been found, indicated as "Ancient distinctive sign of the monks of the Teutonic Hospital of Jerusalem, still in use at the end of the twelfth century" [8]. Various interpretations have been given on the emblem of Torre Alemanna, and some scholars have identified the monogram of the Knights of the Teutonic Order (*Ordo fratrum domus hospitalis Sanctae Mariae Theutonicorum in Jerusalem*). On the left side of the main entrance to the monumental complex of Torre Alemanna, an ancient emblem of the Teutonic Knights has been found, dating back to the fourteenth century. On the right, there is a coat of arms that belonged to one of the Teutonic commanders of Torre Alemanna (**Figure 4**). This was supposed to be the commander Thile Dagicter

Figure 4.
Coat of arms on the main access portal.

von Lorich (Thyle von Lorch) because the coat of arms in Torre Alemanna was the same as that found on the diptych found in the castle of Marienburg, the main seat of the Teutonic Order in Prussia (currently in Poland). The same coat of arms is present in the graffiti on the frescoes inside the gothic church incorporated in the tower.

3. Anthropological studies

3.1 Anthropological material

The cemetery area is located in the northwest corner of the complex, which was called area 5.

All individuals are buried in earthly pit with an east-west orientation.

Six of the individuals examined (USS22, USS23, USS25, USS27, T1S3, and T1S4) were in primary deposition, in dorsal decubitus.

Decomposition took place in an empty space, and the bodies were probably laid inside wooden boxes or wrapped in a tight shrouds, as the joints did not maintain the connections and their original positions.

The individuals T1S1, T1S2, USS24, USS26, USS32, and USS33 are instead in secondary and reduction deposition that is the skeletal remains have been moved from the place where the decomposition took place.

Almost all individuals have fragmented and incomplete bones. For the purpose of a correct analysis of the conservation status, the bone quality index (I.Q.O.) has been applied, which was rather high only for a few individuals, with a healthy cortical surface exceeding three quarters, that is 75–99%.

The results of analysis of the skeletal sample from area 5 show a total of 12 individuals subdivided as follows: 2 subadults, including 5-year-old male and 12-year-old female, and 10 adult individuals, including 6 males between the age of 37 and 45 years and 4 females between the age of 25 and 35 years.

3.2 Methods of anthropological analysis

The biological and paleopathological profile of individuals is reconstructed on the basis of the following aspects: the identification of morphometric characters [15]; the determination of age and sex [16, 17]; nutritional and/or stress diseases and the detection of periodontal disease and caries [18, 19], tartar deposit evaluations [20], and the degree of dental [21]; the enamel hypoplasia lines [22]; markers of skeletal biomechanical stress—syndesmosis injuries, enthesopathies, new articular surfaces, and degenerative joint diseases [23–27]; degenerative changes of the spine [28]; biomass body [29]; the investigation of the cross-sectional geometry of the humerus and femur [19, 30–32]; and the human typologies [33]. The degree of representation of the individual's skeleton is calculated as a percentage of the total theoretical number of human bones. Statistical analyses are based on the incidence and percentage frequencies of individual data. Unlike the other bones that change in relation to environmental influences, keeping a trace of stress, the skull is quite conservative of its original genetic characteristics as regards some absolute measures and morphological reliefs and is not affected by the environmental interferences to which it is subjected. On the basis of this characteristic, it is possible to start the study of the biogenetic dynamics affecting the territory in question, through constant integration with historiographical and archeological sources. Populations from different geographic regions of the world have apparently different skull features, especially the shapes of orbital cavity and nasion (**Figures 5–8**).

Craniometry involves quantifying characteristics on an objective scale in an attempt to define the ancestral identity of an individual. Measurements are continuous and may be subjected to multivariate analysis to provide estimates of distance and probabilities of affinity to the reference sample.

In total, 12 cranial measurements [15] were used: 5 to the vault, 1 to the base, and 6 to the face: glabello-occipital length (GOL), basion-nasion length (BNL), maximum cranial breadth (XCB), minimum frontal breadth (WFB), porion-bregma height (PBH), basion-prosthion length (BPL), bimaxillary breadth (ZMB), nasion prosthion length (NPH), orbital breadth (OBB), orbital height (OBH), nasal breadth (NLB), and nasal height (NLH).

Determination of the type of injury and weapon recognition was performed by comparing with study collections and data known in the literature [34, 35]. The definition of the blows—"downward cuts," "middle cuts," "upward cuts," "blow from left to right," and "blow from right to left"—follows the terminology noted in the medieval defensive treaties. As for the possible weapon identification, this is determined by the combined reading of the morphology of the lesion and the historical context of reference.

3.3 Paleodiet studies and laboratory procedure

Paleodiet is a discipline that has the objective of reconstructing the dietary habits of the populations of the past through investigations of chemical-physical

Figure 5.
Skull in norma frontalis *and* lateralis *of male individual T1S1.*

Figure 6.
Skull in norma frontalis *and* lateralis *of male individual T1S4.*

Figure 7.
Skull in norma frontalis *and* lateralis *of male individual USS25.*

Figure 8.
Skull in norma frontalis *and* lateralis *of male individual USS26.*

type. The information obtained through the study of the paleodiet together with the anthropological, archaeozoological, and archaeobotanic data turns out to be an important contribution for the archeology [36].

In the human body, there are two categories of elements. Majority elements have a concentration greater than 0.01%, whereas the trace elements have a concentration less than 0.01% of body mass [37]. In addition, it is necessary to distinguish the trace elements in essential for diet, potentially essential, nonessential, and toxic [38].

On the basis of this classification, the most considered food markers are strontium, magnesium, zinc, copper, calcium, lead, and iron.

Strontium and magnesium are indicators of a mainly vegetarian diet.

Strontium is mainly concentrated not only in plants but also in mollusks of marine and terrestrial origin and in small fish [39].

Magnesium is an indicator of a diet mainly based on cereals and legumes [40, 41]. Its presence may also indicate the intake of wheat germ, oatmeal, maize, beans, peas, lentils, and dried fruit. The refined flours used in more recent times contain a reduced quantity of magnesium, contrary to the whole grain flours usually employed in the oldest phases.

Zinc and copper are indicators of a predominantly protein diet. High concentrations of zinc are due to the intake of red meat: horse, veal, pig, and lamb [42]. It can be found to a modest extent in fish products, with the exception of oysters and crustaceans in general, and in some vegetables, particularly beans, peas, soya, and lentils.

The food with high content of copper is the ox's and calf's liver and the offal in general; it is very high in the mollusks, in the crustaceans, and in the greater part of the seafood [42].

Calcium, although not a trace element, is essential to evaluate the *intravitam* health status and the *postmortem* conservation status of the individual [43–45].

It is necessary to relate to calcium each element analyzed in order to compare the data and mitigate the influence of any diagenetic contamination. The relationship with nondiagenetic elements can be problematic because calcium is an element subject to frequent *postmortem* alterations [46]. An additional method of correction is generally applied, which consists in correlating the Sr/Ca and Zn/Ca ratios of the human sample to those of animals living in the same site at the same time as humans [47]. The greater compactness of the animal bone matrix leads to a less interchange of elements between the bone and the soil and consequently a less loss of calcium.

The selection of the sample is fundamentally important for the result of the paleonutritional analyses. In the course of this study, fragments of long bones were taken, the cortical component of which is less prone to diagenetic phenomena and allows to remove internal and external encrustations easily. In addition, in order to make the correction with the site, a sample of *bovis* was taken that was found in the same cemetery context.

The surface portion of the samples was removed using a scalpel and a probe. In order to eliminate the organic component, the samples were placed inside a muffle at 600°C. Once extracted, they were pulverized in a mortar and placed under a bell dryer to eliminate the hydration water present inside.

About 0.500 g were taken from the pulverized samples and then subjected to two consecutive acid attacks (HNO_3 in pure concentration and HCl in 1 M) on a plate with a temperature of approximately 140°C.

The liquid samples were made up to volume in 50 ml flasks with bidistillate water and, if necessary, filtered. Subsequently, the dilution of the nondirect elements, namely calcium, magnesium, and strontium, which are essential for reading in the atomic absorption spectrometer (AAS), was carried out.

In addition, standard calibration solutions have been prepared: white and calibrated for each element. White is a solution composed of bidistillate water and acids with the same concentration as those present in the samples. It allows both to establish the relative zero of the calibration line and to provide the spectrometer with the exact composition of the solutions that will have to be read.

Calibrates are taken from a standard solution with a known concentration and are of three different qualities (useful for creating a calibration line). HNO_3 and HCl are added in the same quantity as in the samples and made up to volume with bidistillate water. For nondirect elements (Ca, Mg, and Sr), lanthanum (0.1% m/V) should be added to reduce interference during analysis in both analytical and blank samples and standards.

Finally, the samples were read using the atomic absorption spectrometer (AAS). The AAS is a widespread technique since it is easy to use and has low costs.

3.4 Radiocarbon dating

The sample was directly radiocarbon dated using accelerator mass spectrometry (AMS) at Beta Analytic Inc. (Miami, Florida). The date of this sample was calibrated to years cal BP using Oxcal v4.3.2 software based on the IntCal13 atmospheric curve.

4. Results and discussion

4.1 Results of anthropological analysis

4.1.1 The biological profile

The average stature for males is 1.72 m and for females is 1.56 m. Average body mass for males is 70 kg and for females is 60 kg.

Craniometric measurements and indices of all adult subjects are shown in **Tables 1** and **2**.

4.1.2 The shape distance and PCA analyses

The Penrose shape distance analysis cranial series used to provide a comparative basis for medieval remains includes 6 Apulian samples [48–53], 3 Italian

	GOL	BNL	XCB	WFB	PBH	BPL	ZMB	NPH	OBB	OBH	NLB	NLH
T1S1 M	165	87	140	93	106,2	87	125	64	39,5/37,9	31,6/31,6	22,0	43,0
T1S3 F	170	99	145	92	110,2	91,8	124	60,7	39,8/-	29,3/-	25,3	47,7
T1S4 M	176	93	150	106	109,7	91	137	66,7	39,9/41,8	35,8/36,6	23,8	55,9
USS22 F	-	-	150	102	-	99,4	133	-	-	-	22,7	-
USS23 M	181	93	142	-	112,9	85	-	61,6	41,5/-	33,7/-	25,8	52,3
USS25 M	181	94	152	93	119,8	86	128	72,3	41,4/40,7	33,3/34,2	23,4	53,7
USS26 M	-	108	-	-	-	104	-	67,3	38/-	30,6/-	-	44,3
USS32 F	-	95	-	92	-	90	125	63,8	37,0/38,9	33,0/32,4	23,6	45,4
USS33 M	180	98	131	95	113,2	97	129	67,2	39,7/40,3	30,5/30,9	24,8	49,7

Table 1.
Cranial measurement of adult individuals.

	8/1	9/8	20/1	20/8	40/5	48/45	52/51d	54/55
T1S1 M	84,85	66,43	64,35	75,48	100,00	51,20	80,00	51,16
T1S3 F	85,29	63,44	64,82	76,00	92,72	48,95	73,62	53,03
T1S4 M	85,22	70,67	62,32	73,13	97,85	48,69	89,72	42,58
USS22 F	-	68,00	-	-	-	-	-	-
USS23 M	78,45	-	62,36	79,48	91,39	-	81,20	49,33
USS25 M	83,98	61,19	66,19	78,82	87,23	56,48	80,43	43,57
USS26 M	-	-	-	-	96,24	-	80,53	-
USS32 F	-	-	-	-	94,70	51,04	89,19	51,98
USS33 M	72,78	72,52	62,91	85,14	98,98	52,09	76,83	50,00

Table 2.
Cranial indices of adult individuals.

samples [54–56], and 7 European samples [35, 57–60]. Penrose shape distances were calculated between each pair of compared populations. The shape distance actually measures the precision of the mean difference between two populations [61]. Accordingly, it is considered to be a reliable indicator of morphological difference based on body form, rather than difference based on absolute body size.

For each comparison, once the distance of Mahalanobis (d^2) and the distance of generalized form of Penrose (C^2_H) have been calculated, the shape distance (C^2_Z), that is the difference in proportions and the size distance (C^2_Q), which is the difference between dimensions, is examined [33].

The shape distance (C^2_Z) allows to obtain an estimate of the "genetic distance" between the individuals in question and the populations of comparison, so as to return a location ethnicity of the individuals themselves. Determination of ancestry has been based on the morphological and metrical examination of certain skeletal traits in the skull. In addition, considering that the individuals could be the result of the mixture of different, physically contrasting groups, according to historical data, a number of morphological and mathematical criteria were used to classify each skull into one of the so-called groups or subracial types (Baltic, Mediterranean, Dinaric, and Alpine) [62, 63] in order to recognize morphological affinities among them.

In terms of morphological features, the skull was typologically similar to the Northern European skeletal range, referred to as Borreby phenotype, short-skulled with East Baltid and Alpinid tendencies, characterized by wide and planoccipital skull with spheroid shape in superior view, face roundish, leptorrhine, and nasion depression.

Borreby was a Danish village where neolithic skeletons mixed with bell-beaker invaders at the end of the Copper Age.

Throughout history, Pomeranian Region was a meeting place for different populations such as Baltic, Slavic, and Germanic.

Particularly, four male skulls (T1S1, T1S4, USS25, and USS23) have metric features very close to the sample of the Late Middle Ages that came from Aleksandrów Kujawski and Radziejów Kujawski (Poland) [64], and it has been tested with a multivariate analysis using the *shape distance* [33] (**Tables 3**–7). Both sites were

Geogr. locations	Geographical coordinates	Chronological dating	Skeletal series	Amb.5 TA07 t1s1	Amb.5 TA07 t1s4	Amb.5 TA07 uss25	Amb.5 TA07 uss23
Puglia	40.922N 17.128E	XIV - XV	Conversano (Castiglione)	0,52	1,08	0,80	0,52
Puglia	41.130N 16.870E	XII - XIV	Bari	0,92	1,50	1,50	1,13
Puglia	41.223N 16.286E	1155-1285*	Andria	0,90	1,53	1,41	1,03
Puglia	40.954N 16.919E	884-1024*	Casamassima	0,97	1,34	1,55	0,96
Puglia	40.144N 18.494E	XV	Otranto	0,50	1,04	0,91	1,12
Puglia	40.954N 17.303E	XI - XIII	Monopoli	0,88	1,38	1,15	0,97
Abruzzo	42.821N 13.556E	VI - VII	Castel Trosino	1,27	1,76	2,37	1,29
Latium	42.500N 11.681E	VII	Ischia di Castro	1,24	2,19	1,87	0,99
Tuscany	43.310N 10.509E	V - VIII	Livorno Cecina	1,38	1,70	1,73	0,83
Ungary	47.158N 18.402E	X - XI	Szekesfehervar	0,99	2,11	2,38	2,47
Germany	54.311N 10.086E	XIV	Kiel	0,68	1,50	1,39	0,82
Poland	52.867N 18.699E	Late med.	Aleksandrow Kujawski	0,61	**0,70**	**0,50**	0,69
Poland	52.616N 18.533E	Late med.	Radziejow Kujawski	**0,38**	**0,70**	0,86	**0,41**
Poland	54.164N 19.402E	Late med.	Elblag	1,59	1,33	1,63	0,93
Croatia	45.497N 18.894E	Early med.	Croatia	1,46	1,92	1,72	1,46
Russia	60.004N 32.289E	XII-XIII	Staraya Ladoga	0,86	2,21	1,10	1,07

Table 3.
The shape distance (C2Z) of 16 medieval cranial series with four individuals of Torre Alemanna. Males only.

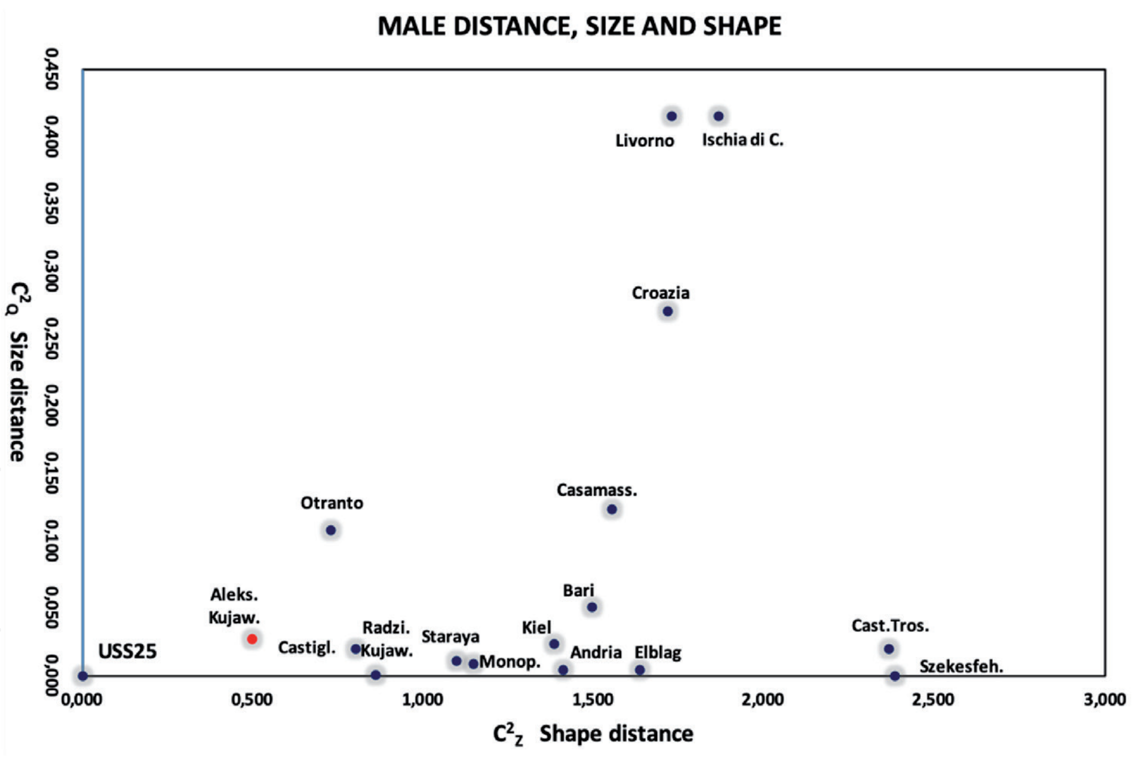

Table 4.
The affinities of 16 medieval people with the individual USS25, employing the "size" and "shape" method of 12 skull measurement. Males only.

located in ancient Pomeranian Region, near the town of Torun, and were taken over by Teutonic Knights in the first half of the fourteenth century.

Other subjects (USS32, USS33, and T1S2) show craniometric affinities with medieval samples of Puglia.

Male skeletal sampling as a whole tested with shape distance shows affinity with both Castiglione and Aleksandrów Kujawski and Radziejów Kujawski sites (**Table 8**).

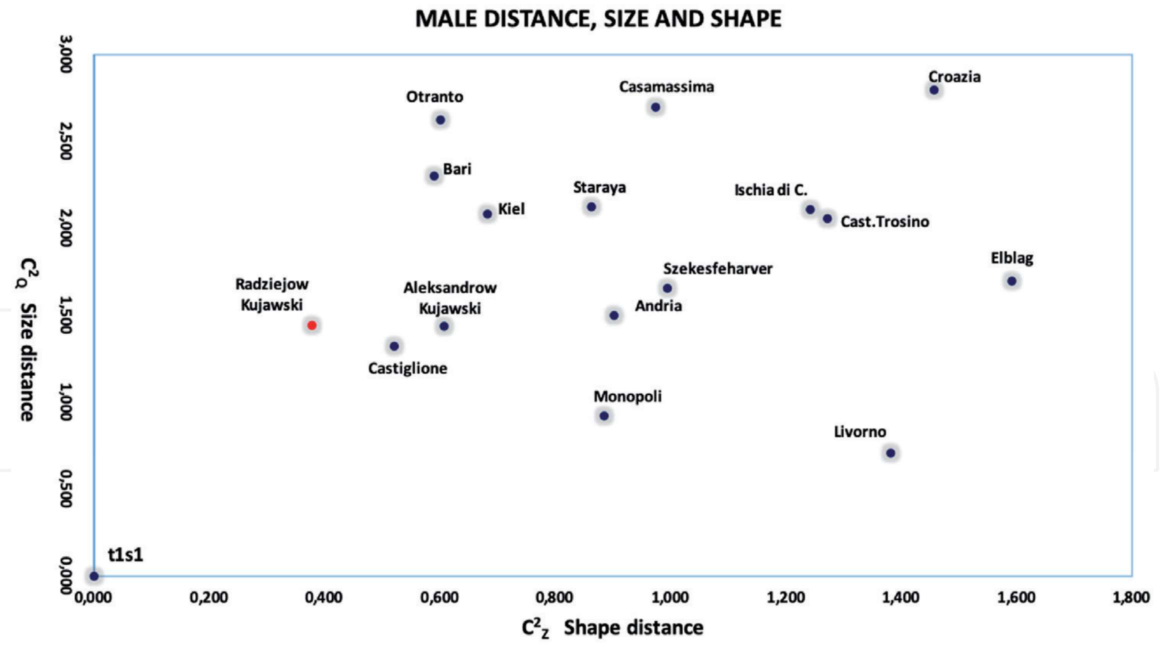

Table 5.
The affinities of 16 medieval people with the individual T1S1, employing the "size" and "shape" method of 12 skull measurement. Males only.

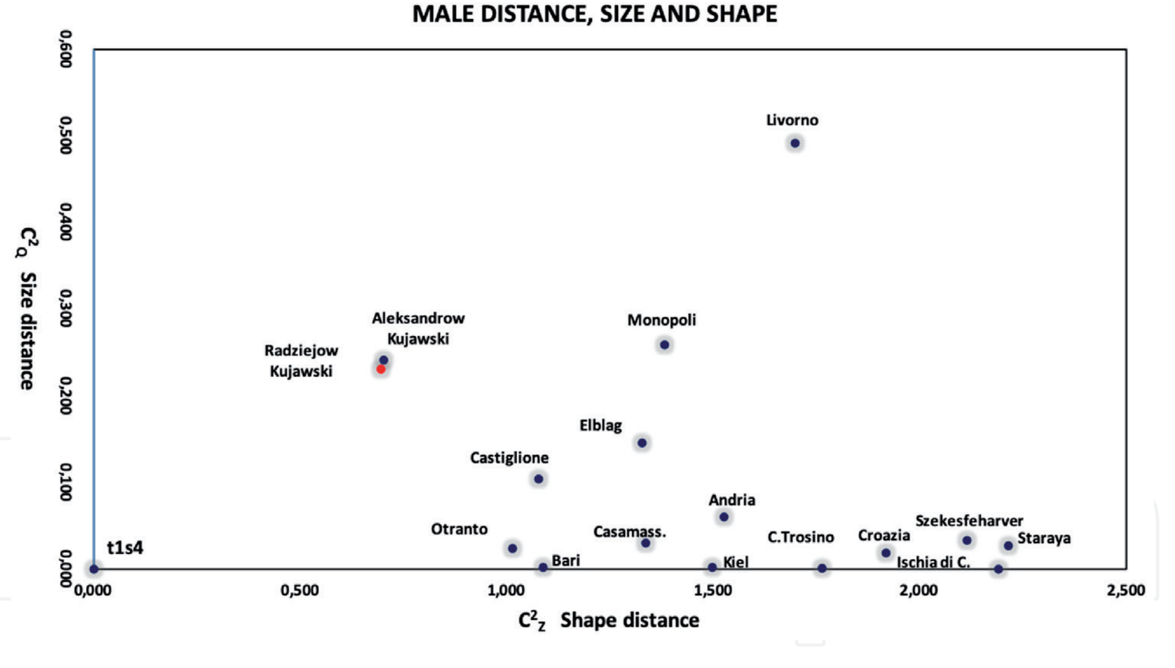

Table 6.
The affinities of 16 medieval people with the individual T1S4, employing the "size" and "shape" method of 12 skull measurement. Males only.

The diagonal matrix obtained through Penrose distance values was used as input for cluster analyses and PCA [64].

The principal component analysis (PCA) aims to reduce a high number of data (in this case, the main craniometric measurements) to a few representative values defined as "principal components" in order to highlight any intergroup correlations.

Two types of approach were used to analyze the Torre Alemanna sample.

The first type of approach compared the Torre Alemanna sample with the other medieval comparison samples.

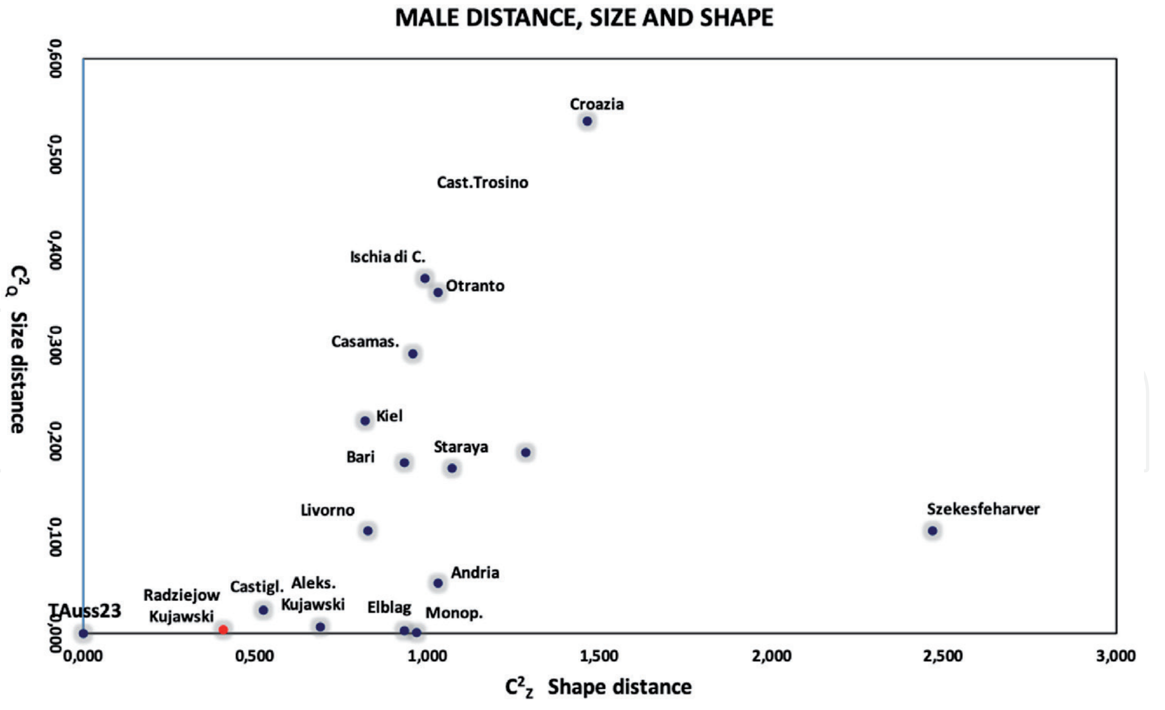

Table 7.
The affinities of 16 medieval people with the individual USS23, employing the "size" and "shape" method of 12 skull measurement. Males only.

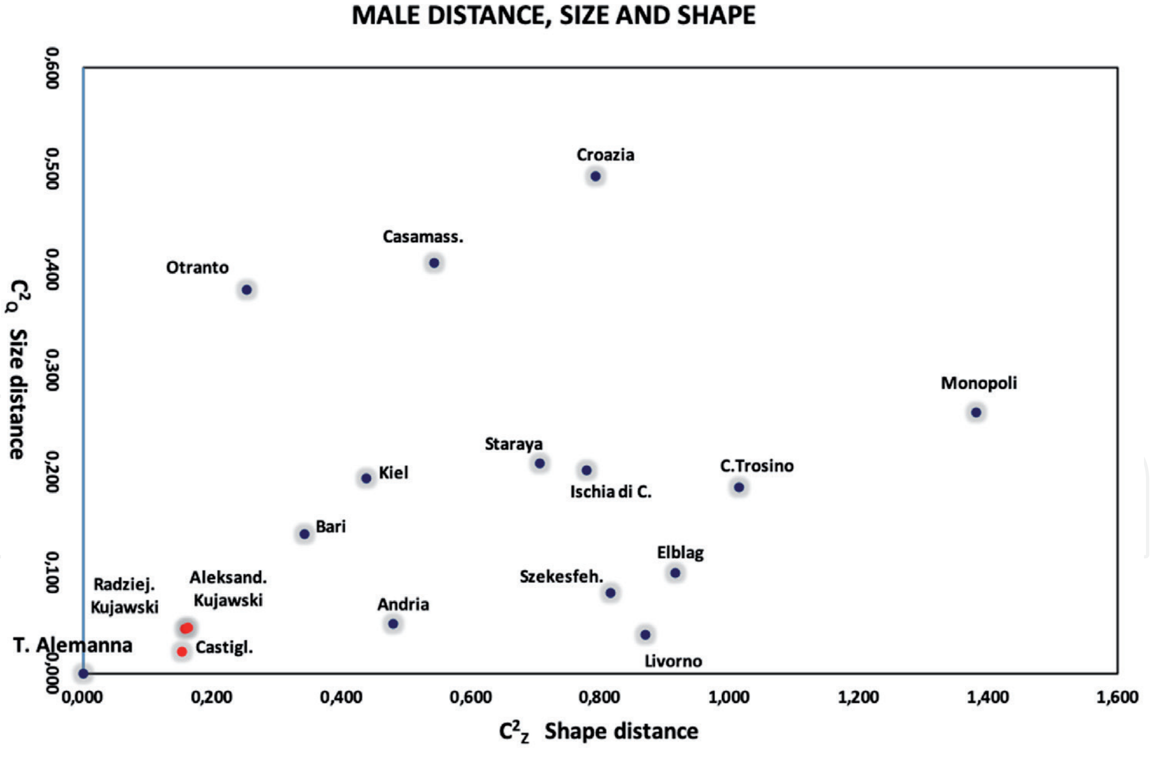

Table 8.
The affinities of 16 medieval people with Torre Alemanna sample, employing the "size" and "shape" method of 12 skull measurement. Males only.

The second one compared the individuals to investigate the behavior between each of them and the other medieval comparison samples.

Due to the absence of some data, craniometric measurements 5, 20, and 40 have been excluded from the PCA.

For the same reason, in order to obtain a more reliable result, the "USS23" individual was not considered.

Considering the first type of approach, it is possible to note that most of the variance is almost equally distributed among the first four principal components, underlining the homogeneity of the sample.

The first and third main components (respectively, 28.85 and 16.91% of the common variance) describe the sample in terms of face shape showing a certain closeness to the Apulian sampling of Andria and to the Pomeranian groups. The second and fourth main components (23.38 and 12.27% of common variance) describe the craniometric set in terms of shape and above all size of the skull, showing a strong affinity with Castiglione, Aleksandrów Kujawski, and Radziejów Kujawski sites, confirming what emerged from the other statistical investigations carried out (**Table 9**).

The second type of approach allows a targeted comparison taking into consideration the individuals "USS25," "T1S1," and "T1S4."

The variance is well distributed among the first four principal components also in this case, with a cumulative value of 80.43% (**Table 10**).

The first three principal components describe the set of individuals mainly in terms of face shape. The fourth component instead describes the size of the skull (**Table 11**). The behavior of individuals in relation to the principal components is investigated with the aim of assessing the affinity of each of them to the Pomeranian groups.

Through the first three principal components, and therefore in terms of face shape, the individuals "USS25," "T1S1," and "T1S4" show a certain closeness with the samples of Aleksandrów Kujawski and Radziejów Kujawski. Only with the fourth principal component, and therefore in terms of skull size, it is possible to describe the strongest affinity, confirming once again what has already been highlighted by the other multivariate statistical studies conducted.

Finally, the individual who most of all seems to be related to the Pomeranian groups turns out to be t1s1.

4.1.3 Occupational stress markers

Starting from the upper limbs, on the collarbones, the strength index was assessed, based on the percentage ratio between the circumference in the middle and the maximum length, and the data obtained showed a very high index for all individuals. The clavo-humeral index, based on the percentage ratio between the maximum length of the

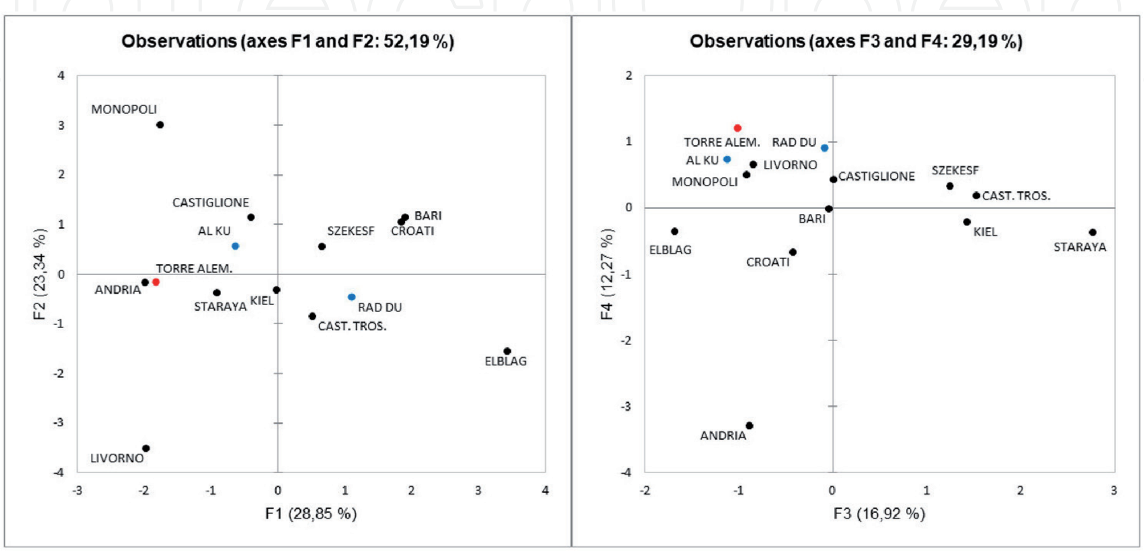

Table 9.
Principal component analysis of the Torre Alemanna sample.

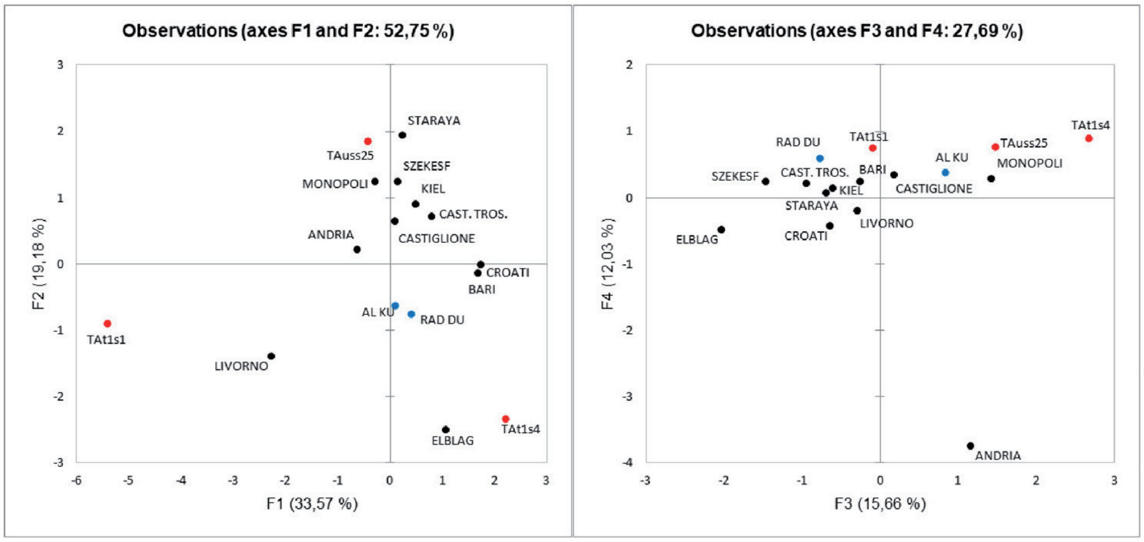

Table 10.
Principal component analysis of three male individuals (USS25, T1S1, and T1S4).

Acronym	*Sex, age*	*Bone/district*	*Wound*	*Timeline*
USS23	M Mat	Nasal bone	Sharp	Ante-mortem
USS25	M Ad	Skull, L. Parietal Skull, Frontal Skull, Maxillary L. Clavicle R. IX Rib	Puncture Sharp Blunt Sharp Fracture	Ante-mortem Ante-mortem Ante-mortem Peri-mortem Ante-mortem
USS26	M Ad	Cervical vertebrae Rib	Fracture Puncture	Ante-mortem Ante-mortem
T1S1	M Ad	Rib Fourth metacarpal L. Femur	Fracture (2) Fracture Sharp	Ante-mortem Ante-mortem Peri-mortem
T1S3	F Ad	L. Clavicle L. Humerus R. Coxal	Sharp Sharp Sharp (2)	Peri-mortem Peri-mortem Peri-mortem

Table 11.
List of individuals with injuries.

clavicle and the width of the lower distal epiphysis of the humerus, is characterized by a short clavicle. When it was possible, the index of platibrachy, or diaphyseal, was evaluated on the humerus of the above-mentioned individuals and showed a rounded diaphyseal section (euribrachy and hypereuribrachy), a symptom of poor development of the *Deltoid* muscle and the *Pectoralis major*. The radius has an average strength and diaphyseal index as found also in the ulna analysis. As far as the lower limbs are concerned, the situation of platymeria is common; therefore, morphological modification of the femur in the part located below the trochanters, which is flattened in the anteroposterior direction. The analysis of the tibial indices shows a condition of euricnemia with the absence of transverse flattening of the upper portion of the diaphysis, indicating a limited level of stress on the quadriceps and soleus muscles. Forces repeated over time and concentrated on a muscle or on a specific ligament can produce different types and grades of markers, detectable through the analysis of enthesopathies, changes in the insertion points of the tendons, and syndesmopathies, changes in ligament insertion points.

The main movements that our skeleton can do are abduction, movement lateral removal from the medial line of the trunk; adduction, movement toward the midline of the trunk; flexion, bending resulting from the decrease in the angle of a joint; extension, increases the angle of a joint; external rotation, rotational movement around a longitudinal axis of a bone that moves away from the medial line of the body; and internal rotation, rotational movement around a longitudinal axis of a bone that approaches the midline of the body.

By analyzing the development and distribution of markers, it is possible to reconstruct the movements and actions most carried out in life by the individuals considered.

The data obtained revealed a good development of the ligaments and muscles in particular, a case of syndesmopathy of the costoclavicular ligament, a strong development of the *Teres minor* and *Teres major* of the scapula, and a case of enthesopathy of the *Gluteus maximus* of the femur were evaluated.

The acromioclavicular joint is responsible for the lifting movement of the arm above the head. It helps the movement of the scapula with consequent rotation of the arm. A common injury to the acromioclavicular joint is the dislocation, and this is different from the dislocation of the shoulder, which refers to the dislocation of the glenohumeral joint. Dislocation of the acromioclavicular joint is particularly common for those who practice swimming, horse riding, mountain biking, and cycling.

The accessory articular facets are small supplementary articular surfaces that have formed on the bone following load stress or taking specific postures. The individuals of Torre Alemanna have some accessory facets located on the femur, patella, and pelvis.

As regards the femur, the following were identified: in-depth articular fovea (dimples of the femoral head, in which the round ligament of the femur is inserted); Allen pits located bilaterally, due to compression of the neck of the femur by the edge of the acetabulum; and facets of Poiriers, located on the articular surface of the head of the left femur and indicating an extension of the coxofemoral joint at the hip level is given by the extension of the articular surface of the femoral head on the anterior surface of the femoral neck. The stressors that underlie this marker are two: the extreme flexion and abduction of the femur it produces contact between the head of the femur itself and the edge of the acetabulum.

The second factor, however, is due to the pressure exerted by the iliopsoas muscle on the medial edge of the femoral neck. It was originally described as a marker due to squatting; presence on the left femur of the third trochanter; strong alterations of the first trochanter; and important rough line.

On the patella, a slight fossa of the vast lateral was detected, portion of the muscle *Quadriceps*. With its action, it extends the leg and stabilizes the patella opposing its tendency to dislocate itself, and it also increases the effectiveness of the quadriceps by bringing forward its traction force and is the major producer of force during the movement of extension of the leg on the thigh.

The pelvis has rough edges along the margins of the acetabular cavity, which due to mechanical stress is ovalized and shows also the ischial bursitis (**Figure 9**).

Finally, on the front surface of the lower end of the tibia, kneeling facets have been identified, directed parallel to the front edge of the articular surface with the talus, which indicate a hyperflexion condition of the foot in the squatting position. On the basis of the results obtained from the analysis of the musculoskeletal markers and of the accessory joint facets, it is possible to argue that the individuals had the "rider's syndrome," that is individuals who frequently ride horses.

Specifically, the characteristics of the aforementioned syndrome and which are found in the analyzed subject are oval-shaped slab acetabulum; facets of Poiriers; head with deep fovea of the right femur; presence of the third trochanter of the left femur, and marked muscle pressures of the small and medium buttock.

This situation is particularly evident in the USS25 individual, in T1S4 and USS23. Furthermore, the presence of the important costoclavicular ligament in all

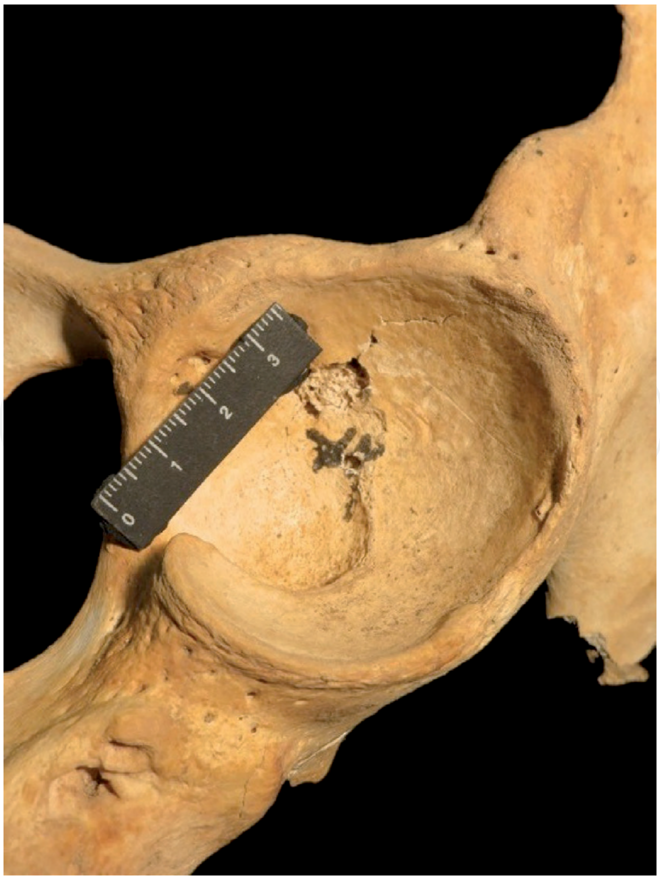

Figure 9.
USS25. Pelvis with rough edges along the margins of the acetabular cavity, oval due to mechanical stress.

individuals is related to stresses on the clavicles and ribs due to a weight overload such as, for example, the presence of an armor.

In conclusion, it can be said that the individuals in question had a first period of horse-riding activity followed by the habit, in recent years, of using a wagon as a means of transport.

Osteoarthrosis is a degenerative joint disease, noninflammatory, chronic, and progressive, characterized by the loss of articular cartilage, which leads to the formation of lesions deriving from direct interosseous contact.

Not only it can be caused by biomechanical stress due to heavy physical activities or small traumas, but also advancing age and genetic predisposition can be causes of appearance. In addition, it has been observed that the onset of osteoarthrosis is due to climatic factors; in fact, countries with colder temperatures show a high percentage of the pathology.

There is therefore a loss of the cartilage located in the diarthrosis joint, inside which the synovial membrane is located, which covers and nourishes the joint surface and lubricates it with the synovial fluid, which covers the central part of the epiphysis.

This results in interosseous contact and abrasion of the subchondral bone, which leads to bone remodeling due to bone neoformations at the joint margins, called osteophytes.

It is possible to distinguish different degrees of lesion of the surface, starting from the slightest shape characterized by thin barely perceptible bone edges, up to the most serious cases, which show evident spicules protruding from the bone surface. The destruction of the cartilage and the consequent interosseous contact cause the smoothing of the articular surface, so as to make the bone take on the appearance of ivory, eburnation.

The individuals under analysis have generally mild osteoarthrosis and, in most cases, characterized by the loosening of the margins of the joints with a rim that does not protrude more than 2 mm.

In some cases, a slight porosity has been detected, particularly in the sternal end of the clavicle, at the level of the femoral head.

4.1.4 Study of traumatic injuries

The study of traumatic injuries is very important in the paleopathological field since they are the most commonly encountered pathological conditions. It is possible to distinguish injuries in: accidental, they provide information about a lifestyle individual; intentional trauma, such as war, allows to obtain information about combat techniques and the type of weapons used; and surgical injury, produced by therapeutic interventions by ancient physicians.

Through the analysis of the fractures, it is possible to detect if it is a cause of death of the studied subject or if a scarring process has occurred. During the reparative phase, a good vascularization is necessary that allows a good supply of blood and nutrients, in order to facilitate bone neoformation.

The presence and location of traumatic injuries in an individual depend on factors related to lifestyle, age, sex, health conditions, employment, and social status within a group. The sample shows 16 lesions distributed over 5 adult subjects including 4 males and 1 female.

There are 8 sharp injuries, 1 puncture lesion, 1 blunt lesion, and 6 fractures: 6 of these, on 3 individuals, are perimortem wounds (**Table 11**).

The USS23 individual shows an healed sharp lesion on left nasal bone (**Figure 10**).

The USS25 individual has the following injuries:

- puncture lesion (4.7 × 3 mm) located on the left parietal bone, nearby of the sagittal suture. The hole is oval, and the margins are rounded. The remark endocranial revealed the presence of a bone scale anterior to the lesion for the penetration of the pointed body. Waiting for an X-ray report, it can be said that this is not a cause of death (**Figure 11**);

- perforation (16.4 × 13.2 mm) located on the frontal bone, 37.6 mm from the point bregma on the median sagittal plane. The color of the margins is clear. It is probably an inexperience in the archeological excavation;

- sharp lesion (12.1 × 7.7 mm) of elliptical shape on the frontal bone, located at 26.5 mm from the temporal crest and 29 mm from the top of the right orbit. It is antemortem injury since there are traces of bone repair in the form of osteosclerotic islands (**Figure 12**);

- localized lesion on the maxillary bone, which led to a sinking with subsequent probable loss of the right medial and incisive tooth bone neoformation of a ridge, on the medial sagittal plane in correspondence of the suture margin between the two maxillary bones, below the pyriform opening (**Figure 13**);

- there is an extensive area of inflammation consisting of several raised areas of osteosclerosis associated with porosity zones. The portion of the anterior face of the right maxilla shows a slight but different angle from the left, with the lower part tending to protrude anteriorly. Etiogenesis is not yet known, but it is possible to hypothesize a direct traumatic event or inflammation process following the odontogenic abscesses visible in the right portion of the maxillary bone;

DOI: http://dx.doi.org/10.5772/intechopen.93039

- cutting lesion (5.8 × 1.8 mm) located on the medial third of the left clavicle, in north-south direction on the anterior diaphyseal arch. There are bone neoformations. It is probably a blow inflicted by an aggressor placed anteriorly and right-handed, through a backhand slash (**Figure 14**); and

Figure 10.
USS23. Healed sharp lesion on left nasal bone.

Figure 11.
Puncture lesion located on the left parietal bone USS25.

Figure 12.
USS25. Sharp lesion located on the frontal bone.

Figure 13.
USS25. Lesion on maxillary bone.

- probable fracture with subsequent repair on the IX rib on the right.

The USS26 individual shows a half circular lesion on a rib, followed by inflammation of the bone (**Figure 15**). It seems to be related to an intentional trauma during an episode of interpersonal violence. Two cervical vertebrae are partially fused along the left margin of the bodies, probably as a result of a trauma (**Figure 16**).

The T1S1 individual presents:

- the fracture of two ribs, which, given their condition, could not be numbered (**Figure 17**);

Figure 14.
USS25. Cutting lesion located on the medial third of the left clavicle.

Figure 15.
USS26. Half circular lesion on a rib, followed by inflammation of the bone.

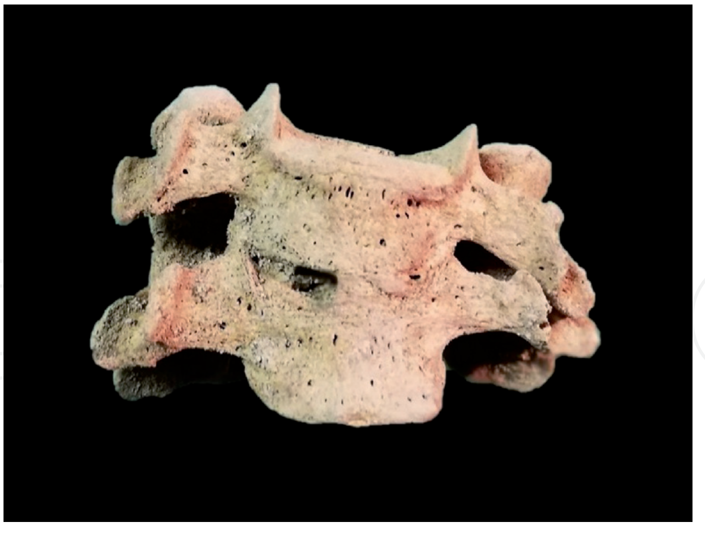

Figure 16.
USS26. Two cervical vertebrae partially fused.

- a healed fracture of the fourth metacarpal of the right hand (**Figure 18**); and
- a sharp lesion on the anterior surface of the diaphysis of the left femur, as perimortem injury.

The T1S3 individual presents four sharp lesions: one of these was on the acromial extremity of the left clavicle, one on the greater tuberosity of the left humerus, and two on the right coxal bone (**Figure 19**), of which one is localized on the iliac wing, the other

Figure 17.
T1S1. Fracture of the rib.

Figure 18.
T1S1. Healed fracture of the fourth metacarpal.

on the posterior edge of the acetabulum. They are all perimortem injuries; some of these show elastic bone reaction and are probably consequence of interpersonal violence.

4.1.5 Dental and bone markers of nutritional stress

Finally, from the analysis of the dental records, it appears that the dental wear is of a mild degree and basically due to chewing and not to work activities. Only a few individuals show caries but in a small number; however, the presence of tartar is more important, confirming the mainly meaty diet. Both of these situations suggest poor levels of dental hygiene.

Periodontal disease is an inflammatory disease affecting the gums and involves bone resorption of the alveolar margins with consequent exposure of the tooth root and its possible loss. The detection consists in measuring, using the caliper, the distance created between the alveolar margin and the dental crown. The categories of periodontal disease identified vary from mild, more frequent, to moderate.

Figure 19.
T1S3. Two sharp peri-mortem *lesions on the right coxal bone.*

Dental enamel hypoplasia is an indicator of stress and is caused by deficient enamel matrix formation. It manifests itself in the form of lines or wells on the surface of the teeth, following the slowdown or interruption of the production of enamel by the ameloblasts during the development phases.

Interruptions can be caused by malnutrition or disease that occurred during childhood; as a result, they can provide important information regarding the health and quality of life of a population.

The teeth most affected by hypoplasia are the incisors and canines, followed by the molars; it is found on their buccal surface. By examining the location of the defect hypoplastic, it is possible to go back to the moment of its formation, which in the studied subjects turns out to be between 2.5 and 5 years of age.

The percentage values of the Cortical Area (%CA) were evaluated on the diaphysary midsection of the humerus and are considered a bone indicator of nutrition.

The average %CA for males is 74% that means a good dietary condition.

4.2 Paleonutritional data

In order to evaluate possible diagenetic alterations of the test samples, the pH of the soil has been assessed. The result obtained is based on a basic pH indicating an essentially conservative soil. However, depletion may have occurred in the concentration levels of some elements (Ca^{2+}-Sr^{2+}-Mg^{2+}), due to the permanence of skeletal remains in the soil (**Table 12**).

All samples have an optimal level of calcium, except for the USS25 sample, probably due to a bad condition of *postmortem* preservation.

The magnesium intake differs considerably but remains within the reference standards. The sample data T1S1 shows a significant cereal intake, as opposed to the USS33 sample.

Zinc concentrations show good protein intake, particularly in T1S4 and USS23 samples.

The evaluation of copper data shows a minimal intake of mollusks and offal in general in the T1S4 and USS33 samples. However, they are below the minimum standard. Lead was only investigated in two samples, which show no significant contamination (**Table 13**).

For the analysis of strontium, it is in this case fundamental to relate the results of human osteological samples with that of the faunistic osteological sample of *Bovis* that lived in the site at the same time as the individuals under examination (**Table 14**).

It can be seen that both strontium results from the analysis of human and animal samples have low values (**Table 15**).

Despite the correction of the data, only the USS25 sample indicates a plant contribution.

Therefore, based on the evaluation of the data, it is possible to state that the only individual to have a diversified and balance diet is USS25.

4.3 Results of radiocarbon dating

A fragment of a rib (~500 mg) of the USS25 skeleton was used for radiometric analyses.

This radiocarbon date places this individual between 1342 and 1378 AD, meaning that he would have been active during the second half of the fourteenth century most likely died before the end of the century.

The date fully coincides with the Teutonic occupation of the settlement.

Chemical solution	*Level of acidity (pH)*	*Temperature (°C)*
Torre Alemanna	8,71	24,9°
Double-distilled water	5,38	24,3°

Table 12.
Level of acidity of the soil.

Samples of Torre Alemanna	Calcium (mg/g)	Strontium (ppm)	Magnesium (ppm)	Zinc (ppm)	Copper (ppm)	Lead (ppm)
T1S1	383	29	2929	134	9	/
T1S4	361	28	2525	189	20	/
USS23	429	26	2052	199	15	/
USS33	266	/	1580	131	23	18
USS25	80	50	1835	167	3	45
Standard	250-350	150-400	1500-2500	120-250	30-60	24-70

Table 13.
Concentrations of elements considered as nutritional markers found in the human osteological samples.

Sample	Calcium (mg/g)	Strontium (ppm)	Magnesium (ppm)	Zinc (ppm)	Copper (ppm)	Lead (ppm)
TA Fauna	99	70	3278	139	20	28
Standard	250-350	150-400	1500-2500	120-250	30-60	24-70

Table 14.
Concentrations of elements considered as nutritional markers found in the faunistic osteological sample.

Samples of Torre Alemanna	Strontium	Human strontium/ Animal Strontium
T1S1	29	0.41
T1S4	28	0,40
USS23	26	0,37
USS25	50	0,71

Table 15.
Correction of the data.

5. Conclusions

The taphonomic, anthropological, and paleopathological investigation of the osteological remains of the burials of area 5 of Torre Alemanna has allowed to reconstruct a complete biological stage of the individuals.

The burials belong to the cemeterial occupation's phase of area 5, situated in the northwestern corner of the complex, dated presumably to the initial phase of the Teutonic settlement, on the basis of the ceramic material found in the stratigraphy. Part of area 5 was cut after the construction of a semi-hypogeal environment, which intercepted a series of depositions. All individuals are buried in earthly pit with an east-west orientation. The results of analysis of the skeletal sample from area 5 show a total of 12 individuals subdivided as follows: 2 subadults, including 5-year-old male and 12-year-old female, and 10 adult individuals, including 6 males between the age of 37 and 45 years and 4 females between the age of 25 and 35 years.

The skulls have metrical characteristics very close to the sample of the Middle Ages coming from Radziejów Kujawski and Aleksandrów Kujawski (Poland), located in the ancient Pomerania, conquered by the Teutonic around 1309. From the morphological point of view, they show a typology similar to the northern European skeletal series indicated as Borreby. Borreby is a Danish village, where paleolithic skeletons were found with characteristics indicating a hybridization between the northern (Scandinavian) and the Baltic and Slavic populations.

The skulls of this type are found in the meeting areas between different populations, such as Pomerania, where historically Slavic, Baltic, and Germanic populations have had the opportunity to cross for centuries.

Particular syndromes related to riding horses and carrying weight overloads have been found, which suggest that the individuals examined have spent part of their lives in a very active way.

Several lesions were found, indicating episodes of interpersonal violence occurred *antemortem* and *perimortem* injuries, which some were the cause of death.

The data obtained from the paleonutritional analysis indicate a nutrition especially based on a good supply of cereals and protein. Only the individual USS25 has a balanced diet characterized also by a good supply of vegetable plant.

In the light of all these considerations, it is assumed that the individuals, presumably not autochthonous, participated actively in the military life and that they could therefore be part of the community of the monks-warriors who occupied the complex of Torre Alemanna for 200 years.

This publication is the first part of the project that will also include the manual facial reconstruction of the one of individuals found in area 5.

These were the results of a combination of humanistic and scientific studies.

It is a multidisciplinary project in which researchers of different training and competence have joined. The perspective is to enhance an extraordinary archeological site located in our region.

Acknowledgements

We would like to thank Prof. ssa Caterina Laganara for the archeological review. We would also like to thank Dr. ssa Giovanna Pacilio for allowing the study of the archeological and anthropological materials and Archt. Vincenzo Russo for the continuous exchanges of views and information on the archeological site. The chapter was financed by the University of Bari through the extraordinary contribution for activities of scientific and cultural interest (D.R. n. 801/2020).

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