ORIGINAL RESEARCH

REFEREED

Association of Racing Performance with Specific Abnormal Radiographic Findings in Thoroughbred Yearlings Sold in Texas

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ABSTRACT

The objective of this prospective study was to determine the association between presence of abnormal radiographic findings attributed to orthopedic disorders of development (ARF) with subsequent performance among yearlings in Texas. The study population was 348 yearlings offered for sale at the Texas Summer Yearling Sale during 2002 and 2003 for which presale radiographs of limbs were available for review. Radiographs of yearlings were reviewed and presence of ARF were recorded. Additionally, the following data were recorded for each horse: identifiers [name of dam, name of sire, hip number, and name (when available)], year of sale, state of birth, and sales price. Subsequent performance data were obtained for each horse at the conclusion of their 2nd and 3rd years of life. Results indicated that no ARF was significantly associated with performance outcomes. Lesions of the proximal dorsal aspect of the sagittal ridge of the 3rd metacarpus/metatarsus resulted in significantly lower sales prices than either horses without this ARF or horses without any ARF. In conclusion, multiple radiographic abnormalities of Thoroughbred yearlings were not associated with reduced performance during the first 2 years of the racing careers of horses studied. Presence of some abnormalities, however, may be associated with reduced sales price.

Keywords: Radiography; Horses; Performance; Epidemiology; Developmental orthopedic disease

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INTRODUCTION

Because of the economic value of yearlings offered for sale as racing prospects and because skeletal disorders affecting limbs and joints can impact performance of these horses, radiography of the limbs of yearlings is often performed before sale.[1-3] Many sales companies maintain a repository of the radiographs of yearlings offered at their sale. Such repositories are generally available for review by prospective buyers or their agents. Interpretation of these radiographic data, however, is limited by the paucity of information regarding the importance of bony lesions identified by radiography relative to subsequent performance of affected horses. To the authors' knowledge, only a single study among horses in the United States has addressed the issue of the association of radiographic findings with subsequent performance.[1,2] Although this study was well designed, conducted with scientific rigor, and identified certain lesions that were associated with performance, it was limited to horses from a single state, viz., Kentucky. Evidence exists for regional differences among racing horses in the prevalence and risk factors for racing injury.[4-8] Thus, differences may occur among regions in the prevalence of bony abnormalities among Thoroughbred yearlings sold for racing, and in the association of these bony lesions with racing performance. Furthermore, replication of previous findings would help to substantiate the external validity of those results. The purpose of this study was to determine the prevalence of abnormal radiographic findings attributed to disorders of orthopedic development in the limbs of Thoroughbred yearlings offered for sale in Texas, and to determine prospectively the association between the presence of these osseous abnormalities and indicators of performance.

MATERIALS AND METHODS

Study Population

Two of the authors (G.K.C. and J.P.W.) attended the Fasig-Tipton Summer Yearling Sale in Grand Prairie, Texas, during 2002 and 2003. The purpose of their attendance was twofold: first, they reviewed radiographs of

yearlings offered for sale on behalf of clients for whom they were consulting; and, second, they reviewed radiographs of all other yearlings for which complete sets of radiographs were available. A radiographic set comprised those radiographs available for a given horse. A radiographic set was considered complete when it included recommended images of the metacarpophalangeal (flexed lateromedial, dorsal 30° proximal-palmar oblique, dorsal 45° medial-palmarolateral oblique, and dorsal 45° lateral-palmaromedial oblique views), metatarsophalangeal (straight lateromedial, dorsal 30° proximal-plantar oblique, dorsal 45° medial-plantarolateral oblique, and dorsal 45° lateral-plantaromedial oblique views), carpal (flexed lateromedial, dorsal 30° medial palmarolateral oblique, and dorsal 45° lateral-palmaromedial oblique views), tarsal (lateromedial, dorsal 45° medial-plantarolateral, and dorsal 10° lateral-plantaromedial oblique views), and femorotibial joints (lateromedial, lateral, and lateral 20° caudal-mediocranial oblique views, with 20° cranial-mediocaudal oblique and caudocranial views suggested but optional).[9] All yearlings for which a complete set of radiographs were available were included in the study.

For each horse included in the study, the authors who reviewed radiographs completed a study data form describing the presence of and limb affected by specific abnormal radiographic findings (ARF; Table 1). These abnormalities were selected on the basis of previous reports[1-3] and the clinical experiences and judgment of two of the authors (G.K.C. and J.P.W.). The hip number, year of sale, state of birth, sire name, dam name, and name (when available) for each study yearling were recorded on the study form. Whether the horse was sold or retained by the seller and the sale price for each yearling also were recorded; these data were obtained electronically from the sale company (Fasig-Tipton, Lexington, KY).

The following racing performance data were obtained from the Equineline database (www.euqineline.com) for each horse included in the study for the second year of life (i.e., as a 2-year-old), the third year of life, and their sum: (a) whether the horse ever started a race; (b) number of race starts; (c) whether the horse ever won a race; (d) number of wins; (e) whether the horse ever ran in a graded stakes race; (f) whether the horse ever won a graded stakes race; (g) number of finishes in the top three positions for a race; and (h) earnings (in dollars). Earnings per start was calculated from these data by dividing the earnings (either in a given year of age or for both years) by the appropriate number of starts.

Data Analysis

The aforementioned performance variables were compared between horses with radiographic lesions (presence of any lesion) and by specific lesions [e.g., bony fragments of the proximal aspect of the first phalanx (P1)] and horses that did not have radiographic lesions. Continuous variables (e.g., career earnings) were compared between groups using the Wilcoxon rank-sum test,[10] and categorical variables (e.g., whether the horse ever started a race) were compared using the chi-square test.[10] Because of the multiplicity of comparisons, comparisons were adjusted to control the family-wise type 1 error rate (significance level) at .05 by using the method of Hochberg.[11] The *P* values were adjusted for the multiplicity of comparisons of a given variable (e.g., sale price) among the group of horses with a given lesion and horses that either did not have that lesion or horses that did not have any ARF across the multiple lesion types [e.g., 12 *P* values were generated for sales price comparisons (6 lesion types and 2 comparisons among groups)]. Analysis was performed using commercial software (S-PLUS version 1.0, Insightful, Seattle, WA) and freely available software (www.r-project.org).

RESULTS

Descriptive Findings

A total of 348 yearlings (201 from 2002 and 147 from 2003) were included in the study. These horses represented 53% (201/381) and 51% (147/290) of yearlings offered for sale; horses were not included in the study either because no radiographs were obtained (the majority) or because radiographic sets were incomplete. Of these 348 horses, 106 (30%) had ARF. There was no significant difference in the proportion of horses with ARF in the first (32%; 65/201) and second (28%; 41/147) years of the study. Most of the horses were foaled in Texas (52%; 181/348); other states of birth included Arkansas (n = 3), Arizona (n = 1), California (n = 1), Florida (n = 17), Indiana (n = 1), Kentucky (127; 36%), Louisiana (n = 1), Maryland (n = 7), New York (n = 3), Ohio (n = 1), Oklahoma (n = 4), and Pennsylvania (n = 1). The proportion of horses with ARF did not differ significantly among horses bred in Texas (34%; 62/181) and other states (26%; 44/167). There was no significant difference in the distribution of sales price between horses with ARF (median, $7,500; range, $1,000–$82,000) and unaffected horses (median, $9,700; range, $600–$125,000). The proportion of horses not sold did not differ significantly between horses with ARF (32%) and unaffected horses (27%).

The frequency distribution of specific lesions was tabulated (Table 2). The 106 horses had a total of 154 individual limbs that had ARF (i.e., counting twice a single type of lesion that affected two limbs). The 106 horses had a total of 126 individual types of lesions [i.e., counting a type of lesion affecting multiple limbs (e.g., SBC of the medial femoral condyle affecting both hind limbs) as a single type of lesion], indicating that most horses only had a single type of lesion. The most common combina-

Table 1. Radiographic findings recorded for 348 Thoroughbred yearlings offered for sale in Texas during 2002 and 2003

Metacarpophalangeal or metarsophalangeal (fetlock) region
- Bone fragment(s) of the dorsal aspect of the first phalanx (P1)
- Bone fragment(s) of the palmar/plantar aspect of P1
- Abnormality of the proximal dorsal aspect of the sagittal ridge of the 3rd metacarpus/metatarsus (PSRA): irregular margin, flattening, or lucency of the subchondral bone
  If yes, was a bone fragment present with PSRA?
- Abnormality of the distal aspect of the dorsal sagittal ridge of the 3rd metacarpus/metatarsus (DSRA)
  If yes, was a bony fragment present with DSRL?
- Proximal P1 subchondral bone cysts (SBC)
- Distal third metacarpal/distal third metatarsal SBC

Tarsal (hock) region
- Abnormal lucency of the medial malleolus
- Abnormality (fragmentation or concavity) of the distal intermediate ridge of the tibia (DIRT)
- Abnormality (flattening, lucency, concavity, or fragmentation) of the lateral trochlear ridge of the talus
- Abnormality (flattening, lucency, concavity, or fragmentation) of the medial trochlear ridge of the talus

Femorotibial (stifle) region
- Abnormality (lucency or fragmentation) of the lateral trochlear ridge of the femur
- Abnormality (lucency or fragmentation) of the medial trochlear ridge of the femur
- SBC of the medial femoral condyle
- SBC of the proximal tibia

Other findings
- SBC of the distal aspect of P1
- SBC of proximal aspect of the second phalanx (P2)
- SBC of proximal aspect of the third phalanx (P2)
- SBC of proximal aspect of the third phalanx (P3)
- Other lesions

tions of lesions were lesions of dorsal P1 and the lateral trochlear ridge of the femur [two horses, with both lesions in a horse affecting the same limb (right rear and left rear)] and lesions of the proximal, dorsal sagittal ridge of the metacarpus or metatarsus and the distal intermediate ridge of the tibia (two horses; one horse affected with lesions in three limbs and one horse affected with lesions occurring bilaterally in the hind limbs). No other combination of lesions affected more than one horse.

Association of Any ARF with Performance

No significant differences were seen in the distribution of the number of starts at 2 years, 3 years, total for both years, or total starts in stakes races between horses with ARF (medians = 2 starts, 5.5 starts, 7.5 starts, and 0 starts, respectively) and unaffected horses (medians = 2 starts, 5 starts, 8 starts, and 0 starts, respectively). No significant differences were seen in the distributions of any other performance factors between horses with ARF and unaffected horses. For example, no significant difference was found in the proportion of horses that ever started between ARF horses (79%; 84/106) and unaffected horses (81%; 197/242), and there was no significant difference in the career earnings by 3 years of age between ARF horses (median, $10,268; range, $0–$252,036) and unaffected horses (median, $10,585; range, $0–$250,000). Results were similar with respect to magnitude and statistical significance whether or not horses that never started were excluded from analyses.

Association of Specific ARF and Performance

The association of performance was examined for horses with types of ARF for which eight or more horses were affected (Tables 3 and 4).

Abnormalities of the proximal, dorsal aspect of the distal sagittal ridge of the 3rd metacarpus or metatarsus (PSRA) The proportion of horses that ever started a race was similar for horses with PSRA (88%; 15/17), all other horses (80%; 266/331), and horses without PSRA (81%; 197/242). Horses with PSRA did not differ significantly from all other horses

Table 2. Distribution of 155 total radiographic lesions in 106 horses by affected limb among 348 yearling Thoroughbreds offered for sale in Texas during 2002 and 2003

Abnormal Radiographic Finding (ARF)	Right Front (RF)	Left Front (LF)	Right Rear (RR)	Left Rear (LR)	Multiple Limbs	Total Horses (Lesions)
Dorsal, proximal P1* fragment	2	1	2	4	1 (RR&LR)	10 (11)
Palmar/plantar, proximal P1 fragment	0	1	1	9	0	11
Proximal P1 subchondral bone cyst (SBC)	1	0	0	1	1 (RR&LR)	3 (4)
Distal P1 SBC	0	0	1	0	1 (RR&LR)	2 (3)
Proximal dorsal sagittal ridge of MC3/MT3* (PSRA)	2	1	3	4	7(RF&LF[N=1], RR&LR[4], RF&RR[2])	17 (24)
PSRA with fragment	0	0	0	1	2 (RR&LR)	3 (5)
Distal dorsal sagittal ridge of MC3/MT3* (DSRA)	6	8	2	10	1(RR&LR)	27 (28)
DSRA with fragment	1	1	0	0	0	2
Medial maleolus	0	0	1	0	0	1
Distal intermediate ridge tibia	0	0	0	6	2 (RR&LR)	8 (10)
Lateral trocheal ridge talus	0	0	2	1	1 (RR&LR)	4 (5)
Medial trochlear ridge talus	0	0	1	1	0	2
Lateral trochlear ridge of the femur	0	0	7	4	4 (RR&LR)	15 (19)
Medial trochlear ridge of the femur	0	0	2	0	1 (RR&LR)	3 (4)
SBC of the medial femoral condyle	0	0	9	2	7 (RR&LR)	18 (25)

Abbreviations: P1, first phalanx; MC3, third metacarpal bone; MT3, third metatarsal bone.

or horses without PSRA in the number of starts, in the number of starts in their second or third years, or in both years combined. Although not significant (P = .10 and .12, respectively), PSRA horses tended to earn less money at age 2 (median, $0; range, $0–$14,120) than did other horses (median, $660; range, $0–$251,496) or horses without ARF (median, $750; range, $0–$199,500). Among horses that ever started, the proportion of horses that ever finished a race in the top three positions did not differ significantly between horses with PSRA (93%; 14/15) and either all other horses (82%; 218/266) or control horses (81%; 160/197) for the 2-year-old year, the 3-year-old year, or both; the proportion of horses starting that ever finished in the top three positions was 93% (14/15) for the PSRA group, compared with 82% (218/266) and 81% (160/197) for all other horses and horses with no ARF, respectively. The proportion of horses that started races that ever won a race was not significantly different between PSRA horses (73%; 11/15) and either all other horses (68%; 181/266) or unaffected horses (66%; 130/197). None of the PSRA horses, five horses with other lesions, and five unaffected horses ever won a stakes race during the study period; these differences were not significant.

The sales prices of horses with PSRA were significantly (P = .02 and .02, respectively) lower (median, $5,500; range, $1,200–$18,000) than those of horses without these lesions (median, $9,100; range, $600–$125,000) or horses without ARF (median, $9,700; range, $600–$125,000). Although the proportion of horses with PSRA that were not sold (41%; 7/17) appeared greater than that of control horses (28%; 66/242), the difference was not significant.

Table 3. Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002–2003: continuous variables reported as median (range)

	Abnormal Radiographic Finding of the Proximal Dorsal Sagittal Ridge of MC/MTIII					Abnormal Radiographic Finding of the Distal Dorsal Sagittal Ridge of MC/MTIII			
	Yes (N = 17)	No (N = 331)	*P*	No lesions (N = 242)	P_{NI}*	Yes (N = 27)	No (N = 321)	*P*	P_{NI}*
Starts									
Starts at 2	1 (0–8)	2 (0–14)	.14	2 (0–14)	NS	2 (0–10)	2 (0–14)	NS	NS
Starts at 3	8 (0–13)	5 (0–17)	NS	5 (0–17)	NS	7 (0–17)	5 (0–17)	NS	NS
Starts 2 & 3	10 (0–17)	8 (0–25)	NS	8 (0–25)	NS	8 (0–22)	8 (0–25)	NS	NS
Stakes starts	0 (0–6)	0 (0–3)	NS	0 (0–6)	NS	0 (0–3)	0 (0–6)	NS	NS
Earnings									
Earnings 2	$0 ($0–$14,120)	$660 ($0–$251,496)	.10	$750 (0–$199,500)	.12	$605 ($0–$44,164)	$555 ($0–$251,496)	NS	NS
Earnings 3	$6,200 ($0–$25,080)	$7,144 ($0–$143,901)	NS	$6,680 ($0–$143,901)	NS	$11,901 ($0–$44,164)	$7,072 ($0–$143,901)	NS	NS
Earnings 2 & 3	$6,200 ($0–31,880)	$10,633 ($0–$252,036)	NS	$10,585 ($0–$250,000)	NS	$18,400 ($0–$108,650)	$10,478 ($0–$252,036)	NS	NS
Sales									
Sales price	$5,500 ($1,200–$18,000)	$9,100 ($600–$125,000)	.02	$9,700 ($600–$125,000)	0.02	$9,500 ($1,500–$55,000)	$9,000 ($600–$125,000)	NS	NS

*P_{NI}, *P* value for comparison of affected group with horses that had no radiographic lesions detected.

#Among horses that ever started; 2 = as 2-year-old horse; 3 = as 3-year-old horse; 2 & 3 = cumulative for 2- and 3-year-old years.

Table 3 (continued). Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002-2003: continuous variables reported as median (range)

	Fragmentation of Dorsal, Proximal P1					Fragmentation of Palmar/Plantar Proximal P1			
	Yes (N = 10)	No (N = 338)	*P*	No lesions (N = 242)	P_{NI}*	Yes (N = 11)	No (N = 337)	*P*	P_{NI}*
Starts									
Starts at 2#	3 (0–7)	2 (0–14)	NS	2 (0–14)	NS	2 (0–10)	2 (0–14)	NS	NS
Starts at 3#	7 (0–14)	5 (0–17)	NS	5 (0–17)	NS	7 (0–17)	5 (0–17)	NS	NS
Starts 2 & 3#	10 (0–21)	8 (0–25)	NS	8 (0–25)	NS	8 (0–22)	8 (0–25)	NS	NS
Stakes starts#	0 (0–2)	0 (0–6)	NS	0 (0–6)	NS	0 (0–3)	0 (0–6)	NS	NS
Earnings									
Earnings 2#	$7,760 ($0–$18,420)	$480 ($0–$251,496)	NS	$750 ($0–$199,500)	NS	$605 ($0–$44,164)	$555 ($0–$251,496)	NS	NS
Earnings 3#	$8,907 ($0–$25,080)	$7,100 ($0–$143,901)	NS	$6,680 ($0–$143,901)	NS	$11,901 ($0–$44,164)	$7,072 ($0–$143,901)	NS	NS
Earnings 2 & 3#	$15,677 ($0–31,880)	$10,491 ($0–$252,036)	NS	$10,585 ($0–$250,000)	NS	$18,400 ($0–$108,650)	$10,478 ($0–$252,036)	NS	NS
Sales									
Sales price	$6,500 ($2,000–$17,000)	$9,000 ($600–$125,000)	NS	$9,700 ($600–$125,000)	NS	$6,000 ($1,500–$82,000)	$9,000 ($600–$125,000)	NS	NS

*P_{NI}, *P* value for comparison of affected group with horses that had no radiographic lesions detected; NS = $P > .20$.

#Among horses that ever started; 2 = as 2-year-old horse; 3 = as 3-year-old horse; 2 & 3 = cumulative for 2- and 3-year-old years.

Table 3. Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002-2003: continuous variables reported as median (range)

	Abnormal Radiographic Finding of the Trochlear Ridge of the Femur				Subchondral Bone Cyst of the Medial Femoral Condyle				Abnormal Radiographic Finding of the Distal Intermediate Ridge of the Tibia			
	Yes (N = 18)	No (N = 330)	*P*	No lesions (N = 242)	P_{NI}*	Yes (N = 18)	No (N = 330)	*P*	P_{NI}*	Yes (N = 8)	No (N = 340)	*P*	P_{NI}*
Starts													
Starts at 2#	2.5 (0–10)	2 (0–14)	NS	2 (0–14)	NS	2 (0–9)	2 (0–14)	NS	NS	2 (0–8)	2 (0–14)	NS	NS
Starts at 3#	5 (0–11)	5 (0–17)	NS	5 (0–17)	NS	4 (0–10)	5 (0–17)	NS	NS	7 (0–11)	5 (0–17)	NS	NS
Starts 2 & 3#	6.5 (0–12)	8 (0–25)	NS	8 (0–25)	NS	7 (0–16)	8 (0–25)	NS	NS	8.5 (0–13)	8 (0–25)	NS	NS
Stakes starts#	0 (0–5)	0 (0–6)	NS	0 (0–6)	NS	0 (0–4)	0 (0–6)	NS	NS	0	0 (0–6)	NS	NS
Earnings													
Earnings 2#	$1,429 ($0–$251,496)	$605 ($0–$199,500)	NS	$750 ($0–$199,500)	NS	$3,220 ($0–$159,728)	$390 ($0–$251,496)	NS	NS	$0 ($0–$638)	$630 ($0–$251,496)	NS	NS
Earnings 3#	$3,758 ($0–$15,054)	$7,365 ($0–$143,901)	NS	$6,680 ($0–$143,901)	NS	$8,284 ($0–$64,413)	$7,120 ($0–$143,901)	NS	NS	$7,578 ($0–$12,900)	$7,139 ($0–$143901)	NS	NS
Earnings 2 & 3#	$6,587 ($0–252,036)	$10,681 ($0–$250,000)	NS	$10,585 ($0–$250,000)	NS	$12,337 ($0–$224,141)	$10,485 ($0–$252,036)	NS	NS	$7,897 ($0–$12,900)	$10,491 ($0–$252,036)	NS	NS
Sales													
Sales price	$7,500 ($2,000–$40,000)	$9,000 ($600–$125,000)	NS	$9,700 ($600–$125,000)	NS	$10,250 ($2,200–$55,00)	$8,700 ($600–$125,000)	NS	NS	$5,000 ($1,200–14,000)	$9,000 ($600–$125,000)	NS	NS

*P_{NI}, *P* value for comparison of affected group with horses that had no radiographic lesions detected; NS = $P \geq .20$.

#Among horses that ever started; 2 = as 2-year-old horse; 3 = as 3-year-old horse; 2 & 3 = cumulative for 2- and 3-year-old years.

Table 4. Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002–2003: categorical variables

	Abnormal Radiographic Finding of the Proximal Dorsal Sagittal Ridge of MC/MT III					Abnormal Radiographic Finding of the Distal Dorsal Sagittal Ridge of MC/MT III			
	Yes (N = 17)	No (N = 331)	*P*	No Lesions (N = 242)	P_{NI}*	Yes (N = 27)	No (N = 321)	*P*	P_{NI}*
Starts									
Ever started	88%	80%	NS	81%	NS	70%	81%	NS	NS
Finish position									
Ever in Top 3 as 2#	27%	47%	NS	46%	NS	53%	45%	NS	NS
Ever in Top 3 as 3#	87%	69%	NS	68%	NS	68%	70%	NS	NS
Ever in Top 3 as 2&3#	93%	82%	NS	81%	NS	79%	83%	NS	NS
Ever win #	73%	68%	NS	66%	NS	68%	68%	NS	NS
Ever win stakes race#	0%	4%	NS	3%	NS	11%	3%	NS	NS
Sales status									
Sold as yearling	59%	72%	NS	73%	NS	77%	71%	NS	NS

*P_{NI}, *P* value for comparison of affected group with horses that had no radiographic lesions detected; NS = $P \geq .20$.

#Among horses that ever started; as 2 = as 2-year-old horse; as 3 = as 3-year-old horse; as 2 & 3 = cumulative for 2- and 3-year-old years.

Table 4 (continued). Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002–2003: Categorical variables

	Fragmentation of Dorsal Proximal P1					Fragmentation of Palmar/Plantar Proximal P1			
	Yes (N = 17)	No (N = 331)	*P*	No lesions (N = 242)	P_{NI}*	Yes (N = 11)	No (N = 337)	*P*	P_{NI}*
Starts									
Ever started	80%	81%	NS	81%	NS	82%	81%	NS	NS
Finish position									
Ever in Top 3 as 2#	62%	45%	NS	46%	NS	33%	46%	NS	NS
Ever in Top 3 as 3#	88%	69%	NS	68%	NS	89%	69%	NS	NS
Ever in Top 3 as 2 & 3#	88%	82%	NS	81%	NS	89%	82%	NS	NS
Ever win#	62%	68%	NS	66%	NS	78%	68%	NS	NS
Ever win stakes race#	12%	3%	NS	3%	NS	0%	4%	NS	NS
Sales status									
Sold as yearling	60%	72%	NS	73%	NS	73%	72%	NS	NS

*P_{NI} = *P* value for comparison of affected group with horses that had no radiographic lesions detected; NS = $P \geq .20$.

#Among horses that ever started; as 2 = as 2-year-old horse; as 3 = as 3-year-old horse; as 2 & 3 = cumulative for 2- and 3-year-old years.

Table 4 (continued). Association of radiographic abnormalities with racing performance among 348 yearlings offered for sale in Texas during 2002–2003: categorical variables

	Abnormal Radiographic Finding of the Trochlear Ridge of the Femur					Subchondral Bone Cyst of the Medial Femoral Condyle				Abnormal Radiographic Finding of the Distal Intermediate Ridge of the Tibia			
	Yes (N = 18)	No (N = 330)	P	No Lesions (N = 242)	P_{NI}*	Yes (N = 18)	No (N = 330)	P	P_{NI}*	Yes (N = 18)	No (N = 330)	P	P_{NI}*
Starts													
Ever started	78%	81%	NS	81%	NS	72%	81%	NS	NS	50%	81%	NS	NS
Finish position													
Ever in Top 3 as 2#	50%	46%	NS	46%	NS	62%	45%	NS	NS	25%	46%	NS	NS
Ever in Top 3 as 3#	64%	70%	NS	68%	NS	69%	70%	NS	NS	75%	70%	NS	NS
Ever in Top 3 as 2 & 3#	93%	82%	NS	81%	NS	92%	82%	NS	NS	75%	83%	NS	NS
Ever win#	79%	68%	NS	66%	NS	77%	68%	NS	NS	75%	68%	NS	NS
Ever win stakes race#	7%	4%	NS	3%	NS	8%	3%	NS	NS	0%	4%	NS	NS
Sales status													
Sold	89%	71%	NS	73%	NS	56%	72%	NS	N	100%	71%	NS	NS

*P_{NI}, P value for comparison of affected group with horses that had no radiographic lesions detected; NS = $P > .20$.

#Among horses that ever started; as 2 = as 2-year-old horse; as 3 = as 3-year-old horse; as 2&3 = cumulative for 2- and 3-year-old years.

Other ARF No significant differences were found in any performance variables between horses with fragmentation of the palmar/plantar proximal aspect of P1, fragmentation of the dorsal aspect of proximal P1, abnormalities of the distal aspect of the dorsal sagittal ridge of the third metacarpus or metatarsus, abnormalities of the lateral or medial trochlear ridge of the femur, subchondral bone cysts of the medial femoral condyle, or abnormalities of the distal intermediate ridge of the tibia when compared either with all other horses without each of these specific lesions or with horses without any ARF.

DISCUSSION

In this study, no abnormality was significantly associated with any of the various indicators of performance studied. Lack of statistical significance may have been related to the small sample size: only 348 horses were studied, and the prevalence of any ARF was 30%. Although lack of power is a plausible concern, the authors considered the likelihood of a type 1 error (i.e., erroneously identifying an association as significant when the association was not truly significant) resulting from the multiplicity of comparisons to be a greater and more likely statistical problem with analysis: significant associations might have been observed by chance alone. Although the descriptive results do not indicate a clear or consistent pattern of specific ARFs being associated with reduced performance, a larger study might have revealed effects beyond the power of resolution of this study. This is particularly true for specific ARFs. For example, only 18 horses had subchondral bone cysts of the medial femoral condyle: a study including more horses with this lesion might have revealed significant differences.

Explanations other than limited statistical power for the absence of statistically significant associations of ARF with indicators of performance exist. Horses were followed only for the first 2 years of their racing careers. Conceivably, longer follow-up might have revealed associations with reduced performance. The study was longitudinal in design, and some horses were lost to follow-up or never raced. Thus, statistical methods that account for time-varying variables or censoring (e.g., survival or time-series analysis) might have been more powerful for detecting associations of lesions with performance. Factors that might influence performance or sales outcomes that were not examined in this study (such as pedigree/bloodlines, subsequent surgical intervention, etc.) might have masked true associations of ARF with performance.

Kane et al.[2] observed that horses with fragmentation of the dorsal, proximal aspect of P1 in the hindlimb tended to be less likely to ever start a race. In this study, horses with these lesions of P1 were equally likely to start a race, and these lesions were not associated with any indicators of diminished racing performance. A number of possible explanations may account for the apparent discrepancy between the previous study[2] and ours. Statistically, there is no discrepancy between studies because both results were not significant. The study populations were different. The number of horses with these lesions of P1 was smaller (n = 10) than that in the study by Kane et al. (n = 25). The proportion of horses bred and foaled in Texas in this study was likely much greater than that of the Kentucky-based study by Kane et al. The median sales price of horses in that study ($40,000 during 1993–1996) was considerably larger than that of horses in this study ($9,000 during 2002–2003). Sales price may reflect differences in perceived quality of the horses on the basis of their pedigree. Sales price also might influence the extent to which an owner might be willing to invest in medical or surgical management of a horse's orthopedic problems. Although it might be argued that owners of a more expensive horse might put more effort into ensuring that their horse participates in racing, a lower purchase price—or a difference in perception of the importance of the problem (i.e., if horse owners in Texas were more likely than horse owners in Kentucky to perceive that these lesions of P1 in the hindlimb lesions were an important clinical problem then they might be more likely to have surgical management of these lesions in their horses)—might influence an owner to invest further in the health management of a horse. Regional differences in purses, incentive programs, perception of the clinical importance of lesions, and so forth, also might have explained some of the differences. Interestingly, the career earnings of horses that started a race in this study (median, $10,491) was similar to the geometric mean earnings of starters ($9,300) in the study by Kane et al.[2]

Kane et al.[2] reported their results separately for forelimb lesions and hindlimb lesions,[2] whereas results of this study considered lesions of the bones and joints of metacarpophalangeal and metatarsophalangeal areas together. We believe this difference is unlikely to explain the discrepancy between studies. Ten of 11 horses with fragmentation of the palmar/plantar aspect of P1 were affected in their hindlimbs, and 7 of 10 horses with fragmentation of the dorsal aspect of P1 were affected in the hindlimbs. Moreover, analysis restricted to only horses with these lesions in their hindlimbs did not alter the significance, magnitude, or direction of the results.

Radiographic outcomes were assessed differently in the study reported here and those reported by Kane et al. For example, Kane et al. categorized radiographic abnormalities of the distal sagittal ridge of MC3 as being absent, flat, or lucent, whereas in this study we reported the presence or absence of lesions of the distal sagittal ridge of MC3, and whether the lesions had osteochondral fragmentation. Kane et al.[2] also observed that Thoroughbred yearlings offered for sale with moderate or extreme lysis of the palmar, supracondylar area of the third metacarpus were significantly less likely to start races than were horses

without these lesions. In the study reported here, this radiographic abnormality was not considered because the investigators wished to emphasize lesions that were considered developmental (abnormalities thought to represent developmental orthopedic disease).

Perhaps the most likely reason for the discrepant results between our study and that of Kane et al. is the difference between studies in statistical power: radiographs of 1,162 horses were reviewed in their report compared with 348 horses in our study. Thus, they had power to detect a tendency (but not statistical significance) for a difference in proportions of horses that ever started a race equal to 13% between horses with fragmentation of the proximal, dorsal aspect of P1 (69%; 25/36) and horses without this lesion (82%; 874/1,066). In our study, approximately 80% of horses with or without this lesion ever started a race during the 2-year period of follow-up. Another possible statistical explanation for the discrepancy in results is that we attempted to account for the multiplicity of comparisons made in this study by controlling for the family-wise type 1 error rate.

The only significant association observed in this study was that for the sales price for horses with lesions of the proximal dorsal aspect of the sagittal ridge of the third metacarpus or metatarsus compared with horses without this lesion (or horses without any lesions). The meaning and importance of this finding is unclear to us. Among the seven types of radiographic abnormalities considered individually, there was no consistent pattern of the sales prices being lower for horses with a given ARF versus either horses without that particular ARF or without any ARF. However, the presence of this specific ARF may have resulted in a lower sales price. Alternatively, some other factor related to sales price and to presence of this ARF (such as pedigree) might have confounded the association. Despite efforts to control for multiple comparisons, this result might have been attributable to chance alone. Nevertheless, this finding underscores the importance of continued study of the impact of radiographic findings on both performance and sales price. Conceivably, sellers may experience reduced profits as a result of the presence of radiographic findings of little or no clinical significance.

A number of important limitations occurred in this study other than those previously mentioned. This study did not consider other factors that might have influenced performance such as other injuries or diseases, medical or surgical interventions for orthopedic lesions, change of occupation of the horse, etc. Accounting for these unmeasured factors might reveal significant associations of performance with selected ARFs. Radiographic changes of the vascular channels of the proximal sesamoid bones were not examined; though commonly observed, changes associated with these channels were not significantly associated with performance in Thoroughbred yearlings.[2] We did not examine the impact of the presence of a given ARF present in multiple limbs relative to horses affected either only in a single limb or without ARF. The classes of races in which horses competed were not examined, other than determining whether the horse competed in or won a stakes race. Conceivably, horses without certain types of ARF may have performed in lower classes of races; although earnings would likely be greater for horses performing in higher classes of races, the potential confounding effect of class of race was not considered. Because sales prices generally did not differ significantly between affected and unaffected horses, we did not attempt to control for sales price. An interesting observation (data not shown) was that sales price was not correlated either with earnings or total number of starts. Nearly half of the yearlings at the sales included in this study did not have radiographs available for review. The extent to which results would have been different with inclusion of these other horses is unknown, but it is possible that results were biased by the absence of data on these horses. Analysis of performance data can be complicated by the way in which horses that are sold but never start are dealt with in analysis. Analysis of the number of starts and earnings were conducted, both including only those horses that ever raced (as reported) and also including those horses that never raced. Results for both analyses were indistinguishable. Similarly, results of categorical performance variables (e.g., ever finished in the top three positions) were indistinguishable whether horses that never raced were excluded (as reported) or included.

Despite the limitations of this study, results are consistent with previous reports indicating that many ARF observed among Thoroughbred yearlings do not appear to significantly impact future racing performance. Differences may exist among populations of yearlings from different regions or breeding backgrounds. If possible, further longitudinal studies that can more completely account for factors potentially confounding association of ARF with performance should be conducted.

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