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Changes in Navicular Bone (*os sesamoideum distale*) Shape in Horses as a Result of Pathological Alterations

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The main aim of the study was to compare the shape of navicular bones classified as normal and pathologically changed. A comparison of metric features of the navicular bone between different types of horses and associating the examined parameters to the size of the middle and distal phalanges was an additional aspect of the study. The material comprised 53 horses of various breeds which were divided into three types. Through anatomical examinations it was concluded that as many as 30 navicular bones were normal, while 23 were found to present pathological changes. The following methods of statistical analysis were used: Levene's test, one-way ANOVA, T-test, LSD test and Pearson correlation. The shape of the navicular bone was described by seven indices developed for this purpose. From among them, three show statistically higher values in the affected bones compared to the healthy ones. The main result of the study is that navicular bones with defects are relatively thicker and have a higher flexor surface and a higher articular surface for the joint with the middle phalanx. Therefore our hypothesis is that the occurrence of pathological changes of the navicular bone is preceded by an increase in the thickness and height of this bone. Adverse changes occur only in the subsequent stage of the process. The study also revealed the interrelations between the phalanges and some metric features of the navicular bone. There were strong correlations between the breadth of the middle and distal phalanx, and the breadth and thickness of the navicular bone. Also, the height of the flexor surface of the navicular bone is strongly correlated with the breadth of the phalanges.

Key words: Horse, navicular bone, navicular syndrome, middle phalanx, distal phalanx.

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The navicular bone (*os sesamoideum distale*) is an element of the distal interphalangeal joint (*art. interphalangea distalis*) between the middle and distal phalanx (*phalanx media et phalanx distalis*) within the hoof (*ungula*). Despite its small size, it plays an important role in the movement of the limb. It is a bone pad on which the deep digital flexor tendon – DDFT (*m. flexor digitorum profundus*) slides. It also stabilizes the distal interphalangeal joint. Recently, navicular problems have frequently been diagnosed, especially in sport horses. The disease affects thoracic limbs (*membra thoracica*), usually bilaterally. Therefore, during the veterinary inspection accompanying horse purchase, checking the status of the navicular bone has become one of the most important steps. Navicular lameness leads to significant financial losses and often ends the career of the horse. The causes of navicular disease are still not fully understood, and treatment usually only slows down the progression of the disease. An additional difficulty is that the clinical symptoms of altered navicular bone are diverse. X-ray pictures of horses with diagnosed navicular syndrome (NS) frequently show four types of changes: cavities on the flexor surface (*facies flexoria*), distal border fragments, enlarged synovial fossa and osteophytes (CLAERHOUDT *et al.* 2012;, BIGGI & DYSON 2011). These lesions may occur independently or, in some cases, collectively.

It is believed that before the occurrence of these deformities in the navicular bone, visible in the X-ray, adjacent soft tissues are affected. A typical condition for horses with NS is that lesions are not only observed within the bone tissue (*textus os-*

seus). Frequently, the disease also affects the fibrocartilage (*cartilago fibros*) covering the tissue's flexor surface (DOIGE & HOFFER 1983; DYSON *et al.* 2006). Moreover, lesions may also affect navicular ligaments – distal sesamoid ligament and collateral sesamoid ligaments (*lig. sesamoideum distale et ligg. sesamoidea collateralia*). Thus, the subtendinous bursa (*bursa podotrochlearis*) and deep digital flexor tendon may be damaged. Many authors indicate there is an interaction between lesions within these structures and alterations in the navicular bone (BLUNDEN *et al.* 2006; CRUZ *et al.* 2001; DYSON & MURRAY 2007). Therefore, we think that problems with the navicular bone in horses deserve a comprehensive approach. Analysing the shape and size of the navicular bone will allow for the determination of additional factors that may be related to the risk of disease.

From among several hypotheses on the causes of the navicular syndrome, one suggests that NS mainly affects horses whose hooves are too small in relation to their weight (GABRIEL *et al.* 1998; KUMMER *et al.* 2006). According to this theory, a small hoof capsule (*capsula ungulae*) contains a navicular bone which is too small to withstand the pressure exerted on it. This pressure is exerted via the DDFT, which slides over the area and stretches to the solar surface (*facies solearis*) of the distal phalanx. Work performed by the tendon is the source of the compression load. Ligaments play an important role as well because they are also subject to tension generated during the movement of the horse. But unlike the function of the DDFT, these are stretching forces because the role of ligaments is to maintain the navicular bone in a fixed position despite the pressure of the tendon and adjacent phalanges. Therefore, it seems that apart from its size, the shape of the navicular bone is also important. Spatial structure type may be connected with better or worse adaptation of the bone to various forces to which it is subjected. A correlation between the shape of the navicular bone and pathological changes in Dutch Warmblood horses was shown by DIK and BROEK (1995) and DIK *et al.* (2001). Also CLAERHOUDT *et al.* (2011b) identified the existence of an association between navicular bone fragmentation and shape in the case of Belgian Warmbloods. These authors based their conclusions on radiological studies. This paper presents the metric variability of the navicular bone using postdissectional anatomical preparations, which allows for a broader description of its form. In the next stage of the analysis, indices were used to compare the shape of the navicular bone in healthy horses and in horses with navicular defects. The size of the navicular bone was also compared to the dimensions of the middle and distal phalanx. The distal phalanx may be an indicator of the size of the hoof.

Material and Methods

All experiments were approved by the Local Ethics Committee in Poznań (application 40/2010).

The study was conducted on 53 horses destined for slaughter for reasons unrelated to this research. Their age ranged from 4 to 14 years. Lower parts of the left thoracic limb were collected *post mortem* from each of the horses. Next, the navicular bone and the distal phalanx were dissected and macerated. The animals studied represented different breeds and types, and their pedigrees were not always known. Therefore, the horses were divided according to their function instead of breed. In the next stage, the navicular bones were classified as normal and pathologically changed. The grouping is shown in Table 1. In the international system navicular bones are scored from 0 to 4 (0 – excellent, 1 – good, 2 – fair, 3 – poor, 4 – bad). This system is used especially in radiological examination but it can also be used to evaluate dissected navicu-

Table 1

Groups of examined horses and the condition of their navicular bones

Group	Breed	N	Unaffected navicular bones	Navicular bones with pathological changes
Saddle type	Polish warmblood horses Unknown breeds	28	15	13
Harness type	Polish coldblood horses Crossbred horses	12	7	5
Ponies	Fiord horse Konik horses Shetland Unknown and crossbred ponies	13	8	5
Total		53	30	23

lar bones. In our study navicular bones that scored from 2 to 4 were classified as altered (KOMOSA *et al.* 2012). Navicular bones classified as pathologically deformed showed cavities on the flexor surface, osteophytes and enlarged nutrient foramens (Fig. 1). Overall, 23 navicular bones had at least one of the three aforementioned lesions but in most cases these lesions coexisted. The remaining 30 bones were considered normal. In the next stage of analysis, 8 measurements were taken with regard to each of the preparations (Fig. 2). The measurements were partly performed according to DRIESCH's method (1976):

1. Greatest breadth of the navicular bone (GB)
2. Greatest thickness of the navicular bone (GTh)
3. Smallest thickness of the navicular bone (STh)
4. Breadth of the articular surface for contact with the middle phalanx (BAMPh)
5. Height of the articular surface for contact with the middle phalanx (HAMPh)
6. Breadth of the articular surface for contact with the distal phalanx (BADPh)
7. Height of the articular surface for contact with the distal phalanx (HADPh)
8. Height of the flexor surface (HF)

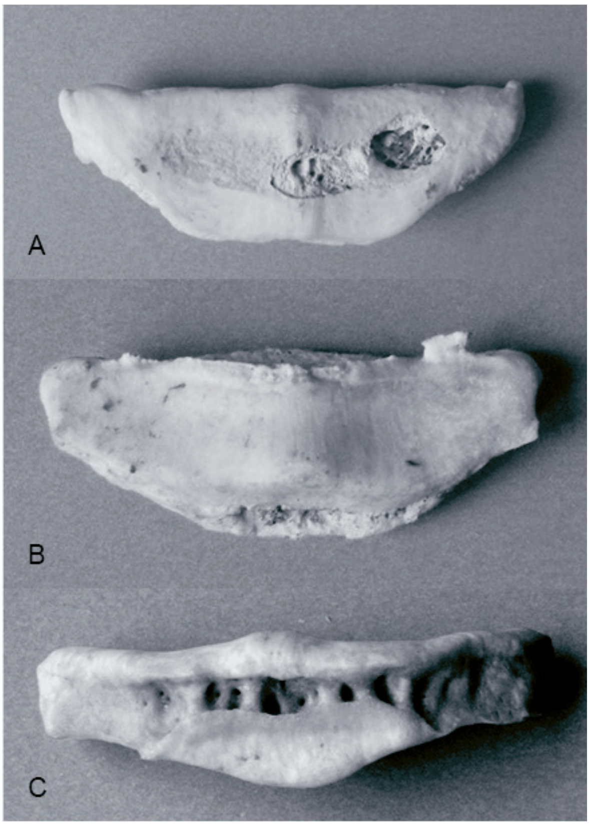

Fig. 1. Navicular bones with pathological alterations: A – cavities on the flexor surface; B – osteophytes; C – enlarged nutrient foramens.

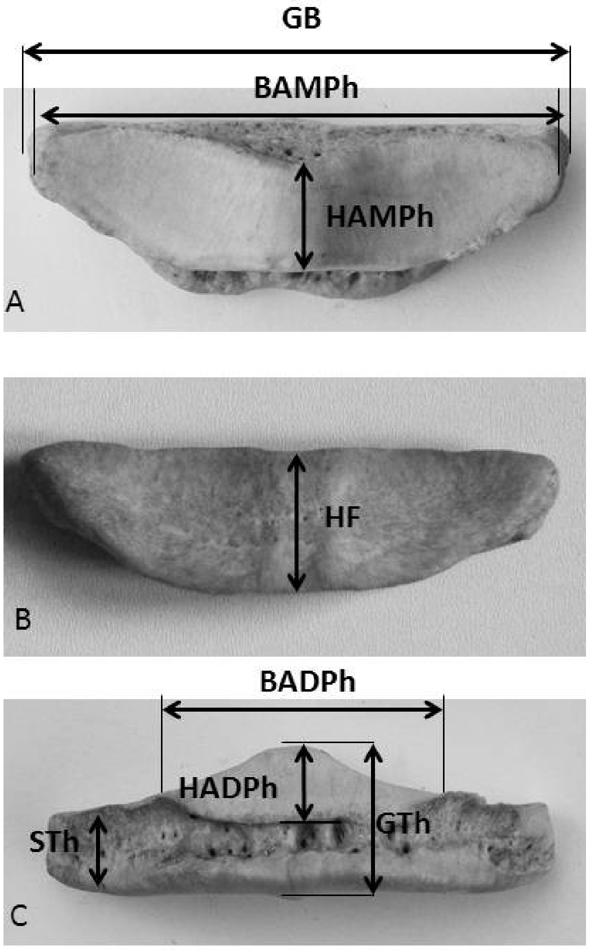

Fig. 2. Measurements of navicular bone. A – the articular surface; B – the flexor surface; C – the distal border. Abbreviations: Greatest breadth of the navicular bone (GB), Greatest thickness of the navicular bone (GTh), Smallest thickness of the navicular bone (STh), Breadth of the articular surface for contact with the middle phalanx (BAMPh), Height of the articular surface for contact with the middle phalanx (HAMPh), Breadth of the articular surface for contact with the distal phalanx (BADPh), Height of the articular surface for contact with the distal phalanx (HADPh), Height of the flexor surface (HF).

The distal end of the middle phalanx was measured because this part of the bone is in contact with the navicular bone (Fig. 3A). The following measurements were performed:

1. Middle phalanx – Breadth of the distal end (MPh-Bd)
2. Middle phalanx – Thickness of the distal end (MPh-Thd)

In order to obtain an estimated comparison of the hoof size, two basic measurements of the distal phalanx were made (Fig 3B):

1. Distal phalanx – Total length (DPh-TL)
2. Distal phalanx – Total breadth (DPh-TB)

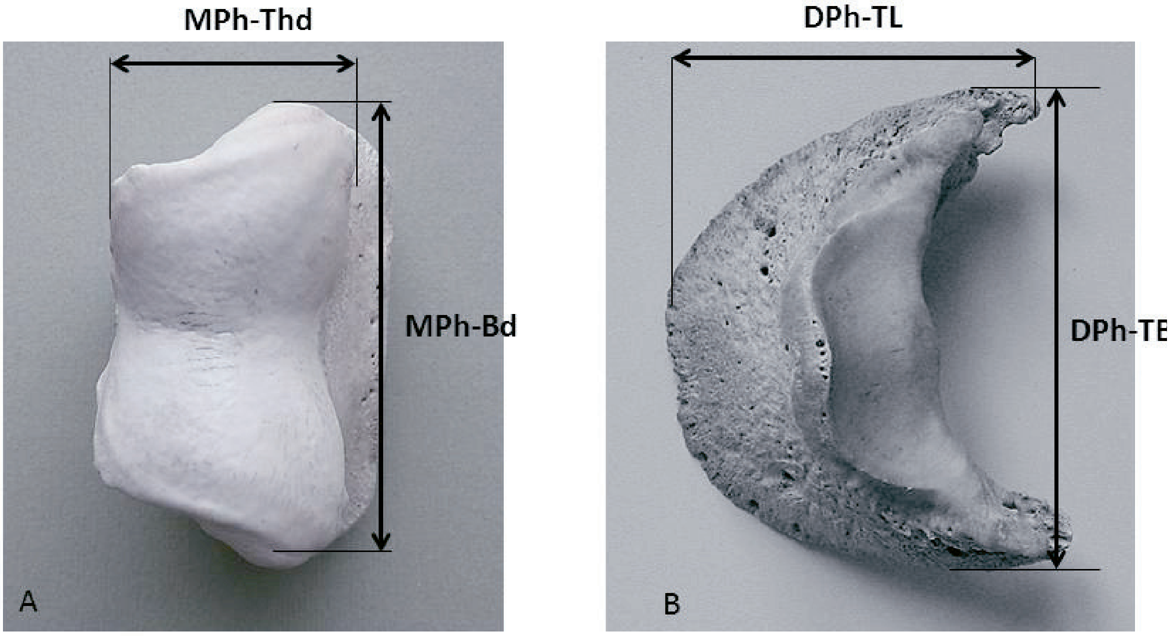

Fig. 3. Measurements of: A – middle phalanx; B – distal phalanx.
Abbreviations: Middle phalanx – Breadth of the distal end (MPh-Bd), Middle phalanx – Thickness of the distal end (MPh-Thd), Distal phalanx – Total length (DPh-TL), Distal phalanx – Total breadth (DPh-TB).

On the basis of these measurements, 7 indices of navicular bone shape were developed. These indices comprise the ratio of selected parameters. Their values are given in percent in order to provide clear size relations between the characteristics of the navicular bone:

1. Navicular bone thickness index GTh/GB x100%

2. Flexor surface height index HF/GB x 100%

3. Articular surface (for middle phalanx) breadth index BAMPh /GB x 100%

4. Articular surface (for middle phalanx) height index HAMPh/GB x 100%

5. Articular surface (for distal phalanx) breadth index BADPh/GB x 100%

6. Articular surface (for distal phalanx) height index HADPh/GB x 100%

7. Navicular bone depth index STh/GTh x 100%

Measurements were taken using callipers with an accuracy of one millimeter. Anatomical names of the bone structures are compliant with the Nomina Anatomica Veterinaria 5th edition (2005).

The following statistical methods were used to evaluate the raw data: Levene's test with one-way ANOVA, the least significant difference test (LSD-test), T-test and Pearson correlation analysis. Also, basic statistical description was provided for the studied groups of horses, including the mean, minimum, maximum and standard deviation values. The analysis was conducted in Statistica software ver. 10.0.

Results

Comparison of the navicular bone and the distal phalanx in different types of horses

The first stage of the study involved a basic statistical analysis of the navicular bone, middle and distal phalanx dimensions in the horse groups studied (Table 2). Next, we verified whether horse type determined the size of the animal's phalanges and navicular bones. For this purpose, all the measurements were compared by one-way ANOVA. The verification of homogeneity of variance in groups preceded ANOVA application. Levene's test confirmed that variances of all the metric traits are homogeneous at the 95 % confidence level. Furthermore, the distributions of the variables were normal. The mean values of the metric traits differed significantly between the groups of horses studied. The significance level for all analyzed features was set at $P \leq 0.05$.

In the following stage of the statistical procedure, we determined which group of horses had the

Table 2

Basic statistics for metric features of the navicular bone, middle and distal phalanges (measured in mm)

Types of horses	Mean value	Minimumvalue	Maximum value	Standard deviation
Greatest breadth of the navicular bone (GB)				
Saddle horses	56.8	47.0	67.0	4.7
Harness horses	60.5	54.0	65.0	3.7
Ponies	51.1	38.0	64.0	6.2
Greatest thickness of the navicular bone (GTh)				
Saddle horses	14.6	12.0	17.0	1.2
Harness horses	15.7	15.0	18.0	1.0
Ponies	13.4	10.0	15.0	1.4
Smallest thickness of the navicular bone (STh)				
Saddle horses	7.7	6.0	10.0	0.8
Harness horses	7.6	6.0	9.0	0.8
Ponies	6.7	5.0	8.0	1.0
Breadth of the articular surface for contact with the middle phalanx (BAMPh)				
Saddle horses	54.8	45.0	65.0	4.5
Harness horses	58.4	50.0	62.0	4.0
Ponies	48.6	36.0	61.0	6.2
Height of the articular surface for contact with the middle phalanx (HAMPh)				
Saddle horses	12.1	11.0	14.0	0.9
Harness horses	13.0	11.0	15.0	1.2
Ponies	11.0	9.0	13.0	1.4
Breadth of the articular surface for contact with the distal phalanx (BADPh)				
Saddle horses	31.9	24.0	45.0	4.0
Harness horses	35.9	28.0	46.0	5.6
Ponies	29.7	24.0	37.0	3.6
Height of the articular surface for contact with the distal phalanx (HADPh)				
Saddle horses	7.2	5.0	10.0	1.1
Harness horses	7.7	6.0	10.0	1.0
Ponies	6.3	4.0	8.0	1.1
Height of the flexor surface (HF)				
Saddle horses	19.3	16.0	23.0	1.7
Harness horses	20.6	18.0	25.0	1.9
Ponies	16.7	11.0	20.0	2.5
Middle phalanx – Breadth of the distal end (MPh-Bd)				
Saddle horses	59.6	53.0	69.0	3.7
Harness horses	63.7	56.0	70.0	3.9
Ponies	53.2	38.0	63.0	5.6
Middle phalanx – Thickness of the distal end (MPh-Thd)				
Saddle horses	30.9	24.0	38.0	2.9
Harness horses	35.5	33.0	38.0	1.8
Ponies	28.9	21.0	36.0	3.9
Distal phalanx – Total length (DPh-TL)				
Saddle horses	81.0	66.0	98.0	7.5
Harness horses	87.9	71.0	105.0	11.0
Ponies	74.1	57.0	96.0	10.2
Distal phalanx – Total breadth (DPh-TB)				
Saddle horses	89.7	81.0	103.0	6.5
Harness horses	101.6	84.0	120.0	8.9
Ponies	83.0	58.0	100.0	11.3

Table 3

Least Significant Difference (LSD) test for the navicular bone, middle and distal phalanx features – horse type comparison. Values in bold express statistically significant differences between the groups of horses. Significance level was set at $P \leq 0.05$

Greatest breadth of the navicular bone (GB)		
Types of horses	Harness	Ponies
Saddle	**0.036**	**0.001**
Harness	–	**0.000**
Greatest thickness of the navicular bone (GTh)		
Types of horses	Harness	Ponies
Saddle	**0.013**	**0.003**
Harness	–	**0.000**
Smallest thickness of the navicular bone (STh)		
Types of horses	Harness	Ponies
Saddle	0.752	**0.001**
Harness	–	**0.013**
Breadth of the articular surface for contact with the middle phalanx (BAMPh)		
Types of horses	Harness	Ponies
Saddle	**0.038**	**0.000**
Harness	–	**0.000**
Height of the articular surface for contact with the middle phalanx (HAMPh)		
Types of horses	Harness	Ponies
Saddle	**0.029**	**0.003**
Harness	–	**0.000**
Breadth of the articular surface for contact with the distal phalanx (BADPh)		
Types of horses	Harness	Ponies
Saddle	**0.009**	0.143
Harness	–	**0.001**
Height of the articular surface for contact with the distal phalanx (HADPh)		
Types of horses	Harness	Ponies
Saddle	0.185	**0.012**
Harness	–	**0.002**
Height of the flexor surface (HF)		
Types of horses	Harness	Ponies
Saddle	0.063	**0.000**
Harness	–	**0.000**
Middle phalanx – Breadth of the distal end (MPh-Bd)		
Types of horses	Harness	Ponies
Saddle	**0.013**	**0.000**
Harness	–	**0.000**
Middle phalanx – Thickness of the distal end (MPh-Thd)		
Types of horses	Harness	Ponies
Saddle	**0.000**	0.065
Harness	–	**0.000**
Distal phalanx – Total length (DP-hTL)		
Types of horses	Harness	Ponies
Saddle	**0.032**	**0.029**
Harness	–	**0.000**
Distal phalanx – Total breadth (DPh-TB)		
Types of horses	Harness	Ponies
Saddle	**0.000**	**0.021**
Harness	–	**0.000**

largest navicular bones and in which group the bones had the lowest parameter values by application of the LSD test at a significance level of $P \leq 0.05$ (Table 3). The test indicated that harness-type horses dominated in most of the metric characteristics over saddle-type horses and ponies. However, we did not observe differences between the saddle-type and harness-type horses in the case of three features. A lack of differences in the height of the flexor surface (HF) is particularly interesting. This is a very important part of the navicular bone as it is here that cavities develop in horses with navicular syndrome.

The same procedure was repeated for indices in the next stage. However, in this case, the variance analysis did not reveal any statistically significant differences between different types of horses ($P>0.05$). The type of horse does not affect the proportions and architecture of the navicular bone. Therefore a *post hoc* analysis in the form of an LSD test was not necessary.

The correlation between the metric features of the navicular bone and the size of the middle and distal phalanges was the next focal point of the study. However, the analysis was conducted for all horses jointly due to the relatively small number of horses in each group. The Pearson correlation coefficient values are presented in Table 4. It is important that the breadth (GB), thickness (GTh) and height of the flexor surface of navicular bone (HF) are strongly correlated with the breadth of the phalanges. This may indicate that the navicular bone in horses with broad middle and distal phalanges will also be of large size.

Comparison of normal and pathologically changed navicular bones

The ratio between the number of normal and affected navicular bones was similar in different types of horses. Each group contained slightly over 50% of healthy horses. We aimed at finding the association between the three-dimensional morphology of the navicular bone and the occurrence of pathologic changes through the use of indices for comparison. Values obtained for normal and affected bones were compared by the T-test (Table 5). The analysis revealed that three out of seven indices are significantly different. These include the navicular bone thickness index, flexor surface height index and articular surface height index (for the middle phalanx). In each of these cases, the index value for affected bones was greater than in normal ones.

Table 4

Analysis of the correlation between phalanges and navicular bone features. Coefficients in bold are statistically significant at $P \leq 0.05$

Metric feature	Middle phalanx – Breadth of the distal end (MPh-Bd)	Middle phalanx – Thickness of the distal end (MPh-Thd)	Distal phalanx – Total length (DPh-TL)	Distal phalanx – Total breadth (DPh-TB)
Greatest breadth of the navicular bone (GB)	**0.90**	**0.85**	**0.47**	**0.83**
Greatest thickness of the navicular bone (GTh)	**0.77**	**0.78**	**0.54**	**0.73**
Smallest thickness of the navicular bone (STh)	**0.53**	**0.50**	**0.30**	**0.41**
Breadth of the articular surface for contact with the middle phalanx (BAMPh)	**0.88**	**0.82**	**0.42**	**0.82**
Height of the articular surface for contact with the middle phalanx (HAMPh)	**0.57**	**0.57**	0.26	**0.45**
Breadth of the articular surface for contact with the distal phalanx (BADPh)	**0.43**	**0.41**	**0.29**	**0.49**
Height of the articular surface for contact with the distal phalanx (HADPh)	**0.50**	**0.47**	0.12	**0.40**
Height of the flexor surface (HF)	**0.82**	**0.76**	**0.52**	**0.67**

Table 5

T-test results – comparison of navicular bone indices. Values in bold are statistically significant at $P \leq 0.05$

Index	T	P	Mean pathological bones (n=23)	Mean normal bones (n=30)	SD pathological bones	SD normal bones
Navicular bone thickness index GTh/GB x100%	**-2.60**	**0.01**	**26.71**	**25.36**	**2.04**	**1.71**
Flexor surface height index HF/GB x 100%	**-2.50**	**0.01**	**34.58**	**32.95**	**2.64**	**2.11**
Articular surface (for middle phalanx) breadth index BAMPh /GB x 100%	1.80	0.08	95.46	96.69	3.36	1.47
Articular surface (for middle phalanx) height index HAMPh/GB x 100%	**-2.14**	**0.04**	**22.23**	**20.99**	**2.26**	**1.97**
Articular surface (for distal phalanx) breadth index BADPh/GB x 100%	-0.30	0.76	57.95	57.28	7.37	8.40
Articular surface (for distal phalanx) height index HADPh/GB x 100%	-0.73	0.47	12.92	12.54	2.33	1.37
Navicular bone depth index STh/GTh x 100%	-0.35	0.73	51.65	51.08	5.81	5.87

Discussion

In this study, the navicular bones classified as affected were characterized by different types of changes. Nevertheless, they may be interrelated. Cavities were often observed on the flexor surface together with changes to the proximal and distal borders as well as increased synovial invagination (BIGGI & DYSON 2011; DYSON *et al.* 2011a). This last feature is inextricably linked to enlarged nutrient foramens at the distal border (CLAERHOUDT *et al.* 2011a). A number of potential changes can result from one or many factors. On the basis of molecular studies it was concluded that there are genetic conditions making an individual horse prone to navicular disease, however, genes that could code for this defect are numerous (DIESTERBECK & DISTL 2007; DIESTERBECK *et al.* 2007; LOPES *et al.* 2009). These studies have determined specific regions on chromosomes with nucleotide polymorphisms responsible for dysfunction which may contribute to the development of navicular syndrome. The candidate genes may be related to an abnormal response of the skeleton to strain including alterations in the process of remodeling of the navicular bone. In addition, the articular surface for contact with the middle phalanx can also be genetically determined (DIK & BROEK 1995). The variability of this feature is also linked to the risk of pathological changes.

The conformation and size of the hoof are aspects of significant importance. The shape of the hoof capsule was not analyzed in this study, however, we indirectly investigated hoof size. Due to differences in the height at the withers, the hoofs of ponies are smaller than the hoofs of horses belonging to big breeds. Additionally, there is also a difference of hoof size between warmblooded and coldblooded horses. This is why we expected that harness type horses would have bigger hooves than saddle horses, supported by the observation of greater width and length of the distal phalanx in the former horse type. This bone is the basis for the corneal capsule and can be deemed as an indicator of size. The differences in the size of the distal phalanx are reflected in the size of the navicular bone. It can be assumed that the broader the distal phalanx, the broader the navicular bone. No pronounced correlation between the length of the distal phalanx and any of the navicular bone features was observed and in the case of the height of the joint surfaces, the correlations were low and statistically insignificant. Based on the above correlations, it can be assumed that horses with broad hooves also have a large navicular bone. Hoof length, on the other hand, is not likely to be an indicator of navicular bone parameters. These observations however need to be supported with further studies, which would also include corneal capsule measurements.

The highest metric values in the study were those of navicular bones in harness horses, while the lowest – in ponies. Significantly, no differences between horses were found in the index values, i.e. the size ratios of the navicular bone parameters are similar in ponies, saddle horses and harness horses. Different results were obtained by comparing the indices in healthy and affected horses. According to this classification, the navicular bones with pathological changes had larger values in three out of seven indices.

Many studies indicate horse overuse as an external factor being the direct reason for many navicular bone diseases. High body mass of the horse combined with relatively small hooves increases the load, which usually results in disease if the horse trains regularly (DYSON *et al.* 2011b; ELIASHAR *et al.* 2004; RIJKENHUIZEN 2006). This is why problems regarding the navicular bone most often occur in horses starting advanced sport training cycles. As an effect of physical activity at a proper level, adaptation processes, usually called remodeling, occur in the bones of horses (as in other mammals) (FROST 1990). The remodeling process of the navicular bone in horses was described by SANDLER *et al.* (2000). As a result of intense movement, a significant increase of bone-forming processes can be detected. This results in increasing the thickness of the cortical bone layer. The highest level of this process is observed on the flexor surface of the navicular bone and then on the articular surface, which is in contact with the middle phalanx. In trained horses, cortical bone prevails over cancellous bone constituting a higher level of navicular bone volume (GABRIEL *et al.* 1998). However, according to MUIR *et al.* (2008), overly intense training may result in pathological weakening of the bone tissue, monotonic overload and injuries, which in turn may make the horse prone to bone fracture in this area. In response, the navicular bone may cumulate microcracks, which may lead to the so called uncoupled Basic Multicellular Unit (BMU). Histological examination revealed that bone resorption processes prevailed over bone formation (BENTLEY *et al.* 2007; DENOIX *et al.* 2003). This is why the most characteristic result of this process in the navicular bone is the formation of erosion cavities on the saggital ridge of the flexor surface and in its vicinity. Intense friction of the DDFT may be the direct cause of this process. The changes occurring at the borders are the result of tensions on the ligament of the navicular bone.

In our study, navicular bones qualified as pathological were characterized by higher navicular bone thickness index, flexor surface height index and articular surface (for the middle phalanx) height index than in healthy horses. Our hypothesis is that the occurrence of pathological changes of the navicular bone is preceded by an increase in the thickness and height of this element. Adverse changes occur only in the next stage when the number of microcracks constantly increases due to continuous overload. Thus correct remodeling may turn pathological if the threshold of positive response is exceeded. It is only at this stage that defects may occur in the navicular bone. We do not know the history of physical activity of the examined horses. Our hypotheses need to be confirmed by further studies supported by medical documentation of horses.

In conclusions:

1. Navicular bones with pathological defects are relatively thicker and higher compared to normal ones. The features of the navicular bone showing greater values compared to its breadth are: greatest thickness, height of flexor surface, height of articular surface up to the joint with the middle phalanx.

2. No differences were found in the values of navicular bone indices between horse types included in the study.

3. The absolute dimensions of the navicular bone are associated with horse type. In harness horses, the navicular bone usually shows higher values for metric features.

4. The breadth of the distal phalanx is more strongly correlated with the metric parameters of the navicular bone than its length.

5. Breadth and thickness of the distal end of the middle phalanx are significantly correlated with each of the metric features of the navicular bone.

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