using a dataset of 274 male thoroughbred racehorses in the united states, we study the effect of age on racing performance. beyer speed figures, which are uniform measures of racing performance across distance and racing surface, are utilized in this study. a system of equations is estimated to determine quadratic improvement and decline in racing performance. we find that a typical horse’s peak racing age is 4.45 years. the rate of improvement from age 2 to 4½ is greater than the rate of decline after age 4½. a typical horse will improve by 10 (horse) lengths in sprints (less than 1 mile) and 15 lengths in routes (one mile or greater) from age 2 to 4½. over the next five years the typical decline is 6 lengths for sprints and 9½ lengths for routes.

key words: age, peak performance, racing, speed figures, thoroughbred
figures do not account for weighted carried. Once a race is rated, every horse in the race then receives a speed figure based on how many lengths behind the leader he finished. Table 1 [2] shows speed figures translated from the raw times in 6 furlong (3/4 mile; raced around one turn) and 9 furlong (1 1/8 mile) races. On a typical track a 1:12 for 6 furlongs is almost equivalent to a 1:53 for 9 furlongs (78 and 77 speed figure respectively). Adjustments are made to account for how quick races were run on a particular day.

Table 2 [2] is the conversion for beaten horse lengths for the two distances. A horse beaten by two lengths in a 6 furlong sprint will receive a speed figure 5 points lower than the winner.

A high caliber racehorse that competes in the top races (called stakes races) will run between a 100 and 120. A horse’s speed figures may vary widely over the course of a career. The average speed figure for the top Breeders’ Cup Juvenile, the top U.S. race for male two-year-olds (run in the fall), the Kentucky Derby, the top U.S. race for male three-year-olds (run in the spring), and the Breeders’ Cup Classic, one of the top U.S. races with no age restrictions (run in the fall), are 100, 109, and 117, respectively, indicating substantial improvement with age. The differences between the speed figures indicate that for a 1¼ mile race, the typical Kentucky Derby winner would finish six (horse) lengths ahead of the typical Breeders’ Cup Juvenile and 5½ lengths behind the typical Breeders’ Cup Classic winner.

Materials and Methods

The dataset is composed of 274 male horses that are at least six years old and have made at least 45 starts. These two requirements yield horses with a sufficiently extensive career for an analysis of peak performance. A potential sample selection problem exists because the top male horses often are retired to be breeding stallions well before they satisfy these cutoffs. A stallion can be bred to an excess of one hundred mares a year. Therefore, very few male horses are retired to stallion duty, and most have no breeding value and are eventually castrated (called geldings). The horses that meet the criteria for the dataset have no residual breeding value and the majority of them are geldings. Likewise, many female horses have breeding value and therefore are more likely to have shorter racing careers. For this reason we focused exclusively on older male horses. Another potential issue is that in the U.S. many of the most prestigious races are restricted to younger horses. The Triple Crown, consisting of the Kentucky Derby, Preakness, and Belmont, is run in the spring and restricted to three-year-olds. Of the 14 races of the Breeders’ Cup, four are for two-year-olds. A precocious horse is rewarded by the high purses in these age-restricted races and often ends up retiring early to stud. Therefore, a concern is whether horses that meet the criteria stipulated for the sample are an adequate representation of the male Thoroughbred population. If so, then the peak age and rate of incline and decline for the sample should be reasonable estimates for the entire population.

Summary statistics for the 274 horses in the sample are in Table 3. The age referred to throughout this paper is the horse’s actual age rather than the age according to the uniform January 1st birthday. Cool N Collective, born March 22, 1997, is the oldest horse in the dataset at 12.4 years old when he ran at Suffolk.

| Table 1. Speed Figures |
|------------------------|
| **3/4 mile** | **1 1/8 mile** |
| Time | Speed Figure | Time | Speed Figure |
| 1:08 | 135 | 1:47 | 132 |
| 1:09 | 120 | 1:48 | 122 |
| 1:10 | 106 | 1:49 | 113 |
| 1:11 | 92 | 1:50 | 104 |
| 1:12 | 78 | 1:51 | 95 |
| 1:13 | 64 | 1:52 | 86 |
| 1:14 | 51 | 1:53 | 77 |
| 1:15 | 37 | 1:54 | 68 |
| 1:16 | 24 | 1:55 | 60 |
| 1:17 | 11 | 1:56 | 51 |
| 1:18 | 24 | 1:57 | 42 |

| Table 2. Beaten Lengths Adjustments |
|-------------------------------------|
| **Margin** | **3/4 mile** | **1 1/8 mile** |
| 0.5 | 1 | 1 |
| 1 | 2 | 2 |
| 2 | 5 | 3 |
| 3 | 7 | 5 |
| 4 | 10 | 6 |
| 5 | 12 | 8 |
| 6 | 15 | 9 |
| 7 | 17 | 11 |
| 8 | 20 | 13 |
| 9 | 22 | 14 |
| 10 | 25 | 16 |
Table 3. Summary Statistics for Horses

| Variable                  | Mean | Min | Max  |
|---------------------------|------|-----|------|
| Starts                    | 65.1 | 45  | 121  |
| Age at last start         | 8.0  | 4.7 | 12.4 |
| Wins                      | 9    | 1   | 29   |
| Earnings                  | $178,914 | $28,699 | $1,174,781 |
| Avg Speed Figure          | 59.1 | 31.0| 88.7 |
| St Dev Speed Figure       | 15.3 | 8.6 | 25.4 |
| Best Speed Figure         | 84.5 | 50  | 108  |
| Avg Distance (furlongs)   | 6.91 | 5.22| 9.24 |
run an average 7.1 points slower than their career mean and 12.1 points slower than the peak age category. According to the table, horses improve by 22.2 points as young two-year-olds to the middle part of their four-year-old year and then decline by 12.1 points over the next five years. In sprint races this translates to a 9 length improvement to the peak and a 5 length decline. In route races it is a 13⅓ length improvement to peak.
and a 7½ length decline. Pct High SF is the percentage of horses that earned their career highest speed figure when they were the age of the corresponding category. Just over 3% of the sample earned their best figure as a two-year-old. This increases to 23.1% as a three-year-old, 32.9% as a four-year-old, and 21.2% as a five-year-old. 80% of all horses in the sample earned their top speed figure below the age of six. Three horses earned their top speed figure as nine-year-olds: Sunshine Bear ran a 91, winning by 14 lengths at 9.3 years of age, Messenger Springs earned a 73 to win by a length at 9.46 years of age, and My Friend Jim ran a 63 at 9.94 years of age. Highest Speed Figure is the best figure run in the corresponding age category.

The effect of age on racing distance is studied by looking at the difference and standard difference between the distance of a specific race and the mean distance of all races that the horse competed in. There is a large increase in racing distance over the course of a horse’s two-year-old year. In the spring of the two-year-old year, horses compete in short sprint races between 4½ furlongs and 6 furlongs. Typically a two-year-old will not run a route race (8 furlongs or longer) until the fall. Therefore, horses less than 2½ years old have the smallest average distance run by a significant margin. Horses in this category run 0.75 furlongs less in distance than their career average.

Table 5 presents the regression estimates of equation (2).

| Age | R_k | D_k |
|-----|-----|-----|
| 2   | -26.32 | 37.43 |
| 3   | -9.09  | 21.70 |
| 4   | -1.02  | 5.98  |
| 5   | -0.58  | -1.23 |
| 6   | -1.87  | -3.21 |
| 7   | -4.32  | -5.20 |
| 8   | -7.93  | -7.18 |

Peak age is estimated to be 4.45 years. At age 2 a horse is predicted to be 26 points slower than at peak age. The improvement over the first two years is dramatic and the subsequent decline is more gradual. Predicted speed figure by age for the mean ability horse is depicted in Fig. 2.

References

1. Baker, J., Deakin, J., Horton, S., and Pearce, G.W. 2007. Maintenance of skilled performance with age: a descriptive examination of professional golfers. J. Aging Phys. Act. 15: 300–317.
2. Beyer, A. 1993. Beyer on Speed. Houghton Mifflin, New York.
3. Bailey, C.J., Reid, S.W.J., Hodgson, D.R., and Rose, R.J. 1999. Impact of injuries and disease on a cohort of two- and three-year-old thoroughbreds in training. Vet. Rec. 145: 487–493.
4. Bradbury, J.C. 2008. Peak athletic performance and ageing: evidence from baseball. J. Sports Sci. 27: 599–610.
5. Brown-Douglas, C.G., Pagan, J.D., and Stromberg, A.J. 2006. Thoroughbred growth and future racing performance. Proc. Kentucky Equine Res. Nutr. Conf. 15: 16–29.
6. Fair, R.C. 1994. How fast do old men slow down? Rev. of Econ. and Stat. 76: 103–118.
7. Fair, R.C. 2006. Estimated age effects in athletic
events and chess. Cowles Foundation Discussion Papers: 1536, Cowles Foundation, Yale University, New Haven.

8. Fair, R.C. 2008. Estimated age effects in baseball. *J. of Quan. Anal. in Sports* 4: 1–39.

9. Green, D.A. 1969. A study of growth rate in Thoroughbred foals. *British Vet. J.* 125: 539–546.

10. Hintz, H.F., Hintz, R.L., and Van Vleck, L.D. 1979. Growth rate of Thoroughbreds: effect of age of dam, year and month of birth, and sex of foal. *J. of Anim. Sci.* 48: 480–487.

11. McCarthy, D., and Mitchell, J. 1974. A study of growth rate in Thoroughbred foals and yearlings. *Irish J. of Ag. Res.* 13: 111–117.

12. More, S.J. 1999. A longitudinal study of racing Thoroughbreds: performance during the first years of racing. *Aust. Vet. J.* 77: 105–112.

13. Over, R., and Thomas, P. 1995. Age and skilled psychomotor performance: a comparison of younger and older golfers. *Int. J. Aging Hum. Dev.* 41: 1–12.

14. Sobczynska, M. 2007. The effect of selected factors on length of racing career in Thoroughbred racehorses in Poland. *Anim. Sci. Papers and Reports*, 25: 131–141.

15. Thompson, K.N. 1995. Skeletal growth rates in weanling and yearling Thoroughbred horses. *J. Anim. Sci.* 73: 2513–2517.