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Culling Rate of Icelandic Horses due to Bone Spavin

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Björnsdóttir S, Árnason Th, Lord P: Culling rate of Icelandic horses due to bone spavin. Acta vet. scand. 2003, 44, 161-169. – A survival analysis was used to compare the culling rate of Icelandic horses due to the presence of radiographic and clinical signs of bone spavin. A follow-up study of 508 horses from a survey five years earlier was performed. In the original survey 46% of the horses had radiographic signs of bone spavin (RS) and / or lameness after flexion test of the tarsus. The horse owners were interviewed by telephone. The owners were asked if the horses were still used for riding and if not, they were regarded as culled. The owners were then asked when and why the horses were culled. During the 5 years, 98 horses had been culled, 151 had been withdrawn (sold or selected for breeding) and 259 were still used for riding. Hind limb lameness (HLL) was the most common reason for culling (n=42). The rate of culling was low up to the age of 11 years, when it rose to 0.05 for horses with RS. The risk ratio for culling was twice as high for horses with RS compared with horses without RS and 5.5 times higher for culling because of HLL. The risk of culling (prognostic value) was highest for the combination of RS with lameness after flexion test, next highest for RS and lowest for lameness after flexion test as the only finding.
It was concluded that bone spavin affects the duration of use of Icelandic horses and is the most common cause of culling due to disease of riding horses in the age range of 7-17 years.

Icelandic horses; bone spavin osteoarthroses; survival analysis; questionnaire.

Introduction

The Icelandic horse is a riding horse used for pleasure riding and special gait competitions. The native population counts approximately 75,000 horses and the population abroad (almost all countries in Western Europe and North America) has exceeded 100,000 horses (Statistics from the Icelandic Farmers Association 2001). The horses are broken to saddle at the age of 4 - 5 and the most active period for riding is between 6 and 12 years although they are often used up to the age of 20 years. The horses have been regarded as robust and long lasting. Statistics on the longevity and causes of deaths are however not available for horses in Iceland. Insurance of horses is not a common practice and culling is most often done without consulting a veterinarian.

Bone spavin (BS), defined as osteoarthrosis (OA) in the distal tarsal joints, is common in Icelandic horses and most often subclinically manifested (*Eksell et al.* 1998, *Björnsdóttir et al.* 2000). A radiographic and clinical survey of 614 Icelandic horses aged 6-12 years (mean age 7.9 years) and in use for riding, revealed a prevalence of 30.3% for the radiographic signs (RS) of the disease. Lameness after a flexion test of the tarsus was found in 32.4% of the horses. The prevalence of RS alone was 13.8%, lameness after flexion test alone 16.0% and RS with lameness after flexion test 16.4% (*Björns-*

dóttir et al. 2000). It has not been determined how seriously RS affects the durability of the horses and therefore the correct interpretation of radiographic findings detected on pre-sale examinations of clinically sound horses has been a question.

The aim of the study was to compare the rate of culling of Icelandic horses with and without radiographic and clinical signs of bone spavin and thus to determine the prognostic value of the diagnostic methods. A second aim was to study the reasons for culling of Icelandic riding horses in the age range of 7-17 years.

Material and methods

Study design and questionnarie

A follow-up study of 614 horses examined for bone spavin in a survey five years earlier (*Björnsdóttir et al.* 2000) was performed. Horse owners and trainers in Reykjavík, in the south, west and north of Iceland were invited through an official advertisement to participate in the original survey with horses in the age range of 6-12 years and in use for riding. Offspring from 17 selected sires which represented all the major breeding lines in Iceland, were requested, but horses by other sires were also included. The owners were informed subsequently, by a letter, about the result of the examination for their horses.

The owners were interviewed by telephone and asked if the horses were still used for riding. If not, they were asked when and why the horses were not in use anymore. Horses not in use were defined as culled. The reasons were classified as: musculoskeletal disorders in which hind limb lameness (HLL) was specified, other diseases, accidents, temperamental disorders, and bad performance. In the case of miscellaneous causes of culling the main reason, according to the owner, was recorded. The diagnoses were in all cases made by the owner, although a veterinary practitioner had been consulted in some cases. Horses that had been sold and mares selected for breeding during the five years were classified as withdrawn and together with horses still in use for riding at the end of the study, regarded as right hand censored data. The information was recorded as years after examination; an event that occurred during the first year after examination was recorded as one. All the interviews were performed by the same person (SB). Telephone calls were repeated up to twice to owners who did not respond to the first and the second call.

Statistical analysis

In order to evaluate the relation between radiographic signs of osteoarthrosis in the distal tarsal joints (RS), lameness after flexion test of the tarsus and age when the horse was not used for riding anymore, a survival analysis was used. Two dependent variables were defined. Culling: age when the horse was not used for riding anymore, and culling because of HLL: age when the horse was not used for riding anymore because of hind limb lameness.

The explanatory variables were RS, lameness after flexion test and gender. In an additional analysis a new explanatory variable was created on the basis of combined information on the status of RS and lameness after flexion test. The RS/Lameness status variable had four classes which were formed according to the following rules:

RS/Lameness class 0: (RS = 0) & (lameness after flexion test = 0); no signs.
RS/Lameness class 1: (RS =0) & (lameness after flexion test = 1); lameness after flexion test alone.
RS/Lameness class 2: (RS =1) & (lameness after flexion test = 0); radiographic signs alone.
RS/Lameness class 3: (RS =1) & (lameness after flexion test = 1); both radiographic signs and lameness after flexion test observed.

The Kaplan-Meier estimator of the survivor function (*Klein & Moeschberger* 1997), is defined as follows:

$$\hat{S}(t) = \prod_{t_k < t} (1 - d_k/n_k), \text{ if } t \geq t_1; \text{ and } \hat{S}(t) = 1, \text{ if } t < t_1$$

where d_k denote the number of observed events (*e.g.* cullings), at time t_k and n_k are the corresponding number at risk at time t_k. A corresponding estimator of the hazard function during the interval $[t_{k-1}, t_k]$ is:

$$\hat{h}_k = d_k/n_k$$

The age was registered in years. Horses which were withdrawn (w_k) during the year (sold or selected for breeding) were assumed to be at risk half the year of withdrawal, on average. Therefore, the actual hazard was computed as:

$$\hat{h}_k = d_k/(n_k - 0.5\, w_k).$$

The association between the hazard function and the explanatory variables was analysed by using a modification of Cox proportional hazards regression models.

When the failure time is discrete within few categories and many observations with the same failure time (ties), as in the present study, the basic traditional proportional hazards models should be replaced by the model for grouped data of *Prentice & Gloeckler* (1978).

Ducrocq (1999) showed that the Prentice and Gloeckler´s model for grouped data can be closely approximated by an exponential regression model which includes a time dependent explanatory variable. The baseline hazard is estimated at every discrete failure time k and the hazard function simplifies to:

$$\lambda(t=k; \mathbf{x}) = \exp\, [\xi_k + \mathbf{x}'\beta]$$

where ξ_k is computed as a function of the conditional survival probability at time k, $\mathbf{x}$ is an vector of fixed explanatory variables considered to affect failure time, and β is a vector of regression coefficients.

This approximation is included in the program package "The Survival Kit V3.1" (*Ducrocq & Sölkner* 1999), which was used for carrying out the regression analysis. The significance of the regression coefficients, β, was tested by χ^2 and the risk ratio was computed as the exponential of the estimate of the regression coefficient. The fit of the model was evaluated by R^2 of *Maddala* (1983) which measures the proportion of the variation, which is explained by the survival model.

Results

Information was obtained for 508 (response rate: 83%) of the horses, 13,0% with RS alone, 16.3% with lameness after flexion test alone, 16.7% with both RS and lameness after flexion test and 54% without findings in the survey five years earlier. The owners of the remaining 106 horses could not be located. Ninety eight horses were culled during the five years, of which 63 had died. Approximately one third of the horses (n=151) were withdrawn from the study, but 51.0% (n=259) were still in use for riding after 5 years. Hind limb lameness (HLL), sometimes

Table 1. Distribution of causes of culling of 98 Icelandic horses.

Cause of culling	Number	(%)
Hind limb lameness	42	(42.9)
Other musculoskeletal disorders	11	(11.2)
Other diseases	6	(6.1)
Accidents	12	(12.2)
Temperamental disorders	16	(16.3)
Bad performance	11	(11.2)
Total	98	

Table 2. Survival table for Icelandic riding horses, distributed by age and RS.

	Without RS						With RS					
Age k	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$
6	357	0	0	0	0.000	1.000	151	0	0	0	0.000	1.000
7	357	3	3	2	0.006	0.994	151	1	1	2	0.013	0.987
8	352	19	19	3	0.009	0.986	148	2	2	2	0.014	0.973
9	330	37	37	2	0.006	0.979	144	6	6	6	0.043	0.932
10	291	25	25	8	0.029	0.951	132	7	7	1	0.008	0.925
11	258	57	11	8	0.032	0.921	124	14	7	7	0.058	0.871
12	193	57	14	4	0.022	0.901	103	16	0	8	0.078	0.803
13	132	49	8	2	0.016	0.887	79	18	3	14	0.181	0.668
14	81	25	3	7	0.088	0.809	47	10	4	6	0.133	0.570
15	49	18	0	6	0.122	0.710	31	12	0	2	0.065	0.534
16	25	13	1	4	0.163	0.594	17	11	0	3	0.176	0.439
17	8	7	0	1	0.125	0.520	3	3	0	0	0.000	0.439
Total		310	121	47				100	30	51		

RS: radiographic sign of bone spavin
Culling: not used for riding anymore
Withdrawn: horses that were sold or selected for breeding
Censored: Withdrawn + horses still in use after 5 years

Table 3. Survival table for Icelandic riding horses, distributed by age and lameness after flexion test.

	Without lameness after flexion test						With lameness after flexion test					
Age k	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$
6	340	0	0	0	0.000	1.000	168	0	0	0	0.000	1.000
7	340	2	2	2	0.006	0.994	168	2	2	2	0.012	0.988
8	336	13	13	3	0.009	0.985	164	8	8	2	0.013	0.976
9	320	31	31	3	0.010	0.975	154	12	12	5	0.034	0.943
10	286	22	22	5	0.018	0.958	137	10	10	4	0.030	0.914
11	259	55	14	13	0.052	0.908	123	16	4	2	0.017	0.899
12	191	49	12	3	0.016	0.893	105	24	2	9	0.087	0.821
13	139	50	8	5	0.037	0.860	72	17	3	11	0.156	0.693
14	84	23	4	7	0.085	0.787	44	12	3	6	0.141	0.595
15	54	19	0	7	0.130	0.685	26	11	0	1	0.038	0.572
16	28	15	1	5	0.182	0.560	14	9	0	2	0.143	0.491
17	8	7	0	1	0.125	0.490	3	3	0	0	0.000	0.491
Total		286	107	54				124	44	44		

Lameness after flexion test: HLL after flexion test of the tarsus
Culling: not used for riding anymore
Withdrawn: horses that were sold or selected for breeding
Censored: Withdrawn + horses still in use after 5 years

Table 4. Survival table, regarding to culling because of HLL, for Icelandic riding horses, distributed by age and RS.

	Without RS						With RS					
Age k	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$
6	357	0	0	0	0.000	1.000	151	0	0	0	0.000	1.000
7	357	3	3	2	0.006	0.994	151	1	1	1	0.007	0.993
8	352	19	19	0	0.000	0.994	149	2	2	1	0.007	0.987
9	333	37	37	0	0.000	0.994	146	6	6	5	0.035	0.952
10	296	25	25	1	0.004	0.991	135	7	7	0	0.000	0.952
11	270	66	11	1	0.004	0.987	128	17	7	4	0.032	0.922
12	203	64	14	2	0.010	0.977	107	19	0	6	0.056	0.870
13	137	55	8	0	0.000	0.977	82	21	3	10	0.124	0.762
14	82	28	3	1	0.012	0.965	51	15	4	2	0.041	0.731
15	53	23	0	2	0.038	0.929	34	16	0	0	0.000	0.731
16	28	18	1	1	0.036	0.895	18	12	0	2	0.111	0.650
17	9	8	0	1	0.111	0.795	4	4	0	0	0.000	0.650
Total		346	121	11				120	30	31		

RS: radiographic signs of bone spavin
CHLL: culling because of hind limb lameness
Withdrawn: horses that were sold or selected for breeding
Censored: withdrawn + horses still in use after 5 years

Table 5. Survival table, regarding to culling because of HLL, for Icelandic riding horses, distributed by age and lameness after flexion test.

	Without lameness after flexion test						With lameness after flexion test					
Age k	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$	n_k	Censored c_k	Withdrawn w_k	Culling d_k	Rate of culling $\hat{h}$	Survival function $\hat{S}$
6	340	0	0	0	0.000	1.000	168	0	0	0	0.000	1.000
7	340	2	2	2	0.006	0.994	168	2	2	1	0.006	0.994
8	336	13	13	0	0.000	0.994	165	8	8	1	0.006	0.988
9	323	31	31	2	0.007	0.988	156	12	12	3	0.020	0.968
10	290	22	22	0	0.000	0.988	141	10	10	1	0.007	0.961
11	268	64	14	3	0.011	0.976	130	19	4	2	0.016	0.946
12	201	56	12	1	0.005	0.971	109	27	2	7	0.065	0.885
13	144	56	8	1	0.007	0.964	75	20	3	9	0.122	0.776
14	87	28	4	0	0.000	0.964	46	15	3	3	0.067	0.724
15	59	26	0	2	0.034	0.932	28	13	0	0	0.000	0.724
16	31	21	1	1	0.033	0.901	15	9	0	2	0.133	0.627
17	9	8	0	1	0.111	0.801	4	4	0	0	0.000	0.627
Total		327	107	13				139	44	29		

Lameness after flexion test: hind limb lameness after flexion test of the tarsus
CHLL: culling because of hind limb lameness
Withdrawn: horses that were sold or selected for breeding
Censored: withdrawn + horses still in use after 5 years

Table 6. Estimated risk ratios and significance tests for the lameness after flexion test and RS variables in the Prentice and Gloeckler's regression model.

Explanatory variable	Dependent variables	
	RR culling	RR CHLL
lameness after flexion test	1.647	4.523
Significance	$\chi^2 = 5.87$*	$\chi^2 = 22.69$***
	df=1	df=1
	$R^2 = 0.34$	$R^2 = 0.17$
RS	2.103	5.493
Significance	$\chi^2 = 13.27$***	$\chi^2 = 27.73$***
	df=1	df=1
	$R^2 = 0.34$	$R^2 = 0.17$

p< 0.05, ** p<0.01. *** p<0.001

RR: risk ratio
RS: radiographic signs of bone spavin
CHLL: culling because of hind limb lameness

Table 7. Estimated risk ratios, significance tests for the combined RS/lameness variables, and fit of the Prentice and Gloeckler's regression model.

Explanatory variable RS/Lameness status:	Dependent variables	
	RR culling	RR CHLL
0	1.000	1.000
1	1.294	1.916
2	1.871	2.709
3	2.572	10.156
Significance of the explanatory variable	$\chi^2 = 15.12$**	$\chi^2 = 39.19$***
	df=3	df=3
	$R^2 = 0.34$	$R^2 = 0.17$
Fit of the model	$R^2 = 0.36$	$R^2 = 0.23$

p< 0.05, ** p<0.01. *** p<0.001

RR: risk ratio
RS: radiographic signs of bone spavin
CHLL: culling because of hind limb lameness

in combination with other signs, was the most common reason for culling, n=42 (Table 1). Other musculoskeletal disorders were given as the main reason for culling of 11 horses. They included problems in the forelimbs and back pain. Other diseases were rare: three horses died of colic, one because of infection in the digestive system, one had a tumour and one laminitis.

Hazard estimates and the survival function distributed by radiographic and clinical findings are shown in tables 2-5. The rate of culling was low for the youngest horses in the study but rose to 0.05 per year at the age of 11 years for horses with RS and at the age of 14 years for horses for horses without RS. Up to the age of nine, the rate of culling was less than 0.01 for horses without RS. Similar differences were found for lameness after flexion test. The rate of culling because of HLL exceeded 0.05 per year at the age of 12 years for horses with RS and at17 years for horses without RS.

The risk ratio (RR) of culling was twice as high for horses with RS as for horses without RS and they had five times higher RR for being culled for HLL during the five years interval (Table 6). For horses having RS and lameness after flexion test, the risk ratio for culling was 2.6 times higher than for horses without these findings and the risk ratio for culling because of HLL was 10 times higher (Table 7). No difference was found in the RR of the dependent variables between sexes.

The survival functions within the four RS/Lameness status classes are shown in Figures 1 and 2.

Discussion

The material used in the original survey was considered to reflect the population of active riding horses in Iceland. The material and the radiographic and clinical methods are discussed elsewhere (*Björnsdóttir et al.* 2000). The 508 horses in this study had approximately

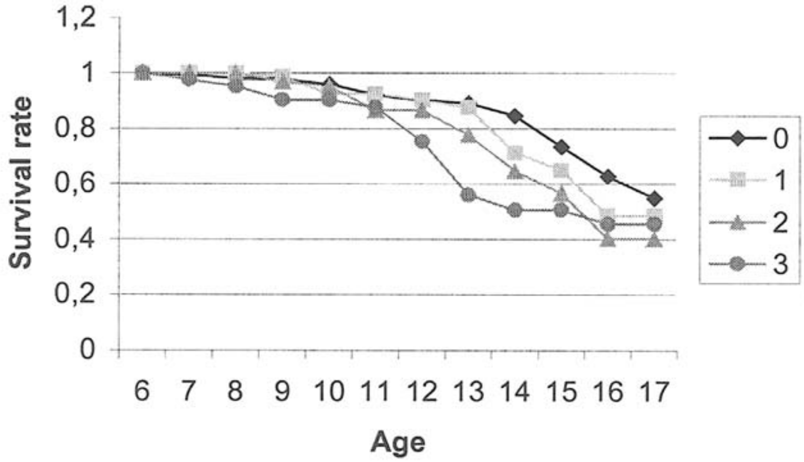

Figure 1. Survival function (K-M) for culling
RS/Lameness classes
0: no signs
1: lameness after flexion test alone
2: radiographic signs alone
3: both radiographic signs and lameness after flexion test observed

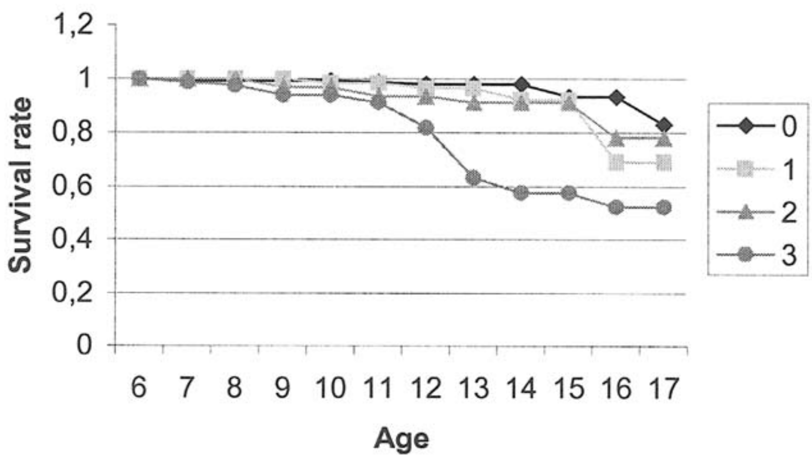

Figure 2. Survival function (K-M) for culling because of hind limb lameness
RS/Lameness classes
0: no signs
1: lameness after flexion test alone
2: radiographic signs alone
3: both RS and lameness after flexion test

the same prevalences of findings in the survey as the original material of 614 horses.

The owners were informed about the radiographic and clinical findings after the survey. This might have biased the results in the follow-up study as the owners of horses with positive findings might have been more conscious of the health status of their horses and more easily regarded them as HLL, in the case of reduced riding capacity, than owners of horses without findings. The results indicate, however, that horses were not taken out of use because of either RS or positive flexion test if their riding abilities were not affected. The high proportion of horses with RS and lameness after flexion test in the original survey that were still in use for riding after five years confirms this. The information about the horses' duration of use was based on the owners' opinions, and they might have been unwilling to admit that their horses were culled because of bone spavin. For this reason and as the level of performance or activity was not included, the effect of the disease might have been underestimated in the study.

HLL accounted for 43% of the reasons of culling but a more detailed diagnosis was not possible to obtain from the owners. Although other diseases in the hind limb cannot be excluded, the high prevalence of bone spavin in the population indicates strongly that this disease was the main cause of HLL. Developmental orthopaedic diseases have not been described in Icelandic horses and radiographic signs of osteochondrosis in the tarsus were not identified in the survey (*Björnsdóttir et al.* 2000). Wear and tear together with accidents seem to be the most common reason for other musculoskeletal disorders.

The low numbers of horses that were culled during the five years reflect the general good health of the Icelandic horse. Respiratory disorders were not recorded as a reason for culling, and very few horses died because of colic. Most of the contagious diseases known to affect horses have never been reported in Iceland (*Gunnarsson* 1998). Summer dermatitis, commonly affecting Icelandic horses in other countries, is not known in Iceland (*Halldórsdóttir* 1987). As the material included only horses that were in use for riding, diseases in the reproductive tract and other problems affecting breeding mares were not recorded. The number of accidents was rather high, which should be possible to reduce by improving the environment and the management of the horses. Temperamental disorders that usually included stress or difficulty in controlling the horses were common. These could be genetic or due to bad schooling. It could, in some cases, have been a reaction to pain caused by BS. Poor performance was most often explained by problems with the gaits and unwillingness. Most of the horses with temperamental disorders, poor gaits or conformation have however been selected out at a younger age than this study examined.

The results of this study cannot be compared with survival analysis of other breeds as the material did not include horses younger than 6 years and mares selected for breeding were regarded as withdrawn (*Wallin et al.* 2000, *Richard & Fournet-Hanocq* 1997).

The rate of culling was very low up to the age of 11 when it started to rise. The hazard exceeded 0.05 three years earlier for horses with RS than for horses without RS and became more than 0.1 two years earlier. For culling because of HLL the difference was 5 and 4 years, respectively. The difference in the survival function between horses with and without RS was highest for 14 years old horses.

The higher rate of culling and culling because of HLL for horses with RS compared with horses with lameness after flexion test of the tarsus indicates a higher prognostic value of the radiographic examination than the flexion test of the tarsus. A radiographic examination of the distal tarsus should therefore be required as part of a pre-sale examination together with a clinical examination. The presence of both RS and lameness after flexion test increases the likelihood of cullling due to HLL after the age of 11 years compared to presence of only one of the signs.

Icelandic horses are commonly exported in the age range examined in the study, explaining the high proportion of withdrawn horses in the study. The relatively fewer withdrawn horses in the RS-positive group compared to the RS-negative group reflected difficulties in selling these horses and fewer mares were also selected for breeding.

The late clinical manifestation of bone spavin in Icelandic horses may prevent natural and artificial selection against the disease and be an important reason for the high prevalence in the population.

Conclusions

Although the culling rate due to bone spavin was low up to middle age, bone spavin affects the duration of use of Icelandic horses and is, by far the most common cause of culling of riding horses due to disease in the age range of 7-17 years. Both clinical and radiological examinations should be performed to predict the prognosis.

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