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Contents

REVIEWS

Anthropological analysis of the skeletons discovered at Pecica “Rovine” (Arad County). Identification of certain occupational stress markers specific to horseback riding practice[1*]

Luminița Andreica-Szilagyi

Abstract: Enthesopathies represent changes to the insertion point of muscles and ligaments occurring in response to repeated mechanical actions. These occupational stress markers are frequently associated with the individuals’ daily activities. From the point of view of identifying such changes on bone areas, focus lay on the skeleton discovered in feature marked Cx_46a from the Pecica “Rovine” site. Namely, an adult individual, male, whose bones surface exhibits markers of occupational stress, related to the so-called “horseman syndrome”.

Keywords: Pecica “Rovine”; the Avar period; enthesopathies; “horseman syndrome”; nomad population.

Introduction

The 2014 archaeological excavations conducted in the site of Pecica “Rovine” (Arad County), yielded four skeletons dated to the Avar period, namely the 6th–7th century AD[2]. In the first feature (Cx_46) were found three skeletons, an adult and two sub-adults, while in the second feature (Cx_47) an adult skeleton was identified. Anthropologically, focus was directed onto the adult skeleton from feature Cx_46, which exhibited on bone surfaces markers of occupational stress, related to the so-called “horseman syndrome”.

In the historical and archaeological sources, the horseback riding abilities of the Avars are well known. Since they were a nomad population, horseback riding was important not only economically and socially, but also from the view of warfare related activities; in military organisation, cavalry played the main role[3].

Materials and methods

This study comprises the anthropologic analysis of the four skeletons discovered in features Cx_46 and Cx_47, in the Pecica “Rovine” site, numbered Cx_46a, Cx_46b, Cx_46c and Cx_47.

In the case of adult skeletons, sex determination was possible by the use of several markers like the morphology of the skull bones[4] and the morphological features of the coxal bones[5]. For estimating the age of the individuals, changes at coxal levels were examined, more specifically the changes occurring at the level of the pubic symphysis and auricular aspect of the ilium[6], but also the appearance of the sternal extremity of the ribs[7].

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* We express our thanks here for the opportunity to process the osteological material, Mr. G. P. Hurezan PhD †, supervisor of the archaeological site, yet also the research team composed of F. Mărginean PhD (National Museum of Transylvanian History) and V. Sava Phd, N. Kapcsos Phd student (the Arad Museum Complex).

1 The preliminary results of the anthropological analysis were also mentioned in study: Gáll, Mărginean, *The Graves from Pecic-Rovine/Căprăvanul Mic and Distribution Networks of Amber and Personal Adornments in the 6th and 7th Centuries*. Journal of the Archaeological Museum in Zagreb, Vol. 54, Nr. 1, 2021, in press.
English translation: Gabriela Safta.

2 Gáll, Mărginean 2021.

3 Đukić 2016, 52.

4 Buikstra, Ubelaker 1994, 19–20.

5 Buikstra, Ubelaker 1994, 17–18.

6 Meindl, Lovejoy 1989.

7 Ișcan 1989, 108–111.

In order to establish the height of the adult individuals, maximum lengths of the humerus, radius, femur and tibia were used. Measurements were taken in accordance with R. Martin's guidelines[8], while height was computed based on K. Pearson's formulas[9]. Framing in height classes was made based R. Martin's classifications[10].

Age estimation in sub-adult individuals was made by using two indices, namely length of the long bones[11] and teething[12]. Height was computed by using the method from M. Maresh[13].

Regarding the enthesopathies scoring, a binary scoring method, drafted by Villotte *et al.*[14] was used.

Results

Cx. 46a

A well preserved and represented skeleton of a male individual of an approximate age of 30–40 years. With a computed height of 167.9 cm, it was framed in the upper-average height class.

Notably, at this individual, certain changes at the insertion point of muscles, tendons and ligaments are present. These markers of occupational stress represent the bone's response to a habitual mechanical activity, being associated with the individual's daily activities[15]. When a muscle is repeatedly and constantly used, changes occur at the place on its insertion to the bone, which emerge as hypertrophies or ethesopathies[16]. The location of these enthesopathies is suggested by the stressor type.

On both humeri are visible enthesopathic lesions at the insertion point of muscles *Pectoralis major, Deltoid* and *Triceps Brachii,* with a slight asymmetry concerning the development degree of the ethesopathies, according to the side; the insertion place of the muscle *Deltoid* and *Triceps Brachii* is more marked on the left side (Fig.1/a). Such asymmetry may be the results of the bow and arrow use[17].

On both radii (slightly more marked on the left side one) the bicipital tuberosity is robust

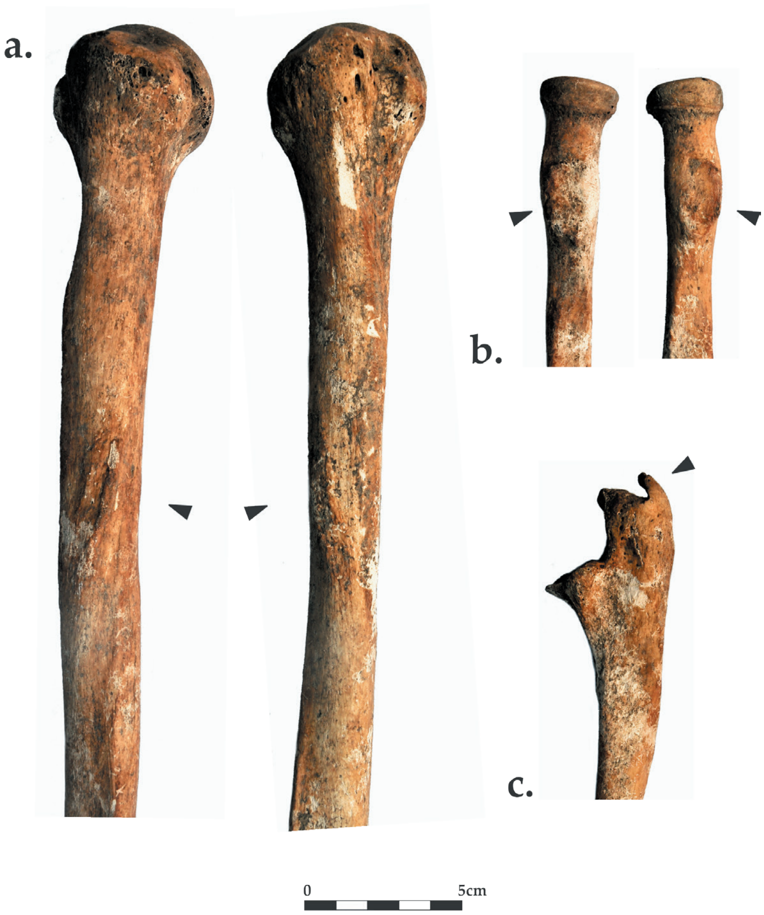

Fig. 1. Examples of enthesopathic changes at upper limbs level: a) enthesopathic changes at insertion level of muscle *Deltoid*, on the humerus left-right; b) marked bicipital tuberosity on the radius left-right; c) the presence of an osseous spicule at the level of the right ulna olecranon.

8 Bräuer 1988, 160–232.
9 Olivier 1960, 263.
10 Martin, Saller 1957.
11 Bernert *et al*. 2007, 202, table 3.
12 Buikstra, Ubelaker 1994, 51, fig. 24.
13 Visser 1998, 415.
14 Villotte *et al.* 2010.
15 Capasso *et al.* 1998.
16 Larsen 1997, 188.
17 Dutour 1986, 222–223.

(Fig.1/b). Possible explanations for the development of this enthesopathy are related to activities involving elbow flexing, like archery[18], carrying heavy objects, yet also the bone's response to mechanical stress owed to farming activities[19]. At the level of the right ulna olecranon, more specifically at the insertion point of muscle *Triceps brachii,* was noted the presence of an osseous spicule (Fig.1/c). Some authors argue this change emerged subsequent to the long-term use of the bow and arrow[20], or spear or boomerang throwing[21].

Moreover, some of the markers of occupational stress at spine, pelvis and lower limbs bone levels may be associated with the so-called "horseman syndrome" (Table 1, Table 2). Their presence in these body areas is explained by the fact that during horseback riding, the lower body part acts like an anchor and as a "safety belt"[22].

On coxals and lower limb bones were identified a number of six enthesopathies related to the "horseman syndrome" (Table 1). On coxals, the insertion place of several muscles, like *Semimembranosus, Semitendinosus* and *Biceps femoris,* is hypertrophic. On the proximal half of the femuri are visible osteophytes at the place of insertion of muscle *Gluteus minimus* (Fig.2/a), yet also the hypertrophy of the gluteal tuberosity (Fig. 2/b). Still on femuri, changes in the form of osseous spicule or exostosis are also visible at trochanteric fossa level, by the insertion place of muscles *Obturator externus* and *Obturator internus.* The presence of osteophytes, discrete and medially oriented, mark the insertion of adductor muscles on *Linia aspera* (Fig. 2/c).

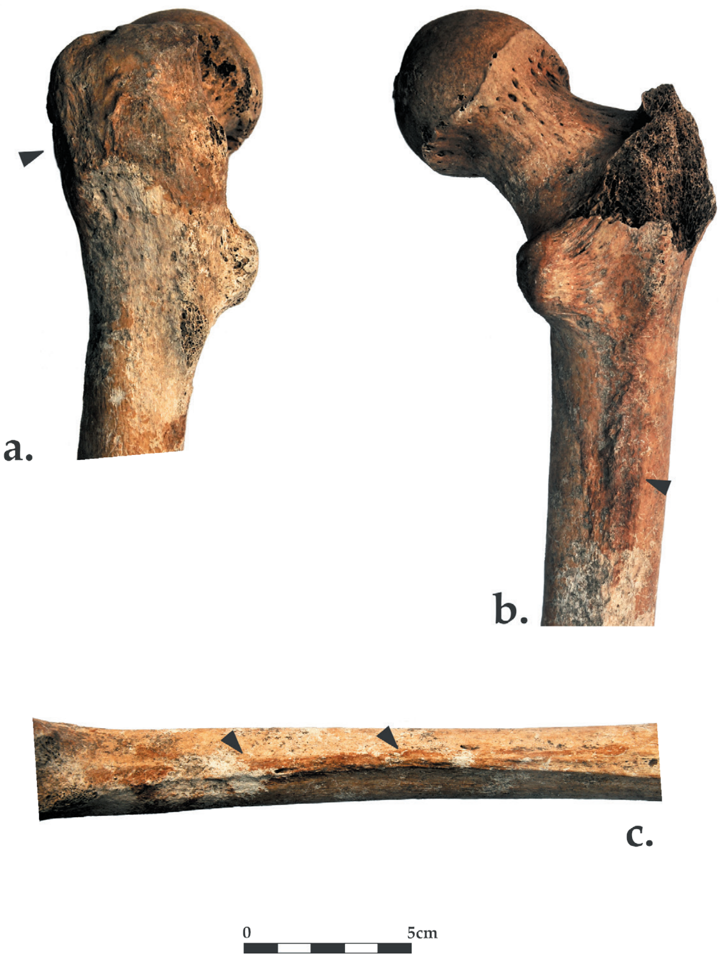

Fig. 2. Examples of enthesopathic changes on the femur: a) anterior aspect of the large trochanter on the left femur; b) the gluteal tuberosity on the right femur; c) *linia aspera* on the left femur.

18 Dutour 1986.
19 Capasso *et. al*. 1998.
20 Dutour 1986.
21 Nadal *et al*. 2002, 103–104; Kennedy 1989.
22 Zaia 2019, 4.

On the tibiae, the tuberosity of the tibia exhibits oseeos spicule, moderate, superiorly oriented. Present, still moderate exostosis, was identified also on the tuberosity of the right-side calcaneus (that on the left side exhibits postmortem destruction).

At spine level, more specifically, on the thoracic and lumbar vertebrae were noted traces of osteoarthritis and the presence of Schmor'l nodes.

The osteoarthritis at vertebrae level occurs owing to the atrophy of the intervertebral disc, which eventually leads to direct contact between vertebrae edges. Irritation caused by the direct contact between vertebral edges favours the production of new periosteum in the form of osteophytes[23] (Fig.3/a). In horsemen, the back is subject to constant compression, which leads to stress applied to the intervertebral disc[24]. Authors like G. Pálfi[25], J. Blondiaux[26], R. K. Wentz and N. T. De Grummond[27] or J. Zaia[28] associated the occurrence of these vertebral changes with the practice of horseback riding.

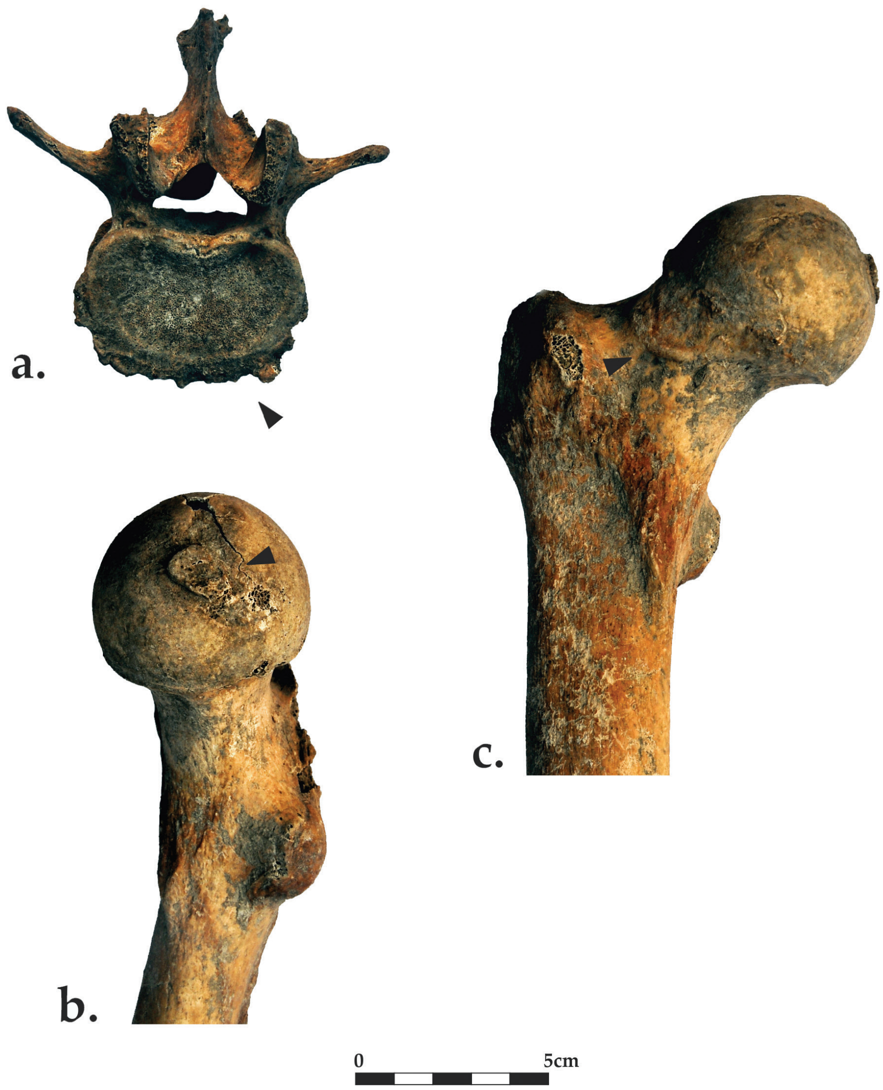

Fig. 3. Examples of changes at joint levels: a) osteoarthritis on a lumbar vertebra b) osteophytes at the right femur *fovea capitis* level; c) Poirier's facet on the right femur.

The Schmor'l nodes emerge subsequent to the vertical herniation of the intervertebral disc by the penetration of the intervertebral disc in the spongious tissue of the vertebrae. Commonly, cavities

23 Aufdaheide, Rodriguez-Martin 1998, 96; Roberts, Manchester 2010, 139–140.
24 Zaia 2019, 5.
25 Pálfi 1992.
26 Blondiaux 1994.
27 Wentz, De Grummond 2009.
28 Zaia 2019.

5 mm in diameter and 1–1.5 mm deep result. These changes emerge following the constant stress over the intervertebral disc, possibly due to trauma, frequent spine bending or lifting heavy weights on the back[29]. During horse riding, each body part is subject to a certain degree of stress, however the spine and pelvis are the most affected[30]. At present, this pathology is frequently encountered among high performance athletes. In bioarchaeological studies, Schmor'l nodes are often associated with horseback riding[31].

Table 1. Enthesopathies related to the "horseman syndrome".

Bone	**Insertion area**	**Muscle**	**Author (s)**
Coxal bone			
	Ischial tuberosity	*Semimembranosus; Semitendinosus; Biceps femoris*	Pálfi G. 1992; Pálfi, Dutour 1996; Đukić 2016; Berthon 2019.
Femur			
	Anterior aspect of greater trochanter	*Gluteus minimus*	Pálfi G. 1992; Blondiaux 1994; Reinhard *et a*l. 1994.
	Trochanteric fossa	*Obturator externus; Obturator internus*	Blondiaux 1994; Berthon 2019.
	Gluteal tuberosity	*Gluteus maximus*	Pálfi G. 1992; Alduc-Le Bagousse *et al*. 1992; Blondiaux 1994; Bartsiokas *et a*l. 2015; Pálfi, Dutour 1996
	Linia aspera	*Adductor longus*	Pálfi G. 1992; Blondiaux 1994; Đukić 2016
Tibia	Tibial tuberosity	*Quadriceps femoris*	Bartsiokas *et al*. 2015
Calcaneus	Calcaneal tuberosity	*Triceps surae*	Bartsiokas *et al*. 2015; Berthon 2019

Table 2. Changes at the level of joints and bones related to the "horseman syndrome".

Bone	Anatomical area	Joints and bone changes	Author (s)
Thoracic and lumbar spine	Thoracic and lumbar vertebrae	Schmor'l nodes	Wentz, de Grummond 2009; Zaia 2019; Berthon 2019
Thoracic and lumbar spine	Thoracic and lumbar vertebrae	Osteoarthritis	Pálfi G. 1992; Blondiaux 1994; Wentz, de Grummond 2009, Zaia 2019
Femur	Junction of the femoral head with the superoanterior extremity of the femoral column	Poirier's facet	Pálfi G. 1992; Bartsiokas *et al*. 2015; Berthon 2019
Femur	Coxofemoral joint	Osteophytes at the level of *fovea capitis*	Baillif-Ducros 2012
Femur	Patelar aspect of the patellofemoral joint	Degenerative changes	Baillif-Ducros 2018
Coxal	Acetabular aspect of the coxofemoral joint	Arthrosis at the level of the acetabular aspect	Larentis 2017

Certain studies mention the degenerative changes at the coxo-femoral joint level, like perifoveal osteophytes on the femoral head (Fig.3/b), as being associated with the "horseman syndrome"[32].

Another consequence of horseback riding practice is also believed the presence of a morphological variation of the femur, termed *Poirier's facet* (Fig.3/c), located at the junction of the femoral head with the superoanterior extremity of the femoral column[33].

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29 Aufdaheide, Rodriguez-Martin 1998, 96–97; Roberts, Manchester 2010, 139.
30 Zaia 2019, 6.
31 Wentz, De Grummond 2009; Zaia 2019; Berthon 2019.
32 Larentis 2017; Baillif-Ducros 2018.
33 Pálfi 1992; Bartsiokas *et al.* 2015.

Cx. 46b

There were identified osteological fragments which belonged to a sub-adult. The preservation and representation state are rather poor, best represented being long bone diaphyses. From the skull bones were retrieved fragments of the skull cap and a fragment of the left jaw, corresponding to dental pieces 12, C, M1 and M2 deciduous.

A tibia length on the left side of 187 mm, left side humerus of 168.4 mm as well as the teething are suggestive of an approximate age of 6–7 years.

Based on the humerus and tibia length, an average height of 105.9 cm was computed.

Regarding the pathology elements, on the anterior aspect of the vertebral bodies (especially those thoracic and lumbar) are visible traces of hypervascularisation, which may be indicative of tuberculosis. It must be specified though that the lack of other pathology elements indicative of such pathology and molecular analyses impede a more accurate establishment of such pathology.

Cx. 46c

A sub-adult skeleton in a rather poor preservation and representation state. From the skull bones were recovered fragments of the skull cap, yet also the intact jaw; the postcranial skeleton is best represented by left side osteological fragments (the scapular belt, upper limb bones), the pelvic belt and fragmentary diaphyses of the lower limb bones.

An approximate age of 2–3 years could be estimated by using bone lengths (left humerus: 123 mm, left clavicle: 70 mm) and the teething chart.

According to the left side humerus length, an 84.8 cm height was appreciated.

No pathology elements could be identified.

Cx. 47.

The skeleton is poorly preserved and represented. Worst represented are the skull bones, followed by the ribcage bones. The two humeri were recovered intact, together with the right femur and the two tibiae.

This is the skeleton of a female individual, aged approximately 45–55 years; the computed height is of 150.2 cm.

According to the occupational stress markers, it may be argued that the deceased was a female who extensively physically worked throughout her life.

The hypertrophy of the conoid process and groove formation at the insertion point of the costoclavicular ligament on the clavicle may be the result of continuous use of the scapular belt, like for instance in movements supposing arm rising. On the humerus, muscle *Pectoralis major* is involved in rotation and adduction movements, with arm bending[34]. Still at the humerus diaphysis level is noticeable the development of the deltoid tuberosity, which explains the bone response to constant exercise, consisting in circular and above the head arm abduction movements; this may be the result of domestic and animal herding activities[35].

The muscle *Biceps brachii*, which is inserted in the radius tuberosity is used for bending and stretching the arm, being the main responsible for flexing the elbow. This enthesopathy may be related to certain activities, like carrying heavy objects with elbows flexed[36].

On the right femoral head is noticeable an exostosis collar, possibly a hip dislocation.

Discussion

Among the first studies to associate occupational markers with the so-called "horseman syndrome" count those carried out by G. Pálfi[37] and G. Pálfi and O. Dutour[38]. The first comprises the analysis of a 263 skeletons' lot from the Sárrétudvari-Hízóföld cemetery in Hungary, dated to the 10th century. In the second study, beside the osteological material coming from the Hungarian cemetery, a

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34 Mann, Murphy 1990.

35 Gonzaléz, Concepción 2003, 180, 190.

36 Dutour 1986, 222.

37 Pálfi 1992.

38 Pálfi, Dutour 1996.

lot of skeletons, retrieved from a 4th century cemetery from the Var geographical area, in France, was added.

Later, W. Berthon[39] went further and analysed a number of 67 skeletons from the Sárrétudvari-Hízóföld cemetery in Hungary. The author divided the investigated material in two sub-groups, on the basis of the presence (RD = Riding Deposit) or absence of grave goods (NRD = no Riding Deposit) and started from the presumption that individuals whose grave goods were connected to horseback riding very likely did so; instead, the situation should have been different in the case of those where such grave goods were missing.

This hypothesis had to be checked, since the grave goods might have fulfilled only a symbolical function without any direct connection with the horseback riding practice or the grave furnishing might have consisted of materials that did not survive the taphonomic processes or their consistency was rather poor.

In order to obtain most relevant results, the author chose a comparative study lot, with a known socio-cultural context, in which horseback riding practice was much less likely; this lot is the Luis Lopes Skeletal Collection with the National Museum of History and Natural Science of Lisbon. The collection contains 1692 individuals, deceased between 1805–1975. For his study, W. Berthon chose a number of 47 male individuals, of whom information regarding their activities throughout their life existed. Subsequent to the bioarchaeological analysis, the author noted there was no significant difference regarding the presence of enthesopathies associated with horseback riding practice in the two skeleton lots from Hungary (RD and NRD). This may suggest that both groups practiced horseback riding to the same extent, regardless the grave goods present within the burials. Instead, significant differences were identified between the two groups of individuals from Hungary and those analysed from the Lisbon collection; the presence of occupational stress markers was found in much higher percentages in the case of the lots from the Sárrétudvari-Hízóföld cemetery.

Based on the results obtained by W. Berthon, and in the case here, the lack of harness items or even of horse fragments, we do not necessarily exclude the fact this individual practiced horseback riding; it is likely these grave goods were not deposited because of an existing social hierarchical stratification of the Avar community[40].

Significant differences were also recorded by k. M. Đukić[41], when comparing a population of Avar horsemen with a populace of farmers, of medieval date, from Serbia; certain enthesopathies were more marked among male individuals in the lot of Avar skeletons. This is namely the case of muscle *Subscapularis* on the humerus, muscle *Biceps femoris*, *Semitendinosus* and *Semimembranosus* at the pelvis level yet also the muscles attached to *linea aspera* and muscle *Adductor magnus* on the femur.

Similar studies on the topic were also drawn up by Alduc-Le Bagousse *et al*.[42], J. Blondiaux[43], S. Villotte and Ch. J. Knüsel[44], Baillif-Ducros *et al*.[45], A. Bartsiokas *et al*.[46] or R. Fuka.[47]

Also notable are the occupational stress markers at upper limb levels in the individual discovered in feature Cx_46a; their aetiology may be related to a specific combat technique. Historical sources describe the Avar military forces as composed of light cavalry, heavy cavalry and foot archers, who were most often providing support for lancers[48].

Conclusions

The presence of occupational stress markers on human skeletons may contribute to the reconstruction of the main activities carried out by an individual over the course of his/her lifetime. For the individual discovered in feature Cx_46a, degenerative changes at joints level, yet also the occurrence

39 Berthon 2019.
40 Bede 2012, 47.
41 Đukić 2016.
42 Alduc-Le Bagousse *et al.* 1992.
43 Blondiaux 1994.
44 Villotte, Knüsel 2009.
45 Baillif-Ducros *et al.* 2012.
46 Bartsiokas *et al.* 2015.
47 Fuka 2018.
48 Đukić 2016, 52–53.

of certain enthesopathies on the lower limb bones, may suggest the practice of horseback riding. Furthermore, the location of the occupational stress markers on upper limbs bones, yet also their unequal distribution, may be the result of a combat technique, in which the bow and arrow or spear throwing were involved.

One should not disregard the case of the individual in feature Cx_47; the presence of enthesopathies at clavicle and upper limb bone levels are suggestive of a habitual performance of certain circular and above the head arm abduction movements, yet also of arm bending and stretching; since this was a female individual, one may assume such movements occurred during household or animal herding activities.

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Visser 1998	E. P. Visser, *Little waifs: estimating child body size from historic skeletal material*. International Journal of Osteoarchaeology 8, 1998, 413–423.
Wentz, De Grummond 2009	R. K. Wentz, N. T. De Grummond, *Life on Horseback: Palaeopathology of Two Scythian Skeletons from Alexandropol, Ukraine*. International Journal of Osteoarchaeology 19, 2009, 107–115.
Zaia 2019	J. Zaia, *Saddle Sore: Skeletal Occupational Markers of Habitual Horseback Riding*. Senior Honors Theses. The College at Brockport, State University of New York, 2019.

Abbreaviations

AEM	Archäologisch-epigraphische Mitteilungen aus Österreich-Ungarn, Vienna.
AM	Arheologia Moldovei, Iași.
AMN	Acta Musei Napocensis, Cluj-Napoca.
AMP	Acta Musei Porolissensis, Zalău.
AMV	Acta Musei Varnaensis, Varna.
Angustia	Angustia. Revista Muzeului Național al Carpaților Răsăriteni, Sf. Gheorghe.
Anuarul MJIAP (S.N.)	Anuarul Muzeului de Istorie și Arheologie Prahova, Serie Nouă, Ploiești.
Antiquity	Antiquity. A review of world archaeology, Durham.
Archaeological Journal	Archaeological Journal. New Series. Chișinău.
ArchÉrt	Archaeologiai Értesitő, Budapest.
ArchPol	Archaeologia Polona, Warsaw.
ArchRozhledy	Archeologické Rozhledy, Praha.
ASM	Archaeologica Slovaca Monographiae, Bratislava.
BAR (Int. S.)	British Archaeological Reports (International Series), Oxford.
Biharea	Biharea. Culegere de studii și materiale de etnografie și artă, Oradea.
BMG	Bibliotheca Musei Giurgiuvensis, Giurgiu.
BMJT	Buletinul Muzeului Județean Teleorman. Seria Arheologie, Alexandria.
BMM	Bibliotheca Musei Marisiensis, Târgu Mureș.
Budapest Régiségei	Budapest Régiségei Régészeti és Történeti Évkönyv. Budapest.
CA București	Cercetări arheologice în București, București.
CCA	Cronica Cercetărilor Arheologice, București.
CIL	Corpus Inscriptionum Latinarum, Berlin.
CsSzMÉ	A Csíki Székely Múzeum Évkönyve. Csíkszereda.
Dacia (N.S.)	Dacia. Revue d'archéologie et d'histoire ancienne. Nouvelle serie. Bucureşti.
Dolgozatok	Dolgozatok a Magyar Királyi Ferencz József Tudományegyetem Archaeológiai Intézetéből. Szeged.
EphNap	Ephemeris Napocensis, Cluj-Napoca.
Erdély	Erdély. Turistai, fürdőügyi és néprajzi folyóirat, Cluj-Napoca.
FontArchPrag	Fontes Archaeologici Pragenses, Prague.
Földtközl.	Földtani közlöny, Budapest.
HOMÉ	A Herman Ottó Muzeum Ėvkönyve, Miskolc.
ILD	C. C. Petolescu, *Inscripții latine din Dacia*, Bucharest 2005.
JAHA	Journal of Ancient History and Archaeology, Cluj-Napoca.
Jahrb. RGZM	Jahrbuch des Römisch Germanischen Zentralmuseums zu Mainz, Mainz.
JAMÉ	Jósa András Múzeum Évkönyve, Nyiregyháza.
Karpatika	Karpatika, Uzhorod.
LMI	List of Historic Monuments, updated 2015.
Marisia	Marisia. Studies and Materials. Archeology. Târgu-Mureș.
MCA (S.N.)	Materiale și Cercetări Arheologice Serie Nouă. București
MemAntiq	Memoria Antiquitatis, Piatra Neamț.
NNA	Nordisk Numismatisk Årsskrift, Stockholm.
PAS	Prähistorische Archäologie in Südosteuropa, Rahden/Westf.
PAT	Patrimonium Archaeologicum Transylvanicum, Cluj-Napoca.
Paléo	PALEO – Revue d'archéologie préhistorique, Les Eyzies-de-Tayac-Sireuil.
Pallas	Pallas. Revue d'études antiques, Toulouse.

PNAS	Proceedings of the National Academy of Sciences of the United States of America, Washington.
PZ	Prähistorische Zeitschrift. Berlin.
RAN	National Archaeological Repertory.
RM	Revista Muzeelor, București.
Sargetia	Sargetia. Acta Musei Devensis, Deva.
SatuMareSC	Satu Mare Studii și Comunicări, Satu Mare.
SCIV(A)	Studii şi Cercetări de Istorie Veche şi Arheologie, Bucureşti.
SCȘMI	Studii și Comunicări Științifice ale Muzeelor de Istorie, București.
SIB	Studii de Istorie a Banatului, Timişoara.
SlovArch	Slovenská archeológia, Nitra.
SP	Studii de Preiostorie, București.
St.Cerc.Antropol.	Studii și Cercetări de Antropologie, București.
StudUBB-G	Studia Universitatis Babeș-Bolyai. Seria Geologia, Cluj-Napoca.
ZborníkSlovNMA	Zborník Slovenského Národného Múzea. Archeológia, Bratislava.
ZSA	Ziridava. Studia Archaeologica, Arad.
ИАИ	Известия на Археолигическия Институт при БАН, София.