

# The Relationship of Subsequent Racing Performance to Foreleg Flight Patterns During Racing Speed Workouts of Unraced 2-Year-Old Thoroughbred Racehorses at Auctions

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### SUMMARY

Workouts of 980 unraced 2-year-old Thoroughbred racehorses at major U.S. auctions were videotaped using digital high-speed video equipment (ie, slow motion) and studied for signs of extraneous foreleg motion.<sup>a</sup> Extraneous foreleg motion included, but was not limited to: 1) hyper rotation of the cannon bone on an axis parallel to the plane of the running surface (ie, moving in sagittal plane; hoof hitting an elbow in extreme cases) and perpendicular to the direction of the racetrack longitudinally; and 2) foreleg flight patterns not symmetrical and/or not parallel to the vector of the forward momentum of the horse's center of gravity (eg, winging, paddling, and/or wobbling at joints). Experienced Thoroughbred racehorse industry videographers and gait analysis researchers were trained and used as film reviewers who rated foreleg motion on a scale of 1 to 5, with 1 indicating little or no extraneous motion, 3.5 indicating average extraneous motion (relative to the other unraced 2-year-olds at these auctions and to more than 20,000 similar horses at similar auctions over the past 10 years), and 5 indicating extreme extraneous motion (ie, at least 1 standard deviation or more from the mean). Because these were subjective ratings, only the more extreme rankings were used for comparison purposes in this study—that is, a minority (15.3%) of the overall study population.

A group of 73 horses with “good” foreleg motion had ratings from 1 to 3. A group of 77 horses with “bad” foreleg motion had ratings from 4 to 5. The subsequent North American racing performance of horses with good and bad foreleg motion was compared. Both groups had similar average velocity and similar distribution patterns of the velocities of the workouts, so the differences be-

tween the groups that are discussed in this study were not caused by different overall workout velocities.

Extraneous foreleg motion was shown to be related to subsequent racing earnings and the level of racing competition achieved. Horses with good foreleg motion (as defined herein) earned more and had greater stakes-level success than horses with bad foreleg motion. For example, the median earnings per start of horses with good foreleg motion was 83% higher than those of horses with bad foreleg motion, and horses with good foreleg motion were 58% more likely to win a top race (ie, one designated as a “graded” stakes) than horses with bad foreleg motion. However, the “good movers” raced less overall than the “bad movers.”

A secondary finding of this study is that although there is a widely held industry belief that horses with high action or bad foreleg motion are more suited to turf racing, horses with good foreleg motion were more likely than horses with bad foreleg motion to race at least once on turf, and, among horses to race on turf, horses with good foreleg motion were more likely than horses with bad foreleg motion to win and to finish “in the money” (ie, at least third).

### INTRODUCTION

Thousands of unraced 2-year-old Thoroughbred racehorses are sold at public auctions each year. Most of these horses exercise within a week of their auction with a rider and tack for viewing by potential buyers. The vast majority of these horses gallop 1 to 3 furlongs (a furlong is 1/8 mile or 660 ft) at racing speeds of 10 to 12 seconds per furlong (66 to 55 ft/sec). Potential buyers watch the live workouts because they believe it will aid their judgments of the horses' ability and potential racing performance. Although buyers can and do view videotaped workouts, often instead of the actual workouts, those who do rarely use slow-motion or stop-action video technology. Comparing the ratings in this study with the names of the purchasers of the horses involved revealed that even experienced buyers, who spend millions of dol-

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lars annually, buy horses with inefficient and/or anomalous foreleg flight patterns.<sup>b</sup> Note: The foreleg flight patterns rated 4.0 and higher in this study (ie, bad or high foreleg motion group) were, in the authors' opinions, often difficult for even a trained experienced eye to identify during observation at live workouts and when using standard video speeds of 30 frames per second (fps). The authors have produced a DVD with examples of anomalous leg motion.<sup>c</sup>

Fast workouts are statistically associated with high auction prices (see [appendix 2](#) for data to verify this statement). This study sought to see if variables of the motion other than overall velocity were also as important. The authors have used slow-motion and stop-action film and video technology to analyze the motion of more than 50,000 2-year-old Thoroughbreds at auctions over the past 20 years. While biomechanic and biometric analysis at auctions is used to precisely record data including temporal measurements, it also involves experts' visual assessments of extraneous leg motions that become easy to see when slow-motion video replay is used but are difficult to quantify in engineering terms in vivo within the methodologic protocol, equipment, time, and financial constraints of the auction environment.

Research has shown that biomechanic abnormalities can be associated with lameness.<sup>1,2</sup> Anomalous and/or asymmetric limb flight paths may result in dangerous limb loading patterns during the stance phase of the leg via changes in the quantities and temporal variables of forces and in the direction of the vectors of forces generated. That is, they may cause changes in the hoof contact's angle, center of pressure, and the distributions and timings of the associated forces.

## MATERIALS AND METHODS

### Sample Bias

A sample bias existed because this study used only major, select auctions where horses were preselected by auction companies based on above average commercial assessment of pedigree, conformation, and soundness. This bias made predicting poor performance theoretically more difficult because horses analyzed had far fewer conformation, pedigree, and obvious veterinary issue excuses for failing than the breed as a whole.

### Race Records

North American horses celebrate their "birthdays" on January 1 each year for racing purposes. North American race records were recorded through July of each horse's 5-year-old year (through July 2003 for horses born in 1998

and July 2004 for horses born in 1999). Race records recorded for each race included race date, track, distance, surface, race level of competition (ie, difficulty and purse levels), finish time, finish position, and earnings.<sup>d</sup> Fourteen horses that subsequently had racing careers that were completely outside the U.S., racing primarily in Japan, were removed from the study because the circumstances surrounding their earnings and performances weren't comparable with those of North American runners. See [appendixes 1A](#) and [1B](#) for racing performance data detail on the horses that were used in this study.

### Auctions

Horses studied were filmed at what are commercially generally considered the best East Coast 2-year-old auctions in terms of the highest level of prescreening for conformation and for their resulting average auction prices and subsequent racing earnings and stakes performance.<sup>3</sup> The auctions were as follows:

Ocala Breeders' Sales Company, select 2-year-olds in training, Calder, Florida, February 2000

Ocala Breeders' Sales Company, select 2-year-olds in training, Calder, Florida, February 2001

Fasig-Tipton, select 2-year-olds in training, Calder, Florida, February 2001

Keeneland, select 2-year-olds in training, Keeneland, Kentucky, April 2001

### Conformation

Horses in this study, while standing and walking on a firm, flat surface, had reasonable conformation, as rated by conformation experts employed by auction companies and the authors.<sup>e</sup>

### Rider Weight, Rider Quality, and Tack Used

Although there was a general similarity to the size, weight, riding style, use of whip, and skill of the exercise riders used, these variables were not at all uniform, nor were the details of those variables published anywhere or (other than whip use) known to the authors here.

### Video Equipment

Three types of videocameras were used, as described in the following text. Cameras zoomed in on each horse and followed its motion (ie, panned from a fixed location). Horses worked individually. Cameras were located perpendicular to the direction of the racetrack, on a plane 20 to 50 feet above the racetrack and 150 to 250 feet away from the racetrack's inside rail, alongside which most horses worked out. Some horses worked as much as 30 feet away from the inside rail and toward the cameras.

#### Auction Company Cameras

Auction companies commissioned professional firms to videotape the workouts using professional color video at 30 fps with standard shutter speeds. Auction company cameras were placed approximately perpendicular to the finish line. The images were then transferred to standard VHS videotapes by the auction companies' subcontractors. Owing to the frame rate and level of picture resolution, anyone attempting to get stop-action pictures from the use of those VHS videotapes, even if viewed on professional videocassette players, could see only fuzzy images of the forelegs.

#### Betacam Cameras

A professional video photographer was contracted by the authors to use a professional Betacam videocamera using color video at 30 fps and a shutter speed of 1/500th of a second. The beta videotapes were transferred to S-VHS videotapes. Stop-action pictures were clear, though not as clear as the high-speed 250 fps camera videos mentioned below. These cameras were placed approximately perpendicular to the 1/16th pole (330 ft before the wire).

#### High-Speed Cameras

Workouts were filmed by the authors using a Redlake Motionscope HR 8000 videocamera. The camera took black-and-white pictures that were stored in a digital hard drive and then transferred to S-VHS videotape. Stop-action pictures were clear. The final one-eighth mile of workouts was filmed at 250 fps with a shutter speed of 1/750th of a second. The camera was placed approximately midway between the 1/16th pole and the finish line (165 ft before the finish line).

#### S-VHS VCR Equipment

Three types of S-VHS VCRs were used. Each had a remote-control, single-frame jog shuttle. The JVC VCR model HR-S4600U had a model SR-S365U professional editing control device attached. Mitsubishi VCR models HS-HD2000U and HS-U790 were used to record images from the Redlake Motionscope cameras. All of the S-VHS VCRs were used to review videotaped workouts.

#### Visual Ratings of Foreleg Motion

Experienced Thoroughbred racehorse industry film reviewers, trained by (and including) the authors, used stop-action video equipment to step frame by frame through each workout at various speeds to detect primarily foreleg flight patterns, including (but not limited to) lift, rotation of cannon bone (foreleg curling), winging—which is also called paddling (being abducted) or plaiting (being adducted)—and other types of high knee actions and/or excessive leg or leg joint wobbling. Each

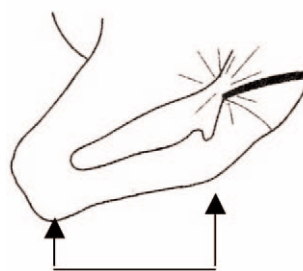
horse's foreleg motion was rated from 1 to 5, with 5 being the worst (ie, having the most asymmetric and anomalous extraneous foreleg motion in the limb flight pattern). Horses with good foreleg motion were defined as those with ratings of 3 and less. Horses with bad foreleg motion had ratings of 4 or higher. Because these were subjective ratings, only the more extreme rankings, as just described, were used for comparison purposes in this study—that is, a minority (15.3%) of the overall study population.

The authors have filmed hundreds of horses in, or preparing for, Grade 1 stakes races. These horses rarely received leg motion ratings of 4 or higher.

#### Foreleg Lift

Foreleg lift during retraction was rated according to the following system. Often it was accompanied by what is commonly referred to as a “high action” or high foreleg knee lift.

1. Forelegs are minimally lifted and the cannon bone is minimally rotated on an axis parallel to the plane of the racetrack and perpendicular to the longitudinal direction of the racetrack, sometimes referred to as a “daisy cutter” or “low action” (ie, moving in sagittal plane).
2. Horse lifts and rotates lead leg's cannon bone not quite parallel to ground.
3. Horse lifts and rotates lead leg's cannon bone parallel to ground.
4. Horse lifts and rotates lead leg's cannon bone past the parallel stage. Hoof almost hits elbow.
5. Horse lifts and rotates lead leg's cannon bone past the parallel stage. Hoof hits elbow.



**Figure 1.** Elbow hitting. The picture at left shows the cannon bone rising beyond parallel to the ground, resulting in the hoof hitting the elbow. (Reprinted with permission.<sup>2</sup>)

*Cannon bone.* The section of foreleg between the brackets in Figure 1 is the cannon bone. The cannon bone's maximum angle of lift relative to the ground during each stride was assessed as “foreleg lift.”

*Winging.* Winging, also called plaiting (abduction) or paddling (adduction), was rated according to the follow-

**Table 1** Number of Horses by Number and Distance of Workouts Analyzed

Category	Once at 1/8 Mile	Twice at 1/8 Mile	Once at 1/4 Mile	Twice at 1/4 Mile	Once at 1/8 Mile and Once at 1/4 Mile	Total Unique Horses
Bad Foreleg Motion	51	15	9	0	2	77
Good Foreleg Motion	43	12	12	2	4	73
Total Unique Horses	94	27	21	2	6	150

ing system. Often, it was accompanied by a wobbling of the leg in flight.

1. Very little lateral motion in forelegs (ie, perpendicular to sagittal plane).
2. Below average lateral motion in forelegs compared with other 2-year-olds.
3. Average lateral motion in forelegs.
4. Above average lateral motion in forelegs.
5. Excessive lateral motion in forelegs, appearing “out of control,” in the area below the knee, appearing similar to a swirling motion, like a helicopter’s propellers, and/or appearing that the leg was wobbly and/or loose-jointed.

**Workout times.** Auction companies provided official workout times, determined by electronic timing devices on the racetrack (the same equipment used during the Thoroughbred racing season) and reported to the nearest fifth of a second.

## RESULTS

### Number and Distance of Workouts

Horses had 2 opportunities, a week apart, to work out publicly at distances of 1 or 2 furlongs. Many horses worked both times, although filmings were not always analyzed for both workouts. [Table 1](#) lists the number and distance of workouts analyzed for each horse. There were 150 unique horses rated 1 to 3 (defined as having good foreleg motion) or 4 to 5 (defined as having bad foreleg motion), for which 185 films were analyzed (a second filming was analyzed for 35 horses, and the foreleg motion ratings of these horses were consistent in both filmings).

### Velocity

The velocity of all horses during the workouts analyzed was relatively uniform. The average velocity during 1-furlong workouts analyzed was 11.01 seconds per furlong (59.95 ft/sec) for horses with good foreleg motion and 10.93 seconds per furlong (60.38 ft/sec) for

horses with bad foreleg motion. This difference was not statistically significant ( $P=.36$ ). The distribution of the horses’ velocities during 1 furlong workouts is shown in [Figure 2](#).

The average time of quarter-mile workouts analyzed was 22.26 seconds for horses with good foreleg motion, and 22.76 seconds for horses with bad foreleg motion. This difference was not statistically significant ( $P=.06$ ).

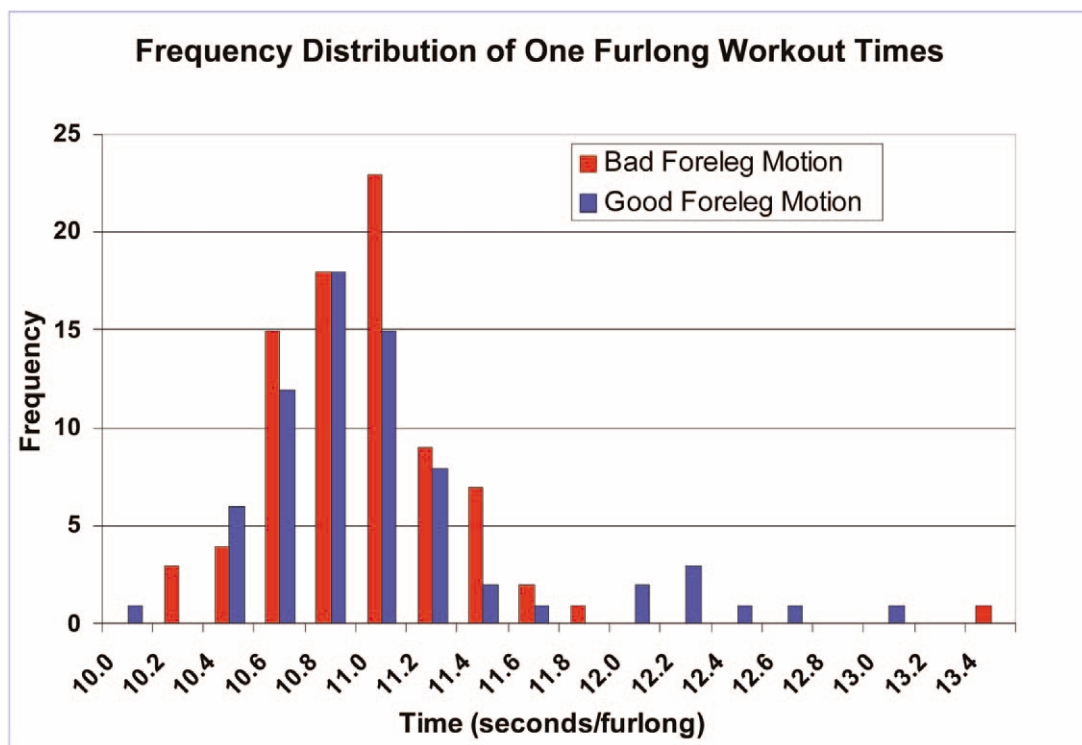
[Table 2](#) shows median and average starts, total earnings, and earnings per start for horses with good and bad foreleg motion. Horses with good foreleg motion earned more than horses with bad foreleg motion. Horses with good foreleg motion raced a median of 12 times, with median earnings of \$48,835 and median earnings per start of \$4500. Horses with bad foreleg motion raced a median of 13 times, with median earnings of \$37,445 and median earnings per start of \$2463.

### Earnings per Start

Average earnings per start were \$6064 among horses with good foreleg motion and \$4072 among horses with bad foreleg motion. These differences were statistically significant ( $P=.04$ ). The average earnings per start value among all horses from these auctions was \$5220.<sup>3</sup> Median earnings per start were \$4500 among horses with good foreleg motion and \$2,463 among horses with bad foreleg motion.

### Starts

The average number of starts for horses with good foreleg motion was 13.49, with 14.22 for horses with bad foreleg motion. On average, horses with bad foreleg motion started 5.1% more often than horses with good foreleg motion. These differences were not statistically significant ( $P=.33$ ). The median number of starts for horses with good foreleg motion was 12, compared with 13 for horses with bad foreleg motion. Higher starts among horses with bad foreleg motion are typical of



**Figure 2.** Frequency Distribution of 1-Furlong Workout Times Racing Performance

**Table 2** Starts, Total Earnings, and Earnings Per Start  
Good Foreleg Motion vs Bad Foreleg Motion

Foreleg Motion	Median			Average		
	Starts	Earnings per Start	Total Earnings	Starts	Earnings per Start	Total Earnings
Bad (n = 77)	13.00	\$2,463	\$37,445	14.22	\$4,072	\$58,489
Good (n = 73)	12.00	\$4,500	\$48,835	13.49	\$6,064	\$91,173

lower level performers, which race more often than higher-level performers.<sup>4</sup>

### Total Earnings

On average, horses with good foreleg motion had higher total earnings than horses with bad foreleg motion. These differences were significant only to the  $P=.08$  level. Total earnings have high variation, making it difficult to differentiate between groups using the usual statistical tool associated with statistical significance, but the median and average values were very different be-

tween the groups. Horses with good foreleg motion had average total earnings of \$91,173, and horses with bad foreleg motion had average total earnings of \$58,489. Horses with good foreleg motion had median total earnings of \$48,835, and horses with bad foreleg motion had median total earnings of \$37,445.

### Stakes Performance

Table 3 shows stakes performance among horses with good and bad foreleg motion. Horses with bad foreleg motion had worse stakes performance than horses



with good foreleg motion. For example, 19.2% of horses with good foreleg motion became at least stakes placed, compared with 11.7% of horses with bad foreleg motion. Compared with horses with bad foreleg motion, those with good foreleg motion were 1.6 times as likely to become at least stakes placed, 2.5 times as likely to win a stakes race, 3.2 times as likely to become at least graded stakes placed, and 1.6 times as likely to win a graded stakes race.<sup>f</sup>

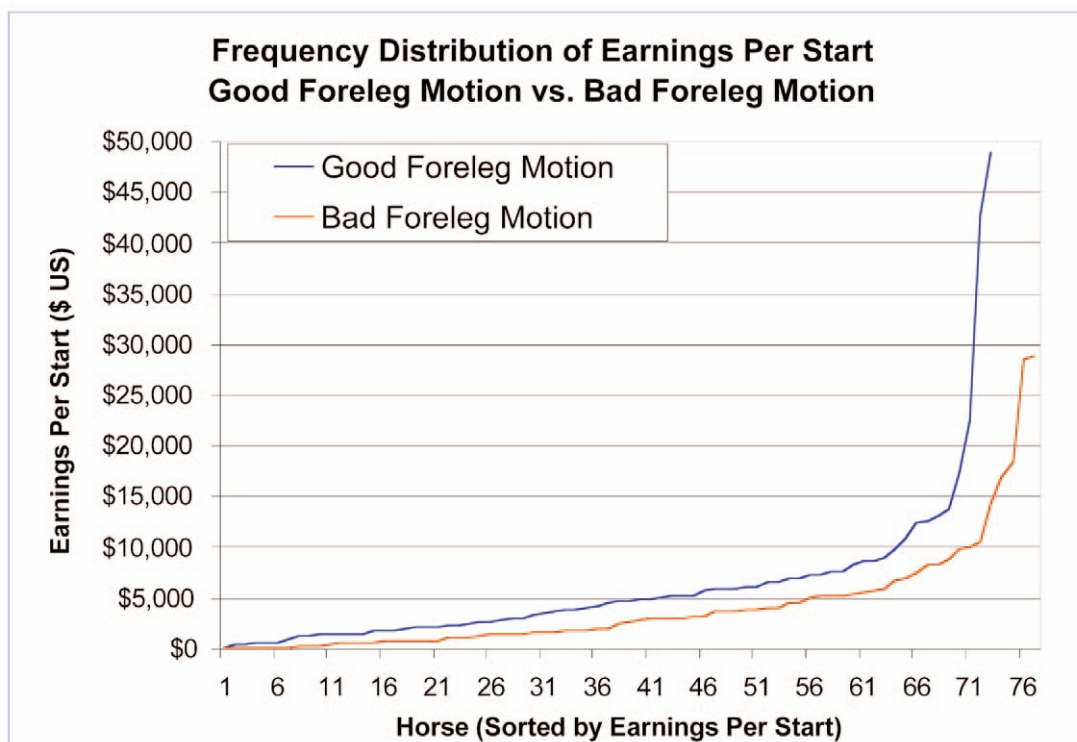
**Table 3** Stakes Performance  
Good Foreleg Motion and Bad Foreleg Motion

Stakes Achievement	Bad Foreleg Motion	Good Foreleg Motion
At least Stakes Placed	11.7%	19.2%
Stakes Winners	3.9%	9.6%
At least Graded Stakes Placed	2.6%	8.2%
Graded Stakes Winners	2.6%	4.1%

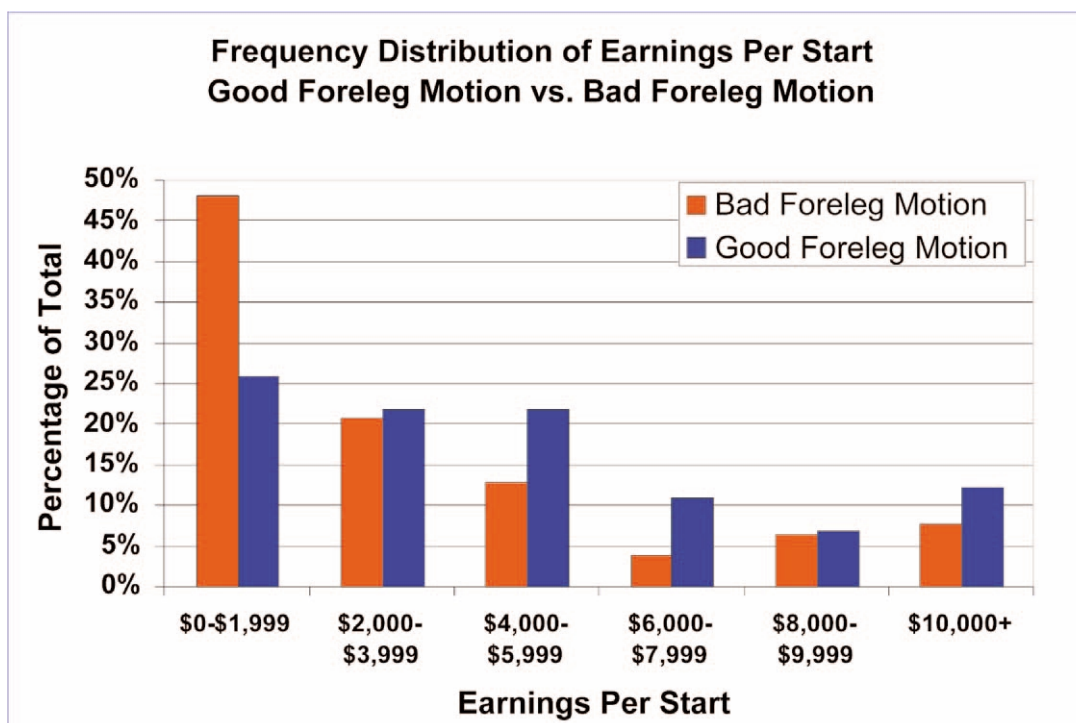
## Frequency Distribution of Earnings per Start

Figure 3 shows the frequency distribution of earnings per start for horses with good and bad foreleg motion. Figure 3 graphs earnings per start for each horse. Horses with good foreleg motion are plotted along the blue line, and horses with bad foreleg motion are plotted along the red line. Horses were sorted by earnings per start. Thus, the earnings per start increased from left to right along the *x*-axis (bottom axis). Horses with good foreleg motion had higher earnings per start. There were about 75 horses in each group. If you look at the midpoint along the bottom axis, you will see that horses with good foreleg motion earned nearly twice as much as horses with bad foreleg motion.

Figure 4 uses a slightly different method, a bar chart, to show the frequency distribution of earnings per start for horses with good and bad foreleg motion. Note that nearly half of horses with bad foreleg motion earned less than \$2000 per start, compared with 26% of horses with good foreleg motion. Thirty percent of horses with good foreleg motion earned at least \$6000 per start, compared with 18% of horses with bad foreleg motion.



**Figure 3.** Frequency Distribution of Earnings Per Start



**Figure 4.** Frequency Distribution of Earnings Per Start

**Table 4** Turf Performance  
Good vs Bad Foreleg Motion

Turf Performance	Bad Foreleg Motion	Good Foreleg Motion
Raced at least once on turf	51.9%	60.3%
Among turf starters, at least placed on turf	40.0%	50.0%
Among turf starters, won on turf	10.0%	18.2%

## Turf Performance

[Table 4](#) shows the percentage of horses with good and bad foreleg motion that raced at least once on turf, along with the percentage of turf starters that at least placed or won on turf. Note that those with the better foreleg motion were more likely to race, and to race better, on turf than those with poor foreleg motion.

## DISCUSSION

Predicting the potential racing performance of unraced 2-year-old Thoroughbreds is difficult. The auctions relevant to this study combined produce an average of

10% stakes winners and 3.6% graded stakes winners. Every buyer hopes to exceed those results, but even most recognized experts rarely do.

This study documents that there is much about the visual appearance of a horse's way of going in a workout that has importance to predicting its racing performance that is as significant as or more significant than simply its velocity (see also [appendix 2](#) regarding this assertion on foreleg action quality vs widely believed importance of velocity as evidenced by auction prices). That is, the authors believe how fast they go is not as important as how they go fast.

## Starts

It is commonly believed that horses with what is perceived as poor “action” or a poor “way of going” (or other indications of below average physical characteristics) race less than horses with good biomechanics. However, after studying the biomechanics of more than 50,000 Thoroughbreds at racing speeds and following their racing careers, the authors have found that the least successful racehorses (in terms of level of racing and earnings) tend to race more often than successful racehorses. Therefore, the authors were not surprised at the counterintuitive result of more starts in this study among horses with bad foreleg motion. The authors have found this result in other studies.<sup>4</sup> This was perhaps due to differences in economics driving racing decisions differently between valuable and less valuable racehorses.

## Turf Racing

Over the years, the authors have encountered a widely held belief in the Thoroughbred racehorse industry that racehorses with bad foreleg motion and/or a higher foreleg “action” perform better on what is called “turf” (ie, racing on grass) than they do on “dirt” (ie, standard American main racetracks with a loose dirt-covering “cushion” of typically 2 to 4 inches over a harder dirt and clay base). Such “dirt” racing forms the vast majority of the number of races run at major U.S. racetracks. The authors suspected that horses with bad foreleg motion would find their way to turf races in greater percentages than horses with good foreleg motion simply because they were more likely to fail in “dirt” racing.

However, an investigation of turf performance among the horses in this study, as summarized in Table 4 in the Results section of this paper, did not support that theory. If trainers believed that turf could benefit horses with bad foreleg motion, this finding suggests that trainers, on average, did not know the degree of their horses’ bad foreleg motion. This was perhaps because until it was truly extreme the bad foreleg motion as defined in this study was difficult to assess at normal video frame rate presentation speeds of viewing, even if readily apparent in high resolution, slow-motion video.

Based on these results, the authors speculate that whatever it is that predisposes some horses to do better running on grass in races than on regular main American racetracks, it is not because they have a “high action.”

Because the hoof gets a stable surface to land on grass, as opposed to a soft dirt cushion to penetrate otherwise, this may allow horses predisposed to a longer stance time to use that style more effectively.

Or perhaps the turf (grass) predisposition is related to breathing. At racing speeds, the breathing becomes synchronized to the mechanical gait. The exhale phase is initiated when the first foreleg begins to bear weight (start of stance time for that hoof) and ends when the second foreleg stops bearing weight (end of that hoof’s stance time). A lengthening of stance times may therefore aid breathing and/or may simply mesh better with a horse’s preferred respiration cycle.

## CONCLUSION

The foreleg flight patterns primarily assessed in this study are basic movements shown to be highly and significantly related to subsequent racing performance. They are difficult to see in ordinary videotapes of workouts, even in slow motion. Professional quality stop-action and slow-motion videotapes make assessment of these significant foreleg motion variables relatively easy.

Earnings per start and stakes-level achievements were lower among horses with bad foreleg motion. Hence, we found that stop-action video analysis can reduce the odds of buying poor performers.

Nonetheless, horses with bad foreleg motion actually raced more often, not less often, than horses with good foreleg motion.

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4. Seder JA, Vickery CE. The relationship of selected two-dimensional echocardiographic measurements to the racing performance of 5431 yearlings and 2003 2-year-old thoroughbred racehorses. J Eq Vet Sci 2003;23:149-67.

## FOOTNOTES

- a. 14 horses that subsequently became exclusively foreign runners were removed from the study. See “Materials and Methods” section infra.
- b. The author’s databases include digitized data of more than 50,000 workouts of two-year-old Thoroughbreds, analyzed, rated, and coupled to race records and purchase data.
- c. The author’s videotaped examples of gait analysis and presented them on a DVD at a technical Symposium of The Thoroughbred Breeders and Owners Association in Ocala, Florida March 2004. This DVD showed examples of normal and abnormal leg motion, and included public auction workouts of horses purchased by a major, experienced, well-respected USA national industry Thoroughbred bloodstock agent. Copies available from the authors, at 501 Hicks Rd., West Grove, PA 19390. E-mail: [jseder@eqb.com](mailto:jseder@eqb.com).
- d. Data source for race records: Bloodstock Research Information Services, Lexington, Kentucky.
- e. Graded stakes are the highest level of races. There are 467 graded stakes scheduled for 2005 in the USA, accounting for less than one percent (0.90%) of all USA races. Graded stakes are classi-



fied as Grade 1 through Grade 3 and reviewed each year by the North American graded stakes committee of the Thoroughbred Owners and Breeders Association. Graded races must be non-restricted, with purses of at least \$50,000, and have been run at least twice before under similar conditions and on the same surface.

- f. In an unpublished study, available through the authors of this paper, the authors here hired conformation experts to rate the conformation of auction horses on a scale of 1-10. Horses were rarely rated lower than 7 because they had been pre-selected for these "Select" auctions by auction companies. In a separate un-

published study, similarly available, the authors found that these "standing" conformation ratings at select auctions showed little correlation to subsequent racing earnings, number of career starts, or foreleg motion patterns at racing speeds.

- g. Abbreviations: FTfEB01 (Fasig-Tipton, Select Two-Year-Olds in Training, Calder, Florida, Feb. 2001); OBSfEB01 (Ocala Breeders' Sales Company, Select Two-Year-Olds in Training, Calder, Florida, Feb. 2001); OBSfEB00 (Ocala Breeders' Sales Company, Select Two-Year-Olds in Training, Calder, Florida, Feb. 2000); KEEAPR01 (Keeneland Select Two-Year-Olds in Training, Keeneland, Kentucky, Apr. 2001).

Appendix 1A: Horses Judged to Have Bad Foreleg Motion in This Study

NAME	STARTS	EARNINGS		HIP #	AUCTION <sup>g</sup>
		EARNINGS	PER START		
AMY'S FALCON	18	146,616	8,145	111	FTFEB01
AMY'S JET	3	7,990	2,663	94	OBSFEB01
ANOTHER IVORY	22	129,000	5,864	251	OBSFEB00
BAY COMMANDER	18	22,875	1,271	165	FTFEB01
BERNIE B	22	77,931	3,542	102	OBSFEB01
BOOKED FLIGHT	17	8,024	472	154	OBSFEB00
CAPTAIN BALLADO	2	1,920	960	149	OBSFEB01
CARDINAL RYAN	19	53,960	2,840	82	FTFEB01
DARTING DOT	14	60,760	4,340	280	FTFEB01
DISTRICT ATTORNEY	0	0	0	204	OBSFEB01
DOUBLE TOWER	35	49,851	1,424	162	OBSFEB00
DR. RAVI K	2	28,200	14,100	33	FTFEB01
DREAM ME	22	117,575	5,344	202	OBSFEB00
ETHAN MAN	8	227,294	28,412	13	OBSFEB01
EXPRESSO LOVE	27	105,233	3,898	76	FTFEB01
FRANKIE'S LADY	10	35,765	3,577	174	OBSFEB00
FROLICUS	26	101,145	3,890	175	OBSFEB00
FUSION	5	2,060	412	104	OBSFEB00
GLITTER MILL	11	17,066	1,551	243	OBSFEB00
GOLD TANGO	27	147,800	5,474	116	FTFEB01
GRAY FORUM	39	66,527	1,706	112	OBSFEB01
HURRICANE SHONDA	19	11,603	611	138	OBSFEB01
I FEEL DESIRE	0	0	0	199	FTFEB01
IAN ENGLISH	0	0	0	174	OBSFEB01
IMAGE OF A CAT	35	197,490	5,643	150	OBSFEB00
IN FULL BLOOM	13	67,160	5,166	291	FTFEB01
JUSTINA	10	17,655	1,766	302	FTFEB01
KWESTIONABLE KISS	10	5,663	566	91	OBSFEB00
LISTEN HERE	10	287,480	28,748	160	FTFEB01
LOOKSLIKETHEDEVIL	8	19,366	2,421	113	OBSFEB01
LOUIE THE JET	22	78,174	3,553	250	OBSFEB00
MASTER SALT	2	960	480	190	OBSFEB00
MATINEE D' AMOUR	8	24,170	3,021	100	OBSFEB00
MECKEME	20	74,520	3,726	186	OBSFEB00
MERE PRESENCE	7	6,640	949	184	OBSFEB00
MR. ENERGY	1	101	101	217	OBSFEB01
MY HEART'S DEELITE	13	128,657	9,897	108	FTFEB01
MY LORD	27	138,980	5,147	164	FTFEB01
MY OL' MAN	1	0	0	190	OBSFEB01
NEWPORT BEACH	2	36,600	18,300	64	FTFEB01
OPPOSING FORCE	27	26,356	976	7	OBSFEB01

Appendix 1A: Horses Judged to Have Bad Foreleg Motion in This Study--Continued

NAME	STARTS	EARNINGS	EARNINGS	HIP #	AUCTION <sup>g</sup>
			PER START		
OUTLAW GULCH	38	49,688	1,308	165	OBSFEB01
PATTONS TOP GUN	4	2,460	615	230	OBSFEB00
PHONE RULER	15	144,960	9,664	34	OBSFEB00
PLAYING 'N GOLD	9	150,730	16,748	173	OBSFEB01
RELUCTANT GROOM	24	163,644	6,819	212	OBSFEB00
RISK FREE RATE	18	7,181	399	115	FTFEB01
ROYAL ROUGHNECK	3	3,640	1,213	7	OBSFEB00
ROYAL STORM	3	505	168	156	OBSFEB00
RUNAWAY THOUGHTS	10	13,186	1,319	107	FTFEB01
RUNNIN WEST	20	145,978	7,299	166	OBSFEB00
SARA'S DREAM	28	41,840	1,494	221	FTFEB01
SCHOOL FOR SCANDAL	14	146,447	10,461	300	FTFEB01
SHINING CAREER	31	157,124	5,069	134	OBSFEB01
SILVER ARTISTRY	27	36,848	1,365	284	FTFEB01
SOVEREIGN SWEEP	23	153,570	6,677	106	OBSFEB01
SPORT'S PACK	0	0	0	236	FTFEB01
SPY HILL	5	43,457	8,691	23	OBSFEB01
STARBRIDGE	0	0	0	203	OBSFEB01
STARBROW	17	48,998	2,882	208	OBSFEB01
STOKIN COAL	13	40,225	3,094	172	FTFEB01
STORM CHRONICLE	44	84,678	1,925	133	OBSFEB00
STORMY CONQUEST	19	46,796	2,463	272	FTFEB01
SUNSET EXPRESS	27	118,565	4,391	288	FTFEB01
SUNSHINE USETA	26	44,015	1,693	11	OBSFEB01
SWEEPIN UP	6	3,750	625	65	OBSFEB00
SYDNEY'S KISS	9	44,060	4,896	255	FTFEB01
THEWAYISEEIT	10	37,445	3,745	96	FTFEB01
THIS PLAYER CANRUN	4	2,440	610	213	OBSFEB00
TIM BUCK TOO	1	380	380	106	OBSFEB00
TO THE MAX	2	1,350	675	213	OBSFEB01
TRACKOFTHECAT	13	106,580	8,198	167	OBSFEB00
TRICKY PROSPECT	3	8,700	2,900	81	OBSFEB00
TYPICAL	0	0	0	206	FTFEB01
WALTHAM	6	10,540	1,757	77	FTFEB01
WILD AND WILLING	1	200	200	113	FTFEB01
WILD MAPLE	40	114,482	2,862	170	FTFEB01

Appendix 1B: Horses Judged to Have Good Foreleg Motion in This Study

NAME	EARNINGS	STARTS	EARNINGS PER START	HIP #	AUCTION <sup>g</sup>
ALEX'S PAL	163,680	19	8,615	214	OBSFEB01
AMERICAN WARRIOR	35,840	6	5,973	132	FTFEB01
AXIS	122,567	27	4,540	186	FTFEB01
BAG OF MISCHIEF	195,715	20	9,786	166	OBSFEB01
BARAZEELI	6,490	5	1,298	1	FTFEB01
BARRISTER KATHLEEN	59,820	12	4,985	26	KEEAPR01
BATTLER BOB	169,635	13	13,049	66	FTFEB01
BEL BAIE	104,775	16	6,548	142	KEEAPR01
BELLA BELLUCCI	511,820	12	42,652	36	FTFEB01
BROAD N BEST	960	2	480	136	KEEAPR01
BRONZE AUTUMN	159,319	13	12,255	107	OBSFEB01
CAPTAIN TIM	23,370	7	3,339	6	OBSFEB01
CAT'S GLOW	120,359	14	8,597	181	OBSFEB01
COPERNICUS	12,020	3	4,007	64	KEEAPR01
CRESCENT SURF	12,140	6	2,023	1	KEEAPR01
DANCE DIANA	59,459	8	7,432	32	OBSFEB01
DANCE TIL NINE	7,845	6	1,308	70	OBSFEB01
DEVILSH INTENTIONS	12,976	5	2,595	26	OBSFEB01
DIAMOND BALLROOM	17,980	11	1,635	175	FTFEB01
DYNAMIC LORD	70,330	12	5,861	292	FTFEB01
ELIZABETHSWILDROSE	26,390	13	2,030	50	OBSFEB01
EXOTIC WAGER	15,530	3	5,177	62	KEEAPR01
EXPLORATIONIST	55,424	15	3,695	71	FTFEB01
FLIGHT	110,019	23	4,783	126	OBSFEB01
FLY BORBOLETA	247,402	18	13,745	100	FTFEB01
GARY'S GAL	13,500	3	4,500	163	FTFEB01
GLORITA	3,510	4	878	99	KEEAPR01
GOODNESS	99,361	14	7,097	67	FTFEB01
GUCCI GIRL	0	0	0	174	KEEAPR01
HANDSOME RANSOM	13,300	11	1,209	79	KEEAPR01
IRISH STORM	56,839	34	1,672	198	KEEAPR01
KEEPTHE NAME	61,995	16	3,875	46	OBSFEB01
MAJANI	23,641	12	1,970	34	OBSFEB01
MEADOW JAKE	22,260	16	1,391	192	OBSFEB01
MEADOW STARLIGHT	36,370	10	3,637	222	FTFEB01
MEESES PIECES	49,115	6	8,186	41	OBSFEB01
MISS MARNI	75,995	16	4,750	19	FTFEB01
MISS N TEXAS	42,690	6	7,115	245	FTFEB01
MISTY WAGER	72,866	23	3,168	35	OBSFEB01
MOE'S MON	130,830	19	6,886	91	OBSFEB01
MR. PAPAGEORGIU	2,300	10	230	31	FTFEB0

Appendix 1B: Horses Judged to Have Good Foreleg Motion in This Study--Continued

NAME	EARNINGS	STARTS	EARNINGS PER START	HIP #	AUCTION <sup>g</sup>
MR. PAT	74,550	13	5,735	182	KEEAPR01
NEVADA KID	51,900	3	17,300	139	FTFEB01
OUT OF NICKLES	48,150	7	6,879	116	OBSFEB01
PERFECT DESIGN	63,690	11	5,790	140	OBSFEB01
PITBULL	30,040	4	7,510	144	FTFEB01
PRIVATE JUSTIN	22,928	20	1,146	4	FTFEB01
ROCKET EXPRESS	35,584	6	5,931	20	OBSFEB01
ROMAN DANCER	269,329	12	22,444	207	FTFEB01
SCORCHING	42,293	17	2,488	107	KEEAPR01
SHERM	40,842	9	4,538	184	FTFEB01
SHORT HAIR	144,110	22	6,550	161	FTFEB01
SIR BEDIVERE	12,630	7	1,804	38	FTFEB01
SLAVE DRIVER	7,038	15	469	132	KEEAPR01
SMOK'N FROLIC	1,512,220	31	48,781	59	OBSFEB01
SOVEREIGN POWER	35,210	20	1,761	200	OBSFEB01
TACTICAL JEFF	22,430	6	3,738	5	OBSFEB01
TEMPESTUOUS WIND	48,835	20	2,442	219	FTFEB01
THEQUIETMAN	6,925	5	1,385	163	KEEAPR01
TIGER TOWN	52,267	18	2,904	262	FTFEB01
TRACEMARK	433,044	40	10,826	133	OBSFEB01
TWO SHAKES	53,580	6	8,930	127	OBSFEB01
UNBRIDLED AFFAIR	85,960	32	2,686	196	FTFEB01
UNBRIDLED PLEASURE	320	1	320	18	FTFEB01
VICTORY SNIT	56,425	45	1,254	60	OBSFEB01
VIDEO'S ACCOUNT	11,410	23	496	19	OBSFEB01
VILLAGE STREAKER	45,470	9	5,052	277	FTFEB01
VOLNAY	26,780	12	2,232	274	FTFEB01
VVS FLAWLESS	90,247	16	5,640	253	FTFEB01
WHATASAIN	127,380	25	5,095	6	FTFEB01
WILD CARSON	25,963	9	2,885	9	FTFEB01
WINNING INTENTIONS	51,172	24	2,132	126	FTFEB01
YOUGHAL BAY	100,440	8	12,555	152	OBSFEB01



## APPENDIX 2: INDIVIDUALS' WORKOUT TIMES VS THEIR SALE PRICES AT MAJOR AUCTIONS OF 2-YEAR-OLD THOROUGHBRED RACEHORSES

### SUMMARY

This study examines the relationship at public Thoroughbred racehorse 2-year-old-in-training auctions between “show day” public, recorded workout times on the main dirt racetrack (also known as “breezes”) and the subsequent auction prices for those same horses.

The Ocala Breeders' Sales Company Select February 8, 2005, auction and the Fasig-Tipton Select March 1, 2005, auction were studied. These major auctions and associated public workouts were conducted in Miami, Florida, at Calder Race Course on its main dirt track.

Public “show day” workout times were statistically significantly inversely related to prices at both auctions. That is, on average, as workout times decreased, respective auction prices for those animals increased (see especially [Table 1](#) below).

### METHODOLOGY

Two major U.S. select Thoroughbred auctions during 2005 were studied. They were conducted by Fasig-Tipton on March 1, 2005 (FT), and Ocala Breeders' Sales Company on February 8, 2005 (OBS). FT had 355 horses cataloged for auction, of which 147 were sold. OBS had 207 horses cataloged for auction, of which 109 were sold.

There were 3 possible sale outcomes for each horse cataloged for auction. Horses were listed as out when they were withdrawn from the auction for reasons including sickness, injury, and private sale. They were listed as not sold after the bidding started when the seller's reserve price was not reached. They were listed as sold when the seller accepted the winning bid. For the purposes of analyzing the relationship between workout times and auction prices, only horses that were sold were included in the study.

Every horse sold at these auctions worked out publicly, either once or twice, at distances of a furlong and/or quarter-mile. Auction companies provided official workout times, determined by electronic timing devices on the racetrack (the same equipment used during the Thoroughbred racing season) and reported to the nearest fifth of a second. For the purposes of this analysis, each horse's fastest workout at a furlong and/or quarter-mile was used.

## RESULTS

### Summarized Results for Horses When They Are Grouped by Workout Distance

#### One-Furlong Workout Times

The median 1-furlong workout time was 10.6 seconds at each auction. The average price of FT horses that worked faster than 10.6 seconds was \$426,081, compared with \$170,857 for horses that worked 10.6 seconds or slower. The average price of OBS horses that worked faster than 10.6 seconds was \$155,063, compared with \$85,636 for horses that worked 10.6 seconds or slower. These differences were statistically significant ( $P<.01$ ).

#### Quarter-Mile Workout Times

The median quarter-mile workout time was 22.0 seconds at FT and 22.2 seconds at OBS. The average price of FT horses that worked faster than 22.0 seconds was \$436,429, compared with \$231,765 for horses that worked 22.0 seconds or slower. The average price of OBS horses that worked faster than 22.2 seconds was \$184,524, compared with \$110,950 for horses that worked 22.2 seconds or slower. These differences were statistically significant ( $P<.05$ ).

### Horses Grouped by Price

#### One-Furlong Workout Times

The median price at the FT auction was \$200,000, and the median price at the OBS auction was \$120,000. The average 1-furlong time of FT horses that cost more than \$200,000 was 10.56 seconds, compared with 10.75 seconds for horses that cost \$200,000 or less. The average 1-furlong time of OBS horses that cost more than \$120,000 was 10.56 seconds, compared with 10.77 seconds for horses that cost \$120,000 or less. These differences were statistically significant ( $P<.01$ ).

#### Quarter-Mile Workout Times

The average quarter-mile time of FT horses that cost more than \$200,000 was 22.02 seconds, compared with 22.16 seconds for horses that cost \$200,000 or less ( $PA_{25}$ ). The average quarter-mile time of OBS horses that cost more than \$120,000 was 22.10 seconds, compared with 22.49 seconds for horses that cost \$120,000 or less ( $P<.02$ ). These differences were significant only for the OBS auction, although differences at FT were in the expected direction.

[Table 1](#) lists price ranges *versus* average workout times for each auction. As prices increased, workout times generally decreased.

#### Acknowledgments

This research was funded by EQB, Inc.

**Appendix Table 1** Average Workout Time by Price Range

Price Range	FT March 1, 2005		OBS February 8, 2005	
	Average 1/8th-Mile Time	Average 1/4-Mile Time	Average 1/8th-Mile Time	Average 1/4-Mile Time
\$0–\$49,999	10.90	22.30	10.89	22.50
\$50,000–\$99,999	10.76	22.20	10.71	22.50
\$100,000–\$149,999	10.73	22.20	10.67	22.37
\$150,000–\$199,999	10.72	22.00	10.57	22.11
\$200,000–\$249,999	10.63	22.00	10.45	22.33
\$250,000+	10.54	22.02	10.40	21.65

FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.

**Appendix Table 2** Summary Statistics for Prices and Workout Times

Stat. Variable	Price		1/8th-Mile Time (s)		1/4-Mile Time (s)	
	OBS	FT	OBS	FT	OBS	FT
N	109	147	81	123	41	38
Average	\$136,890	\$341,034	10.67	10.68	22.30	22.08
Median	\$120,000	\$200,000	10.60	10.60	22.20	22.00
Mode	\$100,000	\$100,000	10.60	10.60	22.20	21.80
Minimum	\$12,000	\$25,000	10.20	9.80	21.40	21.40
Maximum	\$600,000	\$5,200,000	11.60	11.40	23.40	23.00
Standard Dev.	\$95,676	\$569,660	0.2665	0.2529	0.5237	0.3796

FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.

Table 2 provides summary statistics describing each auction's prices and workout times.

Table 3 lists average prices relative to 1-furlong workout times. The median furlong workout time was 10.6 seconds at each auction. The average price of FT horses that worked faster than 10.6 seconds was \$426,081, compared with \$170,857 for horses that worked 10.6 seconds or slower. The average price of OBS horses that worked faster than 10.6 seconds was \$155,063, compared with \$85,636 for horses that worked 10.6 seconds or slower. These differences were statistically significant ( $P < .01$ ).

Table 4 lists average prices relative to quarter-mile workout times. The median quarter-mile workout time was 22.0 seconds at FT and 22.2 seconds at OBS. The average price of FT horses that worked faster than 22.0 seconds was \$436,429, compared with \$231,765 for horses that worked 22.0 seconds or slower. The average price of OBS horses that worked faster than 22.2 seconds was \$184,524, compared with \$110,950 for horses that worked 22.2 seconds or slower. These differences were statistically significant ( $P < .05$ ).

Table 5 lists average 1-furlong times relative to prices. The median price at FT was \$200,000 and the median price at OBS was \$120,000. The average furlong time of FT horses that cost more than \$200,000 was 10.56 seconds, compared with 10.75 seconds for horses that cost \$200,000 or less. The average furlong time of OBS horses that cost more than \$120,000 was 10.56 seconds, compared with 10.77 seconds for horses that cost \$120,000 or less. These differences were statistically significant ( $P < .01$ ).

Table 6 lists average quarter-mile times relative to prices. The average quarter-mile time of FT horses that cost more than \$200,000 was 22.02 seconds, compared with 22.16 seconds for horses that cost \$200,000 or less (PA25). The average quarter-mile time of OBS horses that cost more than \$120,000 was 22.10 seconds, compared with 22.49 seconds for horses that cost \$120,000 or less ( $P < .02$ ). These differences were significant only for OBS, although differences at FT were in the expected direction.

## DISCUSSION

The auction sale prices of unraced 2-year-old Thoroughbred racehorses at major U.S. auctions are in-

Appendix Table 3		T-Test Results—Average Price Relative to Eighth-Mile Time Range			
Statistic	FT March 1, 2005		OBS February 8, 2005		
	1/8-mile time A10.6 s	1/8-mile time >10.6 s	1/8-mile time A10.6 s	1/8-mile time >10.6 s	
N	74	49	48	33	
Average Price	\$426,081	\$170,857	\$155,063	\$85,636	
P-value	0.0060		0.0000		
FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.					

Appendix Table 4		T-Test Results—Average Price Relative to Quarter-Mile Time Range			
Statistic	FT March 1, 2005		OBS February 8, 2005		
	1/4-mile time A22 s	1/4-mile time >22 s	1/4-mile time A22.2 s	1/4-mile time >22.2 s	
N	21	17	21	20	
Average Price	\$436,429	\$231,765	\$184,524	\$110,950	
P-value	0.0250		0.0457		
FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.					

Appendix Table 5		T-Test Results—Average Eighth-Mile Time Relative to Price Range			
Statistic	FT March 1, 2005		OBS February 8, 2005		
	Price A\$200k	Price >\$200k	Price A\$120k	Price >\$120k	
N	74	49	41	40	
Average 1/8-Mile Time	10.75	10.56	10.77	10.56	
P-value	0.0000		0.0005		
FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.					

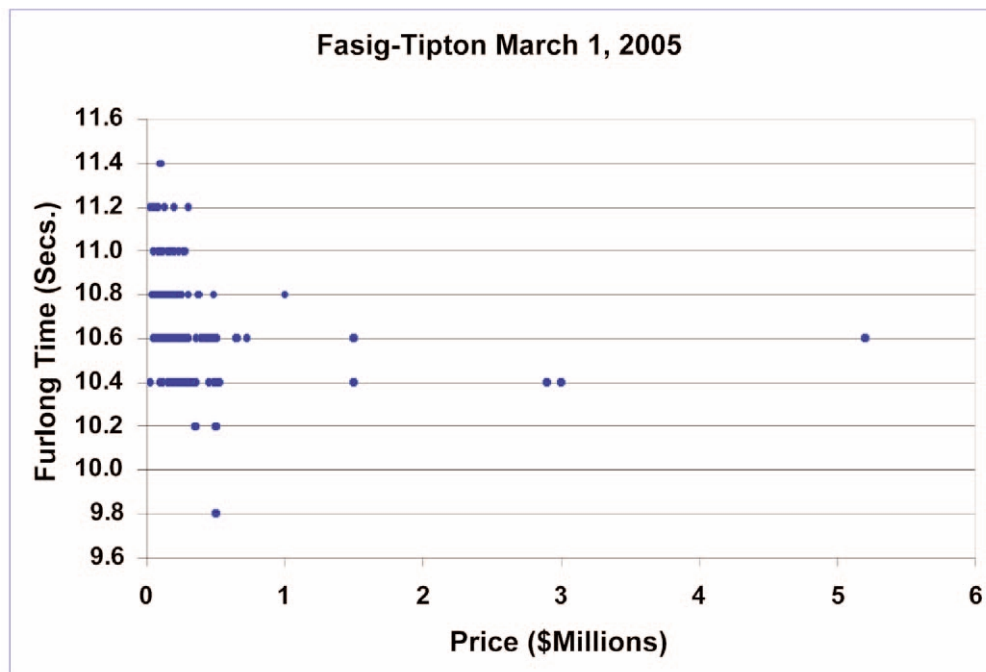
Appendix Table 6		T-Test Results—Average Quarter-Mile Time Relative to Price Range			
Statistic	FT March 1, 2005		OBS February 8, 2005		
	Price A\$200k	Price >\$200k	Price A\$200k	Price >\$200k	
N	17	21	21	20	
Average 1/4-Mile Time	22.16	22.02	22.49	22.10	
P-value	0.2515		0.0168		
FT, Fasig-Tipton; OBS, Ocala Breeders' Sales Company.					

fluenced, inter alia, by pedigree, conformation, veterinary exams, workout performance, and other factors. This study focused on the variable of speed within assessments of workout performance data.

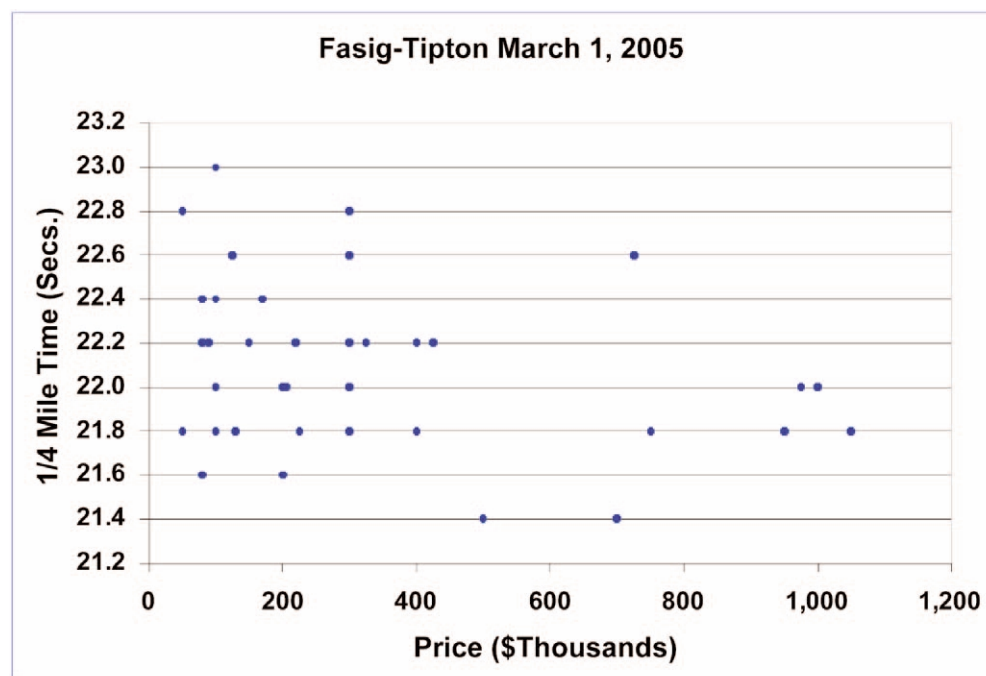
Figures 1–4. The scatter diagrams on the following pages plot workout times versus prices for each horse studied. Separate graphs are shown for furlong and quarter-mile workout times for each auction.

Although the main dirt track breeze workout times overall were strongly significantly statistically related to the associated auction prices for these horses, the actual distribution of the data presented a muddier picture.

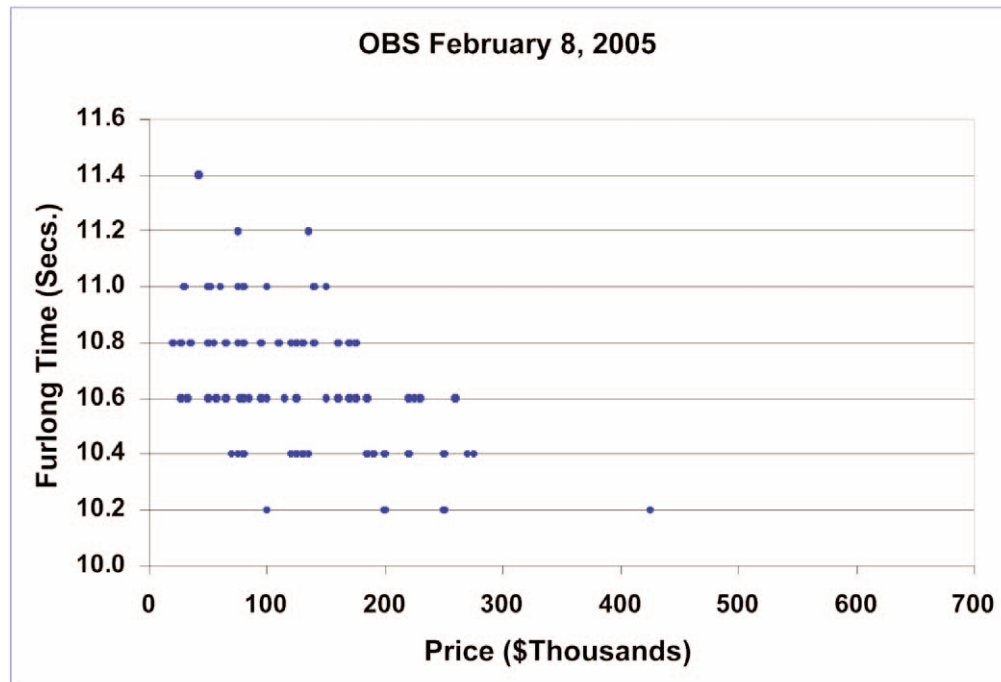
The graphs that follow show the degree of variation between workout times and auction prices. In general, but not always, the highest prices were associated with relatively fast workout times.



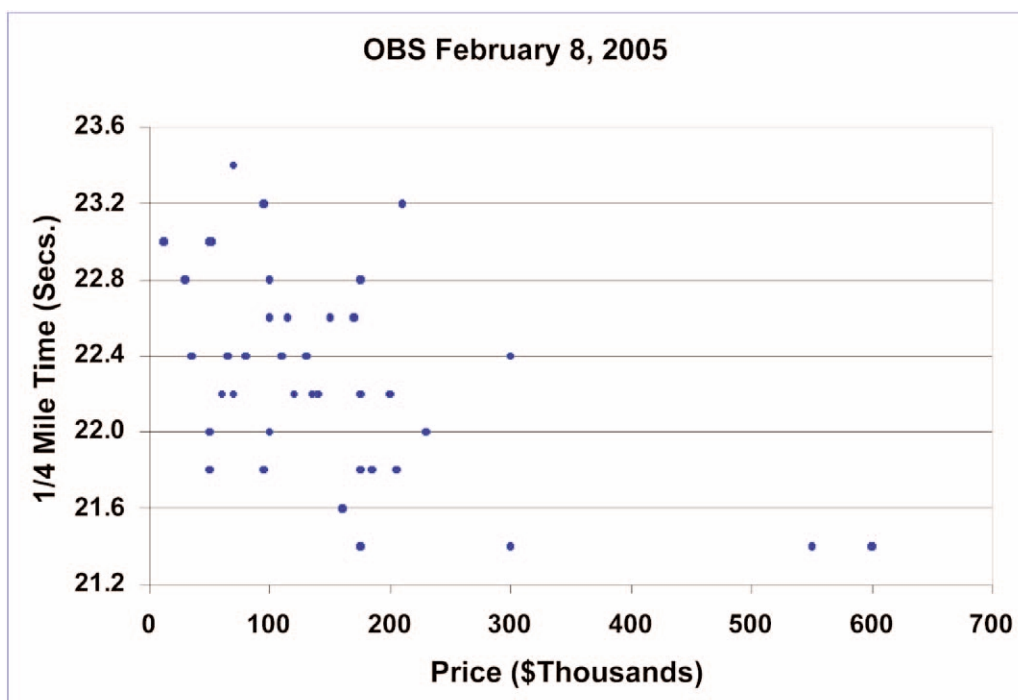
**Appendix Figure 1.** Fasig-Tipton 1-Furlong Workout Time vs. Auction Price



**Appendix Figure 2.** Fasig-Tipton Quarter-Mile Workout Time vs. Auction Price



**Appendix Figure 3.** OBS One-Furlong Workout Time vs. Auction Price



**Appendix Figure 4.** OBS Quarter-Mile Workout Time vs. Auction Price