Different training methods of endurance horses in the off-season and how this affects aerobic fitness

Olika träningsmetoder under vilosäsongen och hur det påverkar distanshästars kondition

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Abstract

Little is known about how the aerobic capacity of endurance horses responds to retraining, rest, and detraining. In this study, 22 Swedish endurance horses, mainly Arabian horses and Arabian crosses, were followed for 23 weeks during the off-season in the winter. Data collected consisted of resting HR, recovery HR, resting respiratory rate, body condition score and HR in exercise to determine V100 as measurements of aerobic fitness by the means of a standardised exercise test. Horses were divided to have been resting, trained on lower intensity or trained on normal intensity in comparison with training efforts during the competition season. Horses were also divided depending on their prior competition achievements. The aim of the study was to investigate how different training strategies affect the aerobic fitness of endurance horses, in order to get a better understanding how to train and manage the endurance horse for optimal performance. Four horses went through a resting period of 7-14 weeks. After 7 weeks of rest, no changes in aerobic fitness was measured, whereas after a 10-week rest, horses showed a minor decrease in V100. After 14 weeks of rest, one horse showed a 17% decrease in V100 and an increased resting and recovery HR. The horses resting for 7-10 weeks increased in V100 after their resting period and improved with up to 24% from the initial pre-resting measurements. Horses trained at normal intensity showed higher recovery HR at the later stage in the collection period - suggesting potential lowered aerobic capacity after long-term training -, but otherwise horses trained at lower or normal intensity showed no changes in aerobic fitness throughout the project. Horses at higher competition levels had a tendency for lower rest HR, quicker recovery HR and a higher V100. Horses with a body condition score under 4 out of 9 were more prone to a decrease of aerobic fitness. Respiratory values did not change whatsoever during the collection period in any of the horses. Combining previous literature and the findings from this study, it can be concluded that endurance horses can be rested for 6 weeks without losing aerobic fitness, however more research is necessary to draw stronger conclusions on this topic.

Preface

I want to thank all the riders who participated for opening their doors to me and making this project an unforgettable experience. It has filled me with motivation for the future and hungry for finding more scientific approaches within our beautiful sport of endurance riding.

This project has been long in the making, starting with just a small, slightly unrealistic idea in 2016. Due to the freedom from the university and the back-up and experience of my supervisor Anna Jansson I have been allowed to form this idea into the Master thesis it became. I hope that the results I found in this project can be used in practice by riders and trainers in endurance riding. Enjoy!

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Abbreviations

BCS - Body condition score
HR - Heart rate
SET - Standard Exercise Test
V100 - Velocity (m/min) at which heart rates reach 100 beats per min
VLA^4 - Velocity (m/min) at which blood lactate reached 4 mmol/L
VO_2max - The maximum rate of oxygen consumption in millilitres of oxygen consumed per minute, per kilogram of body weight (mL/kg/min)

Chapter 1 Introduction

1.1 Introduction

Endurance riding is also known as 'the equestrian's marathon', where horse and rider compete in long-distance events of up to 160 km in one day. Covering long distances on horseback is an age-old tradition, however, endurance riding as we know it today has its roots in the 1950s in the USA, where it was initially part of a horse's military training. It was later made into a competitive sport, and in the 1960s it was brought over to Europe. In Sweden, the first endurance race dates back to 1977, with the first Swedish Championships being ridden in 1987 (Lönas, 2015). In Sweden endurance competitions consist of distances from 40 km up to 160 km in one day with racing speeds between 10 - 20 kph.

To be a successful endurance competitor, the horse needs to be in optimal fitness to withstand the pressure of running such long distances and prevent injuries and disease. Due to the relatively slow nature of endurance riding, aerobic fitness is of high importance, with up to 95% of energy during a race coming from aerobic pathways (Barnes, 2014; Marlin & Nankervis, 2002). To successfully comply to this, horses with a high proportion of type I muscle fibres (long, slow twitch fibres) will be most suitable for this sport (Barnes, 2014; Evans, 2000; Marlin & Nankervis, 2002). Other qualities of top performing endurance horses are smooth, long strided gaits, strong legs and feet, a big heart and a forward-thinking character, according to Marlin and Nankervis (2002).

In Sweden, the competition season is focused on the spring, summer and early autumn, with little to no races held between November and March. Generally, the off-season in winter is used for recovery and preparation for the next competition season. Several studies have been conducted on the conditioning of endurance horses (Fraipont *et al.,* 2012; Trilk *et al.,* 2002; Barnes, 2014) but very little is known on strategies during the off-season and the effect of resting periods. Anecdotal observations indicate a wide array of different training strategies, including resting for some weeks up to a couple of months, cross-training, or lowering the training intensity of the horses. Recovery and training strategies differ between riders and there is currently no research on the effects of these different strategies on endurance horses.

Studies suggest that horses do not immediately loose fitness after being rested for several weeks (Essén-Gustavsson, et al., 1989; Kriz, *et al.*, 2000; Serrano, *et al.*, 2000; Tyler, *et al.*, 1996; and Tyler *et al.*, 1998). This is however hard to say, as there are so many different systems involved into the concept of 'fitness', and mixed results have also been seen in different studies. In this project, the main assessment of fitness will be based on heart rate: V100 (velocity when heart rate is 100 bpm) and heart rate recovery. Heart rate (HR) is strongly linked with a horse's fitness (Poole & Erickson, 2004): working heart rate levels will be lower and recovery quicker in trained horses versus untrained horses (Marlin & Nankervis, 2002). Barnes (2014), Clayton (1991), Marlin & Nankervis (2002) and Robert (2014) give advice that horses can be rested for several weeks to one month without showing loss of cardiovascular fitness. Flaminio *et al.* (1996) mention that a resting period can have great benefits for endurance horses, but lacks further explanation. No prior research has been done on the benefits of long-term resting periods, but recovery periods of 2-3 days after a hard workout are recommended as they allow the horse to replenish its energy stores, repair damaged cell tissue, adapt and strengthen to the stress of training and lowers the risk of overtraining (Barnes, 2014 and Evans, 2000).

For my Master thesis I want to investigate how different training strategies, and especially the use of rest, affect the aerobic fitness and performance of endurance horses during the off-season.

By looking at a horse's heart rate, respiration rate, recovery, V100, body condition and general health, more knowledge can be obtained on how to train and manage endurance horses for optimal performance. This will be valuable information for riders and trainers to provide horses with an ideal preparation for the upcoming competition season. This can in turn lead to fewer injuries and less over- or undertrained horses on the competition grounds, improving animal welfare.

1.2 Objectives

The objective of this project is to follow a group of endurance horses and track their aerobic fitness and health over the course of several months during the off-season. The main research question to fulfil this objective is: *'How will different training and de-training strategies affect the endurance horse's aerobic fitness and health in the off-season?'.* To aid in answering the main question, the following sub-questions were designed:

- How is the detraining period designed in Swedish endurance horses?
- What is the effect of detraining and rest on the horse's aerobic fitness?
- What is the effect of different types of training on the horse's aerobic fitness?

1.3 Hypothesis

It is expected that a period of 4-6 weeks of full rest in the field will not show any loss of aerobic fitness (V100) in the endurance horse. After this period, loss of aerobic fitness might occur.

Chapter 2 Literature Review

In this literature review, a closer look will be taken at the fundamental basis of training endurance horses. The general training of endurance horses will be discussed, as well as de- and retraining and how a resting period can affect the horse. Besides this, a short overview will be given on the currently known effects of diet, body condition and housing on performance.

2.1 Principles of training for endurance

To date, there is little scientific data on specifically training of endurance horses. However, there is a high amount of research on general training principles of horse training, as well as a lot of practical knowledge to find from trainers. It is often seen in practice that the training for an endurance ride highly resembles the training that a runner does for a marathon, with focussing most training time on long and slow sessions. A study from New Zealand by Webb *et al*. (2020) confirms this and shows that 78% of all training consists of long, slow rides with an average speed of 8 kph. Other forms of training included unridden work and schooling. It was found that riding competitions were a big part of the training for these horses, where competing kilometres accounted for 44% of the total ridden distance of a nine month training cycle. Unfortunately, the paper did not discuss in more depth the distance, speed, intensity and variation of individual training sessions. Another article that discussed endurance training is by Goachet & Julliand in 2011, who trained endurance horses for several years using scientific methods. Their training methods include 2-3 outdoor rides per week in different speeds and distances (8-13 kph, 12-30 km), 2-hour canter training on a track (18-20 kph) and sessions in a horse walker, the latter two only for horses performing in 130-160 km competitions. The horses were competed up to 60 km in the first year of training, 90 km in the second, and up to 160 km after three years of conditioning. The authors mention a lack of scientific data and knowledge on training endurance horses, and therefore used their own personal experiences.

The goal with training an endurance horse is to be able to cover a long distance in a relative low speed, using mainly aerobic energy sources. Several authors (AERC, *n.d.*, retrieved 05/2021; Barnes, 2014; Evans, 2000; Kentucky Equine Research, *n.d.*, retrieved 05/2021 and Kohnke, *n.d.,* retrieved 05/2021) have mentioned that the key to a successful training program is to start with short and slow rides of mainly walk and some slow trotting for the first several months. This allows the horse to adapt and strengthen its aerobic fitness: it stimulates the oxygen uptake capacity and boosts the aerobic capacity of the muscular, respiratory and cardiovascular systems (Barnes, 2014). Long and slow exercise will strengthen ligaments and bones before more intense sessions will be incorporated into the training plan. After this ‘base phase’, the training will be elevated to introduce longer distances and faster speeds. Multiple sources (Clayton, 1993; Evans, 2000 and Kohnke, *n.d)* note that the training should be adjusted gradually, with increasing either speed or distance every 10-20 days. This will provide the horse with a training stimulus and promote improvement of aerobic systems, while allowing the body to adjust to the work and not become overtrained. Most endurance horses will be able to trot for several hours in a row without needing a break. It is often seen in practice that when reaching a competition level of 80+ kilometres, canter training is introduced into the training plan (personal communication with multiple endurance riders). During a canter training, horses will be cantered for one to two hours on a speed of 18-30 kph (personal communication and Robert *et al.*, 2011). There is no literature on the reasons or benefits of canter training for endurance horses, but it can be assumed that it will increase aerobic fitness following aspects of exercise and training physiology.

2.1.1 Determining fitness in endurance horses

A handful of studies have been conducted to see how fitness can be determined in endurance horses. Most of these have been executed in the field, especially on race tracks, but some exercise tests have also been done on treadmills. Most studies (Castejón-Riber, 2014; Cottin *et al.*, 2010 and Van Oldruitenborgh-Oosterbaan *et al.*, 1987) have chosen to perform 5-6 short ridden intervals (800-1200 m or 3-4 minutes), where each interval shows an increase in intensity in either speed or HR.

Fraipont *et al.* (2011) chose a more unique design for their Standardised Exercise Test (SET), by first cantering for 27 km at 22 kph, to then increase the speed up to 27 and 32 kph for 1500 m in two interval bouts. This strategy was chosen to mimic an endurance race and to get a clearer picture to what the horses undergo during a competition. It was mentioned that this SET took about 2 hours to completely perform. Fraipont *et al.* also executed a treadmill exercise test with shorter interval bouts of 3 minutes of different speeds, showing comparable results to the field exercise test. The authors mentioned that it was easier to conduct the field study for both the horses (no need to acclimate to a treadmill) and the researchers (easier to conduct with only little equipment), whilst giving useful results.

It has been mentioned in both research (Fraipont et al, 2012) and in practice (personal communication) that it is hard for experienced endurance horses to reach the common parameters of aerobic fitness testing, VLA^4 or HR200, as riders do not want to ride at the faster speeds needed to reach these numbers.

2.2 Detraining

The term detraining means “the partial or complete loss of training-induced adaptations, in response to an insufficient training stimulus” (Mujika & Padilla, 2000). In the literature used in this review, detraining occurs after trained has ceased and horses are confined to boxrest or live in a paddock with free movement. Horses are not trained at all in a detraining period, but exercise occurs through free movement and participation in SETs.

VO_2max is one of the most common measurement to assess fitness. Art & Lekeux (1993) and Knight *et al*. (1991) have found that after as quick as three weeks of inactivity the VO_2max levels had returned to pre-training values. However, Tyler *et al.* in 1996 and 1998 showed that there was no reduction in VO_2max until after the sixth week of detraining. After 12 weeks of detraining, levels had gone down to 8%, but they were still 15% higher than pre-training values. In the studies by Knight *et al*. and Tyler *et al*. horses were exercised every two weeks to perform a SET. In the studies by Art & Lekeux and Knight, the horses were only trained for a mere 2-6 weeks, whereas in Tyler *et al.*’s studies the horses were trained for 34 weeks (8 months). This could mean that a stronger foundation of training, means longer-lasting effects of fitness.

In a study on cardiovascular function, Kriz et al. (2000) found that well-trained Standardbreds show a reduction of cardiac dimension and function after 4 weeks of detraining, where the horses were also checked at 1.5 week of detraining with no differences found. No other studies have looked at cardiovascular properties in such short timeframes, as most studies have only one check up after 10-12 weeks of detraining (McKeever & Lehnhard, 2013; Mukai et al., 2006; Mukai et al., 2017; Tyler et al., 1996).

The musculoskeletal system takes more time to be affected by detraining. Studies by Essén-Gustavsson *et al.* (1989) and Tyler *et al.* (1997) show no alteration in muscle fibre characteristics, capillarisation or oxidative capacity of the muscle after 5-6 weeks of detraining. Only after a 12 week resting period a change in capillary and mitochondrial density was found by Poole & Erickson (2008). In most papers, the detraining period is a small part of the full research, and only one time-stamp of detraining is taken. Due to this, the rate or amount of muscular change is usually not studied in great detail.

Little information is found on how other systems respond to detraining. It has been mentioned by Hutchins et al. (1987) and Nunmaker (2002) that bones show reduced strength in horses that are casted or suspended due to severe orthopaedic injuries. Porr et al. (1998) found that bone mineral content decreases by 0.45% per week in well-trained horses confined to a 12 week box rest. McKeever and Lehnard mention in *'The Athletic Horse'* (2013) that bone-, tendon- and ligament strength might be lowered by detraining, but no further research is available to back-up this statement.

2.3 Rest

Surprisingly little research has been done to the effects of long-term rest in horses. It can be assumed that all the systems in the body deteriorate to a certain level where it just maintains itself. McKeever and Lehnard (2013) state that "without the regular occurrence of exercise-induced stress (training), there is neither a structural need nor a metabolic need for the central or peripheral systems associated with performance to exceed their normal, un-trained capacities."

It can be expected that the following happens when the horse is resting: muscle mass and aerobic fitness decreases and the overall efficiency of the cardiovascular and musculoskeletal systems declines. On the other side, by allowing the horse to rest for a long period of time, the body gets time to heal and recover from training. The typical training of endurance horses, running a high mileage for extended periods of time, may cause damage to the locomotor system, including (stress) fractures (Misheff *et al.*, 2010), as well as gastric ulcers (Tamzali, *et al.* 2011) and respiratory disease (Fraipont *et al.*, 2011).

2.4 Retraining

Retraining is, as the name suggest, the process of bringing the horse back into training after a period of rest. Most research of training horses is focused on starting horses from a long, complete rest, or young horses that have never been trained before, and not on re-training horses after a shorter break. For well-trained and experienced endurance horses results in retraining may differ in practice, as it can be assumed that trained horses maintain fitness and condition for longer periods of time than untrained horses as mentioned before. Besides this, there are many variables connected to successful training response, such as age, nutrition, housing, recovery, and the genetic make-up of the horse.

As with rapid decrease by detraining, the oxygen uptake also increases quickly when training has begun again. Improvements of VO_2max have been analysed in many studies, increasing with 10% in only 2 weeks (Knight *et al.*, 2006), building up to 23% in 7 weeks (Evans & Rose, 2007), 25% in 6 weeks (Art & Lekeux, 1993) and 29% in 9 weeks (Tyler *et al.*, 1996) of endurance training. It can thus be assumed that VO_2max increases further as training progresses. However,

Knight *et al.*'s study (1993) also showed that with no increase in training effort, VO_2max also does not increase further.

Besides an improvement in VO_2max, there is a lack of other pulmonary adaptations caused by training. The above-mentioned papers showed no significant changes in minute ventilation, respiratory frequency or tidal volume after several weeks of training. Conclusions are drawn by these authors that the respiratory system cannot be trained and adapted like the cardiac and musculoskeletal system, and is the one major limitation to further equine performance.

Both the cardiovascular and musculoskeletal systems are known to be incredibly responsive to training (Poole & Erickson, 2014). A literature overview written by Evans in 1985 showed that already back then many studies had been done on a horse's cardiovascular response to training, with differing results. Evans concluded that a horse's heart rate lowers during sub-maximal exercise after a training period of five weeks (Rodiek et al., 1982; Thomas et al., 1983 and Thornton, 1983), as well the resting heart rate in horses subjected to sub-maximal endurance training for 7-8 weeks (Marsland, 1968 and Betros et al., 2013) and trotting training (Ringmark, 2015). Besides changes in heart rate, the size of the heart itself increases with training (Kubo et al., 1974), as well as improved cardiac output, elevated stroke volume (Poole & Erickson, 2014) and a delayed onset of lactic acid in the muscle. In yet another study by Evans (et al., 1995), it was found that V_{LA4} increased after just one week of training, regardless of the type of training the horse had received.

One of the first changes in the musculoskeletal system that can be seen is the increase of glycogen levels by 10-15% after only one to two weeks of very high intensity training, followed by improvements in capillarisation and oxidative capacity between 5-7 weeks of training (Essén-Gustavsson *et al.*, 1989 and Henckel, 1983).

Muscle fibre composition goes through a number of changes when training has started in young or green horses, but it also depends on the type of training. It is of general knowledge that endurance activities affects the slow-twitch, highly oxidate type I muscle fibres, whereas sprint training adjusts the stronger, low oxidative fast-twitch type II^B/IIx fibres. II^A fibre types fall in between type I and II^B, having moderate strength and moderate oxygen usage, making it flexible in its use and possibility to be adapted through training (Marlin & Nankervis, 2002 and Valberg, 2013). Research shows that endurance horses with more successful performance had a higher percentage of type I and II^A muscle fibres (Rivero *et al.*, 1993). A handful of studies (Gondim *et al.*, 2005; Rivero *et al.*, 2001; Serrano *et al.*, 2000 and Tyler *et al.*, 1998) shows that endurance training decreases type II^B muscle fibres, while increasing type I and II^A fibres after a 3-month period. After 8 months of endurance training in a study performed by Serrano *et al.* (2000) horses increased muscle fibre type I by 21%, type II^A by 12% and a large decrease of type II^B was seen with 35%. Improvements in muscle capillarisation and oxidative capacity were seen after 5-7 weeks of high-intensity training (Essén-Gustavsson *et al.*, 1989 and Henckel, 1983).

Most, if not all studies on the adaptation on bone, tendon, joint and other cartilage tissue show an extremely high adaptation rate to exercise in horses under two years of age (Cherdchutham *et al.*, 1999 and Firth, 2006). It is said that these tissues almost fully mature around two years of age and will not see much adaptation through training after this point.

2.5 Maintenance

Besides training, there is a lot more that can influence a horse's performance. In this study, the horse's body condition, diet and housing will also be looked into. In recent years there has been concern by the public on the weight of endurance horses after pictures were spread of underweight horses in desert races. Two studies (Garlinghouse & Burrill, 1999 and Barnes *et al.*, 2010) focused on the body condition of endurance horses, saw that the horses that were excluded of a 160 km race for metabolic reasons had a lower body weight / body condition score than horses excluded for other causes, with average body condition scores of 4.6, 3.8 and 2.9 on the Henneke scale (1-9) for finished, excluded and metabolically excluded horses respectively (Garlinghouse & Burrill, 1999). On the other hand, the same study concluded that heavier horses (BCS 6+) were more prone to lameness as well as heat stress. Recommendations on ideal body condition can be varied, with Garlinghouse & Burrill (1999) seeing higher completion rates with BCS 5-5.5, whilst Harris (2009) recommends an ideal BCS of 4-4.5 for competitive endurance horses. A recommended diet for endurance horses contains high amounts of fibre and fat, whilst high starch and protein is undesired (Crandel, 2005; Goachet and Julliand, 2011; Harris, 2005; Robert, 2014).

Some studies show relations between housing and handling situations and the behaviour of horses. Hockenhull and Creighton (2014) note that horses show more aggressive and abnormal behaviour, as well as problems with handling, when stabled for more than 13 hrs, whilst 24 hr per day turnout with conspecifics show a reduction in abnormal oral behaviour and allows for more time spent foraging and resting. Comparatively, in a study performed by Søndergaard and Ladewig (2004) it was seen that horses spent outdoors in groups responded better to simple training stimuli than single stabled horses. Two studies with trotting horses show that loose housing in a paddock is beneficial for a quicker recovery after intense exercise and can even prevent potential swelling in the lower limbs in comparison with horses stabled for 20 hrs per day (Connysson et al., 2019 and 2021)

Chapter 3 Methodology

3.1 Research design

Data has been collected from 22 Swedish endurance horses in a period between October 2020 and April 2021 for an average of 23 weeks per horse. The riders were visited at their barns or at a riding arena nearby to accommodate the riders as much as possible. The horses underwent a basic health exam and a ridden Standardised Exercise Test (SET). More information about the testing procedure can be found in *3.3 Data Collection*.

3.2 Participants

Participants were invited through social media, personal invitation, and through an advertisement in the flyer for the endurance competition 'Övedsritten Lag-SM' held in August 2020, which was one of the more important endurance races that year. Information about the project was shared on a Facebook page for Swedish endurance riders, called *'Vi som är intresserade av distansritt!'*. After showing interest, personal communication continued through email or text messaging.

3.2.1 Horses

Eleven Swedish endurance riders participated in the study, with a total of 22 horses. 19 of those horses completed the full study while two horses fulfilled only three out of the four testing sessions. These two horses were still included in the data. Three more horses were planned to partake in the study, but did not successfully finish the first session due to either logistical or equipment failures. One more horse got sold after the second visit. These four horses were taken out of the study. All horses were either Arabian horses or Arab crosses, with 19 horses (86%) being purebred Arabs. The other horses consisted of one Anglo-Arab (75% Arab, 25% Thoroughbred), one Shagya Arab and one Arab cross. The group consisted of 15 geldings (68%), six mares (27%) and one stallion. The horses ranged from 8 to 19 years of age and 145 cm to 160 cm in height.

3.2.2 Competition level

The horses' competing levels ranged from 50 km up to the longest distance of 160 km. In 2020, all but two horses had competed, with 17 horses finishing at least one race. In the table below it can be seen how many horses have started a competition at a certain level, and how many have been able to finish the full distance. The highest attempted and finished levels are given. Due to the Covid-19 pandemic, competitions were scarce in 2020 and riders have not been able to compete as they usually would have. The competition season ran from July to November, which is roughly five months shorter than prior years. Covid-19 and an outbreak of Equine rhinovirus (EHV-1) continued to complicate competing in 2021, with only riders with an Elite status allowed to compete. This changed riders' outlook on their training strategies and some chose to train at a lower intensity during 2020 and 2021.

Table 1: The highest competing levels of the participating horses

Competing distance	Number of horses competing at given distance (lifetime, attempted)	Number of horses competing at given distance (2020, attempted)	Number of horses competing at given distance (2020, finished)
No finished competition	-	2	5
40	-	1	2
50	3	7	8
80	8	7	4
100*	-	-	2
120	7	4	1
160	4	1	-

* 100 km classes were implemented from January, 2020

3.2.3 Training methods

Training activities throughout the entire project will be analysed for potential correlations between the different activities and fitness & health. These different rides are classified as:

- Short ride: maximum of 1 hour
- Long, slow ride: at least 1 hour, only walk
- Long, fast ride: at least 1 hour, walk, trot & canter
- Canter training <30 min
- Canter training 30+ min

In the annex an overview of all the horses can be found.

3.3 Data collection

Data was collected from each horse in the study four times. On average there were eight weeks between each collection visit. Data consisted of a basic health examination and a Standardised Exercise Test (SET). In the health examination the horses were checked on their resting heart rate, resting respiratory rate, body condition score and body circumference, as well as health statements to insure the horse was fit to participate: body temperature, gut sounds and mucous membrane colour. Resting heart rate was taken with a stethoscope prior to the exercise test. Body condition score was measured as specified by Henneke, et al. (1983). The diet, housing and general management (type of training, potential clipping and length of the coat) were also noted down. A picture was taken of the horse to compare them over time. The full protocol can be found in the appendix.

The SET consisted of a short warm-up and then a simple test where the horse was ridden in all three gaits over four intervals (see below). The horses were wearing a heart rate monitor (Polar M450) during the test, and were filmed with a standard camera (Canon EOS 1200D) and tri-pod

construction (Hama Star 61). The SET was filmed to note the speed of the horse - as the GPS of the heart rate monitor device was highly inaccurate - and to be able to look back on the film for unexplained readings of the heart rate monitor. The SET looked as the following:

- 3 minute walk (warm-up)
- 3 minute trot (warm-up)
- 1 minute walk (warm-up)
- 2 minute walk
- 2 minute slow trot
- 2 minute fast trot
- 2 minute canter

The time of two minutes per interval was chosen as the horse needs approximately 90-120 seconds to adjust and stabilise to the requested intensity, as mentioned by Marlin & Nankervis (2002) and in personal communication with Jansson, A. The last 30 seconds of each interval was used to take the average heart rate and speed of the horse. The riders were not asked to ride at a specific speed, but rather at a speed that would be comfortable and familiar for their horse. It was very important for the author that the testing procedure was easy to follow for the riders to keep motivation and participation high during the project. Besides this, it also would be impossible for the rider to know their exact speed, as an accurate GPS tracking in (indoor) arenas is usually not possible. Except 3 horses, the individual horses were ridden in the same arena throughout the study. For these 3 horses it was not possible to perform the test in the same arena due to moving of the horse (1 horse) or frost in the previously used outdoor arena (2 horses). All these three horses performed 3 out of 4 tests in the same arena.

After the SET, the horses were walked back to their stable / grooming area and the tack was taken off. Recovery heart rates and respiratory rates were measured at 5 and 10 minutes after the canter interval.

Besides the physiological data, riders were also asked to fill in a short questionnaire after each session about their horse's current level of fitness, the improvement in fitness and the general feeling of the horse that day. The riders also filled in how they had been training their horse since the previous visit.

3.4 Data analysis

Heart rate levels were taken from Polars own digital service, Polar Flow (https://flow.polar.com/). Videos of the ridden exercises were watched to calculate the speed, rather than taking the registered speeds from the Polar GPs watch. Data that was collected during the tests was stored and managed in Apple Numbers (version 10), which is a similar program to Microsoft Excel. Riders were notified on their results as soon as possible for the riders' own interest. After all data was collected, it was analysed using SPSS Statistics (version 27). One-way ANOVA tests were run to compare the different results with each other. A statistical significance of ≤ 0.05 was used in all tests.

For most statistical analyses horses were divided in two categories: rest and no-rest. Horses were categorised to have rested when they had not been exercising for 4 continuous weeks. In some instances three categories of intensity were used: rest, low intensity and normal intensity. Low and normal intensity classes were based on the trainers and how they classified their training

intensity based on comparing training efforts in the competition season versus training in the off-season.

Due to research studies showing that horses in longer term training present different results to detraining than horses receiving only a short period of training, the horses were also divided into groups based on their competition results. The horses were classified into ‘pro’ and ‘amateur’ classes, based on whether they had completed more than one 80 km class in the last two years. The horses were evenly divided with 9 being classified as ‘pro’ and 10 as ‘amateur’.

Chapter 4 Results

In the results section the following questions will be answered:

- How is the detraining period designed in Swedish endurance horses?
- What is the effect of detraining and rest on the horse's aerobic fitness?
- What is the effect of different types of training on the horse's aerobic fitness?

4.1 Effect of rest

Out of 19 horses, five horses had been resting for some length, as can be seen in Table 5. One horse was rested for 14 weeks because of injury. One horse was rested several times during the project due to other commitments of the rider, with the longest continuous rest period being four weeks. Three horses, from two different owners, were rested as part of their training plan, all three immediately after their last competition in November 2020. Two were rested for ten weeks, and one was rested for four weeks and then only walked for three more weeks, counted to have been rested for 7 weeks.

Table 2: Amount of horses experiencing different lengths of resting periods

Resting period (weeks)	Number of horses	Percentage of horses (%)
0	14	73.7
4	1	5.3
7	1	5.3
10	2	10.5
14	1	5.3

Besides full rest, three horses (16%) were trained at a lower intensity than usual. The other 11 horses (58%) were mentioned to sometimes have some lower intensity training weeks due to for example bad weather or the holiday season, but other than that received similar training as they had during the summer season.

Rest and heart rate

The resting HR of horses being rested or trained at lower intensity showed no difference in comparison to the trained horses in any of the visits, as presented in Table 6. Resting horses showed a tendency to have a higher rest HR than non-resting horses in the third visit, but no significant difference was shown. At the point of the third visit, none of the horses were resting.

Table 3: Relation between work intensity and rest HR

	Visit number	Rest (n=5)	Low intensity (n=3)	Normal intensity (n=11)	p-value
Rest HR	1	35 ± 3.3	37 ± 1.7	36 ± 5.9	0.89
	2	34 ± 4.8	39 ± 10	36 ± 6.8	0.71
	3	41 ± 6.6	36 ± 4.0	36 ± 2.3	0.09
	4	39 ± 7.2	42 ± 6.0	39 ± 9.3	0.92

In recovery times, it was seen that horses training in normal intensity showed a significantly higher pulse after both 5 and 10 minutes in the fourth visit than horses having received rest or a lower intensity of work whilst velocity was the same in both groups (330 ± 36 m/min vs 336 ± 42 m/min, p=0.09).

Table 4: Relation between work intensity and recovery HR

	Visit number	Rest	Low intensity	Normal intensity	p-value
Recovery HR 5 min	1	42 ± 3.2	40 ± 3.0	47 ± 8.5	0.26
	2	41 ± 4.8	43 ± 4.2	49 ± 15.6	0.53
	3	44 ± 5.4	41 ± 4.0	52 ± 18.5	0.47
	4	41 ± 1.8	43 ± 3.5	48 ± 4.9	0.03
		Rest	Low intensity	Normal intensity	p-value
Recovery HR 10 min	1	39 ± 2.6	37 ± 2.1	41 ± 5.7	0.36
	2	37 ± 2.6	41 ± 3.2	40 ± 6.2	0.64
	3	41 ± 5.8	36 ± 2.1	41 ± 5.4	0.41
	4	38 ± 2.3	36 ± 0	43 ± 2.1	0.001

Rest and respiratory rate

No differences were found at all between the three groups in either resting or 5/10 minute recovery respiratory rates.

Rest and body condition

On each individual visit, the training method of the horses had no significant effect on their body condition score or change thereof.

It was seen that three horses (27%) in normal training intensity decreased in BCS, from score 5 to 4 and 4 to 3, whilst two of the resting horses (40%) and one of the low intensity horses gained body condition from score 4 to 5. This however does not seem to be a hard correlation as the majority of the working horses were stable in body condition.

Table 5: Relation between work intensity and Body Condition Score

Visit number	Rest (n=5)	Low intensity (n=3)	Normal intensity (n=11)	p-value
1	4.8 ± 0.8	5.0 ± 1.0	5.0 ± 0.6	0.86
2	5.0 ± 0.8	5.5 ± 0.5	4.9 ± 0.9	0.59
3	5.6 ± 0.9	5.3 ± 0.6	5.1 ± 1.0	0.64
4	5.4 ± 0.8	5.0 ± 0	5.1 ± 1.0	0.86

Rest and V100

V100 was taken as the general measurement of fitness during the project. As the V100 measurements are so individual and collected during unique conditions, comparisons between individual horses cannot be made. However, the stability, increase or decrease of the V100 measurement can be easily compared.

In table 9 below the individual and average V100 measurements can be found per training strategy. No statistical differences were seen in the average V100 measurements between the different visits and groups. However, some tendencies can be noted when looked at the individual data.

Table 6: Individual and average V100 levels in different training strategies

Horse #	Training strategy	Visit 1 (V100 m/min)	Visit 2 (V100 m/min)	Visit 3 (V100 m/min)	Visit 4 (V100 m/min)
#1	Rest	236	176 *	153 *	253
#2	Rest	227		259	271
#3	Rest	239	240	270	295
#12	Rest	293		250	
#14	Rest	200	277	187	200
	Average	**239 ± 34**	**231 ± 51**	**224 ± 51**	**255 ± 40**
#6	Low intensity	214	259	242	
#13	Low intensity	275	215	206	224
#22	Low intensity	246	248	222	249
	Average	**245 ± 31**	**240 ± 23**	**223 ± 18**	**237 ± 18**
#5	Normal intensity	207			214
#7	Normal intensity	245	251	267	216
#8	Normal intensity	100 *	262		272
#9	Normal intensity	214	216	130 *	221
#10	Normal intensity	187	183	226	166
#11	Normal intensity	190	207	160	173
#15	Normal intensity	246	277	313	308
#16	Normal intensity	204	185	168	198
#18	Normal intensity	226	259	249	244
#19	Normal intensity	208	314	219	274
#23	Normal intensity	224	223	250	
	Average	**204 ± 40**	**237 ± 42**	**220 ± 58**	**229 ± 46**

* Unrealistic data due to problems with heart rate monitor

Horses #1, #2 and #3 had longer, planned resting periods and were described in *chapter 4.1*. Horse #12, who had been resting for 14 weeks due to injury, saw a 17% drop in V100 level. It was seen that horse #14, who had been resting several times for shorter periods of time (2-4 weeks) had irregular V100 levels. 5 out of 11 normally trained horses (45%) saw an increase in their V100 during the collection period. Two horses with normal training intensity showed decreasing V100 levels. For further details, table 9 can be consulted.

4.2 Effect of different training methods

All horses were trained using a mix of slower, shorter and longer, faster rides out in nature. Small anecdotal differences were seen in the horses that performed canter trainings of more than 30 minutes. These horses had a tendency to have lower resting and recovering HRs and showed elevated V100 levels (see table 10). Albeit mostly not statistically different, these numbers could still give anecdotal differences in the training and competing of endurance horses.

Table 7: Relation between canter training and different fitness values

Value	No canter training	30+ min canter training	p-value
Rest HR (bpm)	40	36	0.09
V100 (m/min)	226	267	0.49
Rec HR 5 min (bpm)	47	42	0.06
Rec HR 10 min (bpm)	42	37	0.01

4.3 Effect of experience

It was observed that out of the 9 horses that were classed as ‘pro’, 5 horses (55%) received a rest or lower intensity training as part of the training plan, in comparison to only 2 of the amateur horses (20%) receiving rest or lower intensity training.

There was a tendency for pro horses to have lower resting HRs, with an average of 5 bpm lower than amateur horses. This trend continued onto the recovery values, in which pro horses show a significantly lower recovery HR during some of the visits, as can be seen in table 11. No differences whatsoever were noted on either rest respiratory rate or respiratory recoveries.

Table 8: Relation between horse experience and different HR values

	Visit number	Pro horses (n=9) (HR bpm)	Amateur horses (n=10) (HR bpm)	p-value
Rest HR	**1**	34 ± 2.7	38 ± 5.7	0.11
	2	33 ± 6.6	39 ± 6.5	0.07
	3	37 ± 3.5	38 ± 5.8	0.62
	4	35 ± 5.8	43 ± 12	0.12

Visit number	Pro horses (n=9) (HR bpm)		Amateur horses (n=10) (HR bpm)		p-value
Recovery 5 min	**Pro horses**	*Difference to rest HR*	**Amateur horses**	*Difference to rest HR*	**p-value between values**
1	41 ± 2.8	*7*	47 ± 8.6	*9*	0.05
2	41 ± 5.2	*8*	51 ± 15.4	*12*	0.10
3	41 ± 3.5	*4*	54 ± 18.3	*16*	0.05
4	42 ± 3.5	*7*	49 ± 4.1	*6*	0.01
Recovery 10 min	**Pro horses**	*Difference to rest HR*	**Amateur horses**	*Difference to rest HR*	**p-value between values**
1	38 ± 2.5	*4*	42 ± 5.7	*4*	0.07
2	37 ±3.8	*4*	43 ± 4.8	*4*	0.01
3	37 ± 3.2	*0*	43 ± 5.5	*5*	0.02
4	39 ± 3.6	*4*	43 ± 2.0	*0*	0.02

Pro horses had a tendency to have a lower body condition score than amateur horses of 4.8 ± 0.88 vs 5.4 ± 0.7 (p=0.13). Pro horses showed to have 10% higher average V100 levels than amateur horses of 240 vs 217 (p=0.25) respectively, but their level of experience did not seem to affect potential changes in V100. 4 out of 9 pro horses (45%) performed a canter training where horses were cantering for longer than 30 minutes, up to two hours at a time. 30% of the amateur horses also executed canter trainings, but none longer than 20-30 minutes.

4.4 Effect of management

Nutrition

11 horses (58%) were on a diet of roughage and grains or a mixed feed while 7 horses (37%) received a diet of roughage and a vitamin/mineral pellet. Horses fed a diet included of grains had a lower average BCS (4.8 ± 0.6) than horses fed a vit/min pellet (5.4 ± 0.8, p=0.007) throughout the collection period. The full data of all visits can be found in table 12.

Table 9: Relation between diet type and Body Condition Score

	Diet type	N	Average Body Condition Score	p-value
Visit 1	**Roughage only**	1	5	0.66
	Vit/min pellet	7	5	
	Grain / complete feed	11	4.8	
Visit 2	**Roughage only**	1	6	0.15
	Vit/min pellet	7	5.4	
	Grain / complete feed	11	4.9	

	Diet type	N	Average Body Condition Score	p-value
Visit 3	Roughage only	1	7	0.01
	Vit/min pellet	7	5.7	
	Grain / complete feed	11	4.7	
Visit 4	Roughage only	1	7.5	0.01
	Vit/min pellet	7	5.3	
	Grain / complete feed	11	4.8	

It was impossible to find correlations between BCS and the parameters of aerobic fitness due to the small sample sizes in each class of condition score.

4.5 De- and retraining of endurance horses

Now that more information is known about a larger population, a closer look will be taken on three individual horses who underwent a resting period.

Horse #001

Horse #001 is a 13-year old Arab gelding who previously performed at 160 km level. The first visit at October 17, 2020 was two weeks before the horse successfully completed a 80 km competition. The owner said that the horse was in a decent training condition at this point. The horse was on the heavier side, scoring a 6 out of 9 on the Henneke BCS chart. The horse successfully finished the SET and marked a V100 value of 236 m/min (Figure 1). Recovery HR was 46 and 43 bpm after 5 and 10 minutes respectively as seen in Table 2.

The second visit was held December 20, 2020 and the horse had been fully rested since the last competition at the 1st of November. The horse was housed freely in a field with access to shelter, but not worked at all. The horse's V100 went down to 176 m/min, and the owner also noted that his condition had worsened since the previous visit. Recovery was similar to the first visit, with heart rates of 48 and 39 bpm after 5 and 10 minutes.

At the third visit (February, 2021) the horse had been resumed training for 6 weeks, which made the total resting period to last 10 weeks. The owner mentioned that usually she only walks the horses for the first 1-2 months of training, but as there had been rare snowfall she made use of the soft grounds and had been trotting and cantering more than she would usually do. The horse's V100 had decreased slightly from the 2nd visit to 153 m/min, but due to issues with the HR monitor in both the 2nd and 3rd visit, these numbers might not be fully accurate. The resting HR was slightly elevated at 40 bpm, but recovery HR dropped down quicker than before with 39 and 36 bpm after 5 and 10 minutes. The owner noted the horse's fitness to have increased and to be at similar level as on the first visit. At this point, the horse was hacked out on both short and longer rides in all three gaits. After the resting period the horse had gained weight and was scored at BCS 7.

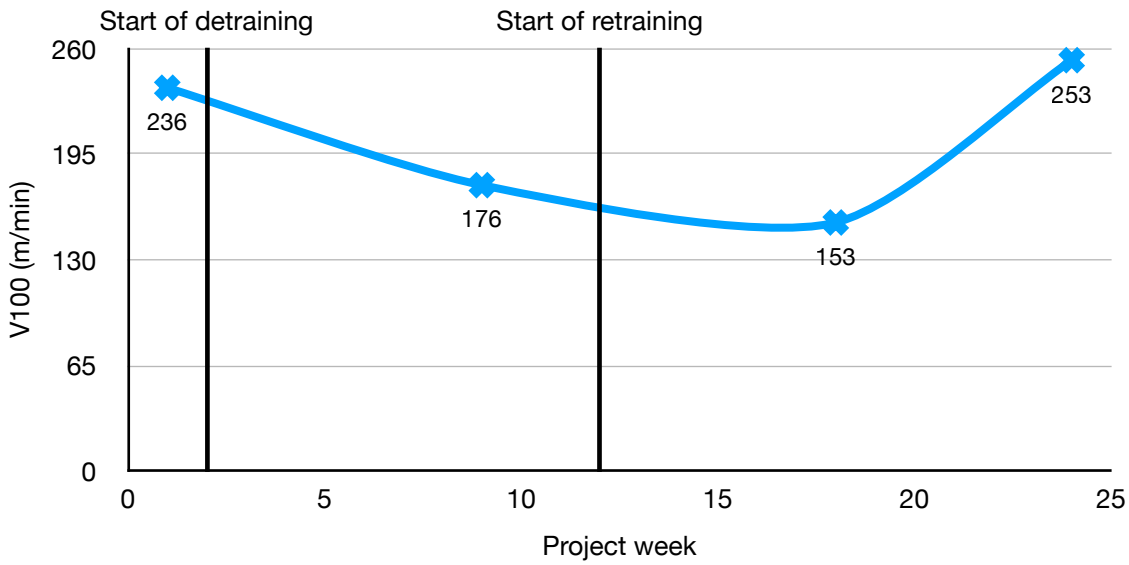

Figure 1: V100 measurements of horse #001

The fourth and final visit in April 2021 showed a large increase in fitness in the horse. The horse measured a V100 of 253 m/min, which was aligned with the owner's feelings and she noted it to be very good. She also mentioned that his energy levels were higher than right after his resting period. Since the previous visit, the owner had introduced canter sessions and the horse had so far cantered some sessions up to 1 hr 20 min. The horse lost some weight but was still rather heavy (BCS 6.5). The recovery HR was slightly elevated than the previous visit, with HRs of 42 and 40 bpm after 5 and 10 minutes. The horse successfully finished a 80 km competition in May.

Horse #001 was fed a diet of haylage, straw and a vitamin & mineral pellet. He lived outside in a herd 24/7.

Table 10: HR values of horse #001

Project week	Rest HR (bpm)	Recovery HR 5 min (bpm)	Recovery HR 10 min (bpm)
1	36	46	43
9	32	48	39
18	40	39	36
24	32	42	40

Figure 2: Stance pictures of horse #001 at the different visits

Horse #002

Horse #002 is a 10-year old Arab mare from the same owner as horse #001. The mare attempted her first 160 km race in July 2020, but could not succeed the full distance. She then successfully finished a 80 km race in August 2020.

At the first visit, the horse's fitness was noted to be very well, but that the horse struggled with nerves, giving the possibility of inaccurate readings throughout the project. The horse was unfamiliar with being in a riding arena but still showed normal readings and a quick recovery, going down to 39/37 bpm after 5/10 minutes respectively. Her V100 value was 227 m/min. The horse was a typical 'skinny fat', having a very big, swollen belly but little topline or developed musculature. She scored a BCS of 4.

The horse was trained and managed in the same way as horse #001, and received a full rest from November 2020 for 10 weeks. Unfortunately, during the 2nd visit the horse's HR was abnormally high and irregular, being either caused by stress or false readings. The HR data had to be excluded, but the owner noted the fitness to have decreased since the first visit. No difference was seen in recovery times and the HR dropped down equally fast as before. The horse had gained some weight and was more filled in the topline. She scored a 4.5 on the BCS chart now.

On the third visit in February 2021, the horse had been back in training for 6 weeks and looked again in better shape than the first and second visits. The belly was not as swollen and her topline

coverage had increased. She now scored a BCS of 5. Her V100 level was 259 m/min and the owner also noted an increase in her fitness and energy levels. Recovery HR was a bit higher in comparison with previous visits due to the horse experiencing some stress.

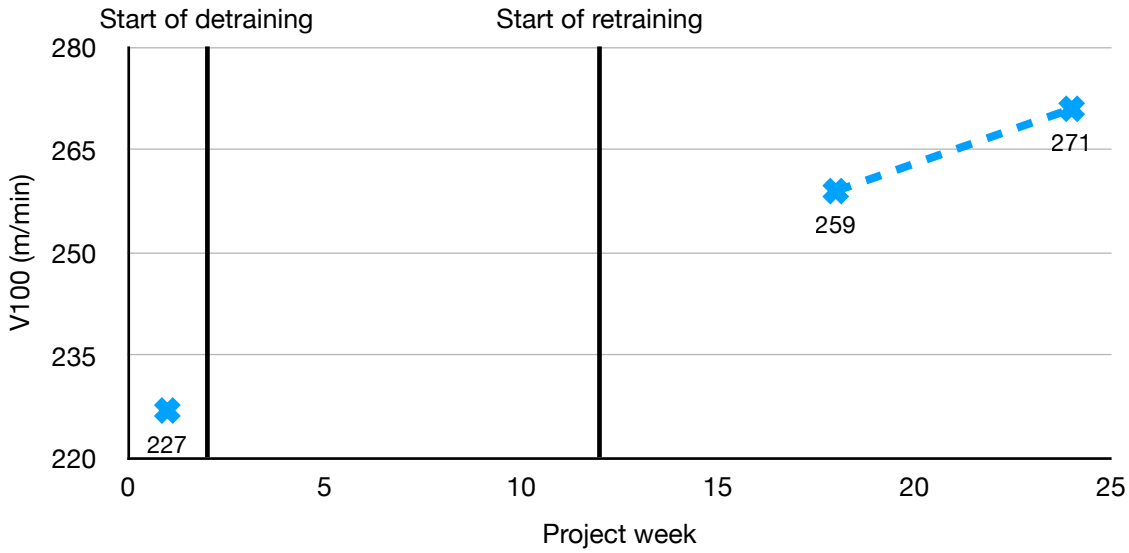

Figure 3: V100 measurements of horse #002

At the fourth and final visit, the horse improved furthermore to a V100 of 271 m/min, which was also in accordance with the rider's feelings. Both rest and recovery HR were lower than on prior visits, with a low rest HR of 28 bpm and recovering down to 36 bpm in 10 minutes. The horse again scored a 5 on the BCS chart. In training, the horse had performed two canter sessions in which the horse cantered for 50 and 55 minutes respectively. In May, the mare successfully finished a 80 km race.

Horse #001 was fed a diet of haylage, straw and a vitamin & mineral pellet. The horse lived outside in a herd 24/7.

Table 11: HR values of horse #002

Project week	Rest HR (bpm)	Recovery HR 5 min (bpm)	Recovery HR 10 min (bpm)
1	32	39	37
9	32	39	38
18	36	44	43 (stress)
24	28	40	36

Figure 4: Stance pictures of horse #002 at the different visits

Horse #003

Horse #003 was a black Arabian gelding of 12 years of age, and owned by a different owner than the other two horses. In 2020, the combination successfully finished two 80 kms races and attempted one 100 km race but got disqualified. In 2019, the horse became Swedish national champion (160 km) and the owner was qualified and planned to ride the World Championships (160 km) in the spring of 2021.

The first visit was held two weeks before the 100 km competition and the owner noted that the horse was in very good condition. The horse had a low resting HR of 32 bpm, and recovered to 37 bpm in 10 minutes time. The horse scored a 4 on the Henneke body condition scale. A V100 value of 239 m/min was measured. The owner planned for the horse to fully rest in the field for 4 weeks after the competition on November 1, 2020.

The second visit, December 12 2020, the horse had been fully rested for 4 weeks and then walked for 3 weeks under saddle and in hand. Due to the natural surroundings, the owner walked a lot of hills with his horse as a ‘strength training’. The owner noted that the horse’s fitness had stayed somewhat the same, being still at a very good level. This was in accordance with the V100 measurement, which was at 240 m/min now, 1 point higher than at the previous visit. The horse’s rest HR had dropped since the first visit with 28 bpm and recovery HR going down quicker with

37/34 bpm after 5/10 minutes respectively. During the resting period, the horse had increased its body condition and was scored a 5 on the BCS chart.

At the third visit in the end of February 2021, the horse had been in full competition training since the visit in December 2020. The owner noted the fitness to have improved and said the horse to be in excellent condition. The V100 measurement confirmed this with an increase to 270 m/min, being in the upper range of all the horses in the project. Trainingwise, the horse had been performing canter trainings of max 1.5 hrs at the time. The owner was very determined in reaching his goals and set up a extensive training plan for his horse. The horse was worked for three days in a row (medium hacking session - 1.5 hr; hard training session - 1.5 hr canter; recovery session - walk) and then rested for one day, for this order to be repeated again. The horse was again scored at BCS 5 and had similar HR values as the first visit: 36 bpm rest HR, 41/36 bpm at 5/10 min recovery.

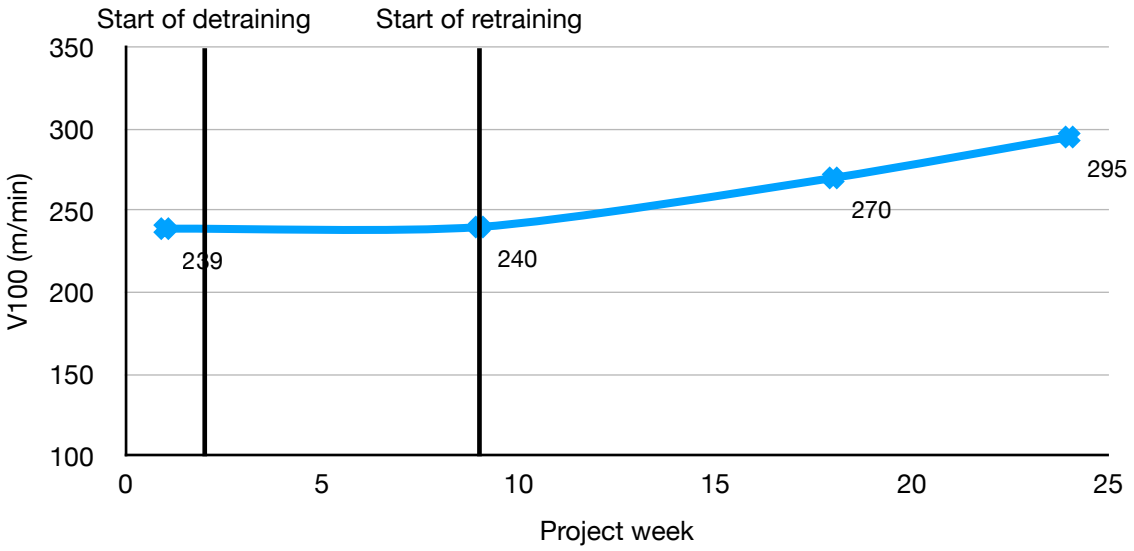

Figure 5: V100 measurements of horse #003

The final visit was at April 4, 2021. The horse was still trained according to the same schedule, but with more intense training rides. Canter sessions were extended to 2 hrs of canterwork. The owner mentioned that the horse's fitness had only increased by a little bit, saying that there was not much room left for further improvement, suggesting the horse was in top shape. The V100 measurement proved even higher aerobic efficiency from the horse, with a final V100 of 295 m/min. Recovery values were almost the same as in the third visit and the horse still scored a BCS of 5. In the end, the combination travelled to the World Championships in May 2021, and got to ride 140 km out of the 160 km race.

Table 12: HR values of horse #003

Project week	Rest HR (bpm)	Recovery HR 5 min (bpm)	Recovery HR 10 min (bpm)
1	32	40	37
9	28	37	34
18	36	41	36
24	36	39	36

Figure 6: Stance pictures of horse #003 at the different visits

Horse #003 received a diet of haylage (7-15 kg, depending on the time of year), Primero Total (1 kg) and vitamin E supplement. The horse lived outside for 14-16 hours per day and stabled inside at night in the winter months. In the spring, summer and autumn the horse was turned out 24/7 in the field.

To summarise, horses #001 and #002 decreased slightly in their aerobic fitness after fully resting for 10 weeks. Horse #003 rested for 4 weeks, to be then walked for a further 3 weeks. Horse #003 did not see any changes in aerobic fitness during and after the resting period, and continued to improve his aerobic fitness as training was started again. No changes were seen in resting or recovering HRs during and after the rest period in any of the horses. All three horses gained body condition during the resting period.

Chapter 5 Discussion

This thesis project allowed to get more insights into the different training and management options, what is used in practice, and how it might affect the horses. Much more in-depth research is necessary to fully understand all the different aspects, but with this research we were able to showcase the tip of the iceberg to riders, trainers and owners of endurance horses.

The main goal of this research was to gain more knowledge on the effects of different training programs for endurance horses in the off-season, with a heavy focus on the use, or lack thereof, of resting periods. It was hypothesised that a resting period of 4-6 weeks will not have a negative impact on the horse's fitness (measured as V100). The hypothesis was approved, with the main finding of the project that endurance horses can rest for 6 weeks without losing any aerobic fitness.

5.1 Effect of training

Detraining and resting of endurance horses

Four horses went through a period of detraining, lasting from 7 weeks up to 14 weeks. The horse that was rested for 7 weeks saw no change in V100 or other HR-related values, whilst two other horses, rested for 10 weeks, saw small decreases in V100 but no changes in resting or recovering HR. These three horses all showed increases in V100 in the training period, up to 24%, but no changes in rest HR or recovery HR. The one horse that was rested for 14 weeks decreased in V100 from 293 to 250 (-17%) and even had an increased resting HR of 14% compared to pre-resting values (36 vs 42 bpm) as well as higher recovery rates after the detraining period. These findings are in line with research, where it has been found that both musculoskeletal and cardiovascular show no decrease in function or efficiency after 4-6 weeks of detraining (Essén-Gustavsson, 1996: Kriz *et al.*, 2000; Poole & Erickson, 2008; Tyler *et al.*, 1996) and the VO_2max shows no signs of decrease up until 6 weeks of rest (Tyler et al., 1996 & 1998). Negative changes in these systems were seen by all these papers after 6 weeks of detraining. It can be taken from both this research and previous studies that horses can be rested for 6 weeks without showing any signs of decreased fitness. Unfortunately, only one horse had been resting for this amount of time, and preferably more scientific data would be necessary to make this a strong statement. It was seen that horses who had been continuously trained had on average higher recovery HRs in the third visit than the rested and lower intensity-trained horses. This can among others show evidence of tiring in horses and a slight loss of fitness after working continuously for long periods of time, proving the benefits of a lower intensity training period for endurance horses. This however would need more scientific back-up.

In this project V100 was the main parameter of determining the aerobic fitness of the horses. On individual level, it is a good tool to determine the horse's physical condition, but it is not reliable for a group of horses. In this project, V100 levels varied wildly in between horses and sometimes even between visits of one individual horse, resulting in the average data not showing any useful knowledge, as can be seen in table 13, where there were no significant differences seen between visits and between training strategies.

Table 13: Average V100 levels of the different training strategies

Training strategy	Visit 1 (V100 m/min)	Visit 2 (V100 m/min)	Visit 3 (V100 m/min)	Visit 4 (V100 m/min)
Rest	239 ± 34	231 ± 51	224 ± 51	255 ± 40
Low intensity	245 ± 31	240 ± 23	223 ± 18	237 ± 18
Normal intensity	204 ± 40	237 ± 42	220 ± 58	229 ± 46

The effect of experience and training

Interesting parallels were seen between the experience of horses and their type of training. Pro horses, who have ridden more than two 80+ km races in the last 24 months, showed to have on average 5 bpm lower resting HR, quicker recovery HR, a more ideal BCS (4.8 vs 5.4) and a higher V100 (240 vs 217), meaning higher efficiency and a longer resistance to fatigue while riding. A pattern was also seen in the training program of the horses, where 45% of pro horses performed canter trainings of at least 30 minutes. These horses were seen to have even higher V100 levels than the others (267 vs 225). Unfortunately, there are barely any scientific texts available on the benefits and use of canter trainings in endurance horses, but exposing the horse to long amounts of canter follows the same principal as any other aerobic conditioning and will further strengthen aerobic capacity. In order to be competitive at the higher levels, horses need to run faster than is necessary at the lower levels and therefore the higher level of conditioning to successfully compete at the high levels is crucial. It is important to note that canter sessions should be carefully introduced and not too early in the horses' training program to prevent overtraining and straining injuries.

Resting HR

The majority of studies done on heart rate of horses found that rest HR does not get influenced by training (Rodiek *et al.*, 1982; Thomas *et al.*, 1983 and Thornton, 1983). However, two separate studies show that rest HR dropped with over 10 bpm in trotting horses after being subjected to either endurance training (Marsland, 1968) for 70-90 days, as well as 'regular' trotting training (Ringmark *et al.*, 2015). This is also in line with findings in this study, where the more trained and experienced horses have on average 5 bpm lower resting HRs than the less experienced ones. As most of the above-mentioned research is focused on high speed training for racehorses, it can be assumed that lowering of rest HR mainly occurs after endurance training. For reaching further knowledge, it would be interesting to also record rest HR of newly started endurance horses for more detailed comparisons. A relation was seen in this study between lower rest HRs and lower HRs in the recovery period, allowing the horse to more quickly reach the demanded HR values at endurance competitions, in the end allowing for higher success rates.

5.2 Effect of management

Nutrition

A pattern was seen in body condition and performance, in which 4 out of 6 horses who deviated from the moderate BCS (BCS 5) level decreased in V100 level. This meant either horses losing weight to become underweight, or horses gaining weight to become overweight. One thin horse showed increased V100 levels as he gained weight to a more ideal body condition. It is unfortunately hard to say what an ideal body condition score is for endurance horses, as the available sources go against each other. Both Garlinghouse & Burrill (1999) and Barnes *et al*.

(2010) noticed that horses who are on a thin body condition score (<3 BCS) are more likely to get vetted out on metabolic reasons, whereas horses with a BCS over 6 have a higher risk to show lameness issues. Even though the highest rate of successful finishes was seen within a range of BCS 5 - 5.5, Harris (2009) recommends endurance horses to have a body condition score of 4 - 4.5. As a personal opinion, the author finds horses to be too thin at BCS 4 to perform long distance competitions, also keeping in mind that horses can loose weight during the travelling time and the competition itself. This project also showed that horses tend to show lower V100 values when reaching body condition scores under 4.5. The skinnier horses in this project often looked less healthy with dull coats and a more tired look in both their posture and movements. Most of the horses with a lower BCS (4 or less) were on a high grain, high starch diet, but it is hard to tell whether this is the cause or the result of this diet and if it has any effect on the V100 values.

Figure 7: Horse #16 showing first a decrease of body condition and an overall perceived health, and then improvement of both

Housing

The housing of the horses was noted down, but as there were no patterns seen between the type of housing and the health and fitness of the horses, it was not further analysed. The lack of patterns through housing might come because all the horses lived in quite similar circumstances. All the horses received at least 8 hours of turn-out each day, with most of them being turned out

for 12+ hrs, and over half of the test subjects (63%) living outside 24/7 in a field. All of the horses had the possibility for social contact with other horses.

5.3 Reflection

Limitations

The largest limitations in the project were financially and logistically. Initially, more in-depth tests were planned, such as gait analysis and equine body weight, but it was not possible to bring the equipment on every visit, endangering the uniformity of the project. Also, the weighing scale could only have fitted in a trailer, making travelling times extremely long due to driving with limited speed for several 100s of kilometres.

Not all riders who initially applied to the project were able to be visited, especially riders in the south and north-west of Sweden. Long travel times, and no financial back-up from the university, made it impossible to travel so long in the author's free time and to afford the travel cost.

It would have also been of interest to have more horses experiencing a resting period to be able to draw stronger conclusions on the detraining of endurance horses.

Another large limiter in the project was the heart rate monitor. It often gave wrong or unclear data and it was hard to get a reliable heart rate with it. It seemed very sensitive to the movement of the horse and sometimes, the rate would be very high (180+ bpm) and unstable in the trot, to go down to 'normal' levels and stabilise in the canter. Due to these mistakes, data was not always presented as how it should have been and the results cannot always be fully trusted. It was hard to tell if the horse was in poor fitness, stressed, or if the heart rate monitor was just giving out incorrect numbers.

Further research

Further research will be necessary to gather more exact knowledge on the detraining of endurance horses. Ideally, horses will be checked every week in order to more precisely tell when the horse starts showing signs of decreased aerobic fitness and if it benefits the horse to rest for some time. Besides the physical aspects of resting and training, it would be good to take a look at the mental aspects also. It is believed by riders and the authors herself also that a resting period of a couple of weeks will benefit the horse mentally, to take a break from training and enjoy free time with other horses. There is however no scientific proof for this.

Another interesting topic would be to get more knowledge during the competition times. What is the best tapering strategy? What are the ideal training strategies for 120+ races? How does the horse recover after competitions and how important is competing as means of training for longer distances? What is the ideal recovering time after competitions? There is very little research specifically on endurance horses and most seem to focus on the performance at competition day itself instead of the management before and after the races.

5.4 Conclusion

The main conclusion that was drawn from this research was that endurance horses can be rested for 6 weeks without showing any negative physical changes in their aerobic fitness, measured through V100, rest HR and recovery HR. A resting period of 10 weeks shows a decrease in V100, but not in resting or recovery HR. Only after resting for 14 weeks can a higher

resting pulse be expected with a 14% increase from pre-resting values as well as a large decrease in V100 in one horse.

Other findings were that more experienced horses, competing regularly at 80+ km competitions, had lower resting and recovery HRs as well as a 10% higher average V100 value than less experienced horses. Horses performing canter trainings of more than 30 min continuous cantering showed a 19% higher V100 value than the other horses and seems to be a necessary training method to be successfully competitive at a higher level.

It was seen that horses becoming either underweight or overweight during the data collection period decreased their V100 level. Horses under BCS 4 were more prone to loss of aerobic fitness and showed lower general health with dull coats and low energy levels according to their riders.

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Chapter 7 Annex

7.1 Overview of the horses in the project

Horse #	Breed	Sex	Age (years)	Level	Rest (weeks)	Training intensity	Canter training (minutes)	Diet
1	Arab	g	13	pro	10	rest	>30	R + V
2	Arab	m	10	pro	10	rest	>30	R + V
3	Arab	g	12	pro	7	rest	>30	R + V
5	Shagya Arab	g	13	amateur	0	normal	<30	R + V
6	Arab	g	13	amateur	0	lower	-	R + V
7	Arab	g	10	amateur	0	normal	<30	R + G
8	Arab	g	12	amateur	0	normal	<30	R + G
9	Arab	g	16	amateur	0	normal	-	R + G
10	Arab	s	17	amateur	0	normal	<30	R + G
11	Arab x	m	15	amateur	0	normal	-	R
12	Anglo Arab	m	9	pro	14	rest	-	R + G
13	Arab	m	17	pro	0	lower	-	R + G
14	Arab	m	7	amateur	4	rest	-	R + G
15	Arab	g	9	pro	0	normal	-	R + G
16	Arab	g	18	pro	0	normal	-	R + G
18	Arab	g	8	pro	0	normal	-	R + G
19	Arab	g	7	amateur	0	normal	<30	R + G
22	Arab	g	8	pro	0	lower	>30	R + V
23	Arab	g	11	amateur	0	normal	-	R + V

g = gelding, m = mare, s = stallion. R + V = roughage & vit pellet, R + G = roughage & grains, R = roughage only

7.2 Advert for the project

Distansryttare sökes!

För en forskningsprojekt i samarbete med Sveriges Lantsbrukuniversitet i Uppsala söker jag distansryttare och hästar som tävlar minst 80 KM. Projektet fokuserar på distanshästens fitness, kondition och träning på vintern, och hur olika typer av träning har effekt på hästens hälsa. Om du deltar, får du värdefulla insikter i din hästens hälsa och kondition, och du hjälper oss att förstå bättre hur hästens kropp fungerar. Är du intresserad? Fantastiskt! Skanna koden för mer information eller mejla **aniekoosterhoff@hotmail.com**.

SCAN ME

7.2 Checklist SET

CHECKLIST EXERCISE TEST FOR ENDURANCE HORSES DATE:
ID #

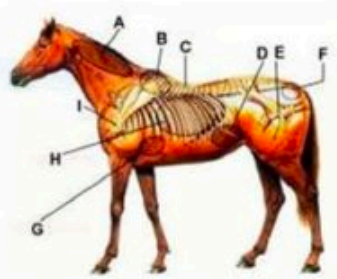
RIDER

HORSE

	Task	Result
☐	Body temperature	
☐	Respiratory rate rest	
☐	HR rest	
☐	Manure sample taken	
☐	Shaved coat	
☐	Hair length chest	
☐	Hair length back	
☐	Gut sounds	
☐	Colour mucous membrane	
☐	**Body Condition Score (1-9)**	overall:
☐	neck:	shoulder:
☐	ribs:	back:
☐	rump:	tailhead:
☐	Body weight horse	
☐	Body weight rider + tack	
☐	Gait test	
☐	**SET ridden**	
☐	State of surface SET (Take picture)	
☐	**Recovery**	
☐	HR 10 min	
☐	HR 15 min	
☐	Respiratory rate 10 min	
☐	Respiratory rate 15 min	
☐	**Diet**	
☐	Concentrates type & amount (analysis)	
☐	Roughage type & amount (analysis)	
☐	Supplements / elektrolytes	
☐	**Type of weather**	
☐		

Kentucky Equine Research INCORPORATED

BODY CONDITION SCORING CHART



Areas of Emphasis for Body Condition Scoring

- **A:** Thickening of the neck
- **B:** Fat covering the withers
- **C:** Fat deposits along backbone
- **D:** Fat deposit on flanks
- **E:** Fat deposits on inner thigh
- **F:** Fat deposits around tailhead
- **G:** Fat deposit behind shoulder
- **H:** Fat covering ribs
- **I:** Shoulder blends into neck

1 *Poor*

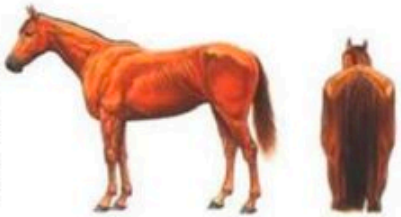
Animal extremely emaciated; spinous processes, ribs, tailhead, tuber coxae, and tuber ischii projecting prominently; bone structure of withers, shoulders, and neck easily noticeable; no fatty tissue can be felt.

2 *Very Thin*

Animal emaciated; slight fat covering over base of spinous processes; transverse processes of lumbar vertebrae feel rounded; spinous processes, ribs, tailhead, tuber coxae, and tuber ischii prominent; withers, shoulders, and neck structure faintly discernable.

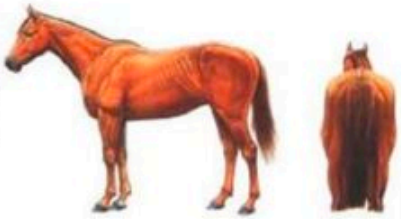
3 *Thin*

Fat buildup about halfway on spinous processes; transverse processes cannot be felt; slight fat cover over ribs; spinous processes and ribs easily discernable; tailhead prominent, but individual vertebrae cannot be identified visually; tuber coxae appear rounded but easily discernable; tuber ischii not distinguishable; withers, shoulders, and neck accentuated.



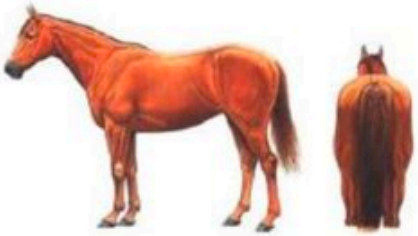
4 *Moderately Thin*

Slight ridge along back; faint outline of ribs discernable; tailhead prominence depends on conformation, fat can be felt around it; tuber coxae not discernable; withers, shoulders, and net not obviously thin.



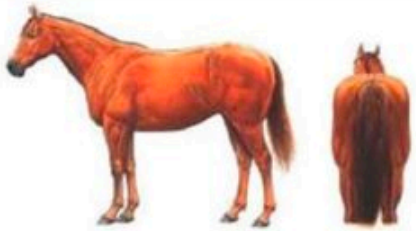
5 *Moderate*

Back is flat (no crease or ridge); ribs not visually distinguishable but easily felt; fat around tailhead beginning to feel spongy; withers appear rounded over spinous processes; shoulders and neck blend smoothly into body.



6 *Moderately Fleshy*

May have slight crease down back; fat over ribs fleshy/spongy; fat around tailhead soft; fat beginning to be deposited along sides of withers, behind shoulders, and along sides of neck.



7 *Fleshy*

May have crease down back; individual ribs can be felt, but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along withers, behind shoulders, and along neck.

8 *Fat*

Crease down back; dificult to feel ribs; fat around tailhead very soft; area along withers filled with fat; area behind shoulder filled with fat; noticeable thickening of neck; fat deposited along inner thighs.

9 *Extremely Fat*

Obvious crease down back; patchy fat appearing.

ASSURANCE
Excellence in Equine Nutrition

Henneke et al., 1983

Illustrations by Japan Racing Association

7.3 Graphs used during the fitness & health check