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Historical progression of racing performance in thoroughbreds and man

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Introduction

In 2006 Barbaro won the first race of the American Triple Crown, The Kentucky Derby, in 2.01.36 min. 110 years earlier the same race was won by Ben Brush in 2.07.00 min. The current record for The Kentucky Derby, still standing, was set by Secretariat in 1973 in a time of 1.59.00. Therefore the winning time for the Kentucky Derby has reduced by only 6-8 secs overall, representing a marginal improvement of 4% since the turn of the 20th Century. For the Epsom Derby, the improvement is slightly greater with a reduction of 25 secs between 1846 and 2006 (Pyrrhus the First, 2.55 min to Sir Percy, 2.35.23 min), but representing an improvement of only 11% in 160 years of organised racing. In comparison, for man, the statute mile record - arguably the historical benchmark track and field event - stands at 3.43.00 min (Hicham El Guerrouj in 1999). The first recorded and officially timed mile was won by Charles Westhall in 1852 in a time of 4.28 min. Thus, the mens mile record has reduced by 45 secs, over 147 years; an improvement of 17%. Therefore a common feature of modern horse races and human athletic contests is that winning times are faster now than in the distant past, but it is the difference in gradual improvement between the two that is of interest in this study.

Specifically, the change in performance for both man and horse over the last 50 years is particularly interesting. Since the 1950's, when Emil Zàtopek (1952 Olympic marathon champion) introduced the concept of 'interval training' and Roger Bannister broke the 4 min mile (1954) there has been an explosion of knowledge in the areas of nutrition, exercise physiology, technology and performance aids and in the practical application of that knowledge, for example in clothing refinements. Hence for the current study I have examined the timed historical data for a number of elite flat races on different surfaces and different continents together with contemporaneous human data in similarly elite track and field events and have examined the relationships between recorded winning time with year from the first recorded data to the current year. It is pertinent however, that whereas human athletes attempt to achieve the best possible times in almost every race, except perhaps the marathon; the jockeys, trainers and owners of racehorses are more concerned about winning *per se*, regardless of time; thus race tactics can influence the winning time in horse races more so than human athletic contests. Also given other external variables that can affect winning times in horse races such as position in the stalls, track conditions, jockey skill; more so than in human athletic contests, then it seems likely that human winning times will improve more regularly than horse winning times. In this study, the change in winning times in elite races in both species are presented and rates of improvement compared prior to and after the 1950's.

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Materials and Methods

Winning times for the following Thoroughbred races were analysed: The English 'Classics'; The Epsom Oaks (since 1852), Epsom Derby (1846), the 1000 guineas (1955), the 2000 guineas (1952) and the St Leger (since 1954). The American Triple Crown of the Kentucky Derby (1875), the Preakness Stakes (1873) and the Belmont Stakes (1867); also the French Arc de Triomphe (1950) and the Melbourne Cup (1861). Including all data for these races over such a long period of time will invariably include instances when the races were modified or run over different courses which may effect the winning time, for example the Melbourne Cup became metric in 1972 shortening the course by 20.5 yards. However these isolated occurrences are not envisaged to have any material effect on the outcome of the current analysis. Available winning times for men and women at the Commonwealth and Olympics Games and the World Championships were analysed for the 100m, 1500m, mile, 10,000m and marathon. The earliest available data were from the first Olympic Games in 1896. The winning times were derived from open access sources including wikipedia (http://en.wikipedia.org) and GB athletics (http://www.gbrathletics.com). Winning times were converted to seconds for regression against year. The statistical significance of the coefficient of slope (with 95% confidence intervals) was determined. As a basis against which to assess winning times over the last fifty years e.g. since the 1950's, the average winning time for the decade of the 1940s was determined. Winning times after the year 1949 are shown as a percentage of this base. For all data Genstat (V8) was used and a P -valus of less than 0.05 was accepted as being statistically significant.

Results

Racehorses

For all races included in the analysis there was a clear trend for the winning time to reduce over time. Figure 1 shows that the winning times for the Kentucky Derby, Epsom Derby and the Melbourne Cup have reduced over time since the 1880's. For all races the coefficient for slope and variance for each trend with time (up to 1949 and 1950-2006) is given in Table 1. Values for slope are clearly greater pre-1949 *vs.* the modern era, indicating the majority of improvement in winning time occurred pre-1949. When the improvement in the modern era (1950-2006) is represented as a percentage difference to a reference time (i.e. 1940's average) then the reduction in time was on average 4.2% (3.3 to 5.0% 95% CI; Table 1). Standardized residual analysis indicated unusually slow times were more common than unusually fast e.g. the 1983 Epsom Derby (Teenoso), the 2005 Oaks (Scorpion) and 2002 Melbourne Cup (Makybe Diva). The only particularly fast race, with a large negative standardized residual was the 1975 Oaks (Juliette Marny). For races restricted to either fillies or colts (e.g. 1000 *vs.* 2000 guineas and Epsom Oaks *vs.* Derby, respectively) there were no differences in slope over time (Table 1) indicating equivalent improvement (or lack of) with time.

Man

Table 2 shows by linear regression that in man, as in the racehorse, winning times have declined over time in all races. Notable exceptions were the women's 10K and 1500m, which failed to reach statistical significance. In most of these races the improvement has tapered in the last 50 years, with the majority of improvement occurring pre-1949, with the exception of the men's mile and 10K, which have continued to improve linearly. The percentage change in the modern era is on average 10.4% (4.9 to 15.8% 95% CI; Table 2); that is, more than 2-fold greater than in the racehorse. Of interest, for the women's marathon the percentage improvement has been 32% since 1964 (reflecting a reduction of almost 1h compared to the first recorded time). As with racehorses, unusually slow times (indicated by

large positive residuals) were much more common; indeed, for man there were no exceptionally fast races (men or women) in any particular era. Figure 2 illustrates the relative improvement in performance in both man and racehorse in the modern era for selected races in man (men's marathon and men's mile) and racehorse (Kentucky Derby and English Derby).

Discussion

The current study has presented an analysis of the racing performance of racehorses and man from the earliest timed events to the current year. It is clear from the analysis that much improvement has occurred over this time in both species and it is tempting to suggest a number of reasons for this improvement, when the inherent physical ability of both as a species has presumably remained unchanged. Some of the improvement is no doubt due to common factors; improved nutrition for example (Harris 1998), but also to esoteric factors associated with each species e.g. for the racehorse through selective breeding and arguably, improved racing surfaces (Perkins *et al.* 2004). For man, the role of sports psychology and knowledge of the rewards that accompany winning is unique. Nevertheless the data clearly show how, over the last 50 years, the improvement in man has far outstripped that observed in the horse.

There are myriad influences on performance in the horse that can be designated broadly as extrinsic (e.g. race surfaces, race picking) or intrinsic (e.g. genes, fitness, physiology) to the horse or a combination of the two (e.g. selective breeding for improved performance). While we have to assume in the current paper that the trainer and/or owner successfully picked the right horse for the right race (since we have only recorded times for the winners) the effect of varying ground conditions over the years almost certainly adds to the variation in winning time. For example the variation in times for the modern era for the American Triple Crown (run on fairly consistent dirt) is far below that for any of the European races (run on not so consistent turf) indicating how 'soft' or 'hard' going may influence the winning time that year. For man, almost certainly the huge technological advances, increased awareness of physiological change during exercise and novel training methods have played a greater part than genetic endowment (Macarthur & North 2005). Since the 1950's interval training, that is training at different paces during a single session, has become an integral part of all athletes programs and has undoubtedly improved fitness and thus racing times (Kubukeli *et al.* 2002). There is also a psychological incentive for human athletes to not only win races but to win them in record-breaking times (Abbiss & Laursen 2005). The horse knows no such incentives. Indeed the winning time of a horse is a complex of its own innate desire to run modified by a range of human and environmental inputs including the jockey, position in the starting gates, the 'going', the tactics, etc. In the Melbourne Cup, which is a handicap, clearly the weight carried is a major variable. For all these reasons, winning time in the horse may not therefore be regarded as the best measure of performance. The huge breeding program of thoroughbreds has arguably produced some gain but this was clearly restricted to pre-1949; since 1950, representing many generations of racehorse, the policy of breeding 'the best to the best' has had little to no effect. The addendum often added to the aforementioned maxim ...'and hope for the best' appears to ring true. Gaffney and Cunningham hypothesised that insufficient genetic variance through generations of inbreeding in the thoroughbred accounted for the lack of change in winning race times, but their analysis showed the contrary; that significant genetic variance was still present in the thoroughbred population as a whole (Gaffney & Cunningham 1988), prompting some initial discussion of possible alternative explanations (Eckhardt *et al.* 1988; Hill 1988). Amongst these, and in part supported by the current analysis, are intrinsic factors in the horse itself.

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Horses have evolved to run at speed and many physiological adaptations, particularly cardiovascular and haemodynamic, facilitate this (Physick-Sheard 1985); however, their respiration is limited by their stride. Galloping horses inspire when their legs are stretched out and expire when they come together; each must be co-ordinated in time (Forster & Pan 1988). Perhaps there is a finite speed horses can gallop based upon their anatomy and physiology i.e. the delivery of oxygen to respiring tissue, which is limited only by their inability to breathe more quickly than their legs are moving. Nevertheless exceptional horses such as 'Secretariat' or 'Mill Reef' (only Juliette Marny stood out in the current analysis) occasionally record exceptional times; but it is unclear at present how this is achieved. It is possible that these exceptional horses had an exceptional metabolism that enabled them to produce such performances. Thus the intramuscular accumulation of lactate (through anaerobic metabolism) ultimately limits muscle performance and appropriate training can delay its onset. Do racehorse trainers regularly sample blood lactate during and after workouts and prepare individualised workouts as occurs in human training programs. In one study, blood lactate taken 2 and 5 min after exercise correlated well with the Timeform rating given to that racehorse (Evans *et al.* 1993). Implementation of such training tools in the elite thoroughbred horse may, in addition to improving results and winning times, reduce injury rate (Williams *et al.* 2001) and occurrences of poor performance (Morris & Seeherman 1991).

While it appears that for most elite races in the horse the greatest improvements occurred 50-100 years ago, for the human the current data also indicate that many human athletic contests appear to have neared their physical limits in the last decade - witness the flattening of the curves in Fig. 2 and the markedly reduced variance and slope in the modern era (Table 2). Thus to speculate on these data, the 2h marathon is perhaps not physically possible, but the 3.30 min mile will be broken around 2036. In conclusion, winning times for some elite races in both horse and human have improved over the last 150 years. Most of this improvement occurred in the last century. In the modern era (1950 to present day) when great advances in technology and knowledge have helped athletic performance, man has improved winning times by, on average, 12-13% as compared to 4% in the racehorse. We have no real measure of the relative input of modern science and technology into the training of man or horse and while it is tempting to suggest that man has benefited more from this input we cannot know for sure. However, it remains to be seen if adoption of modern training methods to racehorse training, applying the principles of exercise physiology, nutrition and interval training can produce similar gains as observed in man over the last 50 years.

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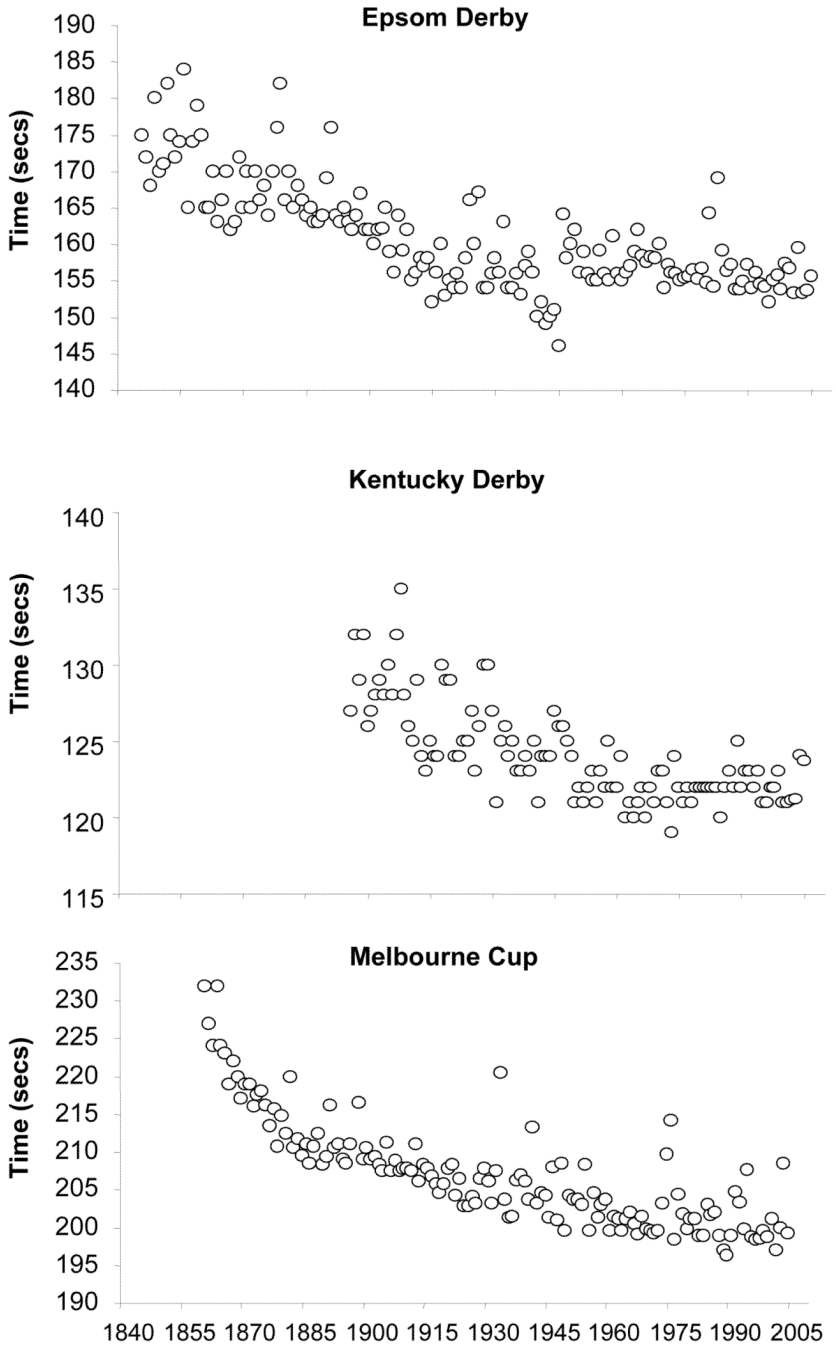

Figure 1.
The change in winning time for the Epsom Derby, Kentucky Derby and Melbourne Cup from the first recorded to current year.

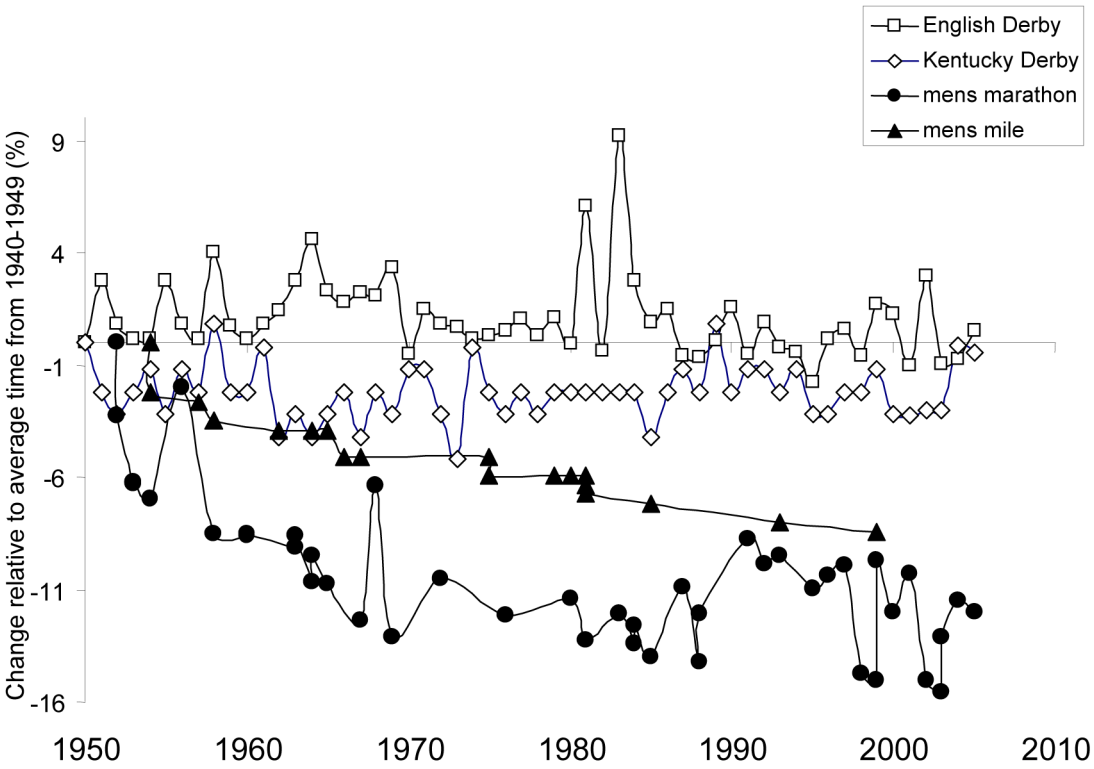

Figure 2.
The percentage change in winning time in the modern era (1950-2006) for the Epsom Derby, the Kentucky Derby and the men's mile and men's marathon relative to the average time recorded for each event from 1940-1949.

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Table 1

Winning time trends in some elite thoroughbred races

	Up to 1949		1950-2006		
Race...	**Slope (95% CI)**	**Variance**	**Slope (95% CI)**	**Variance**	**Δ_{max} (%)**
Kentucky Derby	−0.56(−0.66 to −0.47)	233	−0.007 (−0.01 to 0.02)	1.4	4.1
Preakness Stakes	−0.60(−0.78 to −0.42)	467	−0.04 (−0.02 to −0.06)	1.8	4.7
Belmont Stakes	−0.31(−0.26 to −0.36)	122	−0.02 (−0.01 to 0.006)	2.5	3.6
Epsom Derby	−0.20(−0.23 to −0.17)	60	−0.04 (−0.08 to 0.001)	8	1.8
Oaks	-	-	−0.03 (−0.09 to 0.02)	11.7	4.0
2000 guineas	-	-	−0.07 (−0.11 to 0.03)	6.8	7.2
1000 guineas	-	-	−0.08 (−0.11 to 0.04)	5.0	5.6
St Leger	-	-	−0.11 (−0.20 to −0.01)	29.5	4.2
*King George	-	-	−0.11 (−0.17 to −0.06)	13.4	1.6
Arc de Triomphe	-	-	−0.12 (−0.19 to −0.04)	20	4.8
Melbourne Cup	−0.20(−0.23 to −0.17)	44	−0.04 (−0.09 to 0.01)	11	4.4

*King George and Queen Elizabeth Diamond Stakes. Slope, calculated from linear regression with the *x*-coefficient represented as seconds/year with 95% confidence interval (CI). Δ_{max} (%), represents the fastest time recorded in the last 50 years for each event expressed as a percentage improvement on the average time in the 1940's.

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Table 2

Winning time trends in some elite human athletic contests

	Up to 1949		1950-2006		
Race...	**Slope (95% CI)**	**Variance**	**Slope (95% CI)**	**Variance**	**Δ_{max} (%)**
100m male	−0.02(−0.03 to −0.01)	0.20	−0.01 (−0.01 to −0.007)	0.04	6.9
100m female	−0.04 (−0.06 to −0.03)	0.14	−0.01 (−0.01 to −0.009)	0.05	9.7
1500m male	−0.65 (−0.96 to −0.63)	161	−0.15 (−0.24 to −0.06)	16	11.9
1500m female	-	-	−0.02 (−0.19 to 0.14)	9.9	2.9
Mile men	−0.30(−0.38 to −0.22)	150	−0.33 (−0.38 to −0.29)	20	8.4
10000m male	−2.7 (−5.1 to −0.28)	1615	−2.1 (−2.8 to −1.4)	1869	13.5
10000 female	-	-	−2.1 (−4.9 to 0.6)	2903	10.4
Marathon men	−46 (−63 to −29)	772289	−10.4 (−13.9 to −7.0)	73172	15.6
Marathon women	-	-	−67 (−82 to −61)	1124814	32.1

Slope, calculated from linear regression with the *x*-coefficient represented as seconds/year with 95% confidence interval (CI). Δ_{max} (%), represents the fastest time recorded in the last 50 years for each event expressed as a percentage improvement on the average time in the 1940's.