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Recovery heart rates as a predictor of race position in race-fit National Hunt Racehorses

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Abstract

Prediction of race-fitness using the principles of excess post-exercise oxygen consumption is a potentially valuable applied exercise physiology tool. We hypothesised that horses with a faster heart rate recovery (HRR) after a field test would perform better in their subsequent race. Twenty mature (17 experienced, 3 unraced) National Hunt horses (15 geldings, 5 mares; 6.5 ± 1.1 years; 489 ± 33.5 kg), underwent 34 pre-race 3-interval field exercise tests using telemetric heart rate (HR) and global positioning satellite (GPS) monitoring on a 1400m track inclined 32m. Horses were classified into 3 groups based on post-exercise HRR values obtained 1 minute after peak HR during interval 3 (>140bpm; unfit; 120-140bpm; fit-to-race; < 120bpm; fully fit). All horses were from the same yard, under the same management and in their final stage of training (race-ready). Horses were excluded if they were lame or clinically unwell. The outcome measure of finishing in the top third of the field was compared to classification using 2x2 tables (Statcalc, EpiInfo). Peak HR, peak speed and 1 minute HRR were 213.4±5.1bpm, 49.3±1.8kph and 125.3±15.8 for interval 3. Horses classified as unfit (n=8) did not race. Fully fit and fit-to-race horses competed in 26 jump races (23 hurdles, 3 bumper; 3200 – 5000m). Fully fit (n= 16) horses were more likely to finish in the top 3rd of the field than fit-to-race (n=10) (OR 12.0; 95%CI 1.8-81.7; P=0.01). We conclude that HRR following interval exercise can be used as a predictor of race position in National Hunt racehorses and a useful guide for trainers.

Key words: Equine, GPS, Fitness, interval training, excess post-exercise oxygen consumption (EPOC)

Introduction

Heart rate recovery (HRR) following both sub-maximal and maximal exercise using the principles of excess post-exercise oxygen consumption has been well established as a reliable predictor of overall cardiovascular fitness in human athletes (Hagberg et al., 1980; Blomqvist and Saltin, 1983; Daanen et al., 2012). Additionally, HRR is established as a reliable and independent predictor of cardiovascular mortality in healthy adults (Nishime et al., 2000). The use of HRR provides a non-invasive and inexpensive objective method for clinical practitioners to monitor health and rehabilitation (Nishime et al., 2000) and for exercise physiologists to monitor fitness levels and adjust training loads accordingly (Rabbani et al., 2018).

Field-based exercise testing in equine disciplines has been established as a repeatable and valid tool for monitoring fitness in horses (Couroucé 1999; Davie and Evans, 2000; Davie et al., 2002; Vermeulen and Evans 2006; Munsters et al., 2013). Although field-based exercise testing has inherent limitations, including inability to control environmental variables such as temperature, airflow and ground conditions that can make standardisation of testing difficult (Couroucé-Malblanc and Van Erck-Westergren, 2014), it has been used to predict successful performance in Standardbreds, Thoroughbreds and Warmblood sports horses (Leleu et al., 2005; Gramkow and Evans, 2006; Munsters et al., 2014). Most standardised testing practices rely primarily on monitoring heart rate (HR) for any given sub-maximal workload and measuring concomitant blood lactate (Couroucé 1999; Davie and Evans, 2000; Munsters et al., 2014). HR and concomitant blood lactate responses are greatly dependent on individual aerobic capacity which can be affected by inherent factors such as breed and age, or by the influence of training (Couroucé-Malblanc and Hodgson, 2014).

Field-based exercise testing is ideally minimally invasive and minimally disruptive of routine training practices. Heart rate monitors are non-invasive and can be easily applied by trainers during routine exercise, especially in actively competing animals.

Heart rate responses to submaximal and maximal exercise have been used to assess fitness and predict performance in Thoroughbreds (Gramkow and Evans, 2006; Evans, 2007), yet the use of HRR to assess fitness in racehorses has been relatively limited compared to the human discipline. Despite HRR being well correlated with fitness in endurance horses (Rose, 1983), only one study has been published in the Thoroughbred racehorse. The study evaluated flat racehorses and found lactate but not post exercise HR correlated with timeform ratings following a treadmill exercise test (Evans et al., 1993) which may explain why it appears that HRR has been used infrequently in field exercise tests in Thoroughbreds.

To date, no study has investigated the relationship between HRR in Thoroughbred racehorses and race performance using field-based testing. This study aimed to compare HRR after a three-interval field exercise test to race position in a competition undertaken three days later in a group of National Hunt racehorses. We hypothesised that horses with a faster HRR would perform better in their subsequent race.

Materials and methods

The study was a retrospective analysis of data obtained from a single licensed training centre in Great Britain with standardised management practices during the period of the study. The study was approved by the Veterinary Research Ethics Committee (VREC704), University of Liverpool, and the trainer gave full consent for data to be analysed and published. The data collection was ongoing and part of a protocol set up by one of the authors with the trainer (GW) and managed by the trainer who selected and collected HR data for mature (> 5-years) horses that he (the trainer) determined to be ready to race. By definition, this excluded any horse that was ill, did not eat all of its food or demonstrated musculoskeletal pain or lameness precluding racing. Selection criteria was based on time frame: horses racing between January 2017 and December 2017 under National Hunt rules in GB (www.racingpost.co.uk).

Trainer selected race-ready horses were fitted with a telemetric HR monitor and global positioning satellite (GPS) monitoring system (M400 model, Polar Electro-Oy, Finland) prior to exercise and exercised by their usual exercise rider. The HR monitor electrodes were placed on two anatomical points of the horse; on the left-side wither with the saddle pads and saddle placed over to hold in position, and under the girth of the saddle over the heart base adjacent to the left elbow**,** with the girth placed over to hold position on the skin and secured with a rubber strap. The electrodes were attached to the telemetric unit that was fixed to the neck strap of the bridle and this transmitted a signal to a watch worn by the rider, displaying HR, speed and distance in real time. Prior to the placing of the electrodes, the rider applied a damp sponge to the anatomical sites and also dampened the electrodes to ensure good conductivity. The rider then ensured an established signal on the watch, before mounting for the exercise session. Each electrode unit had been individually paired to an individual watch receiver, to ensure no cross signaling could occur between horses.

Prior to the three-interval field exercise test, all horses were ridden from the stable yard to an all-weather trotting enclosure adjacent to the all-weather gallop and performed trotting circuits as a warm-up. The number of circuits of trotting and length of each was under the trainer's discretion and interspersed with short walking periods. The total duration of warm-up was <10-minute.

The protocol involved a 3-interval field exercise test three days prior to racing. The track was a 1400m (7 furlongs) long wood chip track (CPA Horticulture, England) that gradually inclined to a peak height of 32m. The protocol was untimed but unaltered from the routine fast work days prior to racing (a "work day") and involved horses running singly in an increasing protocol of canter (typically 40 km/h) to half pace (typically 45 km/h) to three quarter pace (typically 49 km/h) over the interval distance. After slowing at the end of each interval at the end of the track, recovery between intervals was for the horses to be ridden at a walk pace back down the side of the track for 600m (3 furlongs). This initial recovery phase incorporated the post-peak HR 1 minute time period that was used to determine the post-exercise HRR analysis for fitness categorisation. After the initial walk, the riders then proceeded to trot their horse for the remainder 800m (4 furlongs) of the all-weather track, back to the start. The procedure was repeated twice during the exercise testing. After the 3rd interval all horses were walked back to the stables to be unsaddled and 'washed down'. The heart rate monitors were stopped after total exercise cessation and the data was downloaded as described below.

Post-exercise, data was downloaded to the online portal (https://flow.polar.com/) via linking the watch receiver unit to a laptop. Individual data was then extracted from each exercise interval including peak HR, peak speed and 1 minute HRR. Given that there does not exist any data in the equine literature on HRR in exercise and subsequent race performance in racehorses, we extrapolated the post 1-minute recovery protocol from the human literature where this is widely used across many sports (Hagberg et al., 1980; Blomqvist and Saltin, 1983; Daanen et al., 2012). The data were accessible by both the trainer and author (GW) and cross referenced with the published race records (www.racingpost.co.uk) for race type (steeplechase, hurdle, or national hunt flat race - known in horse racing in GB as a 'bumper'), race distance and time, race going, any noted problems and finishing position in the subsequent race three days after the field exercise test. Race finishing position was compared with the HRR of the 3rd interval from the exercise session three days earlier.

Data was recorded in a spreadsheet (Microsoft Excel) using horse initials only. Using the HRR following interval three, horses were classified into three groups >140bpm; unfit; 120-140bpm; fit-to-race; < 120bpm; fully fit. Peak HR, speed and HRR was compared between groups for all three intervals using one-way ANOVA (Stata version 10, Statcorp, College Station TX, USA). Where significant group differences were detected post hoc analysis with Bonferroni correction was used. Due to the variable field sizes, finishing position was divided into top third and bottom two thirds of the race and compared against the classification groups. The outcome measure of finishing in the top third of the field was compared to classification using 2x2 tables (Statcalc, EpiInfo). Results are presented as mean ± SD.

Results

There were 20 racehorses, including 15 geldings and five mares, aged 6.5 ± 1.1 years and weighing 489 ± 33.5 kg. Three of the 20 were previously unraced, whilst 17 horses had at least one prior season of racing. The horses underwent a total of 34 exercise tests, collectively, over the testing period. Thirteen horses were tested once, two twice, three were tested three times and two horses were tested four times over the 12 month period. Heart rate recovery measured after the completion of the 3rd interval of the SET resulted in horses being classified as fully fit (n=16), fit-to-race (n=10), or unfit (n=8) .

Overall mean (± SD) peak HR for interval 1 (198.8 ± 5.7 bpm), interval 2 (208.3 ± 5.6 bpm) and interval 3 (213.4 ± 5.0 bpm) was not different between groups (P>0.1). Mean (± SD) peak speed for interval 1 was not different between fully fit (40.0 ± 1.3 kph) and fit-to-race (40.0 ± 1.5 kph), but was higher for unfit horses (43.0 ± 1.9 kph) than fully fit (P<0.001) and fit-to-race (P< 0.01). Peak speed for interval 2 was not different between fully fit (44.5 ± 3.0 kph) and fit-to-race (44.7 ± 3.1 kph), or between unfit (47.6 ± 1.0 kph) and fit-to-race horses (P> 0.1), but was higher for unfit horses than fully fit (P<0.05). Mean (± SD) peak speed for interval 3 (49.3±1.8 kph) was not different between groups (P> 0.1; Table 1).

Mean (± SD) 1 minute post-peak HR for interval 1 was not different between fully fit (102.1 ± 15.5 bpm) and fit-to-race (108.0 ± 8.2 bpm) or between unfit (110.5 ± 4.8 bpm) and fit-to-race horses (P>0.1), but was higher for unfit horses than fully fit (P<0.05). Mean 1 minute post-peak HR for interval 2 was not different between fully fit (108.1 ± 7.2 bpm) and fit-to-race (114.4 ± 7.1 bpm), but was higher for unfit horses (127.1 ± 8.0 bpm) than fully fit (P<0.001) and fit-to-race (P< 0.01). Mean 1 minute post-peak HR for interval 3 was different between all groups (P<0.001). Mean 1 minute post-peak HR was lower in fully fit (113.1 ± 8.4 bpm) compared to fit-to-race (124.4 ± 2.2 bpm; P <0.01) and unfit horses (149.3 ± 8.7.1 bpm; P<0.001). Fit to race horses had lower 1 minute post-peak HRs than unfit horses (P<0.001; Table 1).

Table 1. Descriptive data for 20 racehorses during 34 three interval (INT) exercise tests classified as either ‘fit’ (n= 16; with a heart rate recovery [HRR] 1 minute after the completion of the third interval of the SET of <120 beats per minute [bpm]) or ‘fit-to-race’ (n = 10; with HRR 1 minute after the completion of the third interval of the SET of 120-140 bpm) or unfit (n = 8; HRR 1 minute after the completion of the third interval of the SET of >140 bpm). Results are presented as mean ± SD. Fit-to-race horses had 1 minute HRR significantly higher than fit horses only in interval 3 (P<0.01).

	Fit			Fit-to-race			Unfit		
	INT 1	INT 2	INT 3	INT 1	INT 2	INT 3	INT 1	INT 2	INT 3
Peak speed km/h	40±1	45±3	49±2	40±1	45±3	49±1	43±2*,**	48±1*	50±2
Peak HR bpm	197±6	206±6	212±5	199±4	210±3	216±4	202±6	211±5	213±5
1 minute HRR bpm	102±6	108±7	114±8	108±8	114±7	125±2*	111±5*	127±8*,**	149±7*,**

** significantly different from fully fit horses, ** significantly different from fit-to-race horses (P<0.05)*

There were 26 races which included 3 bumpers (2 miles on the flat) and 23 hurdles with between 8 and 12 flights (jumps) and distance from 2 miles (3200 m) to 3 miles and half a furlong (5000 m). Fully fit (n=16) horses were more likely to finish in the top 3rd of the field than fit-to-race (n=10) (OR 12.0; 95%CI 1.8-81.7; P=0.01; Figure 1). Horses classified as unfit (n=8) did not race.

Figure 1. Recovery heart rates (HRR) compared to finishing position in 20 racehorses following 34 exercise tests (SETs). Horses were classified as either 'fully fit' (n=16; with a post-peak heart rate [HR] 1 minute after the completion of the third interval of the SET of <120 beats per minute [bpm]) or 'fit-to-race' (n=10; with post-peak HR 1 minute after the completion of the third interval of the SET of 120-140 bpm). Fully fit horses had higher odds of finishing in the top third of the field (OR 12.0; 95%CI 1.8-81.7; P=0.01).

Discussion

This results of this study support the hypothesis that horses with a faster HRR following interval exercise training perform better in their subsequent race than horses with slower HRR. This contradicts earlier research in flat racehorses following a two increment treadmill test (Evans et al., 1993) but represented a very different test in a different group of horses. The horses in the current study were all mature with a mean age of 6.5 years compared to 3 years for the flat racehorses. Older horses may be more familiar with their training routine and training environment and less affected by the excitement of interval exercise (Hodgson, 2014).

The current study used a three interval test and differences in HRR between the fully fit and fit-to-race groups were only apparent following the third interval. Tests with fewer intervals may not be as discriminatory, which may explain why the two increment treadmill exercise test in the earlier research did not show a relationship between timeform rating and 1 minute HRR (Evans et al.,1983). It may also be that the small sample size in both studies may have meant there was insufficient power to detect the relationship between performance and HRR. Larger numbers may have allowed discrimination using 1 minute HRR after only one or two intervals. However, the test was designed to be applicable to a typical training yard with similar numbers of horses, in which case the three intervals are likely to be required to discriminate.

The difference may also be related to treadmill testing used by Evans et al. (1993), which may predict racing performance less well than a ridden interval test. Although field exercise testing is inherently more variable, there are significant differences in physical work load and biomechanically when comparing competition horses on a race track and a treadmill, and given field testing includes the effect of a rider, it is likely that the workload is more representative of the competition environment (Munsters et al; 2014).

The performance measure in the flat racehorses was timeform rating (Evans et al., 1993) which indicates cumulative racing ability rather than immediate fitness. In the current study, several horses performed the exercise test more than once, moving between unfit, fit-to-race and fully fit categories. Using HRR allowed differentiation of the current stage of fitness, whereas timeform rating may not.

National Hunt horses are typically trained to run over much longer distances than flat racehorses, as well as including jumping efforts. The horses in this study competed over 3200-5000m so had a greater aerobic contribution to exercise than short distance flat racing horses that raced from 1200m – 2400m without jumping (Evans et al., 1993; Gerard et al., 2014). This means that tests of HRR, which reflect aerobic capacity (Daanen et al., 2012), are likely to be better suited to National Hunt racehorses. This is supported by the fact that HRR is well correlated with fitness in endurance competition (Rose, 1983) and HRR has been shown to be better in higher performing warmblood sport horses than average performing counterparts following various intensities of submaximal standardised exercise testing (Bitschnau et al., 2010).

Despite the significant association of HRR on subsequent performance, the prediction was not perfect where in a small proportion of horses‘ classification did not accurately predict race performance. Further, it is not known if the unfit classified horses would have performed well as they did not race. Unfit classified horses had faster peak speeds than fully fit horses in intervals 1 and 2, and fit-to-race horses in interval 1. It is unknown whether the higher peak speed was brief or throughout the interval, but this could have prolonged HRR in these horses. However, peak speed was not different in interval 3 and there was no difference in peak speed in any interval between fully fit and fit-to-race horses. Various factors could have affected the HRR during the exercise test e.g. excitment, pulling excessively or not putting in a hard run. Similarly, although none of the horses were recorded as to have had a bad run or fall in their subsequent race, there could have been race related factors affecting the finishing position. However, from a fitness and welfare point of view, especially in such long races as National Hunt races, this system is likely to encourage only the fittest horses to be presented for competition which may reduce pulling up or falls during racing (Ely et al., 2010).

This study was a small study with a small group of horses on a single training premises. Cut-offs for fully fit, fit-to-race and unfit classifications were based on extrapolation from the human field and observation. The exercise test was not fully controlled, with the interval timings being judged by the riders and not a timing system.

Furthermore, many factors affect race performance on the day. However, based on the results of this study, further research to confirm these findings in other training centres, on larger groups of horses and in different types of racehorses are warranted.

Conclusion

We conclude that use of HRR following field interval exercise was able to predict subsequent performance measured as race position in National Hunt racehorses. Use of HRR may prove a useful guide for trainers and help ensure horses a fully fit prior to racing.

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