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Results of radiological hip dysplasia monitoring in Tornjak breed

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ABSTRACT

The aim of this retrospective study was to show the prevalence of hip dysplasia (HD) in the indigenous dog breed Bosnian and Herzegovinian - Croatian Shepherd Dog (Tornjak) in the period from 2001 to 2016. A total of 735 radiographs were evaluated according to the FCI protocol. Statistical analysis was performed using the Statistica 13.5.0.17. (TIBCO Software Inc.) software. Significant differences between categorical variables were analysed using the Chi-square test. The median value of age of examined dogs was 18 (13.8-26.0) months, with majority of dogs (523) under 24 months. In the overall examined population 74.97% of hip radiographs were interpreted as healthy (grades A and B) and 25.03% were interpreted as dysplastic (grades C, D and E). In dogs under 24 months of age, the most common age for HD survey, 76.86 % was interpreted as healthy and 23.14% as dysplastic. Comparing the frequency of diagnosed HD according to the breeding licence during the 15 years period there was a statistically significant increase in dogs with HD grades A, B, C, D and a decrease in dogs with grade HD E restricted for further breeding ($P<0.05$). Comparison of frequency according to the FCI standards (AB vs. CDE) showed no significant difference.

The present study shows that the prevalence of HD was reduced over the 15 year period in Tornjak breed.

Key words: Canine hip dysplasia; FCI scoring; prevalence; Bosnian and Herzegovinian - Croatian Shepherd Dog; Tornjak

Introduction

Canine hip dysplasia (HD) is an important heritable developmental disorder in dogs. The etiopathogenesis of HD is not fully understood, although there are two theories - coxofemoral (hip) joint laxity that results in hip joint instability or abnormal endochondral ossification that affects various joints, including the hip joints. In both cases, it leads to osteoarthritis and clinical manifestation of lameness or abnormal gait (MADSEN, 1997; TODHUNTER et al., 1997).

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Based on the literature findings, the model of HD inheritance in dogs is multifactorial, meaning that multiple gene interactions and non-genetic factors contribute to variation in the phenotype (WOOD et al., 2000; LEWIS et al., 2010; WILSON et al., 2011; HUMPHREYS and MCEWAN, 2015).

Clinical signs of HD may already be present during or after growth phase, although clinical presentation is very variable and in some cases does not correlate with the radiographic changes in joint morphology (GINJA et al., 2009). HD has been reported in many dog breeds, however, it is particularly prevalent in large and giant breeds which are explained by the relatively high rate of bone growth (MAKI et al., 2004; JANUTTA and DISTL, 2006).

The Tornjak is a large breed dog, a mountain-type Molossian dog (FCI N° 355). The dogs belonging to the original stock have been dispersed in mountain areas of Bosnia and Herzegovina and Croatia and their surrounding valleys. For the purposes of standardizing the breed officially by FCI, the hip dysplasia monitoring program was introduced by Croatian Kennel Club. Considering the genetic predisposition, prevalence and severity of HD may be reduced on the basis of radiographic selection of breeding animals (OHLERTH et al. 2019). To reduce the prevalence of HD in dogs, implemented screening programs are of great importance in cynology (GIBBS, 1997; LEPPÄNEN et al., 2000; STANIN et al., 2011). Radiographic screening known for 40 years is still a standard diagnostic procedure in many countries including Croatia. The most used and approved methods for radiographic screening include: The Orthopedic Foundation for Animals (OFA), Federation Cynologique Internationale (FCI), British Veterinary Association/ Kennel Club (BVA/KC), Pennsylvania Hip Improvement Program (PennHIP) and Dorsolateral Subluxation Score (DLS) (VERHOEVEN et al., 2012; SCHACHNER and LOPEZ, 2015.).

However, since the HD is a polygenic disease and both genetic and environmental factors play a role in its expression (MAKI et al., 2004; JANUTTA and DISTL, 2006; GINJA et al., 2010), radiographic evaluation is not sufficient in monitoring the prevalence of HD nowadays. Another approach to predict HD would use the estimated breeding values, a mixed-model that calculates the dog's probability for breeding a certain trait, but lacks a universal method, and can contain false positives and negatives from HD radiological scores (PETERSON, 2017).

Genetic screening programs are beeing developed, but are complicated by the polygenic nature of HD and related OA, as well as environmental influences on phenotypic expression (SCHACHNER and LOPEZ, 2015.), with recent findings highlighting the complexity of canine hip dysplasia phenotypes (MIKKOLA et al., 2019).

For several breeds, as for Tornjak, HD scoring is mandatory for breeding licence, although breeding recommendations differ between breeders' clubs, depending on the prevalence of HD and the size of the breeding population.

In most European countries, as in Croatia, the Fédération Cynologique Internationale (FCI) protocol for screening is used (LEPPÄNEN et al., 2000; JANUTTA and DISTL, 2006; GENEVOIS et al., 2008; STANIN et al., 2011; COOPMAN et al., 2014; BALDINGER et al., 2020). This screening protocol uses the ventrodorsal hip extended view (VD) and specific grading systems for classifying HD (MORGAN and STEPHENS, 1985; VERHOEVEN et al., 2012). The FCI grading system comprises five grades- A, B, C, D and E. Grades A and B are considered non-dysplastic whereas grades C, D and E are considered dysplastic hips (VERHOEVEN et al., 2012). The minimum age for screening prescribed by FCI is 12 months for most breeds and 18 months for some large and giant breeds.

The general aim of this study was to estimate the overall prevalence of HD based on the results of radiographic HD screening programme for Tornjak breed in the 15 years period. Specific aims were to analyse correlation of HD grade with age and sex, and to evaluate the HD-E grade prevalence as the breeding pool exclusion grade.

Material and methods

The study included official data collected from the archives of the Department of Radiology, Ultrasound Diagnostic and Physical Therapy,

Faculty of Veterinary Medicine, University of Zagreb in the period from 2001 to 2016. In the revised period 735 radiographs were evaluated and scored. The selected period coincided with the program of the Croatian Kennel Club of monitoring the health status of Tornjak which resulted in official recognition of the breed in 2017 by the FCI. All animals were identified by microchip before to the radiograph were taken and the corresponding number was noted in each dogs findings.

A panel of 4 radiologists scored the hip conformation based on the ventrodorsal hip-extended pelvic radiograph recommended by the Federation Cynologique International (FCI) using the Norberg angle method, formed by a horizontal line connecting the centers of the right and left femoral heads and a line connecting each center to the cranial margin of the corresponding acetabulum. All the X-rays were taken by the institutions radiologists. The radiographs used were classic in the period 2001-2011, and digital in period 2011-2016. The scoring was performed individually and in case of different grades consensus was made. The grading was performed using FCI scoring model (A = no signs of HD, B = findings near normal, C = mild signs of HD, D = moderate signs of HD, E = severe HD).

The results were interpreted on three points. Firstly, according to FCI guidelines, where grades HD A and HD B are considered as healthy hips, while HD C, HD D and HD E as dysplastic hips (FLÜCKIGER, 2007.). Second interpretation of the results is based on the breeding licence determined by Croatian Kennel Club, made on the basis that grades HD A, HD B, HD C and HD D are approved for breeding in combinations of sire and dame decided by kennel club authorites, while HD E are excluded from breeding pool. Third interpretation was based on clinical point of view, where HD-A and HD-B are considered non dysplastic, HD-C mild dysplasia and HD-D and HD-E dysplastic hips.

Since as a prerequisite for the breed recognition all the dogs in the breeding pool had to be evaluated for HD, the survey was performed on all the taken radiographs.

Statistical analysis was performed using the statistics package Statistica 13.5.0.17. (TIBCO Software Inc.) software. Results of continuous data are presented with median and lower – upper quartile (age of animals in months), after normality testing with Kolmogorov-Smirnov test. Categorical data are presented as a percentage or with exact numbers. Significant differences between categorical variables were analysed using the Chi-square test, with Yates correction used when it was necessary. Differences between frequency of variables at the level $P<0.05$ was consider to be significant. Spearman Rank Order Correlation was performed to evaluate correlation between age, age groups, gender, year and HD grades.

Results

The total number of examined dogs per year with HD grade is shown in Table 1. The majority of examined dogs were graded HD A (524/735), while the most severe HD E grade was observed in 79 dogs.

Table 1. Number of examined dogs by year and grade of hip-dysplasia (HD A, B, C, D, E)

Year	Number of examined dogs	Grades of hip-dysplasia				
		A	B	C	D	E
2001	38	20	3	4	2	9
2002	39	21	1	5	5	7
2003	33	22	0	0	1	10
2004	44	27	1	1	4	11
2005	43	33	0	2	4	4
2006	47	33	1	3	4	6
2007	52	35	1	2	5	9

Table 1. Number of examined dogs by year and grade of hip-dysplasia (HD A, B, C, D, E) (continued)

Year	Number of examined dogs	Grades of hip-dysplasia				
		A	B	C	D	E
2008	55	40	2	5	3	5
2009	86	72	1	3	4	6
2010	45	34	1	7	2	1
2011	39	27	1	3	6	2
2012	38	30	1	2	2	3
2013	20	16	0	1	2	1
2014	52	41	4	2	4	1
2015	78	54	8	6	6	4
2016	26	19	2	2	3	0
Total	735	524	27	48	57	79

The median value of age of all examined dogs was 18 (13.8 – 26.0) months. The majority of dogs (71.1 %) were under 24 months of age. The median age of dogs for each HD grade is presented in Table 2. There was no significant difference in age per year (P>0.124).

Table 2. HD grade and median age of dogs

	HD A (n = 524)	HD B (n = 27)	HD C (n = 48)	HD D (n = 57)	HD E (n = 79)
Median	17.4	18.6	17.6	23,0	18.7
(lower – upper quartile)	(13.4 – 25.0)	(15.1 – 32.0)	(14.7 – 29.5)	(15.0 – 32.0)	(13.8 – 26,0)

In dogs under 24 months of age 76.86 % was interpreted as healthy and 23.14% as dysplastic. In overall sample, 75 % was interpreted as healthy and 25% as dysplastic.

Out of the 735 scored radiographs, 45.01 % (337) were male and 54.99% (398) female. The HD grade scores divided into male and female are shown in Table 3.

Table 3. HD grade and sex

	HD A		HD B		HD C		HD D		HD E	
	M	F	M	F	M	F	M	F	M	F
n	237	287	16	11	19	29	23	34	42	37
%	45.2	54.8	59.3	40.7	39.6	60.4	40.4	59.6	53.2	46.8

The distribution of percentages of HD grades trough the period 2001-2016 is shown in Figure 1. The decreasing trend of prevalence of the most severe grade (HD E) is noted.

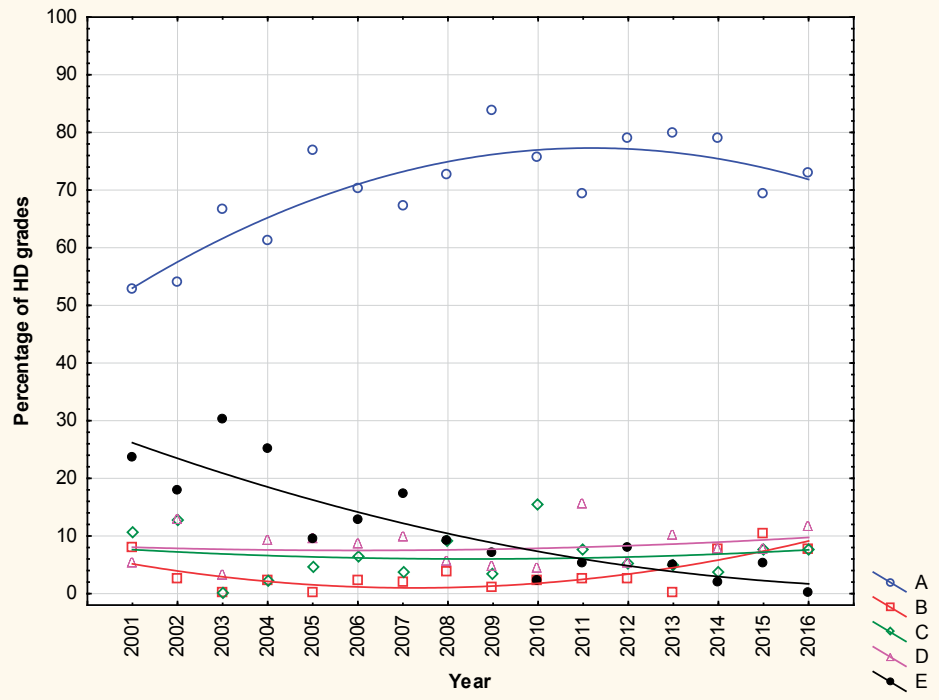

Figure 1. Percentage of HD grade (A, B, C, D, E) in dogs during the period 2001-2016

Table 4. Number (percentage) of examined dogs distributed according to the breeding licence, FCI hip-dysplasia grades (non-dysplastic vs dysplastic hips), and clinical division

Year	Total number of examined dogs	Groups of dogs according to breeding licence				Groups of dogs according to FCI hip-dysplasia				Groups of dogs according to clinical division					
		Dogs with breeding licence (HD grades: A, B, C, D)		Dogs without breeding licence (HD grade E)		Dogs without hip-dysplasia (HD grades: A, B)		Dogs with hip-dysplasia (HD grades: C, D, E)		No signs of HD or findings near normal (HD grades A, B)		Mild signs of HD (HD grade C)		Moderate or severe signs of HD (HD grades D, E)	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
2001	38	29	76.3	9	23.7	23	60.5	15	39.5	23	60.5	4	10.5	11	29.0
2002	39	32	82.1	7	18.0	22	56.4	17	43.6	22	56.4	5	12.8	12	30.8
2003	33	23	69.7	10	30.3	22	66.7	11	33.3	22	66.7	0	0.0	11	33.3
2004	44	33	75.0	11	25.0	28	63.6	16	36.4	28	63.6	1	2.3	15	34.1
2005	43	39	90.7	4	9.3	33	76.7	10	23.3	33	76.7	2	4.7	8	18.6
2006	47	41	87.2	6	12.8	34	72.3	13	27.7	34	72.3	3	6.4	10	21.3
2007	52	43	82.7	9	17.3	36	69.2	16	30.8	36	69.2	2	3.9	14	26.9
2008	55	50	90.9	5	9.1	42	76.4	13	23.6	42	76.4	5	9.1	8	14.5
2009	86	80	93.0	6	7.0	73	84.9	13	15.1	73	84.9	3	3.5	10	11.6
2010	45	44	97.8	1	2.2	35	77.8	10	22.2	35	77.8	7	15.5	3	6.7
2011	39	37	94.9	2	5.1	28	71.8	11	28.2	28	71.8	3	7.7	8	20.5
2012	38	35	92.1	3	7.9	31	81.6	7	18.4	31	81.6	2	5.3	5	13.1
2013	20	19	95.0	1	5.0	16	80.0	4	20.0	16	80.0	1	5.0	3	15.0
2014	52	51	98.1	1	1.9	45	86.5	7	13.5	45	86.5	2	3.9	5	9.6
2015	78	74	94.9	4	5.1	62	79.5	16	20.5	62	79.5	6	7.7	10	12.8
2016	26	26	100.0	0	0.0	21	80.8	5	19.2	21	80.8	2	7.7	3	11.5
Total	735	656	89.3	79	10.7	551	75.0	184	25.0	551	75.0	48	6.5	136	18.5

According to the HD grades, the dogs were divided in three groups, the breeding license group, the division according to the FCI where only grades A and B were considered as non-dysplastic hips and the clinical division (Table 4). Overall, 89.3% of dogs were graded as breeding license acceptable (HD grades A, B, C, D), although 75 % was graded as FCI and clinically non-dysplastic (HD grades A and B). The prevalence of HD grades C, D, E was 25 % (184/735), while the prevalence of the most severe grade HD E was 10.7 %. When comparing the non dysplastic (A and B) versus mild C and moderate to severe (D and E) HD grades during the examined period, the decrease of HD D and HD E is noted. There was no significant difference (χ^2= 2.89; df = 4. p = 0.577) in frequency of HD grades at the beginning and the end of the screening period but increase in HD A grade and a decrease in HD E were observed. Furthermore, comparison according to the breeding licence showed statistically significant difference (χ^2= 5.34; DF = 1. P=0.021) in increased number of dogs with acceptable breeding licence (HD A, B, C and D) and decreased number of those graded HD E. When comparing according to the division non-dysplastic vs. dysplastic e. g. HD A, B vs. HD C, D, E there were no significant differences (Yates correction chi square 2.08; df = 1. P=0.150). The frequency of HD A, B vs. HD C vs. HD D, E in the examined period showed a significant difference (AB vs. C vs. DE χ2 = 23.52; df = 2; P = 0.000) with increase in AB, and decrease in DE grades.

Analysing the examined population, there were no statistically significant correlations between age groups or gender and grade of HD (P>0.05).

There was weak but significant negative correlation (r= -0.14; P<0.05) between year of examination and grade of hip dysplasia.

Discussion

The findings in our study show that in overall 75 % of examined dogs which actually represent the core of the breed today, are HD free (HD A, B) according to the FCI scoring rules. The dogs that were excluded from the breeding pool in the last 15 years are representing 10.7% of the entire examined population. Compared to the other similar breeds monitored HD prevalence, the most severe grade (HD E) is more present in Tornjak than in the dogs of the same group and similar standard as investigated in France (GENEVOIS et al., 2008), but less than Estrella Mountain Dog (GINJA et al., 2009) and Bernese Mountain Dog (OHLERTH et al, 2019). Compared to the results of the study on a larger number of dog breeds in Croatia (STANIN et al., 2011), Tornjak has an overall higher incidence of HD. The higher prevalence in Tornjak could be related to the fact that it is a large breed with high bone growth rate and therefore more likely to the predisposition of developing HD. The other reason could be the fact that prior the 1998 the screening of hips was not mandatory; it was left to the breeders decision (LEMO, 2003).

The analysis of the trends of HD in the examined period shows that the frequency of normal and near normal hip findings (HD A and B) show positive tendency (from 60.53% to 80.77%), and at the same time, there is noticeable decrease of the frequency of the severe form (HD E).

There are opposite findings in literature about prevalence of hip-dysplasia according to the gender: some authors report more frequent HD in female (SWENSON et al., 1997; MORGAN et al., 1999; BEUING et al., 2000.) while others find the same in male dogs (WOOD et al., 2000.; WOOD et al., 2002). There was no significant prevalence of HD by gender in the present study, which is in concurrence with the investigation conducted in several dog breeds in Croatia (STANIN et al., 2011) and other countries (RETTENMAIER et al., 2002; GINJA et al., 2009).

In the present study age was not significantly correlated with the severity of HD, although some (STANIN et al., 2011; COOPMAN et al., 2014) report a significantly increased prevalence in older animals. Since the majority of the investigated Tornjak population was under 24 months of age (71.1 %), as most of the breeders tend to evaluate the hips soon after their dog turns 12 months, it could explain the reason why the number of older dogs was not present in our study to a greater extent. It was reported that younger dogs are known to have better HD scores due to less developed OA (SOO and WORTH. 2015), which could have affected our

results as well. However, no significant difference between age and year of examination were found.

Nevertheless, the fact that the majority of dogs were in the youngest group, the comparison of HD frequency over the 15 years period actually takes into consideration mostly young population of the breeding pool. The number of older dogs might also be explained by the fact that due to the procedure of the recognition of breed, all the breeding pool had to be examined, thus some of the dogs were older than 24 months.

The data of the beginning of the screening process (2001) show significant changes in frequency of different HD grades when compared to results from 2016, mostly due to decrease of HD E and increase in HD A grade after 15 years of screening. This can be explained by the process of exclusion from breeding of dogs with diagnosed HD E grade as prescribed by the Croatian Kennel Club rules.

From a clinical point of view, solely radiographic evaluation of HD is not sufficent and other methods such as joint laxity measurement (PennHip and DLS), breeding value calculation and genomic tests are needed (VERHOEVEN et al., 2012; HEDHAMMAR, 2020). Taking into consideration the clinical point of view of dysplastic hips, HD grades D and E represent 18.5% of examined dogs, with a noted decrease in the examined period.

The limitation of the study could potentially be the fact that dogs with suspected clinical signs of HD were not presented for official scrennning and thus a number of dogs might have been ommited from the whole population. However, since the HD screening was needed for all dogs in the process of formal recognition of the breed leading to its official akcgnowledgenmant in 2017, the authors believe that only a very small amount of dogs might not been included in the study.

Comparing the frequency of diagnosed HD according to the breeding licence during the 15 year period there was a statistically significant increase in dogs with HD grades A , B, C, D and a decrease in dogs with grade HD E restricted for further breeding. Comparison of frequency according to the FCI standards (AB vs. CDE) showed no significant difference. The overall result shows reduction in severity of examined HD grade (D, E) among the investigated population. Results of radiological monitoring HD show statistically significant low negative correlation between the severity of HD grade and year of screening and reduction on severity of HD score.

In overall, the present study shows that the prevalence of HD was reduced over the 15 year period in Tornjak breed but for the full insight on HD additional programs appart form hip scoring should be introduced.

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VRBANAC, Z., B. ŠKRLIN, T. KOVAČ, T. TOŠIĆ, A. E. KABALIN, D. STANIN: Rezultati rendgenološkog praćenja displazije kukova u pasmine tornjak. Vet. arhiv 92, 599-607, 2022.

SAŽETAK

Cilj ovog retrospektivnog istraživanja bio je pokazati prevalenciju displazije kuka (HD) u autohtonie pasmine pasa tornjak u razdoblju od 2001. do 2016. Ukupno je 735 rendgenograma procijenjeno prema FCI protokolu. Statistička analiza provedena je pomoću programa Statistice 13.5.0.17. (TIBCO Software Inc.) Znakovite razlike između kategorija analizirane su pomoću Hi-kvadrat testa. Medijan vrijednosti dobi pregledanih pasa bio je 18 (13,8-26,0) mjeseci, a većina pasa (523) mlađa od 24 mjeseca. U ukupnoj ispitanoj populaciji 74,97% rendgenograma kukova protumačeno je kao zdravo (stupnjevi A i B), a 25,03% kao displastično (stupnjevi C, D i E). U pasa mlađih od 24 mjeseca, što je najčešća dob za pretragu na displaziju, 76,86% protumačeno je kao zdravo, a 23,14% kao displastično. Uspoređujući učestalost dijagnosticirane HD prema uzojnojj dozvoli tijekom 15-godišnjeg razdoblja, zabilježen je statistički znakovit porast pasa s HD ocjenama A, B, C, D i smanjenje pasa s ocjenom HD E ograničeno za daljnji uzgoj ($P < 0,05$). Usporedba učestalosti prema FCI standardima (AB naspram CDE) nije pokazala znakovitu razliku. Ukupni rezultat pokazuje smanjenje težeg HD stupnja (D, E) među ispitivanom populacijom.

Ključne riječi: displazija kuka pasa; FCI bodovanje; prevalencija; bosansko-hercegovački i hrvatski pastirski pas; tornjak