POLAR SPORT ZONES FOR HORSES

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1 Introduction

This paper was written in order to clarify and to provide guidelines regarding training principles for different equestrian athletic disciplines and to give recommendations on the use of heart rate monitoring in training of horses in format of sport zones.

The horse is genetically predisposed to be a top athlete. Through centuries-long breeding selection the horse developed from a herd animal that runs from danger into a highly specialised high-performance athlete, equipped with extraordinary athletic capacities (Table 1).

Table 1: Physiologic data at rest vs. maximal exercise of a horse

	at rest	under maximal work load	incremental factor
Heart rate [1/min]	24–32	210–240	8-10 x
Cardiac output [L/min]	29	310	>10 x
Haematocrit [%]	32–46	60–65	2 x
Respiration rate [1/min]	12–16	120–135	>10 x
Minute ventilation [L/min]	80–95	1600–1900	20 x
Peak flow [l/s]	4–6	85–100	16-20 x
Blood lactate concentration [mmol/L]	0.5	20-30	40-60 x

Because horses are inherently highly developed athletes, for maximum effectiveness, training needs to reflect the demands of the respective sports discipline for which the horse is used and must be

tailored carefully regarding exercise intensities, durations and frequencies. An individually tailored training plan is the key factor for athletic success. Adoption of new techniques in training, fitness assessment, and routine monitoring of athletic horses in training can all contribute to producing fitter athletes with lower rates of injury and risk of overtraining.

Every athlete can benefit from accurate physiological data to guide and monitor its training for maximal effectiveness. Equine heart rate (HR) monitors are very reliable and, combined with a GPS system, can yield for horses important information regarding their daily training and competition[1]. Furthermore, detailed long-term documentation of the horse's training sessions can potentially give a greater insight into the types of training that predispose a horse to injury or overtraining.

In horses, as well as in humans, heart rate increases linearly with increasing workload. Endurance training lowers the heart rate at a given speed; however, maximal heart rate (HR_{max}) is not substantially influenced by training. In relation to performance, it is known that elevated heart rates either during exercise or in the recovery period indicate pain, lameness, fatigue, hyperthermia or dehydration, and has to be interpreted as a warning sign.

While in humans a wide variety of exercise-testing methods exist, each optimised for specific sports disciplines[2], in horses, exercise testing is normally confined to the assessment of endurance capacity[3]. Accordingly, measurements of heart rate and blood lactic acid concentration are the principal methods used in field situations and laboratory measurements on a treadmill.

In order to define for each horse individually exercise intensity zones relating to specific training goals, at least one of two reference parameters needs to be known: HR_{max} and/or the heart rate at which lactate starts to accumulate in the blood (onset of blood lactate accumulation (OBLA)). These indices allow target HR values to be adjusted to an individual horse's HR_{max} and aerobic capacity. However, from a practical point of view the determination of those values is not easy.

A review and analysis of the current scientific literature on equine exercise physiology, testing and training was made to validate the concept and create evidence-based "Polar Sport Zones for horses". The evaluation is based on a literature review and on experimental exercise physiologic data of the University of Zurich and gives recommendations on the use of heart rate monitoring during horse training presented in the format of Sport Zones.

Unfortunately, background information such as reference values for horses of different equestrian sports disciplines and different testing procedures is largely lacking, preventing effective use of performance parameters for evaluating training exercise intensity and refining training plans. A key issue limiting cross-referencing of performance testing data is the lack of standardisation of the way performance tests in horses are conducted.

2 Principles of Polar Sport Zones for horses

Polar Sport Zones for horses introduces a new level of effectiveness in heart rate-based training. It aims primarily to assist horse owners, riders and trainers in heart rate-monitored horse training and consequently to adapt training programs individually to a specific horse and equestrian discipline (Table 2). The final goal was to provide a gradation of training intensity reflecting the specific focus of the training such as endurance capacity or high-speed sprinting. Furthermore, the zones can be

adapted to an individual horse taking into account age, gender and the equestrian discipline in which the horse competes.

Table 2: Equestrian athletic disciplines and physical demands

	description	**abilities**
Horseracing *Thoroughbred* *Standardbred*	**Flat racing:** runs over distances from <1 to 3.2 km on a natural grass surface (turf), sand or on a synthetic surface (all-weather). Horses start racing as 2-year-olds. Thoroughbreds dominate. **Hurdling:** distances of 3.2 to 5.6 km over hurdles of ca. 1 m height. Horses must be at least 3 years old. **Steeplechase:** distances of 3.2 to 7.2 km over fences of ca. 1.40 m height. Horses are at least 3 years old. **Cross-Country:** about 5 km across the country-side and over fixed, mostly natural obstacles such as hedges, trunks and ponds. Horses are at least 4 years old. **Harness racing:** distances of 1.6 to 4.5 km at trot or pace. Horses usually pull a driver sitting on a two-wheeled cart called "sulky"; racing under saddle (trot monté) is also practised in Europe. Standardbreds dominate. Horses start racing as 2-year-olds.	Successful racehorses must be able to accelerate quickly, maintain an efficient movement pattern, cruise at high speeds, and sprint quickly over 200-600 metres at the finish. Steepler and Hurdler depend on acceleration, the ability to run at high speeds and to jump at the same time, as well as sprinting ability.
Eventing	Consists of three distinct tests: Dressage, Cross-Country and Jumping and is conducted over 3 or more days. There are 4 classes, increasing in length, speed and technical difficulty. The cross-country is the most physically demanding of the 3 disciplines. Any breed can compete, but Thoroughbreds and part-Thoroughbreds dominate. Horses must be at least 6 years old.	Success in competition necessitates superior stamina (cross-country), strength (for jumping), coordination and agility skills (dressage, jumping), and a capacity to recover quickly after the cross-country in preparation for the jumping competition.
Endurance	Controlled long-distance races over 80 to 160 km. Winning riders complete 160 km rides in 10-12 hours while stopping periodically to pass a veterinary check that deems the animal in good health and fit to continue. Shorter rides over 40 to 90 km are organised for novice riders or young horses. Any breed can compete, but Arabians dominate. Horses start as 5-year-olds.	An endurance horse must be able to run over long distances of 50-160 kilometres. Endurance and stamina are just as important as an efficient gait generating less heat during exercise.
Jumping	Horse and rider are required to complete a course of 10 to 13 jumps in the designed sequence without knock-downs or mistakes. Any breed can compete, but Warmbloods dominate. Horses must be at least 6 years old to start international competitions for young horses.	Although speed is low and duration relatively short, great efforts are demanded of a horse, requiring aerobic and anaerobic metabolism and testing its strength, coordination and agility.
Dressage	Horse and rider are expected to perform a series of predetermined movements, known as 'figures', in a flat, rectangular arena (60 x 20 m) at walk, trot and canter as well as smooth transitions within and between these gaits. A panel of five judges assesses the figures. Any breed may take part, but Warmbloods dominate. Horses start as 6-year-olds.	Used as the groundwork for all other equestrian disciplines and reflects the lowest metabolic demand and physiological stress. However, certain movements, e.g. Piaffe, may place unusual demands on the horse and require greater conditioning.

2.1. Interpretation of Polar Sport Zones for horses

Training in Sport Zone 1 (very light 30-60% of HR_{max} - recovery training/warm up) is done at a low intensity at 30-60% of HR_{max}. The main goal of this training is to allow the horse's body to recover from more strenuous training sessions or more intense exercise within the current session.

Sport Zone 2 (light 60-70% of HR_{max} - basic training) is commonly used for endurance training to enhance aerobic capacity, an essential part of training that is independent of the equestrian discipline of the horse. Training sessions in this zone are aerobic. Training of 40-80 minutes duration in this light zone increases the metabolism and strengthens the body so that the horse can tolerate higher intensity training.

Aerobic power is enhanced more rapidly in the moderate Sport Zone 3 (moderate 70-80% of HR_{max} - endurance training). The training intensity is higher than in Sport Zones 1 and 2, but still mainly aerobic. Training in Sport Zone 3 may, for example, consist of intervals followed by recovery periods. Exercising in this zone is especially effective for improving blood circulatory capacity of the heart and skeletal muscles.

To compete at maximal exercise intensities requires that a horse trains in Sport Zones 4 (hard 80-90% of HR_{max} - strenuous training) and 5 (maximum 90-100% of HR_{max} - sprint training). In these zones, the horse runs with a significant contribution of net anaerobic power. Sport Zone 4 is used to build up high-speed endurance (stamina) with short 2-3 minute intervals. The shorter the interval, the higher the intensity that can be attained. Sufficient recovery in Sport Zone 1 between intervals is very important.

Finally, at 90-100% of HR_{max}, the maximum Sport Zone 5 is used to increase maximum sprinting capacity and tune the neuromuscular system in short durations of up to 2 minutes.

The heart rate responds to exercise intensity and is additionally influenced by factors such as the horse's fitness and its recovery capacity, as well as environmental factors such as temperature and hydration status. It is essential when working horses at high intensity to be alert for subjective indices of fatigue of the horse, and to adjust the training program accordingly.

The recommendations spelled out above are summarised in a form that can be used in a future leaflet below (Table 3).

Table 3: Sport Zones 1-5 (Intensity in % of HR_{max})

SPORT ZONE 1: VERY LIGHT APPROX. 30-60% - RECOVERY TRAINING / WARM UP
Benefits: Improves overall health and promotes active recovery
Recommended for: Recovery training, rehabilitation, warm up and active recovery from more strenuous training sessions, an essential part of training independent of the equestrian discipline or breed of horse
Horse's heart rate: All breeds and disciplines up to about 140 beats per minute (bpm)
How: Walk and trot - recovery training for a total of 40-80 minutes duration or an initial warm up followed by an active recovery exercise of about 30 minutes
SPORT ZONE 2: LIGHT APPROX. 60-70% - BASIC TRAINING
Benefits: Improves basic endurance, increases the metabolism and strengthens the body so that the horse can tolerate higher intensity training
Recommended for: Aerobic endurance training, an essential part of training independent of the equestrian discipline or breed of horse
Horse's heart rate: Thoroughbreds, Standardbreds and Eventing horses up to about 160 bpm, Endurance horses and Warmbloods up to about 150 bpm
How: Walk, trot and slow canter - training of 40-80 minutes duration
SPORT ZONE 3: MODERATE APPROX. 70-80% - ENDURANCE TRAINING
Benefits: Enhances aerobic power
Recommended for: Mainly aerobic moderate training, an essential part of training independent of the equestrian discipline or breed of horse
Horse's heart rate: Thoroughbreds and Standardbreds between 160-190 bpm, Eventing horses between 160-170 bpm, Endurance horses and Warmbloods between 150-160 bpm
How: Canter - may consist of intervals followed by recovery periods; running in this zone is especially effective for improving blood circulatory capacity of the heart and skeletal muscles
SPORT ZONE 4: HARD APPROX. 80-90% - STRENUOUS TRAINING
Benefits: Build up high-speed endurance (stamina)
Recommended for: Development of anaerobic power for horses that compete at intensities eliciting lactate accumulation or at maximal intensities
Horse's heart rate: Thoroughbreds and Standardbreds around 200 bpm, Eventing horses around 190 bpm, Endurance horses and Warmbloods around 180 bpm
How: Fast trot/gallop - up to 4-6 intervals of short durations of 2-3 minutes; the shorter the interval, the higher the intensity; appropriate warm-up in zones 1-3 and sufficient recovery between intervals are very important
SPORT ZONE 5: MAXIMUM 90-100% - SPRINT TRAINING
Benefits: Increases maximum sprinting capacity and tunes the neuromuscular system
Recommended for: Enhance anaerobic capacity; only for well-preconditioned horses
Horse's heart rate: Maximal heart rate
How: Fast trot/gallop - short duration of up to 2 minutes after an appropriate warm-up in zones 1-3

2.2. Validity of Polar Sport Zones for horses

The classification of Sport Zones ideally relies on information such as the horse's individual HR_{max} and/or the exercise intensity required eliciting OBLA.

The anaerobic threshold concept determined in humans in the 1980s has been adopted for use in the horse[4]. Training at the threshold has been found to improve aerobic capacity in humans[5]; however, this assumption has not been verified yet in horses.

HR_{max} is the highest number of heart beats per minute (bpm) that a horse can achieve during maximal physical exercise. It varies between individuals and decreases with age[6]. The effects on HR_{max} of variables, such as hereditary factors, breed, gender, body weight and fitness level are unknown. It may also vary according to sports discipline performed[7]. Percent HR_{max} is used to express relative exercise intensity.

A horse's HR_{max} can be determined in several ways. The most accurate way is to have its HR_{max} clinically measured, usually by a treadmill or field incremental exercise test supervised by a veterinarian. However, HR_{max} can also be estimated by using the reported equation: 223 – 0.9 x age (years)[8], although research shows that this method is not very accurate. The Polar Sport Zones can be individualised to a certain degree by knowing the HR_{max} value of a horse to calculate the HR values that represent the percentages of HR_{max} that define the Polar Sport Zones.Gender also influences heart rates during training with higher heart rates reported in mares than in geldings or stallions[9].

Due to the extensive data required and impracticality of typical users being able to define for each horse these key parameters, an alternative approach was chosen to base the Polar Sport Zones on data gathered from the current scientific and veterinary literature.

2.3. Reliability of Polar Sport Zones for horses

Over the last 40 years much research has been conducted on exercise physiology of equine athletes. Some of these studies aimed to optimise training methods for improving performance capacity. Such improvements depend not only on the amount of training but also, above all, on the quality of training. The basic training or general conditioning of the horse, valid for all forms of sports, improves a number of physical and health parameters. Discipline-specific training and testing lead to considerable improvements in competitive performance. In order to provide specific guidelines for training regimes targeted toward particular competitive events, it is essential to have knowledge of the discipline-specific requirements relevant to performance, as well as test procedures that cover these parameters and allow a classification of results. As in humans, the athletic potential is a combination of different factors that can be roughly divided into endurance, speed, strength, agility and coordination. These parameters are specifically enhanced through training for each equestrian discipline. It is obvious that some of these abilities, such as strength or coordination, are difficult to directly assess and quantify in the horse. However, the assessment of aerobic capacity is relatively easy to perform with the use of exercise tests. According to Evans[3], more large-scale studies are required of horses in normal training programs if practical measurements of fitness and predictors of performance are to be determined. However, no measurement or combination of measurements will ever be perfectly able to predict the ability to perform. Nevertheless, results of appropriate fitness tests can help in making decisions by horse owners and trainers concerning the training and use of horses in competitions or races. Table 4 gives a refined recommendation for classification of sport zones in horses based on data from the literature and distinguishing different sports disciplines. For more reliable classification, further studies are necessary using a standardised testing procedure that can be cross-referenced between disciplines. Furthermore, the equestrian sports disciplines Polo, Driving, Vaulting, Gaited Horse competitions and Western Sports disciplines are not considered in this report as scientific data are not available.

Table 4: Polar Sport Zones for horses according to equestrian disciplines

	Racing horses	**Eventing horses**	**Endurance horses**	**Jumping and Dressage horses**
Recovery Zone	Up to 140 bpm	Up to 140 bpm	Up to 140 bpm	Up to 140 bpm
Moderate Zone	140-160 bpm	140-160 bpm	140-150 bpm	140-150 bpm
Aerobic Zone	160-190 bpm	160-170 bpm	150-160 bpm	150-160 bpm
Threshold Zone	around 200 bpm	around 190 bpm	around 180 bpm	around 180 bpm
Maximal Zone	HR_{max}	HR_{max}	HR_{max}	HR_{max}

3 Conclusions

3.1. Advantages of using Polar Sport Zones for horses

Training with Polar Sport Zones is straightforward. Polar Sport Zones are easy to follow so horses can safely and effectively be prepared for their competitions with the possibility of adjusting continuously the intensity of training according to the actual training content and based on the horse's individual development and response to training.

Polar Sport Zones for horses will appeal to horse trainers who are interested in adopting new methods that are soundly based on scientific evidence, rather than on hearsay, hope or tradition. Nevertheless, the conclusion from the study of the currently available scientific literature shows that further research is still needed if more precise definitions of the most effective "Polar Sport Zones" for different equine disciplines are to be made. This is particularly true if the influences of factors, e.g., age and gender are to be incorporated.

Monitoring physiological response to exercise in training and competition of sport horses can lead to more optimal training programs in terms of adjusting the intensity and duration of training individually, by placing a defined stimulus on the energy metabolism, and avoiding a failure of training or lack of adaptation due to either excessive or insufficient stimulus on the body.

3.2. Limitations of using Polar Sport Zones for horses

Heart rate is an internal indicator of relative exercise intensity that also takes into account external factors such as deep going or environmental conditions. Nevertheless, it is indispensable when overseeing a training program to be alert for indications of fatigue of the horse, and to adjust the training program accordingly. In particular, one needs to be sensitive to soundness, given especially that lameness can elevate heart rate above normal and can influence the horse's willingness to work.

Horses should only undergo training that matches their physical capabilities and level of maturity for their respective disciplines. Frequently, compromises need to be made in training between successful effects on performance and potential injurious effects that might compromise the horse's welfare.

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