Intensity and Duration of Exercise During Early-Season Training and Competition in Three-Day Event Horses

Part One: Competition

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Introduction

In the lead-up to the 1996 Olympic Games held in Atlanta, Georgia, numerous studies were conducted to measure the intensity of exercise during the cross-country phase of long-format three-day events. These studies were focused on the effect of heat and humidity during competition. In each of these studies, heart rate (HR), and plasma lactate were used as indices of exercise intensity.

Three-day eventers in the United States typically end their competition season in October or November. At that point most horses are taken out of training and allowed to rest throughout the winter. Many eventers based in the eastern United States migrate to Florida, North Carolina, or South Carolina in January where they resume training for the upcoming season. These horses remain there in training until early to mid-April when most return north to enter competitions throughout the spring and summer. During February, March, and early April, these horses compete in three-day events throughout the Southeast.

Exercise intensity has not been previously quantified during these early-season short-format three-day competitions. Therefore, Kentucky Equine Research conducted a study to measure the intensity of exercise in horses competing at several levels in horse trials and three-day events during the early stages of the 2015 eventing season.

Materials and Methods

Horses
Twenty-eight horses (13 Warmbloods, 8 Irish Sport Horses, and 7 Thoroughbreds) were used in the study (Table 1). The horses competed at four different competition levels (8 Training, 4 Preliminary, 3 Intermediate, and 13 Advanced). All horses were in training in either Ocala, Florida; Aiken, South Carolina; or Southern Pines, North Carolina.

Table 1. Horse numbers and breeds measured.

Level	Number of horses	Warmblood/ Warmblood-cross	Irish Sport Horses	Thoroughbreds	Total competitions measured
Advanced	13	5	7	1	14
Intermediate	3	2	0	1	3
Preliminary	4	2	0	2	6
Training	8	4	1	3	9
TOTAL	28	13	8	7	32

Competitions

The horses competed at six different venues in Georgia, Florida, and North Carolina (Table 2). The competitions were held in February, March, and early April 2015.

Table 2. Competition venues

Venue	Venue location (city, state)	Competition level	Date	Number of horses measured	Cross-country distance (m)	Optimal time (min:sec)
The Fork	Norwood, NC	Advanced	Apr 1-5, 2015	8	3650 m @ 570 m/min	6:47
The Fork	Norwood, NC	CIC***	Apr 1-5, 2015	4	3650 m @ 570 m/min	6:49
Carolina Int.	Raeford, NC	Advanced	Mar 19-22, 2015	1	3800 m @ 570 m/min	7:05
Poplar Place	Hamilton, GA	CIC***	Mar 19-22, 2015	1	4000 m @ 570 m/min	6:46
Pine Top	Thomson, GA	Intermediate	Feb 20-22, 2015	1	3500 m @ 550 m/min	6:23
The Fork	Norwood, NC	CIC**	Apr 1-5, 2015	1	3400 m @ 550 m/min	6:00
Carolina Int.	Raeford, NC	Intermediate	Mar 19-22, 2015	1	3600 m @ 550 m/min	6:10
Rocking Horse Spring II	Altoona, FL	Preliminary	Mar 27-29, 2015	3	3120 m @ 520 m/min	5:59
Poplar Place	Hamilton, GA	Preliminary	Mar 19-22, 2015	2	2730 m @ 520 m/min	5:41
Red Hills	Tallahassee, FL	CIC 1*	Mar 5-8, 2015	1	3100 m @ 520 m/min	5:24
Carolina Int.	Raeford, NC	Training	Mar 19-22. 2015	2	2400 m @ 450 m/min	5:47
The Fork	Norwood, NC	Training	Apr 1-5, 2015	2	2400 m @ 470 m/min	5:14
Rocking Horse Spring II	Altoona, FL	Training	Mar 27-29, 2015	4	2400 m @ 450 m/min	5:30
Rocking Horse III	Altoona, FL	Training	Feb 27-Mar 1, 2015	1	2400 m @ 450 m/min	5:25

Measurements

Heart rate, velocity, distance, and altitude were measured in the horses during the cross-country phase of each competition. Measurements began when the riders mounted their horses and included the warm-up and cross-country portion of the ride. These measurements were collected using a smartphone app, KER ClockIt Sport (Kentucky Equine Research), which was installed on the rider's iOS phone. A Bluetooth-equipped heart-rate monitor (Polar H7) was used to measure and transmit heart rate to the phone app. At the conclusion of each exercise session, data were uploaded to a web-based database where they were stored for later analysis.

Blood samples were also taken 5 minutes post-exercise from 11 horses that competed in the advanced and CIC*** divisions of the 2015 International Horse Trials at The Fork, Norwood,

North Carolina, in early April. Plasma was harvested from the blood samples and analyzed for lactate.

Results

Exercise Intensity (Heart Rate)

Exercise intensity for each level of competition is shown in Table 3 and Figure 2. These are expressed as the mean number of minutes the horse's HR remained in one of six heart-rate (HR) zones during each session. HR zones are expressed as a % of maximal HR (HRmax), which was assumed to be 220 bpm.

Zone 1: < 50% of HRmax (<110 bpm)
Zone 2: 50-60% of HRmax (110-130 bpm)
Zone 3: 60-70% HR max (130-150 bpm)
Zone 4: 70-80% HRmax (150-175 bpm)
Zone 5: 80-90% HRmax (175-200 bpm)
Zone 6: > 90% HRmax (> 200 bpm)

These HR zones were developed based on multiple studies conducted at Kentucky Equine Research that have shown that HR is highly correlated with both oxygen consumption (aerobic metabolism) and lactate production (anaerobic metabolism) during exercise on a high-speed treadmill. There is a linear relationship between HR and oxygen consumption. Conversely, blood lactate accumulation does not rise linearly. Instead, lactate accumulation remains low until HR reaches about 175-180 bpm, which is approximately 80% of maximum HR (HRmax), and then lactate increases exponentially as HR approaches a maximum of 220 bpm (Figure 1). HR zone 5 signals the onset of blood lactate accumulation, when there begins to be a significant level of anaerobic energy generation, and zone 6 represents an intensity that will result in fatigue-inducing levels of lactate accumulation.

Figure 1. HR-Lactate relationship in 5 Thoroughbred horses performing a standardized exercise test on a high-speed treadmill.

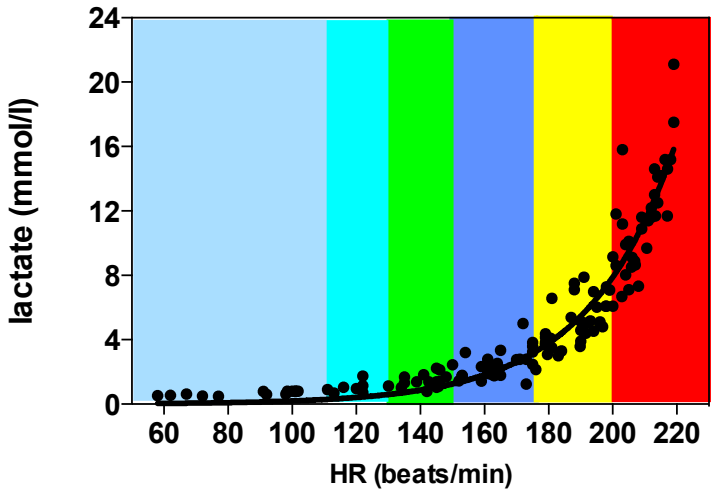
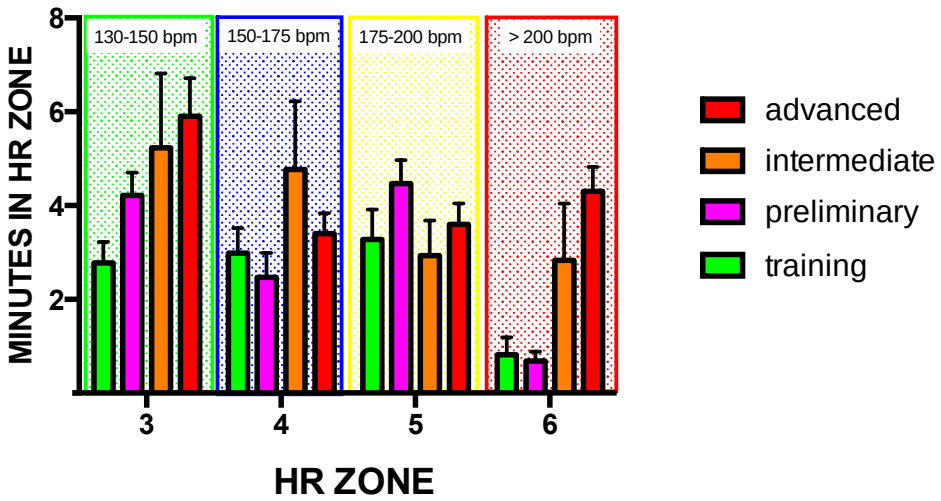


Table 3. Exercise intensity during cross-country phase expressed as minutes in each HR zone for each level of competition (mean ± SD)(n=total number of sessions measured).

Zone	% HRmax	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n
		Training			Preliminary			Intermediate			Advanced		
1	<50%	16.53	9.40	9	30.80	7.08	6	33.62	22.33	3	20.4	6.42	14
2	50%-60%	4.17	1.78	9	4.08	0.87	6	14.75	15.80	3	7.1	3.72	14
3	60%-70%	2.78	1.33	9	4.22	1.18	6	5.23	2.75	3	5.9	3.05	14
4	70%-80%	2.98	1.61	9	2.47	1.27	6	4.77	2.52	3	3.4	1.63	14
5	80%-90%	3.28	1.90	9	4.47	1.22	6	2.93	1.30	3	3.6	1.67	14
6	>90%	0.82	1.10	9	0.68	0.50	6	2.83	2.10	3	4.3	1.97	14

Figure 2. Exercise intensity during cross-country phase expressed as minutes in HR zones 3-6 for each level of competition (mean ± SEM).



The data in Table 4 and Figure 2 include the HR data from the warm-up period before cross-country. Warm-up typically lasted 30-45 minutes. In all 17 horses competing at the Intermediate and Advanced levels, the HR remained entirely in zones 5 and 6 during the actual cross-country phase of the competition. Advanced horses spent significantly more time in HR zone 6 than either the Training or Intermediate horses ($p<.05$). There was no significant difference in how much time each level spent in HR zones 4 and 5.

Plasma Lactate and Heart Rate

Plasma lactate averaged 9.88 ± 1.21 mmol/l (mean ± SEM) in the post-exercise blood samples taken from the 11 horses competing at The Fork advanced and CIC*** competition.

Lactate was lower ($p<.05$) in the Irish Sport Horses (9.07 ± 1.28 mmol/l) (n=6) compared to the Warmbloods (14.15± 1.83 mmol/l) (n=3) in this group. The Irish Sport Horses spent 3.61 ± 0.77 minutes in HR zone 6 during cross-country compared to 4.91 ± 0.94 minutes for the Warmbloods (Holsteiner and Oldenburg).

There was a significant negative correlation (-0.55)($P<.05$) between the number of minutes the horse's HR remained in zone 5 during cross-country and post-exercise plasma lactate, and there was a trend towards a positive correlation (0.44)($p=.09$) between the number of minutes the horse's remained in zone 6 (>200 bpm) and post-exercise plasma lactate. There was a significant positive correlation ($r=0.61$) ($p<.05$) between the ratio of time the horse's HR remained in zone 6 versus zone 5 and post-exercise lactate. In other words, horses that ran around cross-country with lower HRs (HR in zone 5 more than zone 6) tended to accumulate less lactate.

Discussion

This study showed that during the cross-country phase of early-season events, horses exercise in HR zones that are indicative of anaerobic energy generation and blood lactate accumulation. This was the case in all levels of competition studied including Training level. At the higher levels of competition (Intermediate and Advanced), the horses spent the entire duration of their cross-country rounds with HR above 175 bpm and much of the time with HR above 200 bpm. Advanced horses accumulated significant levels of lactate during cross-country and the amount was correlated with their HR, with less lactate accumulating in horses that competed with lower HRs. In the Advanced group, where plasma lactate was measured, Irish Sport Horses accumulated less lactate than Warmbloods (Holsteiner and Oldenburg). The numbers represented for each breed were small (6 and 3), and more data are needed to draw concrete conclusions, but this raises an interesting question about metabolic differences between breeds.

There are numerous questions that still remain unanswered about exercise intensity in eventers. What is the relationship between HR/lactate and performance during a competition (time faults or jumping penalties)? What is the relationship between previous training intensity and performance during a competition? What is the relationship between previous training intensity and incidence of injury during training and competition?

The present study did not answer these questions, but it demonstrated that measuring exercise intensity during competition is possible and practical by combining the use of the KER Clockit Sport smartphone app with an on-board heart rate monitor and post-exercise blood samples.

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