Prognostic Factors Affecting Survival of 507 Horses with Joint Disease: (1983 to 1990)

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ABSTRACT

Between July 1, 1983 and December 31, 1990, risk factors were determined for all horses with joint disease presented to a referral center, of being discharged, of ever becoming sound, or of being alive at 3 mo follow-up. Logistic multiple-regression models were done separately for foals (≤ 4 mo), yearlings (> 4–24 mo) and racing or non-racing adult horses (> 24 mo). The breakdown in this study was 53 foals, 87 yearlings, 141 non-racing adults, and 226 racing adults. Thirty-one foals (58%), 68 yearlings (78%), 119 non-racing adults (84%), and 213 racing adults (94%) were discharged. Foals with a less severe lameness, duration of illness of > 1 d, and infectious arthritis had increased odds of discharge. At follow-up, 12 of 18 (67%) were alive, 10 (56%) of which were sound. Yearlings with osteochondrosis had higher odds of discharge; at follow-up, 38 of 49 (78%) were alive, 32 (65%) of which were sound. For non-racing adults, horses with less severe lameness, without a miscellaneous diagnosis, or intended for pleasure use had increased odds of discharge. At follow-up, 55 of 78 (70%) were alive and 33 of 58 (57%) with soundness data became sound. Risk factors for higher odds of being alive at follow-up were carpal lameness, arthroscopic surgery, a prognosis other than poor, became sound, above-median hospitalization costs, and duration of follow-up. The 161 racing adults (76% of discharges), with follow-up, were more likely to have had osteoarthritis, higher hospital costs, hospitalization > 1 d, and arthroscopy. Sixty-four (60%) of these became sound; the odds increased if the horse was not severely lame at admission or was hospitalized for > 1 d. Risk factors and prognosis differed by age-use group among horses seen at our hospital.

RÉSUMÉ

Entre le 1er juillet 1983 et le 31 décembre 1990, les facteurs de risques associés à l'obtention du congé, le retour éventuel à un état sain et le fait d'être vivant à un examen de suivi après 3 mois, furent déterminés pour tous les chevaux présentés à un centre de référence avec des problèmes articulaires. Des modèles de régressions logistiques multiples ont été établis séparément pour les poulains (≤ 4 mois), les jeunes (> 4–24 mois) et les chevaux adultes (> 24 mois) coureurs ou non. La répartition des animaux était la suivante : 53 poulains, 87 jeunes, 141 adultes non-coureurs et 226 adultes coureurs. Trente et un poulains (58 %), 68 jeunes (78 %), 119 adultes non-coureurs et 213 adultes coureurs (94 %) ont obtenu leur congé. Les facteurs suivants augmentaient les chances d'obtenir un congé : boiterie peu sévère, durée de la condition > 1 j et arthrite infectieuse. Lors de l'examen de suivi, 12 des 18 poulains (67 %) étaient toujours vivants et 10 (56 %) étaient sains. Les jeunes avec de l'ostéochondrose avaient plus de chances d'obtenir leur congé; lors de l'examen de suivi, 38 des 49 (78 %) étaient vivants et 32 (65 %) étaient sains. Pour les adultes non-coureurs une plus grande probabilité d'obtenir un congé était associée avec une boiterie peu sévère, l'absence d'un diagnostic de type divers, et une utilisation comme monture de loisir. Lors de l'examen de suivi, 55 des 78 chevaux (70 %) étaient vivants et 33 des 58 (57 %) étaient guéris. Les facteurs de risque associés à une plus grande probabilité d'être vivants lors de l'examen de suivi étaient : une douleur carpienne, une chirurgie arthroscopique, un pronostic autre que pauvre, la guérison, des coûts d'hospitalisation au-dessus de la médiane, et la durée du suivi. Les 161 chevaux adultes coureurs (76 % de ceux ayant obtenus leur congé) ayant eu un examen de suivi étaient plus susceptible à avoir eu une ostéoarthrite, des coûts d'hospitalisation plus élevés, une hospitalisation de > 1 j et une arthroscopie. Soixante-quatre (60 %) ont guéri; la probabilité augmentait si le cheval ne souffrait pas d'une boiterie sévère lors de l'admission ou était hospitalisé pour > 1 j. Les facteurs de risque et le pronostic diffèrent selon le groupe d'âge des chevaux et l'utilisation à laquelle ils sont destinés.

(Traduit par le docteur Serge Messier)

INTRODUCTION

Based on 1996 data from the American Horse Council, reported by the Barents Group LLC in *The Economic Impact of the Horse Industry*,

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horse-related business in the United States generates about $25 billion annually. Several epidemiologic studies have evaluated causes of loss of horses from the Thoroughbred racing industry (1–3). Lameness was the most significant factor responsible for failure to race. Of 600 racehorses studied in Germany, 401 horses were reported to have training failure (60% of these caused by lameness) (3). In a 2-year study of wastage among racehorses in England, the number of horses experiencing lameness ranged from 36% (1) to 52% (2).

The most common sites of lameness in Thoroughbreds at the racetrack were foot, carpus, metacarpophalangeal/metatarsophalangeal joints (2,4) and muscle (2). Standardbreds were afflicted with foot problems, tendon and ligament lesions, and joint injury (4). Joint abnormalities accounted for approximately 32% of all lameness cases reported by Rose (4). Twenty percent of all lameness problems in horses presented to Cornell University over the time course of this report had joint disease as the primary problem (5). Previous reports document the common sites of joint disease (2,4) and others address the outcome of different joint diseases, usually following conservative or surgical therapy. For example, in 2 recent studies of proximal phalangeal osteochondral fragments, the prognosis was associated most consistently with surgical findings (6,7). Another study compared the outcome following arthrotomy or arthroscopy in horses with osteochondrosis lesions in the femoropatellar joints (8), and comparisons were drawn between the 2 surgical treatments. Similar studies evaluated prognoses in racehorses following treatment for osteochondrosis dissecans lesions from the tarsocrural joint (9–11) and the femoropatellar joint (12,13).

However, reports that evaluate prognostic indicators (derived from signalment, history, physical examination findings, diagnosis, and treatment) in toto for the short- and long-term outcomes for horses affected with a variety of joint diseases in a clinical setting are lacking. These factors, together with consideration of the intended or current use of the horse, are all used by the clinician when discussing the prognosis with the client prior to initiation of treatment. Although the prognosis may be modified as other diagnostic tests and treatment are undertaken, it is important to provide owners with informed, objective information when assessing the potential of horses affected with joint disease to survive and perform again.

The purpose of this study was to describe the distribution of joint diseases in horses presented to a referral hospital with a diagnosis of lameness due to joint disease, and to determine, using logistic multiple regression, which signalment, physical examination, and diagnostic and treatment variables were significant indicators of whether the horse was discharged alive from the hospital, as opposed to dying or being euthanized during hospitalization. Cost and length of hospital stay were also evaluated for their associations with the outcome. Long-term follow up was evaluated in the same manner for the outcomes "still alive at follow-up" (non-racing adult horses) and "ever became sound" (adult racehorses). Logistic multiple regression allowed for simultaneous examination of more than one predictor variable for a successful outcome. Simultaneous examination of variables is important because it "corrects" for relationships among the predictor variables.

Animals were grouped according to age (foals: ≤ 4 mo; yearlings: > 4 to 24 mo, adults: > 24 mo) for statistical evaluation, because the age of the animal would likely be related to the diagnosis and, therefore, to the outcome following treatment. Adult horses were divided into non-racing and racing, with the intended uses declared at admission, because use might relate to management, diagnoses, and financial decisions.

MATERIALS AND METHODS

Medical records of all 513 horses admitted to the Equine Hospital at Cornell University for lameness attributable to joint disease between July 1, 1983 and December 31, 1990 were reviewed. Six lame horses with no recorded age were omitted, leaving 507 for analysis. Two additional data subsets included all the non-racing and racing adults discharged alive for which there was follow-up. An adult horse that had been discharged alive was considered to have follow-up if it had non-missing data for any of the following 4 variables: alive, follow-up time, still owned 6 mo after discharge, and sound. Differences, within subsets, between horses with and without any follow-up (to look for evidence of selection bias), were examined for variables known at the time of discharge. The chi-squared analysis was used to test the categorical variables; Wilcoxon's rank-sum test was used for continuous variables. All tests for selection bias in horses available for follow-up were at $P \leq 0.10$, 2-tailed.

Variables with sufficient proportions of non-missing data and sufficient variation for statistical analysis included signalment, degree (14) and duration of lameness, location and number of joints involved, synovial fluid analyses, procedures performed, diagnosis, and length and cost of hospital stay. We had an interest in the relationship of keratan sulfate concentration in synovial fluid as a prognostic marker, so it was included as a variable (15). The diagnoses were categorized as follows: fracture (osteochondral or other), osteoarthritis (OA), osteochondrosis dissecans (OCD), infectious arthritis (> 50,000 cells/L or a positive bacteriological culture in the synovial fluid), or miscellaneous arthroses (eg, traumatic synovitis).

Within subsets, the potential risk factors (Tables I–IV) were screened for association with the subset's intended outcome at $P \leq 0.20$ (2-tailed). Dichotomous and trichotomous variables were screened by chi-squared test and continuous variables by Wilcoxon's rank-sum test. Nonparametric, rank-based tests were used because some continuous variables were not Gaussian. All dichotomous variables were coded: 1 = yes (factor present), 0 = no (factor absent).

Variables that passed screening were examined for collinearity (within the data subset) for later use in interpreting final models. Two categorical variables were tested against each other by chi-squared test; 2 ordinal and/or continuous variables were tested against each other by Spearman's rank correlation; and a categorical

TABLE I. Percent[a] of horses with factor among horses admitted to the Equine Hospital of Cornell University for joint lameness, 1983–90

	Foals[b] (n = 53) discharged alive		Yearlings[b] (n = 87) discharged alive		Non-racing[b] (n = 141) discharged alive		Racing[b] (n = 226) discharged alive	
Factor	yes (n = 31)	no (n = 22)	yes (n = 68)	no (n = 21)	yes (n = 119)	no (n = 22)	yes (n = 213)	no (n = 13)
Animal breed (52; 87; 140; 226)[c]								
Standardbred	73	46	46	47	20	23	62	38
Thoroughbred	13	32	21	26	22	41	38	62
Other	13	23	34	26	58	36	1	0
Gender (53; 87; 141; 226)								
Intact male	{ 58	{ 50	43	21	10	18	24	38
Castrated male			9	21	43	36	36	31
Female	42	50	48	58	47	46	40	31
Severely lame[c] (36; 62; 108; 149)	41	57	35	63	38	93	31	78
Use (52; 86; 127; 226)								
Racing	27	0	34	22	0	0	100	100
Pleasure	{ 73	{100	19	17	55	14	0	0
Other			47	61	45	86	0	0
Diagnosis[e]								
Chip fracture (–; 87; 141; 226)	—[f]	—	9	0	13	23	31	8
Osteoarthritis (53; 87; 141; 226)	19	9	24	32	66	50	42	38
Fracture (not chip) (–; 87; 141; 226)	—	—	9	16	15	36	31	38
Osteochondrosis (52; 87; 141; 226)	13	18	62	26	8	14	8	31
Infectious arthritis (52; 86; 135; 218)	61	29	90	74	96	81	96	69
Miscellaneous diagnoses (53; 87; 141; 226)	23	27	18	11	9	23	18	0
Joint(s) involved[f] (53; 87; 141; 226)								
Carpus	16	5	18	16	19	32	48	23
Distal to fetlock	—	—	13	5	24	27	7	8
Fetlock	32	14	22	26	26	14	45	38
Hock	39	41	38	53	41	18	18	38
Shoulder or hip	13	23	12	26	4	9	< 1	15
Stifle	26	36	32	16	9	9	7	16
Only one joint[g]	57	55	35	61	46	54	41	46
Procedure (—; 87; 141; 226)								
Arthroscopy	—	—	38	0	16	23	40	15
Arthrotomy	—	—	7	5	6	9	16	15

[a] Some rounding error in percentage
[b] Foals, age ≤ 4 mo; yearlings, 4 mo < age ≤ 24 mo; non-racing, age > 24 mo; racing, age > 24 mo
[c] Numbers of horses with non-missing data for foals, yearlings, non-racing adults, and racing adults, respectively
[d] Severe lameness non-weightbearing, or recumbent vs not lame or only mild or moderate lameness
[e] Diagnoses and joints are not mutually exclusive within the clusters of factors
[f] Factor not screened for modeling for foals
[g] For non-racing and racing adults, n = 138 and 224, respectively
Data enclosed with parentheses ({) have been pooled

variable vs an ordinal or continuous variable was tested using Wilcoxon's rank-sum test or the Kruskal-Wallis test, for dichotomous or trichotomous categorical variables, respectively. Collinearity was declared at $P \leq 0.10$, 2-tailed.

After screening and collinearity checks, but before modeling, dummy (yes/no) variables were created for the trichotomous variables, gender (intact male, female, male castrated; pooling of gender groups was sometimes done based on similar-appearing unconditional associations and sample size) and breed (Standardbred, Thoroughbred, other). Lameness score was dichotomized: severely lame (severe lameness, non-weight-bearing or recumbent) or not severely lame (no, mild, or moderate lameness), as were the number of joints (1 or > 1) and duration of hospitalization (≤ 1 d or > 1 d; < 1 d implied an outpatient visit but still was considered hospitalization). Continuous variables were dichotomized at their medians, because we could not demonstrate linearity in the odds across the ranges of the observed values for 3 variables, ie, we had to categorize to avoid violating assumptions of the models (16). Variables with many missing values were deleted at this step (or earlier — especially if > 50% of cases were missing), as were dichotomous variables where less than 10 or 20 cases had the less common answer, ie, because of poor dichotomous distribution.

The models were tested by stepwise, backwards elimination. The variable with the highest P value on Wald's test (t = b/SE(b)) was deleted and the model re-run. If the change in deviance had $P > 0.05$, according to the likelihood-ratio chi-squared, and the coefficients of the remaining predictors didn't change more than ~2 standard errors of the coefficient, then the variable that now had highest Wald's P in the just-reduced model was deleted. Those 2 checks confirmed that the deleted variable was not contributing importantly to the estimation of the log odds and was probably not confounding the effects of other factors still in the model (16). If at any step the deletion caused too big a change in deviance or in coefficients, the deleted variable was returned to the model and the variable with next highest Wald's P was deleted. The process was continued until no more variables could be deleted. The final (reduced) models were compared to the subset-specific models that had only the intercepts, and were considered significant if the

TABLE II. Measurements among horses admitted to the Equine Hospital of Cornell University for joint lameness, 1983–90

		Foals (n = 53)[a] Discharged alive		Yearlings (n = 87)[a] Discharged alive		Non-racing (n = 141)[a] Discharged alive		Racing (n = 226)[a] Discharged alive	
Measurement	Percentile	yes (n = 31)	no (n = 22)	yes (n = 68)	no (n = 21)	yes (n = 119)	no (n = 22)	yes (n = 213)	no (n = 13)
Age (mo)	25th	0.50	0.45	8	7	48	40	40	34
(53; 87; 141; 226)[b]	50th	1.0	0.88	12	12	77	80	48	47
	75th	2.5	2.0	20	24	126	111	67	63
Cost of hospitalization ($)	25th	361	184	173	134	128	138	228	196
(43; 78; 130; 203)	50th	834	363	799	394	191	203	810	579
	75th	1564	1093	1226	625	774	423	1143	1304
Duration of hospitalization (d)	25th	2 to 5	1	1	2 to 5	1	1	1	1
(44; 74; 137; 209)	50th	> 5	> 5	2 to 5	> 5	2 to 5	2 to 5	2 to 5	2 to 5
	75th	> 5	> 5	> 5	> 5	> 5	> 5	> 5	> 5
Keratan sulfate in synovial fluid (μg/ml)	25th	—	—	2	9.8	3.4	1.9	4.1	13.9
(—; 24; 24; 60)	50th	—	—	2.9	16	5.8	6.4	5.7	24.2
	75th	—	—	6.6	22	18.2	8.8	11.3	59.3
Total solids in synovial fluid (g/dl)	25th	3.5	4.4	2.8	2.9	2.7	2.8	2.5	3.7
(43; 40; 29; 72)	50th	5.6	5.7	4.2	4.5	3.6	5.6	3.2	6.3
	75th	6.3	6.2	6.0	5.5	5.8	6.4	4.3	7.2

[a] Foals, age ≤ 4 mo; yearlings, 4 mo < age ≤ 24 mo; non-racing, age > 24 mo; racing, age > 24 mo
[b] Numbers of foals, yearlings, non-racing adults, and racing adults, respectively, with this measurement

TABLE III. Percent of horses with factor among those with known status as alive or sound on follow-up (horses > 24 mo old, discharged alive after presentation for joint lameness to the Equine Hospital of Cornell University; 1983–1990; at least 6 mo of follow-up available)

	Non-racing (n = 78) Sound at follow-up		Racing (n = 106) Alive at follow-up	
Factor	yes (n = 55)	no (n = 23)	yes (n = 64)	no (n = 42)
Breed (78; 106)[a]				
Standardbred	24	13	58	71
Thoroughbred	24	22	42	29
Other	53	65	—[b]	—
Gender (78; 106)				
Stallion	13	0	17	29
Gelding	46	48	31	43
Female	42	52	52	29
Lameness[c] (60; 73)				
Severe	44	26	18	46
Not severe	56	74	82	54
Use (78; 106)				
Racing	—	—	100	100
Pleasure/work	49	61	—	—
Other	51	39	—	—
Diagnosis[d] (78; 106)				
Chip fracture	18	9	44	29
DJD	66	61	39	26
Fracture (not chip)	18	9	31	33
Osteochondrosis	—	—	5	12
Miscellaneous diagnoses	—	—	23	14
Joint(s) involved[c] (78; 106)				
Carpus	27	9	55	48
Distal to fetlock	13	39	9	10
Fetlock	34	26	47	43
Hock	46	35	19	14
Only 1 joint[e]	42	54	32	40
Procedure (78: 106)				
Arthroscopy	29	9	64	55
Arthrotomy	—	—	12	14
Prognosis (71; 94)				
Good	26	31	20	9
Guarded	62	47	61	41
Poor	12	22	18	50

DJD — degenerative joint disease
[a] Numbers of non-racing and racing horses with non-missing data
[b] Not applicable
[c] Severely lame = severe lameness, non-weightbearing, or recumbent at presentation
[d] Diagnoses and joints involved are not mutually exclusive within general factor category
[e] n = 77 and 105 for non-racing and racing horses, respectively

change in deviance had $P \leq 0.05$. Sample sizes were small, so no other formal goodness-of-fit tests were attempted. No interaction terms were tested; the stratifications into subsets were intended to address what we thought would be the 2 greatest sources of non-homogeneity in effects, namely age and intended use. Odds ratios (OR) and their 95% confidence intervals (CI) were calculated, exponentially from the b's and their SEs, for variables in the final models. Where imprecision was great, presumably due to combinations of small sample sizes, variability in effects, collinearity among variables, and predictions near 0 or 1, some ORs and upper confidence limits were so large that we indicated them as "> 100" in the results. Modeling was performed using STATISTIX 4.1 for Windows (Analytical Software, Tallahassee, Florida, USA).

RESULTS

The foal joints most commonly involved in lameness were the fetlock, hock and stifle. Although most foals (60%) had only single joints involved, 40% had multiple joints affected. In the short term, foals with multiple joints involved did as well as those with only a single joint involved.

Thirty-one of 53 foals (58%) were discharged from the hospital. Chip fracture, other fracture, distal (to fetlock) location of the lesion, arthroscopy, and arthrotomy were ignored for modeling because of poor distribution. Gender was dichotomized to male vs female because there were only 2 castrated male foals. The variables that passed screening were breed, lameness, infectious arthritis, carpal disorder, fetlock disorder, cost of hospitalization, and duration of hospitalization (Tables I and II). Cost of hospitalization was collinear with breed, lameness score, and carpal disorder, and thereafter duration was ignored, because it was also missing for 12 of the 53 foals.

Duration of hospitalization >1 d and a diagnosis of infectious arthritis were associated with increased odds of successful discharge (Table V); 25% of foals had infectious arthritis, and 61% of those were discharged alive (Table I). A severe lameness indicated a less favorable short-term outcome (Table V). The model had good fit (P = 0.64) but should be interpreted with caution because it was based on only 30 foals, ie, only 30 had non-missing data for all 3 risk factors. Breed was not retained in the model, but was partially collinear with infectious arthritis; 8 of 9 foals that were not Standardbred or Thoroughbred had diagnoses other than infectious arthritis.

The joints of yearling horses most commonly involved in lameness were the fetlock, hock, and stifle. Of the 87 yearlings, 78% (68/87) were discharged from the hospital. No variables were ignored because of poor distribution. Ten of 23 potential risk factors passed screening. When these 10 variables were modeled, the model reduced to the single variable arthroscopy (data not shown). This variable was collinear with all 9 of the other variables offered to the model, had an unstable coefficient, and is not a factor inherent to the horse. Therefore, yearling discharge was remodeled without arthroscopy in the starting model.

The 9 offered variables reduced to the diagnosis of OCD (Table V). This model had good fit (P = 0.52) but was poor at classifying horses that would not be discharged alive, even though that classification was done using the same data set from which the model was derived, and should have been "best case." Nevertheless, yearlings with OCD had > 4 times higher odds of being discharged alive than other yearlings. The OCD variable was collinear with all of the other variables offered except chip fracture, duration, and gender — so only these last 3 variables of those offered to the model were ruled out as assisting in the prognosis of discharge status.

TABLE IV. Percentiles of measurements among 24 mo old horses presented to the Equine Hospital of Cornell University for joint lameness with at least 6 mo of follow-up data; 1983–1990

Measurement	Percentile	Non-racing (n = 78)[a]		Racing (n = 106)[a]	
		yes (n = 55)	no (n = 23)	yes (n = 64)	no (n = 42)
Age (mo)	25th	46	60	40	40
(78; 106)[a]	50th	68	96	46	50
	75th	122	140	64	69
Cost of hospitalization ($)	25th	152	105	662	467
(71; 99)	50th	286	155	997	919
	75th	1016	373	1342	1267
Duration of hospitalization (d)	25th	1	0	2 to 5	1
(75; 101)	50th	1	1	2 to 5	2 to 5
	75th	> 5	2 to 5	> 5	> 5
Joint-fluid total solids (g/dl)	25th	2.6	3.2	2.5	2.5
(16; 35)	50th	3.0	6.5	2.8	3.4
	75th	3.7	8.6	3.5	5.4
Length of follow-up (d)	25th	433	1142	220	365
(48; 90)	50th	819	1999	337	643
	75th	1422	2472	720	1339

[a] Foals, age ≤ 4 mo; yearlings, 4 mo < age ≤ 24 mo; non-racing, age > 24 mo; racing, age > 24 mo
[b] Number of non-racing and racing horses with this measurement, respectively

Yearlings that left the hospital tended to have lower concentrations of keratan sulfate in synovial fluid (n = 64) in the short term than those that died or were euthanized (Table II).

The most commonly involved joints in non-racing adult horses were the carpus, distal phalangeal joints, and hock joints. Of 141 horses, 119 (84%) were discharged. The 5 variables ignored because of poor distributions were OCD, infectious arthritis, shoulder or hip involvement, stifle involvement, and arthrotomy. Of the remaining 16 variables, 10 passed screening: breed, lameness score, intended use, fracture, osteoarthritis, miscellaneous arthroses, carpus involved, hock involved, number of joints involved, and cost of hospitalization (Tables III and IV).

The final model (Table V) had good fit (P = 1.00) and was based on 95 of the 141 non-racing adults. In spite of the good fit, this model was poor at correctly classifying horses that did not go home alive. Horses with severe lameness or with miscellaneous arthroses had poorer odds of being discharged alive than other horses. Horses intended for pleasure use, as opposed to other non-racing uses, had high odds of being discharged alive. These 3 variables also somewhat proxied most of the other variables that were offered to, but were eliminated from, the starting model; only hock involvement had no apparent association with any of the variables in the final model.

Out of 226 lame racing adult horses, all but 13 (6%) were discharged alive. With so little variability in the outcome, modeling was not attempted.

For long-term follow-up, follow-up was available on 18 of 31 foals discharged alive. Minimum follow-up was 143 d, median 988, and maximum 1363. Of these, 12 out of 18 were alive at follow-up, 10 out of 12 became sound, and 7 stayed with their owners at least 6 mo. There were too few foals to model the long-term outcome.

Of 68 yearlings discharged alive, follow-up was available for 49 of them. Minimum follow-up was 96 d, median 509 d, maximum 1520 d. Thirty-eight of the 49 were alive at follow-up, 32 of which became sound, and 20 stayed with their owners at least 6 mo. As with foals, there were too few yearlings to model long-term outcome.

Tests for evidence of selection bias were performed between the 85 adult non-race horses with any form of follow-up data, including 7 without data on vital status and excluding horses that had been discharged < 3 mo prior to time of data collection, and the 20 without follow-up. Because 27 tests at

TABLE V. **Final logistic multiple-regression models of risk factors for short-term or long-term follow-up of horses presented to the Equine Hospital of Cornell University for joint lameness 1983 to 1990**

Age-use class	Risk factor	b	SE (b)	Odds ratio	95% Confidence interval	Model: Deviation	Model: Degrees of freedom	Model: Goodness of fit
Outcome = Discharged alive from the hospital								
Foals[a]	Severely lame	−1.5	1.24	0.22	0.02, 2.5	22.90	26	0.64
(n = 30)[b]	Infectious arthritis	7.9	12.8	> 100	0.00, > 100	—	—	—
	Hospitalized > 1 d	10.3	12.8	> 100	0.00, > 100	—	—	—
	Constant	−8.8	—	—	—	—	—	—
Yearlings[a]	Osteochondrosis	1.5	0.6	4.5	1.5, 14.0	83.65	85	0.52
(n = 87)	Constant	0.62	—	—	—	—	—	—
Non-racing adults[a]	Severely lame	−4.1	1.5	0.02	0.00, 0.33	44.06	91	1.00
(n = 95)	Pleasure use	2.9	1.2	17.5	1.8, 168	—	—	—
	Miscellaneous diagnoses	−3.8	1.4	0.02	0.00, 0.36	—	—	—
	Constant	4.4	—	—	—	—	—	—
Outcome = Still alive at follow-up								
Non-racing horses[a]	Carpal involvement	8.7	15.4	> 100	0.0, > 100	20.64	29	0.87
(n = 36; not stable,	Arthroscopy	−7.3	15.5	0.0	0.0, > 100	—	—	—
imprecise,	Poor prognosis	−9.3	15.4	0.0	0.0, > 100	—	—	—
no significant	Ever became sound	1.6	1.4	5.0	0.35, 70.7	—	—	—
variables)	Cost ≥ $192	9.1	15.4	> 100	0.0, > 100	—	—	—
	Follow-up ≥ 871 d	0.9	1.6	2.5	0.10, 63.1	—	—	—
	Constant	−0.2	—	—	—	—	—	—
Outcome = Ever became sound								
Race horses[a]	Severely lame	−1.5	0.6	0.22	0.07, 0.71	76.27	66	0.18
(n = 64)	Hospitalized > 1 d	1.9	0.7	6.5	1.7, 25.1	—	—	—
	Constant	−0.5	—	—	—	—	—	—

[a] Foals, age ≤ 4 mo; yearlings, 4 mo < age ≤ 24 mo; non-racing, age > 24 mo; racing, age > 24 mo
[b] Number of cases with non-missing data for all variables remaining in the final model

α = 10% (2-tailed) were performed, 2.7 (2 to 3) false-positive significant results were expected. There were significant differences in only 2 variables (arthroscopy and length of hospital stay), so we concluded that there was no compelling evidence of selection bias.

Because of the small number (only 2 to 9) of horses in one of the levels of each of 6 dichotomous variables, those 6 variables (arthrotomy, shoulder or hip location, OCD, miscellaneous arthroses, infectious arthritis, and stifle location) were ignored for modeling. There were only 9 stallions with follow-up, and only 7 with known live/dead status, but this variable was retained because all 7 stallions with known status were alive at follow-up.

Nine out of 20 variables failed to pass screening: breed, chip fracture, OA, fetlock, non-chip fracture, hock, lameness score at presentation, number of joints involved, and intended use of the horse (declared at presentation). Only 16 horses had data on both alive at follow-up and joint fluid total solids, so the latter variable also was set aside. Just before modeling, gender was dichotomized to stallion (yes/no), duration of hospitalization > 1 d vs outpatient or 1 d, and poor prognosis vs good or guarded prognosis.

The final model had good fit (P = 0.87) but was unstable (imprecise), had no variable significant on Wald's test, was based on only 36 horses, and had considerable evidence of possible confounding among the 6 retained risk factors. Removal of any variable caused important changes in the coefficients of the remaining variables. The model classified alive horses well, but not those horses that were dead at follow-up.

With adjustments for each other, carpal location of the lameness, not having arthroscopy, a prognosis at discharge other than poor, ever becoming sound, above-median hospitalization costs, and a longer interval between discharge and follow-up implied better odds of being alive at follow-up (Table V). Longer follow-up implies both older age at follow-up (correlation between age at admission and length of follow-up: r_{sp} = 0.40, df = 48, P < 0.01) and earlier calendar year of presentation. Being a stallion did not remain in any final model, and gender was the only variable deleted during modeling that was not collinear with variables retained in the final model. However, all 7 stallions with known live/dead status were alive (100%); lower 95% confidence limit ≈ 40%).

In the analysis for selection bias, only cost and duration of hospitalization, osteoarthritis, arthroscopy, and infectious arthritis were different. The difference with infectious arthritis was discounted, because only 8 horses didn't have high joint-fluid cell counts (all 8 had follow-up). Horses with follow-up were less likely to have had arthritis, had higher costs, tended to be hospitalized > 1 d, and were more likely to have had arthroscopies than horses who did not have follow-up. Because it's likely that 1 or 2 of these last 4 variables were only different due to chance (26 tests at 10% were done; 2 or 3 false-positives were expected), we felt that there was little evidence of selection bias in the horses with follow-up.

Of the 106 adult race horses with soundness data, 64 (60%) were reported to have become sound after discharge. Only 2 horses were breeds other than Standardbred or Thoroughbred, and there was only one horse with follow-up among those with a "high" (shoulder or hip) location of the joint lameness; therefore, these 2 variables were ignored for the screening and modeling. Out of 25 variables, the following 15 failed to pass screening (all P > 0.20): age, arthrotomy, carpus, cost, distal location, fetlock, fracture, hock, number of joints, other diagnoses, owned 6 mo after discharge, prognosis at discharge, arthroscopy, stifle, and joint fluid total solids. Only 5 horses (1 sound, 4 unsound) didn't have high joint fluid cell counts, so infectious arthritis was ignored. Only 8 horses had OCD, but it was offered to the starting model. Risk factors associated with higher odds of adult race horses ever becoming sound were not being severely lame at admission and hospitalization > 1 d (Table V).

DISCUSSION

It is often difficult to provide clients with accurate short- and long-term prognoses for survival and function following diagnosis and treatment of specific joint diseases in the horse. Certain joint diseases, eg, OCD involving the tarsus (10–11), carry a good prognosis for survival and future performance. However, the prognosis for survival with other conditions, such as foals with several infected joints, is less clear. In effect, a clinician dealing with a horse with joint disease has to synthesize many physical examination and diagnostic findings in arriving at a prognosis for the client. Here, we attempted to apply a statistical basis to this approach.

Multivariable modeling of lameness data has the advantage that the variables retained in the final model are adjusted for each other. Independent variables with no discriminating capacity, eg, equal proportions of animals falling into each outcome category, will not pass screening to be offered to the models, and collinear variables will not be retained in the final models. Our modeling strategy is not the only possible methodology; other strategies might have resulted in different conclusions. However, it was thought that multivariable methods could be advantageous over previous studies of the outcome of joint lameness.

We acknowledge several limitations of our study. Ours is a referral hospital, which somewhat limits generalizations. The submissions were from several years ago; however, this allowed for long-term follow-up (our original intention). Unfortunately, it became evident that unless we insisted on a minimum of merely 3 mo of follow-up, we would lose enough data to decrease our power to unacceptable levels. The problems with long-term follow-up and with missing data in hospital records caused some models to be based on only a fraction of the available cases. Nevertheless, all models converged and all final models fit with $P \geq 0.18$. Also, many of our estimates are unstable, listed as "> 100" in Table V, due to small sample sizes, partial collinearity with other variables, and/or due to situations in which the estimated proportions of horses having the outcome are close to either 0 or 1. However, the directions of the associations still allow interpretations.

The 5 models in Table V contain 12 risk factors, of which only being severely lame (3 models) and hospitalization for > 1 d (2 models) appear in multiple models. If we also consider the yearling model that contained only arthroscopy, then there still were only 3 variables that appeared more than once across 6 models. Even if we consider the several collinear variables that were offered to models but not retained, then we still have only 7 of the 12 variables represented in multiple models, and still only severely lame, longer hospitalization, and higher costs in more than 2 of the 5 models. We feel that this supports our decision to stratify the analyses on age-use classes; clearly, the risk factors for the outcomes differ by age and use of the horse.

It made sense to us that severely lame horses were less likely to have successful outcome. That longer hospitalization and higher costs were associated with success in multiple models (either retained or unconditionally associated with the outcome and partially collinear with retained variables) might indicate the owner's willingness to persevere with the horse and financial situation. It was surprising to us that within age and use class, the horse's signalment (age, breed, gender, intended use) made little difference in outcome — neither did the particular joint (with 1 exception) nor the number of joints affected.

It was interesting to us that the presence of infectious arthritis was associated with higher odds of short-term survival. Our interpretation is that when foals with septic joints are given appropriate therapy, they do respond well, at least on a short-term basis. During the period of data collection, arthroscopy was not routinely performed for infectious arthritis in foals. Instead, they were treated with repeated needle lavage and systemic antimicrobials following microbiologic culture and sensitivity testing.

In the yearling group, the only risk factor in the final model, after arthroscopy was discarded, was OCD. The favorable outcome for OCD implies a less favorable outcome for all other diagnoses associated with joint lameness in this age group; OCD affects multiple joints, is often bilateral, and was positively associated with the stifle joint.

As in some other groups, the adult non-racing horses with severe lameness had lower odds of being discharged. This was predictable because most non-racing horses with major articular fractures would be euthanized.

The risk factors that predicted soundness in racehorses were completely different from those that predicted whether non-racehorses would be alive. This justifies the separate analyses. "Racing" and "non-racing" were intended uses declared at presentation, not at discharge. There were many Standardbred and Thoroughbred horses in the non-racing data set, so breed differences did not explain the differences in risk factors between the 2 data sets. Also, more money was spent on race horses than on non-race horses. Adult horses had higher odds of being discharged from the hospital following treatment than yearlings, and yearlings were more likely to be discharged than foals, 90% vs 70% vs 59%, respectively. However, once discharged from the hospital, available long-term outcome with regard to the owner's opinion of soundness for these horses was about 60% for each age group.

This was a large data set with multiple variables. Logistic multiple regression modeling provided a unique objective way to evaluate the prognostic factors. Unfortunately, it is inevitable when dealing with live animals that there are countless confounding factors and barriers to follow-up information. Nevertheless, we feel that some meaningful findings were evident. These include the finding that most foals with infectious arthritis did survive at least in the short term and multiple joint involvement was not a poor prognostic sign. We showed that the prognosis for yearlings with OCD was favorable, at least in the short term. For adult horses in the long term, the likelihood of soundness was similar despite the intended use.

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REFERENCES

1. **JEFFCOTT LB, ROSSDALE PD, FREESTINE J, FRANK CJ, TOWERS-CLARK PF.** An assessment of wastage in Thoroughbred racing from conception to 4 years of age. Equine Vet J 1982; 14: 195–198.
2. **ROSSDALE PD, HOPES R, WINGFIELD DIGBY NJ, OFFORD K.** Epidemiological study of wastage among racehorses 1982 and 1983. Vet Rec 1985; 116: 66–69.
3. **LIDNER A, VONWITTKE P, DINGERKUS A, TEMME M, SOMMER H.** Causes and rate of training failure in Thoroughbreds. Equ Athl 1992; 5: 1–7.
4. **ROSE RJ.** An analysis of conditions causing lameness in the horse. Proc 54th Ann Conf Aust Vet Assoc 1977: 99–102.
5. **TODHUNTER RJ, LUST G.** Pathophysiology of synovitis: clinical signs and examination in horses. Compend Contin Educ Pract Vet 1990; 12: 980–992.
6. **FORTIER LA, FOERNER JJ, NIXON AJ.** Athroscopic removal of axial osteochondral fragments of the plantar/palmar proximal aspect of the proximal phalanx in horses: 119 cases (1988–1992). J Am Vet Med Assoc 1995; 206: 71–74.
7. **WHITTON RC, KANNEGIETER NJ.** Osteochondral fragmentation of the plantar/palmar proximal aspect of the proximal phalanx in racing horses. Aust Vet J 1994; 71: 318–321.
8. **VATISTAS NJ, WRIGHT IM, DYSON SJ.** Comparison of arthroscopy and arthrotomy for the treatment of osteochondritic lesions in the femoropatellar joint of horses. Vet Rec 1995; 137: 629–632.
9. **BEARD WL, BRAMLAGE LR, SCHNEIDER RK, EMBERTSON RM.** Postoperative racing performance in standardbreds and thoroughbreds with osteochondrosis of the tarsocrural joint: 109 cases (1984–1990). J Am Vet Med Assoc 1994; 204: 1655–1659.
10. **LAWS EG, RICHARDSON DW, ROSS MW, MOYER W.** Racing performance of standardbreds after conservative and surgical treatment for tarsocrural osteochondrosis. Equine Vet J 1993; 25: 199–202.
11. **McILWRAITH CW, FOERNER JJ, DAVIS DM.** Osteochondritis dissecans of the tarsocrural joint: results of treatment with arthroscopic surgery [see comments]. Equine Vet J 1991; 23: 155–162.
12. **FOLAND JW, McILWRAITH CW, TROTTER GW.** Arthroscopic surgery for osteochondritis dissecans of the femoropatellar joint of the horse. Equine Vet J 1992; 24: 419–423.
13. **DABAREINER RM, SULLINS KE, WHITE NA.** Progression of femoropatellar osteochondrosis in nine young horses. Clinical, radiographic and arthroscopic findings. Vet Surg 1993; 22: 515–523.
14. **STASHAK TS.** Diagnosis of lameness. In: Stashak TS, ed. Adams' Lameness in Horses. Philadelphia: Lea & Febiger, 1987: 106.
15. **TODHUNTER RJ, FUBINI SL, FREEMAN KP, LUST G.** Keratan sulfate in plasma and synovial fluid from horses with normal and diseased joints: 212 cases (1987-1989). J Am Vet Med Assoc 1997; 210: 369–374.
16. **KLEINBAUM DG, KUPPER LL, MORGENSTERN H.** Principles and Quantitative Methods in Epidemiologic Research. New York: Van Nostrand Reinhold Company, 1982: 427, 450.