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Longitudinal Stretching, a Training Method for Horses: Effect on Behaviour, Gait Quality, Mechanical Nociceptive Threshold, and Pain Sensitivity

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Abstract

Many of today's horses have physiological problems such as tendon injuries and muscle pain in the neck and back, many times as a result of wrongful sub-optimal training, overtraining or lack of variation in the training. To maintain a healthy and sound horse during training at all levels of riding it is important to develop a training method that promotes relaxation, muscle function, and positive effect on welfare

The objective of this project was to study the effects of longitudinal stretching while riding (LSR) on behavioural scores (i.e. for eye, ear, mouth, head and neck, willingness to work and collaborate with the rider) indicating positive or negative behaviour, gait quality, mechanical nociceptive threshold (MNT), and pain sensitivity.

The study was conducted on 12 horses, during a 1-month period. All horses had the same training regime, that included three days of 30 minutes LSR sessions and lunging. Sessions included 5 min lunging in the beginning and end, 20 min LSR with an experimental rider and 10 min with control rider. Before and after treatment all horses underwent a veterinary examination to evaluate their physical state. During training sessions horses were videotaped and scored after a ethogram on different behaviours and gait quality. Before and after LSR mechanical nociceptive threshold and pain sensitivity was measured on 8 locations, these measurements were done both in the beginning and end of the treatment period.

Time (before to after treatment) increased scores for all behaviours, except head and neck position. Most of the behaviours were affected by activity, and only eyes and willingness to work were unaffected. Head and neck position were significant regarding gait, and there were higher scores for walk than for trot. Higher scores were seen after treatment for all activities, except control rider. MNT measurements showed significant changes in pressure from before and after LSR, before and after treatment. No significance was found regarding pain sensitivity.

Conclusion is that longitudinal stretching has a positive impact on behaviour during riding, regardless of the rider. And that gait quality increased during all activities, both in walk and trot, this shows that a positive mental state effects the gait quality. But additional studies are needed to enhance the reliability of this training method.

Sammendrag

Mange av dagens hester har fysiske problemer som seneskader, og muskel smerter i nakke og rygg, ofte som et resultat av mindre optimale treningsmetoder, overtrening eller mangel på variasjon i treningen. For å opprettholde en sunn og frisk hest ved ridning på alle nivåer er det viktig å utvikle en treningsmetode som fremmer avslapning, muskel funksjon, og som har en positiv effekt på atferd.

Formålet med prosjektet var å studere effekten av langsgående fleksjon under ridning på atferdsmessige score (øyne, ører, munn, hode og nakke, samarbeidsvilje, og arbeidsvilje) som indikerer positive eller negative atferder, gangarts kvalitet, trykkmålinger med algometer, og smertesensitivitet.

Forsøket ble utført på 12 hester i løpet av en 1-måneders periode. Alle hestene hadde samme treningsregime, som inkluderte tre dager med 30 minutter LSR og longering. Øktene besto av 5 min longering i begynnelsen og slutten, 20 min LSR med en eksperimentell rytter og 10 min med kontroll rytter. Før og etter behandlingsperioden ble alle hesten undersøkt av en veterinær for å evaluere den fysiske tilstanden. Alle treningsøktene med LSR ble tatt opp på video, og atferder og gangarts kvalitet ble scoret ved hjelp av et etogram i etterkant. Før og etter LSR ble trykkmålingene, samt smertesensitiviteten målet på åtte forskjellige lokasjoner, disse målingene ble utført både før og etter behandlingsperioden.

Tid (fra før til etter behandling) økte alle de atferdsmessige scorene, bortsett fra hode og nakke posisjon. Nesten alle atferder ble påvirket av aktivitet, og det var kun øyne og arbeidsvilje som ikke ble påvirket. Hode og nakkeposisjon ble påvirket av gangart, og det var høyere scores for skritt i forhold til trav. Trykkmålingene hadde en signifikant forskjell i trykk fra før til etter LSR, både før og etter behandling. Ingen signifikant forskjell ble funnet når det kom til smertesensitivitet.

Konklusjonen er at langsgående fleksjon har en positive innvirkning på atferd under ridning, uavhengig av rytter. Og at gangartskvalitet økt for alle aktivitetene, både i skritt og i trav, som viser at en positiv mental tilstand påvirker gangartskvaliteten. Videre forskning trengs for å øke påliteligheten av treningsmetoden og effekten den har.

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1 Introduction

Horses have been used for many different disciplines during their domestication, from meat source through working horses and into different sport disciplines. For both leisure and competition horses, the methods of training and riding may have a negative effect on the welfare resulting in a short longevity due to injuries or behavioural problems caused by chronic stress. Many of today's horses have physiological problems such as tendon injuries and muscle pain in the neck and back, many times as a result of wrongful sub-optimal training, overtraining or lack of variation in the training. To maintain a healthy and sound horse during training at all levels of riding it is important to develop a training method that promotes relaxation, muscle function, and positive effect on welfare. Fédération Equestre Internationale (FEI) says that the goal is to make a "happy" athlete (Fédération Equestre Internationale, 2007), but it is not specified what this means when it comes to welfare and behavioural cues. Therefore, it is important to understand the behaviour of horses so that a reliable evaluation is done.

"Longitudinal flexion", extension or stretching of the horses back is an important part of the daily training as a warm up, because it loosens the muscle and at the same time puts the horse in a calm state (Warren-Smith et al. 2007). Longitudinal stretching during riding (LSR; Fig.1) is when the horse stretches the head and neck in a long and deep form so that the whole top line stretches. This method is used to stretch, loosen and build up core muscle while the horse finds its natural balance without disturbance from the rider.

Fig. 1: *Sylvia Burton demonstrating longitudinal stretching on one of the project horses.*

2 Literature review

2.1 Horse behaviour and signals

All horses have developed adaptive signals to communicate with each other, and behavioural repertoire does not vary much between breeds or individuals. Even if their environment has changed during domestication the horse still retains certain behavioural responses to stimuli even if the underlying mechanism behind them has been altered (Cooper & Albentosa 2005). Horses use body language and physical signals to communicate to each other, and we need to be aware that these are often very subtle signals. In the horse industry many horses are only evaluated by a veterinarian for lameness and sickness, but not for discomfort or temporary pain which can be assessed through behaviour (Hall et al. 2012). If we are better able to communicate and understand signals, the horse's welfare will increase. This is especially true during training and riding. Behaviours during riding and competition has been given more focus in the last decade (Hall et al. 2012), especially negative behaviour that can affect animal welfare. Misinterpreted signals might be perceived by the horse as negative, and affect the bond between horse and human, which could result in negative behavioural expression and lead to dangerous situations. The mental state of a horse is reflected during performance and it is important to be able to evaluate this state in a good way (Hall et al. 2012). This can be achieved through behavioural scores and evaluations (Olafsen 2015).

2.1.1 Communication

Communication between horses is hypothesised to develop as a way to reduce conflict and increase positive interactions between group members (Olafsen 2015). Since the horse is a prey animal, most of the communication cues are through body language. Many of the cues can be seen in different parts of the head, together with neck position. The position of the ears can describe many types of signals, and is often related to other behavioural cues involving the head and neck position and tension in the face. The ears can be moved 180 degrees and an alert and healthy horse will move its ears towards sounds in their surroundings, such as the riders voice. They also have the ability to move the ears independently of each other and focus on two different sounds at the same time. With sudden noises, horses will turn their ears towards the sound, often combined with widening of the nostrils and a tense mouth area (McGreevy 2004). If potential threats are of low intensity, the ears will change direction backwards, and you can see some tension around the nostrils and mouth. If a high intensity threat is perceived, the ears will lay flat back and there will be great tension around the mouth area and sometimes the teeth will be visible (Olafsen 2015). These signals are hypothesised to be a sign of a negative mental or emotionally state (Heleski et al. 2009; Von Borstel et al. 2009).

Some commonly understood body language is seen in the horses face and tail, and the mouth and nostrils are one area where horses show a lot of different signals especially stress, excitement and pain, normally by widening the nostrils and tension in the mouth area, but also on the positive side. Abnormal lip movement and a lot of foam around the mouth is also associated with stress and discomfort during riding (Heleski et al. 2009). FEI regulation says that it is desirable to see a calm, but not immobile mouth with a tiny line of foam around the mouth (Fédération Equestre Internationale, 2007). The position and movement of the tail can also be used to evaluate the mental state, and a lashing tail during riding is seen as a sign of nervousness and tension (Hall et al. 2014; Olafsen 2015). In animals like sheep and cattle the presence of visible eye white is an indicator of fear or pain, and this is also true for horses (Von Borstel et al. 2009).

2.1.2 Pain evaluation

Most people agree that horses express pain, but it is difficult to evaluate when this occurs, especially when it comes to small, subtle cues that most people will miss. During training and handling of horses it is important to recognize these subtle cues so that we might detect bigger issues and problems before they become too severe. It will also be a useful tool in evaluating the influence of rider and training during competitions and events, helping establish a training method that influences the horse in a positive way.

During riding the most common cause of pain is the rider's hands (McGreevy 2004), which can be seen in the mouth area. Tension around the mouth could therefore be a result of the rider and should be taken into consideration when evaluating behaviours cause by pain.

To recognise signs of pain during training, subtle facial cues such as eyes, ears and mouth are important (Gleerup et al. 2015). Gleerup et al. (2015) investigated how to evaluate facial pain expressions through noxious stimuli. They used stimuli that the body would perceive as potentially damaging for the body, but will not make any physically problems as long as they were not applied over an extended period. Horses went through six treatments, two without any pain stimulus (control) and four with a pain stimulus (two with tourniquet and two with capsaicin). Before, right after, and one hour after treatment, heart rate, respiratory rate and temperature (skin and rectal) were measured. Behavioural changes were seen immediately after the tourniquet and after 2 min for the capsaicin. This involved pawing, head movements, and walking around. Only during capsaicin and control did the horses start to get drowsy (15 min for capsaicin and shorter time for the control). During both treatments all horses showed facial signs of pain such as asymmetrical ears, tightening of muscles around the eyes and face, and widening of the nostrils. They also noted that horses in pain interacted more with the handler and that this might be a result of positive reinforcement training before the study; the horse felt safe and was more willing to show pain response to a familiar person.

2.1.3 Human-Horse interaction

It is not easy to evaluate behaviours during riding and in most cases it will not be objective, since different equestrian professionals might have different opinions and therefore interpret behavioural cues differently. Hall et al. (2014) investigated if the professionals' judgment about behavioural cues corresponded to physiological measurements. Results showed that ears relaxed and backwards were typically associated with lack of motivation, and the same applied to a high head position. The nose behind the vertical line for a longer time was often seen as a sign of energy and excitement. Researchers found that there were differences between different groups of equestrian professionals, trainers and the physiological measurements. There was not always agreement between the professionals if a behaviour was negative or positive. Therefore, it is important to consider differences in people's perspective when behaviour is evaluated. Further research is needed to make a reliable and validated method to evaluate ridden horse behaviour in an objective way.

Olafsen (2015) found in her study, done with LSR, that there was a strong correlation between behavioural variables. The strongest ones in walk were between head position and ears, willingness to collaborate and work, and willingness to work and gait quality. In trot the strongest were between head position and willingness to collaborate, head position and willingness to work, and head position and gait quality. The behavioural scores were collected through videos taken during training sessions.

Warren-Smith et al. (2007) investigated if head and neck position influenced behaviour such as licking, chewing and ear position. Among feral horses lowering of head and neck is seen in stallions trying to get a mare or by foals showing submissive behaviour towards older horses. During grazing horses have more or less constantly lowered head. Many people believe this position has a calming effect for the horse. Warren-Smith et al. examined this behaviour by dividing the horses into four groups, A and C (control groups), and B and D (treatment groups). All horses were equipped with heart rate monitors. Group A was measured while standing still and group C measured while a person jumped up and down in front of the horse. Group B was asked to lower the head, achieved with applying pressure on the neck, and group D got the same treatment just with a person jumping up and down. Group B showed less chewing, licking and pawing behaviour, but had more ear movement than group A. No statistical difference was found between heart rate measurements for group A and B, and group C and D. The researchers could not conclude that lowering of the head had any calming effect on the horse, but since it was achieved through pressure the result might become different for horses lowering the head voluntarily.

2.1.4 Learned helplessness

Learned helplessness is a condition were an animal has been exposed to an aversive stimulus over a long period of time or many times, and learned that whatever it does it cannot escape the stimulus and ultimately it gives up fighting (McGreevy & McLean 2010). It is assumed that many riding methods can influence the horse in such a negative way that learned helplessness occurs. Especially if negative reinforcement is done incorrectly or conflicting signals are given making the experience stressful for the horse this condition can develop (Hall et al. 2008). This is also one important aspect to consider when it comes to assess behaviours during training, so that learned helplessness can be avoided. Prolonged restraint or fixation in one posture is one of the common procedures that might lead to learned helplessness, and it is used in many training methods to "break" the horse during initially training. (Hall et al. 2008). This can also come from different draw reins and other devices used during training and handling. Some horses that seems they have "switched of" or seen apathetic might have succumbed to learned helplessness (Hall et al. 2008). There is still a lot to learn about learned helplessness in horses and should be investigated further (McGreevy & McLean 2010). Evaluation of behaviour during training should therefore be important to determine which devices afflict distress, pain and fear.

2.2 Head and neck position

Equine professionals agree the horse's head and neck position influences the kinematics of the back and movements. Debates are still ongoing on which positions have a positive or negative influence in the short or long term. FEI dressage rules says the head should be in front or on the vertical line (Fédération Equestre Internationale, 2007). But today many horses are ridden with the nose behind the vertical line, often achieved by force. The term "on the bit", is often misused to describe this, since it actually means the riders hands and the horse's mouth should have a subtle connection without the need for force (McGreevy et al. 2010).

Because of different opinions, it is important to research the effect head and neck positions have on the horse; which benefits and problems there are concerning different positions. Hall et al. (2014) found that equestrian professionals (instructors, veterinarians and riders) associated a high head and neck with the nose in front of the vertical line as positive, and instructors associated neutral head and neck with the nose on the vertical line as positive. When it came to the riders they associated the nose in front of the vertical line as a negative sign and wanted it more behind the vertical line.

2.2.1 Rollkur

In the last decade there has been a lot of focus on the head and neck position called rollkur, which is practised on many dressage horses. Rollkur is hyperflexion of the neck in a very high and round position, where the horse's jaw often ends up touching the chest. Normally force is used to achieve this position through reins or draw reins. The physical and psychological effects it has on the horse is still an ongoing debate, although most people agree that it has a negative long term effect, but disagree on the short term effect (Von Borstel et al. 2009). Keeping this position over an extended period will compromise pulmonary ventilation and the horse will have trouble breathing, and in severe cases, the tongue will turn blue from oxygen deprivation (McGreevy et al. 2010). It is also assumed that it can reduce the horses vision (Hall et al. 2014; McGreevy et al. 2010) Sometimes rollkur is mistaken for low, deep and round riding or longitudinal stretching, and it is important to separate these. The difference between these positions is that in rollkur the nose is behind the vertical line and pulled towards the chest, while in low deep and round riding or longitudinal riding the neck is stretching forward and down, while the nose is in front of the vertical line.

Von Borstel et al. (2009) investigated rollkur's effect on stress and fear in horses. They hypothesised that horses would choose to be ridden with the nose in front of the vertical line over rollkur, and that heart rate and negative behaviour such as head tossing and tail lashing would be more common during rollkur. To test fear response, horses were presented with a fear stimulus after riding, and the hypothesis was that rollkur would lead to a larger fear response. The ridden test was done in a Y-maze, were one arm led to being ridding in rollkur, and the other being ridden with the nose in front of the vertical line. They found that there was no significant difference between heart rate for the two riding methods, but horses ridden in rollkur used a longer time to do the same exercises, meaning they moved slower.

Most of the negative behavioural categories had a higher frequency during rollkur, but stumbling and snorting did not differ. Behaviour such as backing-up, groaning and presence of eye-white were only seen during rollkur. Riders experienced that when riding in rollkur they used more force, either with the whip or legs to move the horse forward. This showed that horses were more reluctant to be ridden in this position. When the horses got to choose the path in the Y-maze, 14 of 15 horses avoided the arm that led to rollkur riding. During fear stimulus all horses ridden in rollkur showed a higher elevation of heart rate and used longer time to approach the stimulus. Von Borstel et al. concluded that horses perceived rollkur as a negative experience and their preference is to have the nose in front of the vertical line, and that during rollkur horses showed more behaviours related with discomfort and stress. Some reports confirm that rollkur led to skeletal changes inducing pain between 2nd and 3rd cervical.

2.2.2 Effect of head and neck position

A few studies have investigated the effect of different head and neck positions on the flexion and extension of the back and the effect on gait quality. Lowering of the head and neck forward and downward is thought to increase back movement, strengthen the muscles in the back and abdomen, while a higher head and neck position would make extension of the forelimbs and engage the hind limb (Waldern et al. 2009). Álvarez et al. (2006) investigated this and hypothesised that all positions that differed from a free position would affect the kinematics of the back due to bow-string theory, and more extreme positions would have a larger negative effect. Bow-string theory describes how the back muscle together with the spine act as the bow while the abdominal muscles are the string. To achieve this the head needs to have a low position resulting in increased hind limb activity. This will lead to a better position for the horse to carry the weight of the rider. For reference, measurements were done in a free position during different speeds. Álvarez et al. found changes in kinematics on all positions but the most extreme difference was during rollkur (flexion) and during a very high position with the nose considerably in front of the vertical line (extension). The only position that affected both flexion and extension of the back was a very high position, which is also seen in other studies (Rhodin et al. 2005; Waldern et al. 2009). This was also the only position that influenced the protraction of the hind limb. Waldern et al. (2009) similarly investigated the influence of six different head and neck positions on the load distributed between forelimb and hind limb during exercise on a treadmill. They hypothesised that horses stretching the head forward and downward would increase the load on the forelimb, while a high head and neck position would put more of the load on the hind limbs. Control load was measured during an unrestrained free position. The load that most resembled the control position was when they stretched the neck forward and downward, this was the same for both walk and trot. During all other positions the load was more on the hind limb, with the most load during a very high position with the nose considerably in front of the vertical line.

Olafsen (2015) found that during LSR the head and neck position were lower in walk than in trot, and that a low and stretched position was achieved only in walk during the last part of the riding and last lunging. The highest amount of low behavioural scores was seen during a high head and neck position. She concluded that a low and stretched head and neck position gave higher behavioural scores and resulted in improved welfare during riding.

Almost all studies use draw reins or other devices to achieve different head and neck positions, and this is common among many riders that want to shift the load from the forelimb to the hind limb. Rhodin et al. (2005) investigated how different head and neck positions would affect the kinematics of the back and how draw reins would influence it. They used an unrestrained head and neck position as a reference, and looked at the difference between this position and the other with the use of draw reins. Markers were used on the body to measure the kinematics and researchers only used three different head and neck positions: free, high and low. All horses were trained on a treadmill when measurements were taken. During a low position they found a decrease of movement on the back, and that during a high position the flexion-extension of the back was smaller than in the free position. They concluded that restriction and restraining of the movement of the head and neck influenced the movement of the back negatively, and that walk was more affected than trot.

2.2.3 Stride length

Head and neck position have an enormous impact on the stride length. Long strides are often seen as a sign of good movement and use of back and abdomen muscles. During dressage competition long strides are scored high. Waldern et al. (2009) found that the longest stride was gained when the horse either got to choose the position or had the head and neck extended forward and downward. The shortest stride was found when the head and neck was in a very high position with the nose on or in front of the vertical line. The weight of the rider also influenced the overreach, and strides were shorter for all head and neck positions when ridden. During a very high position with the nose in front of the vertical line, researchers could not see any overreach during riding, and this shows that the weight of the rider has a larger influence on some head and neck positions.

2.3 Pressure algometer and pain sensitivity

A pressure algometer is a tool to measure mechanical nociceptive threshold (MNT) in humans and horses. A study done on horses concluded that it is useful, but it is important that the people using it learn to use it before the actual measurements because it might influence the results, and learn to recognise avoidance behaviour of the animal to establish when the pressure should stop (De Heus et al. 2010).

Olafsen (2015) investigated the effect of LSR on MNT using an algometer and found that on almost all body locations tested, the measurements had a higher value after riding then before. The exceptions were brachiocephalicus left side (720.5 ±190,3 before and 640,9 ±150,6 after), and mid-portion of the thoracic longissimus muscle right side (770,1 ±374,1 before and 587,8 ±139,9 after).

De Heus et al. (2010) investigated if the pressure algometer was a reliable tool to measure muscle sensitivity and pain sensitivity at 35 different sites on horses. They found that there are many aspects that will influence the results such as the experience of the person using the device, the horse's response to it and the influence of surroundings such as noise. It can be difficult for a person to use the algometer since the pressure needs to be kept even over time. Horses needed to be accustomed to the pressure algometer, but if measurements are done many times the horse might habituate to the pressure and respond at a later stage which will affect the results. The position of the horse is also important, muscles cannot be flexed or extended, so the horse will need to stand straight. Results showed that measurements taken at different time of the day got different results, and that measurements taken in the evening were normally lower than the ones taken in the evening. This might be important to remember when it comes to other studies that only measure once per day. Even if there were differences between individual horses and between breeds the measurements for the individual horses normally stayed the same from day to day. They concluded that it is useful, but that it is difficult to get reliable scores due to the horse, and person using the device and the large influence it will have on the result.

2.4 Training for a supple horse

In every equestrian discipline which include riding it is important to train the horse correctly so that it is strong enough to carry itself and the rider and at the same time perform different exercises in dressage or having the power to jump a fence. This is not achieved over night and it often takes many years. The basic training principles that is used to strengthen the muscles is fundamental even later in training and should be corporate into the weekly training regime (Olafsen 2015). Stress and fear during training might interfere with the training process and hinder the development of muscle and affect performance negatively. Indications of a relaxed and supple horse is a swinging back (McLean & McGreevy 2010), together with balance and rhythm. Rhythm refers to the regularity in each step, and it should have the same tempo and length over a period of time and throughout different exercises. Even during LSR it is important that the back is engaged and active so that the power is coming from the hind. This also helps the horse to distribute the weight correctly to all four feet instead of the front were most of the weight normally is distributed.

3 Aim and predictions

The objective of this project was to study the effects of longitudinal stretching while riding on behavioural scores indicating positive or negative behaviour, gait quality, mechanical nociceptive threshold (MNT), and pain sensitivity. I also aimed to evaluate the validity of the training method for accomplishing better welfare during riding and at the same time enhancing performance through a physical and biomechanical focus.

3.1 Predictions

If the method is perceived as something positive by the horse mentally and physically, it was predicted that:

1. Behavioural scores (i.e. for eye, ear, mouth, head and neck, willingness to work and collaborate with the rider) and total behavioural score would increase (i.e. a higher value means more positive response) after the treatment period and that this effect should be visible also when ridden by a control rider.
2. Gait quality score during walk and trot would increase after the treatment period for both experimental rider and control rider.
3. Due to muscle development along the topline, MNT measurements and pain score should be affected by treatment.
4. Back, neck and hamstring muscle would develop positively, and as a result the hind should become more round in shape and the back region slightly lifted and flattened compared to before treatment.

4 Material and method

4.1 Horses

The study was conducted on 12 horses with different age (4-20 years old, mean 10,75), sex (7 mares and 5 geldings) and breed (6 Warmblood riding horses, 2 Standardbred trotters, 3 Coldblooded trotters and 1 Friesian horse). Treatment period lasted 1 month. Before treatment, all horses underwent a veterinary examination to evaluate the horses physical state. All of the horses were poorly muscled in different part of the body such as the back and hind, and one horse received a 2,5 on the American Association of Equine Practitioners (AAEP) lameness scale and was ordered to only be ridden in walk for the two first weeks of the treatment period.

4.2 Experimental set-up

Horses were subjected to the following weekly treatment for a month:

- Three days with 30 minutes LSR in the riding house (Monday, Tuesday, Thursday).
- One day of walking on a leash uphill and downhill in an outside track with sand on the ground for 30 minutes (Saturday).
- One day loose in the riding house to move freely for about 15 minutes (Wednesday).
- And two days off with resting in the paddock (Friday and Sunday)

4.3 Housing during the treatment period

During the treatment period, all horses were housed in the same way as they were used to, minimising the effect of stabling. They were kept in individual boxes (2.8 x 3.5m) inside an insulated stable from 19:00 in the evening until 07:30 in the morning, and during the daytime when they were not trained, they were kept outside in a paddock (also individually) between 8am and 7pm. Feeding was done individually, and all horses were fed the same as they were before the study. They got hay outside in the morning and midday, and then inside in the evening. Concentrate was given twice a day in the morning and then in the evening.

4.4 Treatment

All horses were videotaped during training sessions with a handheld camera, so that behaviour could be observed at a later state. The horses were first lunged (L1) for 5 min before riding sessions started. Horses received three riding sessions, 10 min with control rider

(R0) either in the beginning or in the end (were treatment method was not used), and 2 sessions with experimental rider using LSR (R1, R2), each 10 min. After riding another 5 min of lunging (L2) was conducted.

4.5 Behavioural observations

Videos were watched and the horse's behaviour was scored with the help of an ethogram (Table 2). Behaviours were scored on a scale from 1-6 where the lower scores represent negative behaviour and scores above 4 are deemed as positive behaviour. During lunging (L0 and L1) 4 registrations were taken, and during the different riding sessions (R0, R1 and R2) 3 registration was taken. The registrations were taken during different gaits (walk and trot) and different directions (right and left hand). Before and after treatment the horses also got a manageability score from 1-6. Each week of treatment during LSR the horses was scored on mental state and movement (1-6; Table 1). Both handling ability score and movement score was done by the same person throughout the study.

Table 1: *Movement and mental scale measured on weekly basis in the treatment period.*

	Movement	Mental
1	No balance and no elasticity, asymmetric and stiff.	No contact, lack of control and collaboration, stressful.
2	Some elasticity, no balance.	Some contact, but a lot of tension.
3	Some balance.	Some contact and collaboration, but tense.
4	Middles balance.	Good contact, but some tension.
5	Good movement.	Good contact and collaboration.
6	Good movement and balance. Symmetric.	Full contact, relaxed in a low and stretched form and high collaboration. No tension.

Table 2: *Ethogram used to score behaviours (Olafsen 2015)*

	Negative behaviour					Positive behaviour
	1 **Very tens**	**2** **Tens**	**3** **Unfocused**	**4** **Unfocused/but easy to manage**	**5** **Focused/relaxed**	**6** **Focused/very relaxed**
HNP	**HNP1**	**HNP2**	**HNP3**	**HNP4**	**HNP5**	**HNP6**
Head- and neck position	High, tens, nose over the vertical line	High, arched, nose over the vertical line	High, arched, nose near the vertical line	Arched neck, head at elbow height	Arched/ stretched neck, Head at knee height	Arched/ stretched neck, head between knee and pastern
			Behaviour under rider			
Eyes	Open, white is showing	Some of the white is showing	Rolling the eyes, tens.	Shows sign of eye white when focused on something else than the rider.	Eye white is rarely seen, and the horse is for the most part relaxed.	Relaxed, no sign of white in the eyes.
Ears	Ears backward, shows sign of aggression.	Changes between ears backwards and ears pinned. Tense horse with sign of frustration.	Moves quickly back and forward. Tense and unfocused.	Moves calmly between the rider and forward.	Moves sometime forward and backwards. Shows sign of relaxation.	Floppy ears hanging to the sides, horse is focused on the rider and the signals it is given.
Mouth	Mouth open, tongue out, abnormal activity, a lot of foaming, uneasy head.	Mouth open, abnormal activity and a lot of foaming.	Abnormal amount of movement, a lot of foaming and tense.	Immobile mouth, a lot or no foaming.	Easy suction on the bit, few tensions, some foam.	Quiet and relaxed with a little foaming.
			Gait quality			
Walk	Uneven and tense. No rhythmical gait pattern and tense movements.	Uneven and tense, difficult to keep right movement pattern.	Shows some sign of uneven and wrong movement pattern.	Horse shows four-stroke gait with some deviation.	Shows good four-stroke gait, which is even and relaxed.	Shows relaxed and even gait with good four-stroke walk. Good overreach.
Trot	Uneven and tense. No rhythmical gait pattern and tense movements.	Uneven and tense, difficult to keep right movement pattern.	Shows some sign of uneven and wrong movement pattern	Horse shows two-stroke trot with some deviation.	Shows good two-stroke gait, which is even and relaxed.	Shows relaxed and even gait with good two-stroke trot. Good overreach and forward movement.
Willingness to collaborate	Reluctant and resistant. Shows sign of discomfort, prancing/bucking, do not want to move forward.	Reluctant and some resistance. Some sign of discomfort. Do not want to move forward.	Periodically reluctant. Pulls the rains, and shakes the head. Uneasy mouth.	Shows some sign of collaboration. Seeks down and forward. No protests.	Tractable most of the time. Sometimes unfocused, but easily gained back.	Tractable and focused on cues from the rider. No protests and easy to work with.
Willingness to work	Not good, shows large physical/mental limitations for the work it is asked to perform.	Bad, horse shows physical/mental limitations for the work it is asked to perform.	Shows sign of difficulties to work, with balance problems and stumbling.	Horse shows potential through stable work, with some deviation.	Shows good physical /mental ability to perform the work tasks.	Shows very good abilities to perform this type of work. Good balance and masters the physical tasks good.

4.6 Head and neck positions

To register head height six different head positions was used (also see Fig. 2):

HNP1	Head high, tens, and nose in front of the vertical line
HNP2	Head high with arched neck, but nose are in front of the vertical line
HNP3	Head high, arched neck, nose at the vertical line
HNP4	Arched neck, head placed in elbow height
HNP5	Arched and stretched neck, head placed in knee height
HNP6	Arched and stretched neck, head placed in height between pastern and knee

Position HNP6 is the one that the experimental rider wanted to achieve, but horses were not forced into this position.

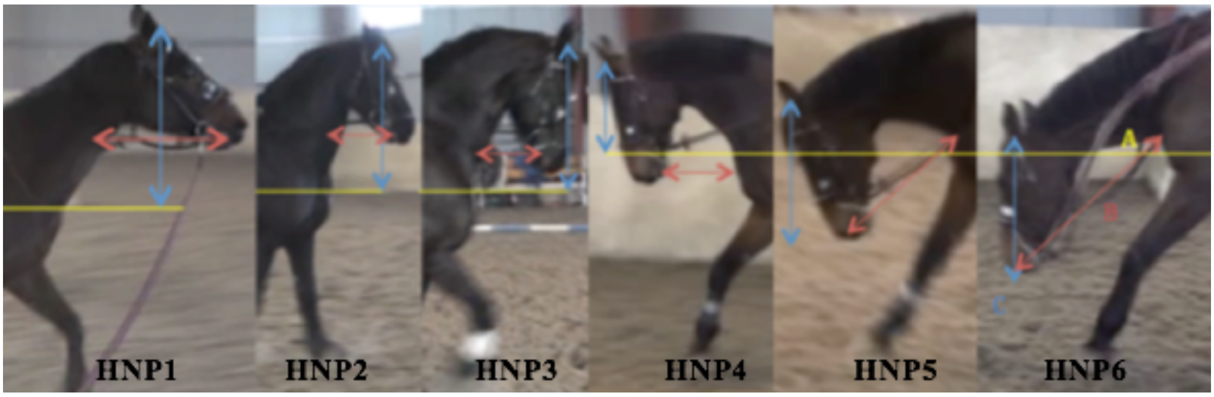


Fig. 2: *Different head and neck positions. A (yellow) illustrates the chest line, B (red) neck length, and C (blue) the vertical line from the ears. (Olafsen 2015).*

4.7 Mechanical nociceptive threshold (MNT) and pain sensitivity

A pressure algometer (Somedic, Hörby, Sweden) was used to measure MNT before and after LSR. It had a 1 cm^2 rubber edge with a maximal pressure of 30kg. The apparatus were used perpendicular to the surface of the horse, and pressure were given on a constant rate of $10kg/cm^2/sec$, recommended by De Heus et al. (2010). Pressure continued until the horse showed avoidance behaviour, either by muscle contractions or by the horse moving away from the pressure. When this behaviour occurred the pressure stopped and the value was logged. It was the same person that did all the measurements, and this person had previous experience with the use of an algometer. Eight different sites were used to measure the MNT (Table 3; Fig. 3). Measurements from one horse was excluded because there were only measurements from before the study and not after.

Table 3: *Description of locations used to measure MNT (De Heus et al. 2010)*

Places (4 bilateral)	Location
1, 5	Middle of the splenius muscle at the third cervical vertebral level
2, 6	Brachiocephalicus muscle at the base of the neck, at the level of C7
3, 7	Mid-portion of the thoracic longissimus muscle at the 13th thoracic vertebral level, 10 cm lateral to the dorsal midline
4, 8	Mid-point between the cranial aspect of the tuber sacral and tuber coxae (middle gluteal muscle)

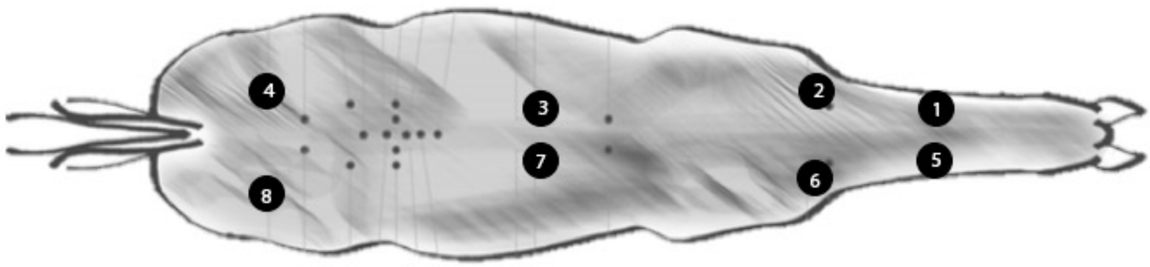


Fig. 3:*Location of MNT measurements (De Heus et al. 2010).*

Pain sensitivity was scored through a method that consisted of applying pressure along the muscles and score the horse's reaction on a scale from 0-3 (Table 4), this was conducted in the same order on all horses. Measuring places were the same as for the MNT.

Table 4: *Pain sensitivity score with description (De Heus et al. 2010)*

Score	Classification	Description
0	No pain	No reaction
1	Light pain	Nose wrinkling, ear flattening, slight spasm on palpation without associated movement
2	Moderate pain	Head jerk, teeth bearing, tail lasing, stamping foreleg, (aggressive tail flattening, rising hind leg, spasm on palpation associated local movement
3	Severe pain	Kicking, biting, rearing, sour attitude, restless, sinking away from the hand

4.8 Topline

Before and after treatment pictures were taken of six horse from each side. This was to assess if there were any changes to the topline before and after the training treatment. Pictures was not taken at the same distance or angel between the camera and the horse. This was the first time this method was used so it is to be considered as a pilot version of a picture analysis method that will be further advanced and improved. Therefore, no statistics is yet presented on these results, only descriptive figures are given and methods will be further discussed in the discussion section.

4.9 Statistics

Analyses of behavioural and gait quality scores were done with a mixed model in SAS (proc mixed), with the following class variables: time (before to after treatment), activity and gait. Interaction between time and activity was also analysed- “Horse” was specified as a random effect in the model. Pearson Correlation Coefficient was used to analyse interactions between behavioural and gait quality scores.

Mental and movement score was analysed using a mixed model in SAS, with time (each week) as class variable. Management was analysed in Excel with a paired T-test. A Genmod model in SAS was used to analyse time and change in MNT and pain sensitivity, with location, and time as a class variable.

5 Results

5.1 Behavioural scores and gait quality

Most behavioural scores increased significantly from before to after the treatment (time) period (Table 5; Fig. 4). Except for head position there were hardly any significant differences between walk and trot in any of the behaviours recorded. None of the horses had scores lower that three. (Fig. 4).

Table 5: *F and P-values for behavioural scores in relation to time (before and after treatment) and gait.*

	Time		Gait	
	$F_{1\text{-}199}$	P-value	$F_{1\text{-}199}$	P-value
Head position	2.76	0.098	9.04	0.003*
Eyes	7.21	0.008*	0.06	0.811
Ears	4.96	0.027*	0.66	0.416
Mouth	17.79	<0.0001*	0.01	0.922
Willingness to collaborate	15.5	0.0001*	0.71	0.402
Willingness to work	23.73	<0.0001*	0	0.952
Total	23.88	<0.0001*	0.95	0.332
Gait quality	24.58	<0.0001*	0	0.975

*Scores that are statistically significant (P< 0,01)

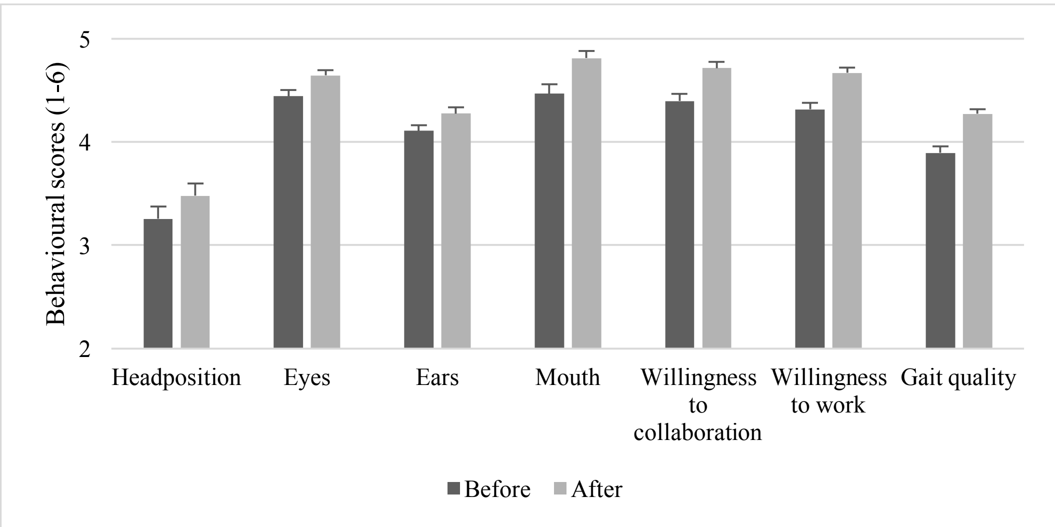


Fig. 4: *Behavioural scores before and after the treatment period (mean +SE).*

5.1.1 Behavioural scores during the different activities

During the different activities, head positon, ear position, mouth, willingness to collaborate, total score and gait quality was positively affected by treatment (Table 6). There was no significant interaction between activities and time. This means that the behavioural scores before and after treatment did not differ between activities irrespective of whether this was before or after treatment. Eyes (F=0.71, P=0.59) and willingness to work (F=0.76, P=0.55) were not significant for activities.

Table 6: *Mean ±SE, F and P-values for behavioural scores during different activities.*

	Statistical values		Behavioural scores (mean ±SE)				
	$F_{4\text{-}199}$	P-value	First lunge	Other rider	First LSR	Last LSR	Last lunge
Head position	22.1	<0.0001*	2.28±0.15	3.39±0.16	4.06±0.17	4.10±0.17	3.18±0.15
Eyes	0.71	0,588	4.65±0.11	4.70±0.11	4.69±0.11	4.73±0.11	4.83±0.11
Ears	4.14	0.003*	3.99±0.10	4.26±0.10	4.44±0.10	4.39±0.10	4.22±0.10
Mouth	19.05	<0.0001*	5.46±0.13	4.90±0.14	4.49±0.14	4.71±0.14	5.51±0.13
Willingness to collaborate	9.87	<0.0001*	4.13±0.09	4.64±0.09	4.66±0.09	4.89±0.09	4.53±0.09
Willingness to work	0.76	0.549	4.59±0.11	4.73±0.11	4.74±0.11	4.73±0.11	4.77±0.11
Total	6.14	0.0001*	25.17±0.5	26.69±0.5	27.14±0.5	27.61±0.5	27.12±0.5
Gait quality	2.61	0.037*	3.98±0.10	4.14±0.11	4.27±0.11	4.27±0.11	4.30±0.10

*Scores that are statistically significant (P< 0,01)

In most activities, ear score was significantly higher after than before treatment, except for last lunging (Fig. 5). After treatment R1 and R2 had higher scores than before treatment. Significant differences were seen between L1 and R1 (P=0.0003), and L1 and R2 (P=0.0015).

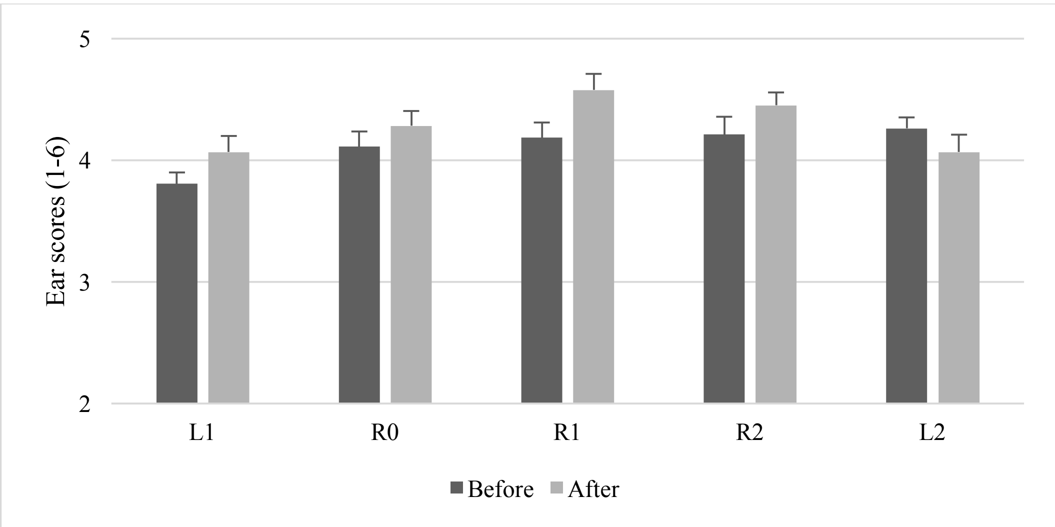


Fig. 5: *Ear position before and after treatment period (mean +SE).*

There were significance differences between activities regarding mouth scores before and after treatment (F=19.05, P=<0.0001; Fig. 6). Between the activities no significant difference was found between L1 and L2 (P=0.70), R0 and R2 (P=0.23), and between R1 and R2 (P=0.14). There was no effect of treatment on lunging, but there was a tendency to higher scores after treatment for all riding sessions (Fig. 6).

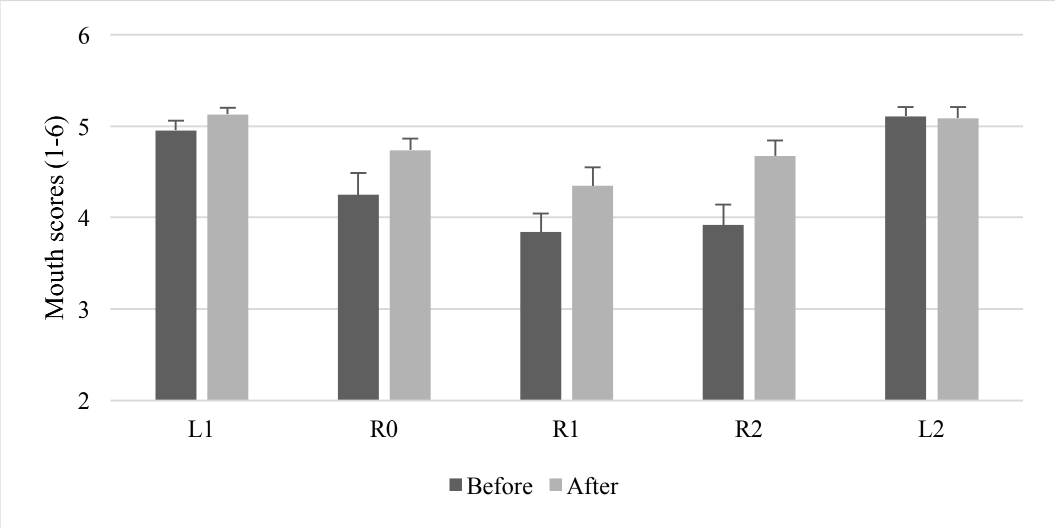


Fig. 6: *Mouth before and after treatment (mean +SE).*

For willingness to collaborate and the different activities there were statistical differences between L1 and all the other activities (P=<0.001), and between R2 and L2 (P=0.006). Except for the last lunging, there was a tendency for higher scores after treatment in all activities (Fig. 7).

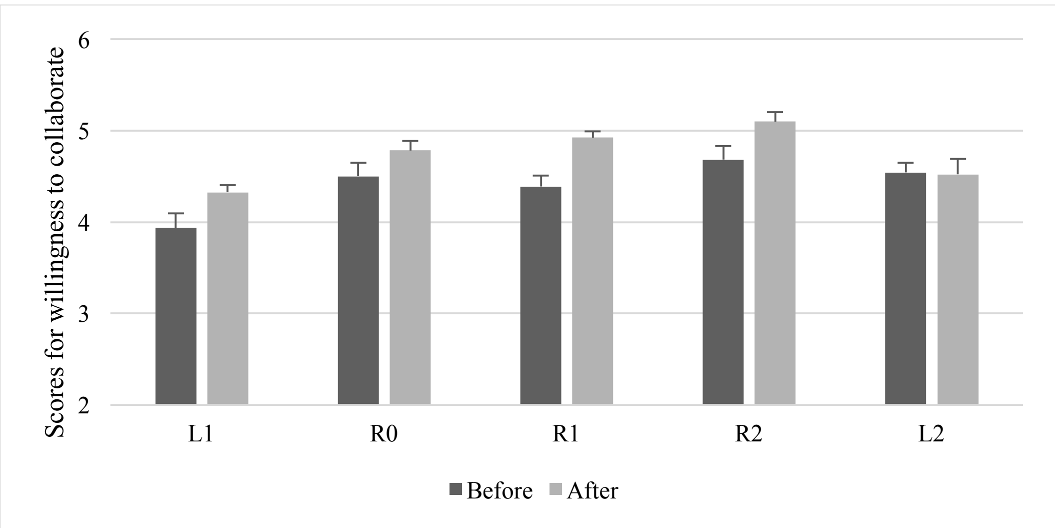


Fig. 7: *Willingness to collaborate before and after treatment (mean +SE).*

For the different activities the only statistical significance regarding total score was between L1 and the other activities (P=<0.006). There was a positive tendency for higher scores in LSR (R1 and R2) after treatment (Fig. 8).

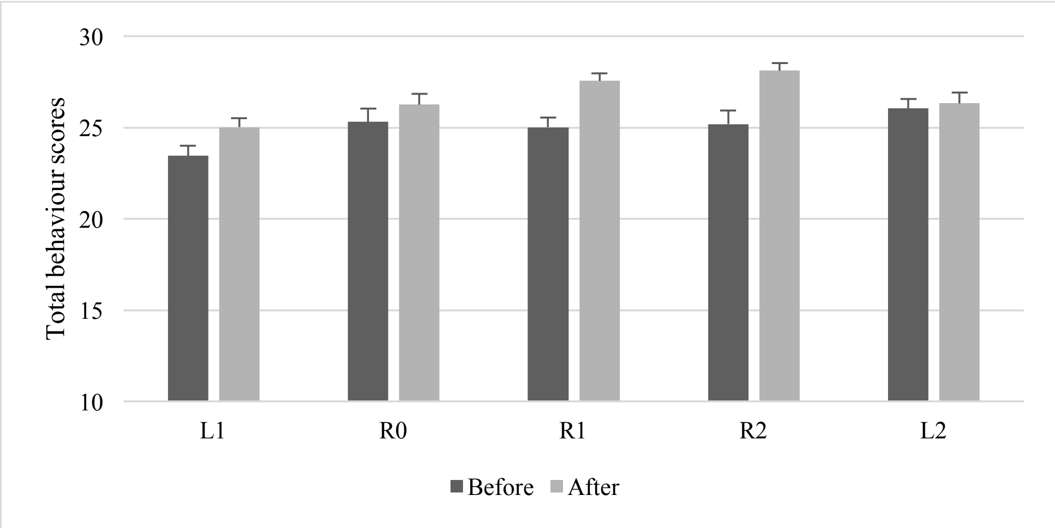


Fig. 8: *Total behavioural scores before and after treatment (mean +SE).*

There was a significant difference between L1 and L2 (P=0.006) regarding gait quality (walk and trot). For all activities there was higher scores after treatment (Fig. 9).

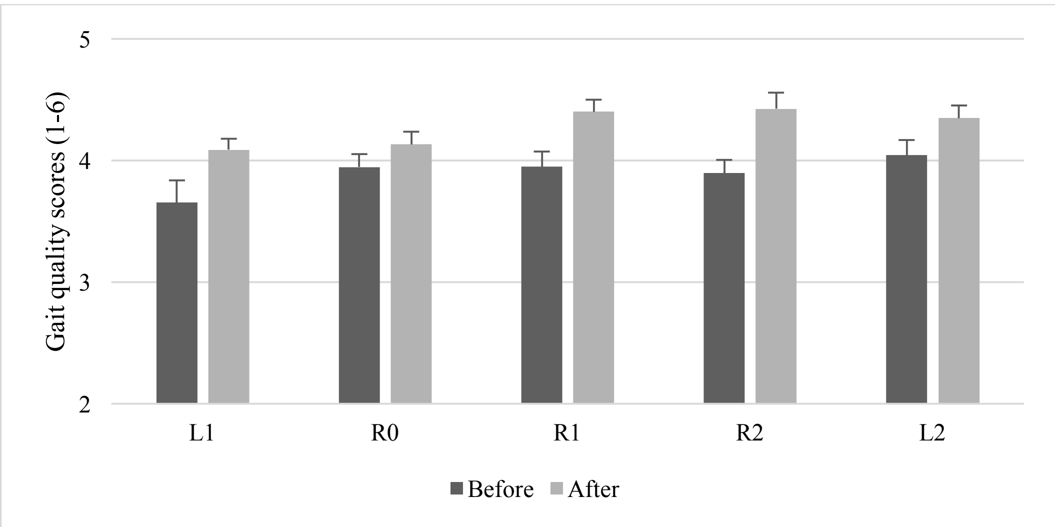


Fig. 9: *Gait quality before and after treatment (mean +SE).*

5.1.2 Correlations between scores

Correlations between scores are shown in Table. 7. Total score was correlated with gait quality. Head position is strongly correlated with ear scores, and moderately with willingness to collaborate and work. Both eyes and ear scores are moderately correlated with willingness to collaborate and work, and gait quality. Willingness to collaborate had positive correlation with gait quality and a strong correlation with willingness to work. Willingness to work and gait quality was also strongly correlated.

Table 7: *Correlations between behavioural scores.*

	Head position	Eyes	Ears	Mouth	Willingness to collaborate	Willingness to work	Total	Gait quality
Head position	1.00	-						
Eyes	0.19	1.00	-					
Ears	0.53**	0.28	1.00	-				
Mouth	-0.14	0.22	0.12	1.00	-			
Willingness to collaborate	0.44*	0.36*	0.47*	0.06	1.00	-		
Willingness to work	0.33*	0.36*	0.38*	0.21	0.53**	1.00	-	
Total	0.72**	0.57**	0.72**	0.36*	0.73**	0.69**	1.00	-
Gait quality	0.26	0.46*	0.33*	0.20	0.47*	0.51**	0.55**	1.00

* Moderate correlation (0.30-0.49)
** Strong correlation (>0.50)

5.1.3 Movement and handling ability

Movement scores was taken each week during LSR. There was a significant improvement from week to week (F=8.18, P=0.0002; Fig. 10). Mental scores did not change significant from week one to four (F=2.14, P=0,11). Handling score was taken before and after treatment and showed a positive improvement (t= -2.57, P= 0.03; Fig. 11).

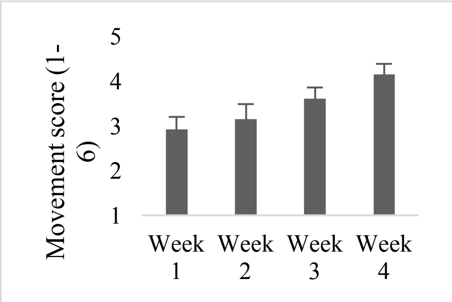


Fig. 10: *Movement score for each week of treatment period (mean +SE).*

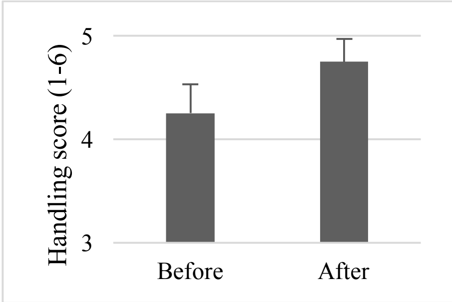


Fig. 11: *Handling score before and after treatment period (mean +SE*

5.2 Effect on head and neck position

Head and neck position were significant regarding gait (F=9.04, P=0.003; Fig. 12). There were higher scores during walk than during trot, and a tendency to improvement for both gaits after treatment.

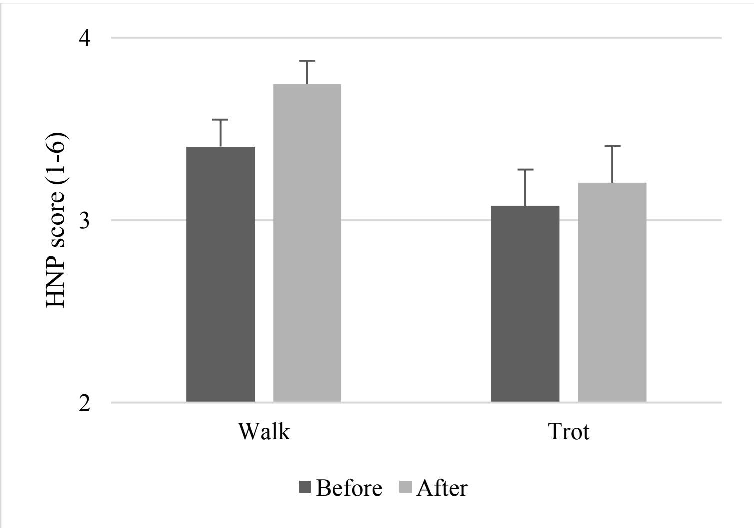


Fig. 12: *Head and neck position in walk and trot (mean +SE).*

Head and neck positions were significant for activities (F=22.10, P<0.0001), but not between all the different activities. R0 and L2 (P=0.34) and between R1 and R2 (P=0.87) no difference was found. Scores during riding had higher scores than during lunging (Fig. 13). R1 and R2 had higher scores than R0. There was a tendency for higher scores for all activities, except R0 after treatment (Fig. 13).

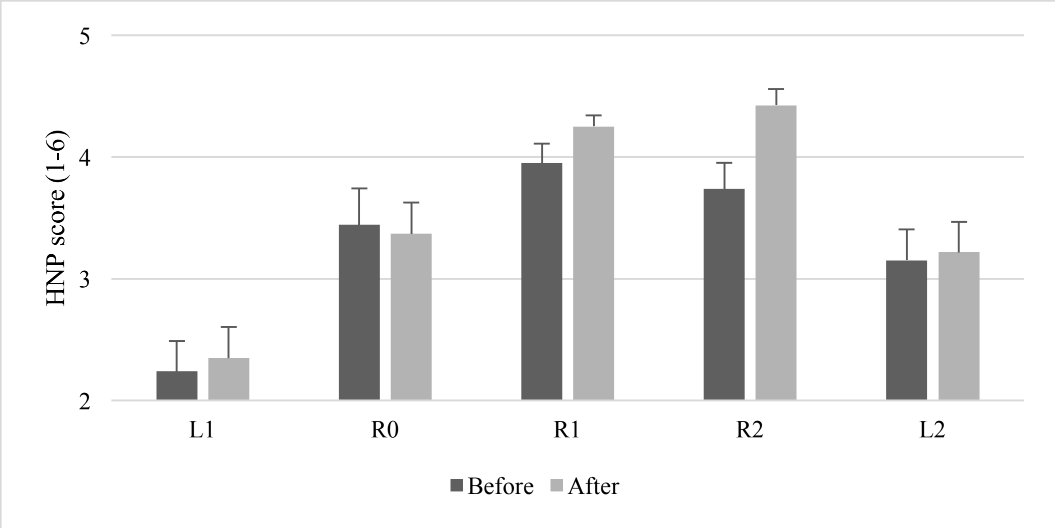


Fig. 13*: Head and neck position before and after treatment (mean +SE).*

There were individual differences between horses, but most horses showed an improved head and neck position after treatment (Fig. 14).

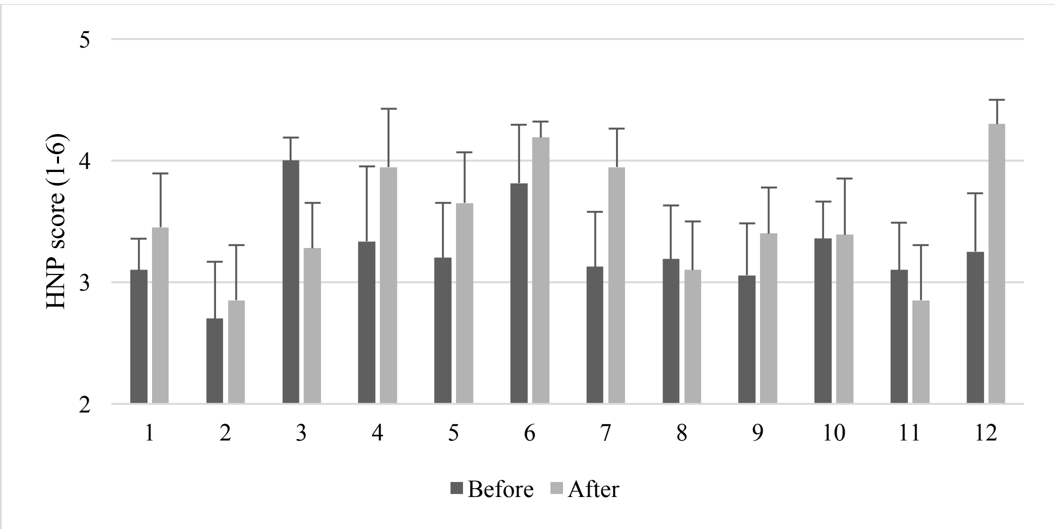


Fig. 14: *Head and neck position for each horse before and after treatment (mean +SE).*

5.3 Mechanical nociceptive threshold (MNT) and pain sensitivity

There was a significant change in MNT pressure from before to after LSR, both before (χ^2=1235.6, P<0.0001; Fig. 15) and after treatment (χ^2=1088.01, P<0.0001; Fig. 16). Before treatment the change in pressure were not statistically different between back and hind left side (P=0.05), back left side and back right side (P=0.80), or between hind left and back right (P=0.03). "Neck left" was the only one with a negative change.

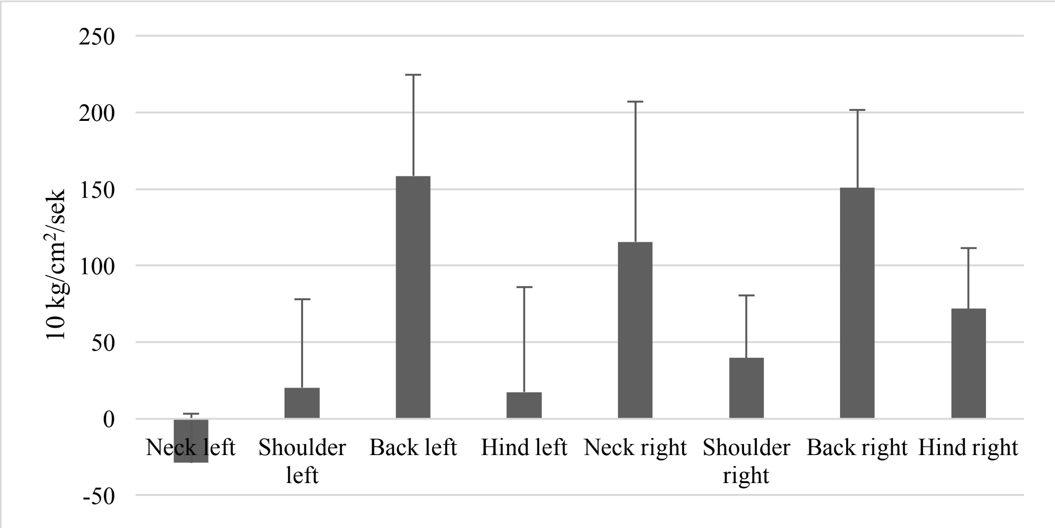


Fig. 15: *Change in MNT pressure (+SE) before and after LSR before treatment.*

After treatment there was no significant difference in changes between “neck left” and right shoulder (P=0.07), back and hind left side (P=0.05), back right and left side (P=0.73), or between hind left side and back right side (P=0.03). “Neck left” was the only one with a negative change.

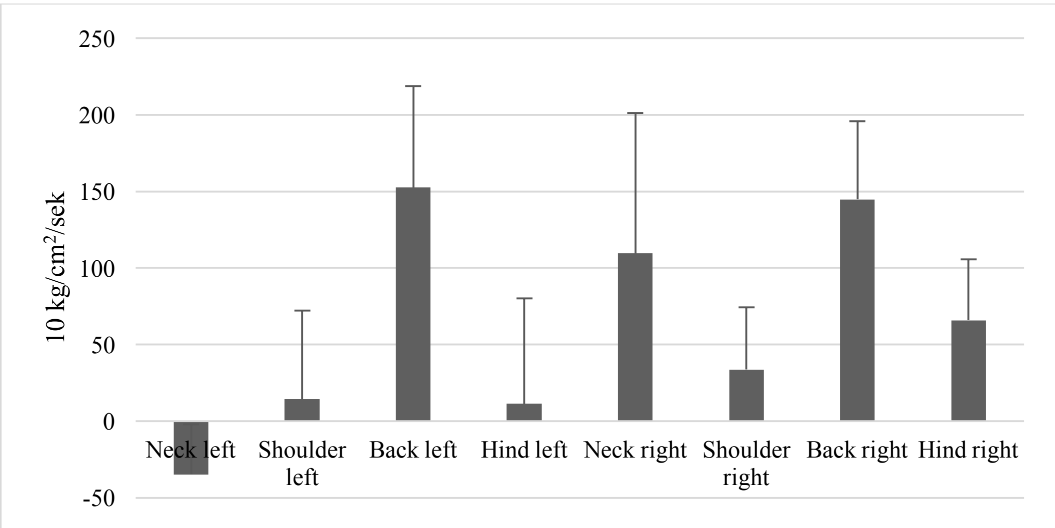


Fig. 16: *Change in MNT pressure (+SE) before and after LSR after treatment..*

When comparing the effect of LSR on MNT, there were no significant difference between measurements taken after LSR before and after treatment (t= -1.78, P=0.1) but there was a small tendency to improved scores after treatment (Fig. 17).

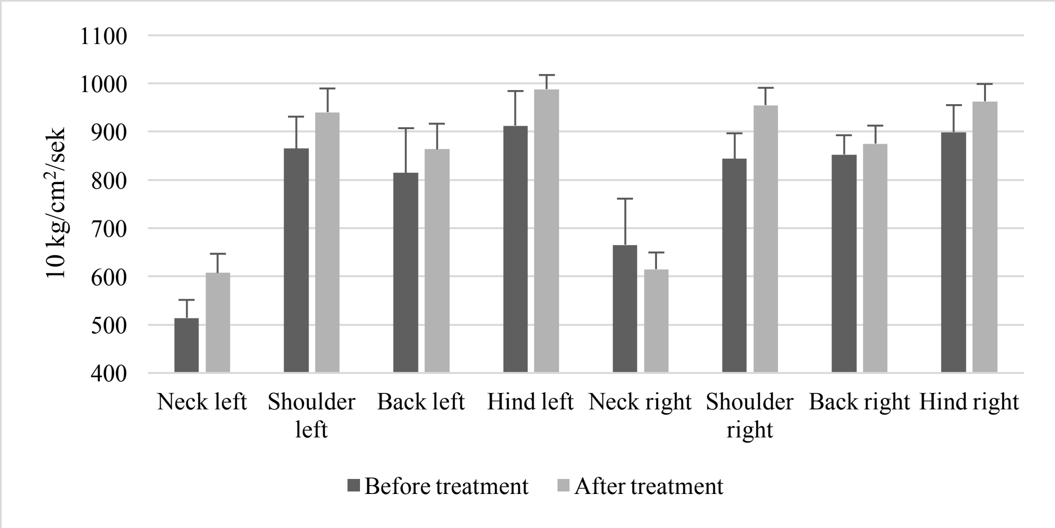


Fig. 17: *MNT pressure after LSR, before and after treatment (mean +SE).*

Only neck left side had a lower pressure after LSR before treatment (Fig. 18). After treatment all, except right hind had a tendency to higher scores after LSR (Fig. 19).

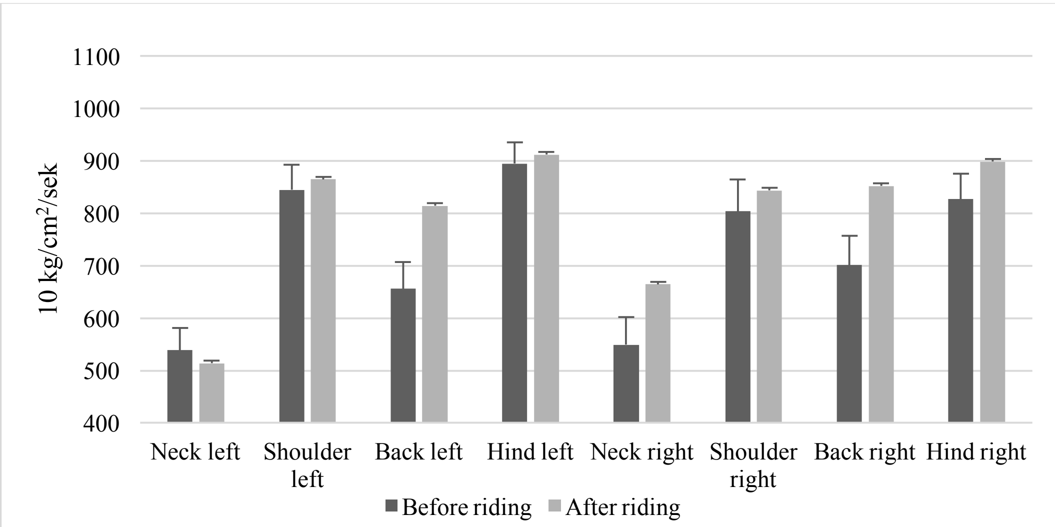


Fig. 18: *MNT pressure before and after LSR, before treatment period (mean +SE).*

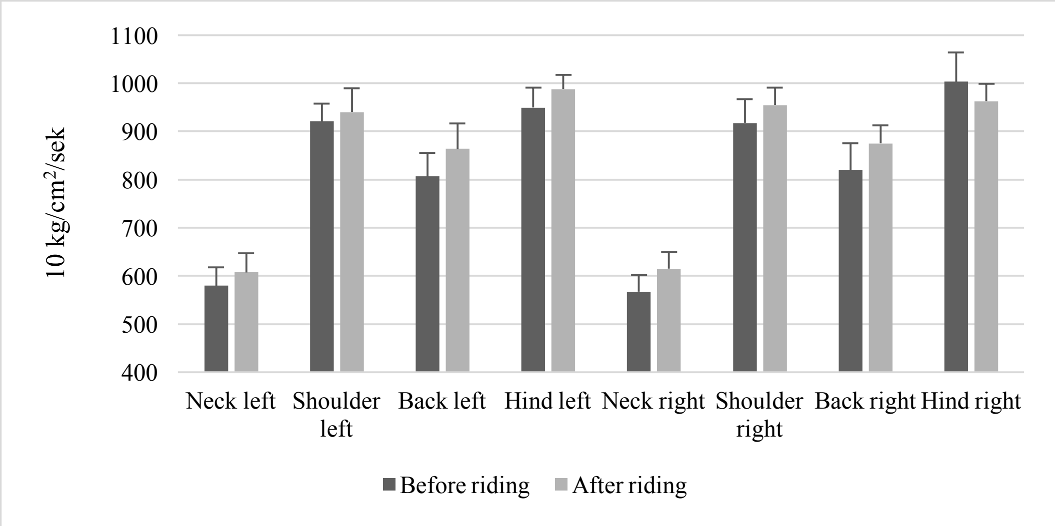


Fig. 19*: MNT pressure before and after LSR, after treatment period (mean +SE).*

There was no statistically significant change in pain sensitivity after LSR, before (χ^2=3.81, P=0.80), or after treatment (χ^2=3.81, P=0.80) And also no significant difference between measurements taken after LSR before and after treatment (t=1.30, P=0.22). Before treatment most scores were lower after LSR (Fig. 20).

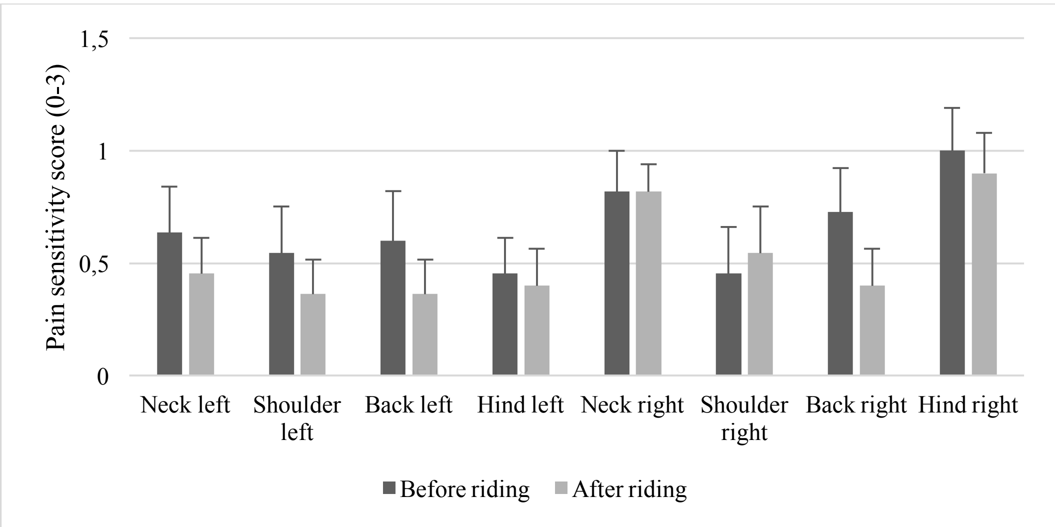


Fig. 20: *Pain sensitivity before and after LSR, before treatment (mean +SE).*

Most scores before and after LSR, after treatment period had a lower score after LSR, the exception was shoulder both sides (Fig. 21). For both before and after treatment scores were not high (<1.2).

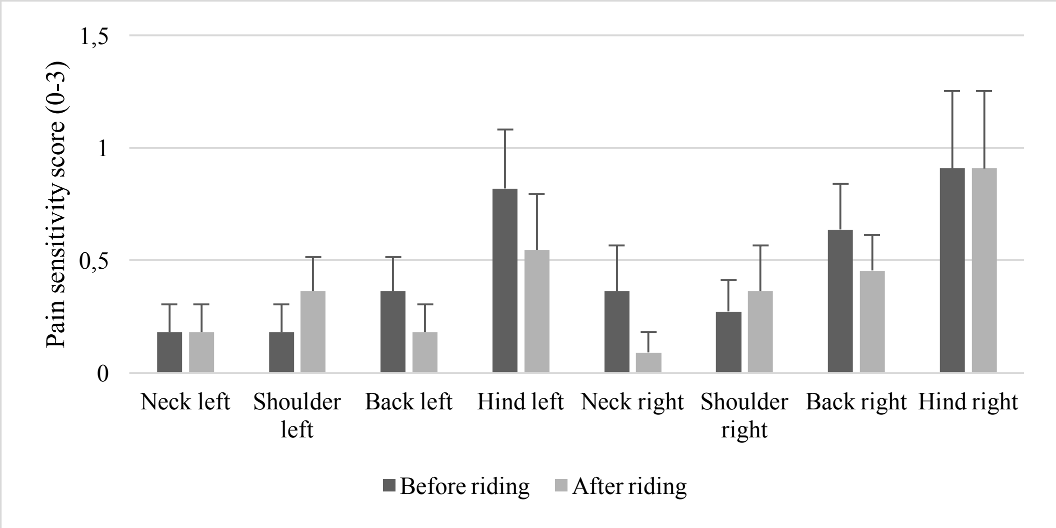
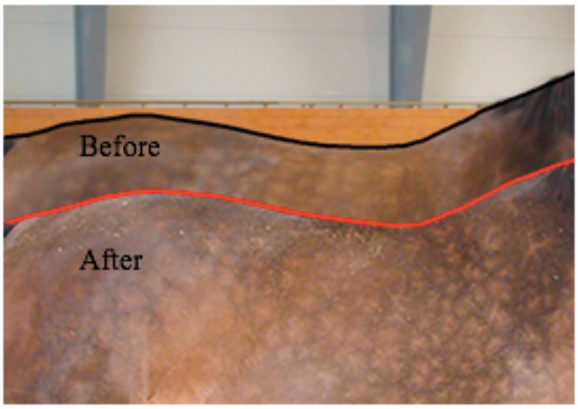
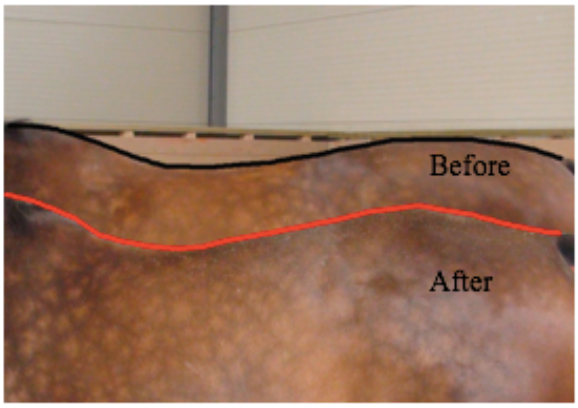


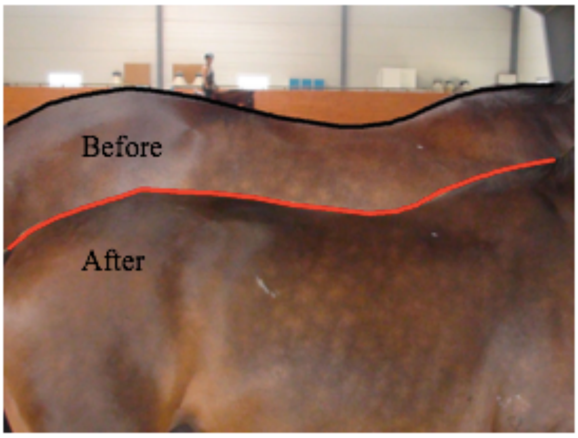
Fig. 21: *Pain sensitivity score before and after LSR, after treatment (mean +SE).*

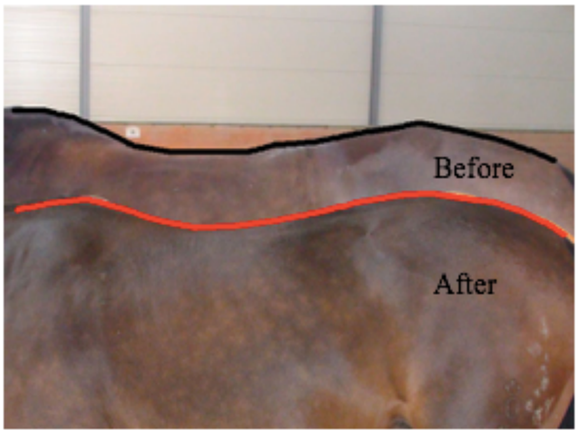
5.4 Topline

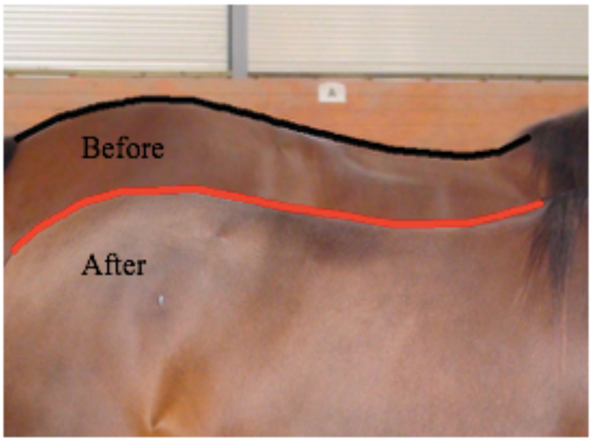
Lateral before and after pictures of six horses (one horse only from the left side). There is a change in curve for each of the horses, but because of inconsistency in photos when taken statistical analyses was impossible.

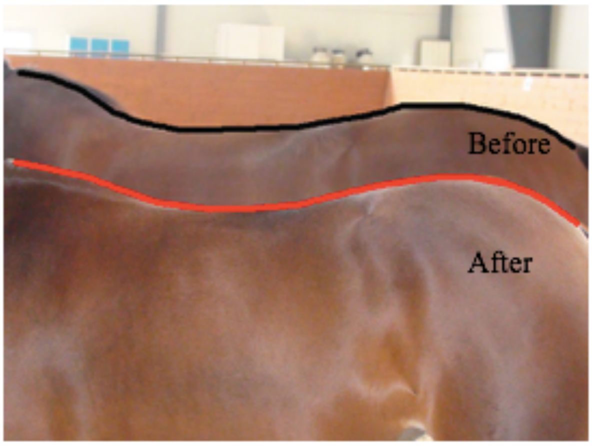


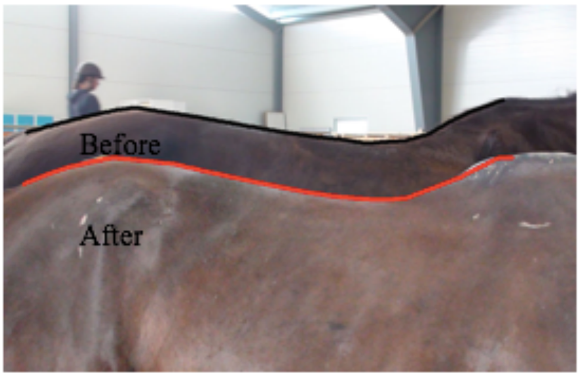


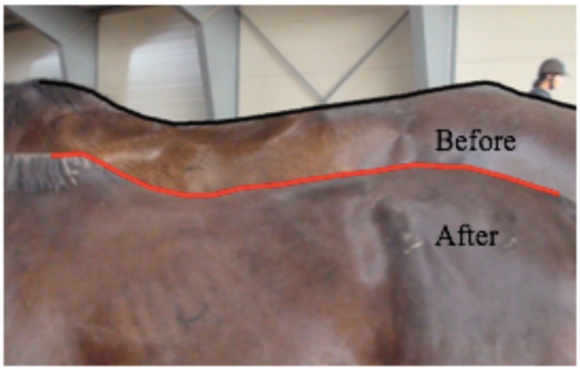


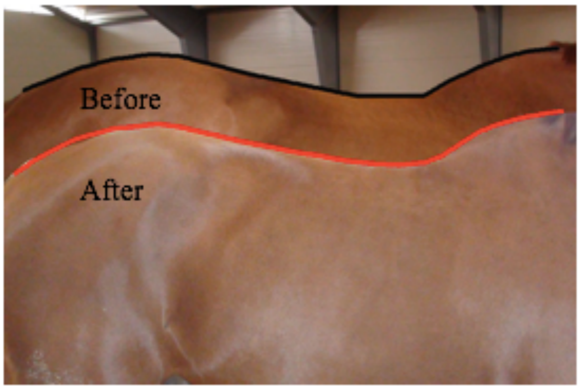


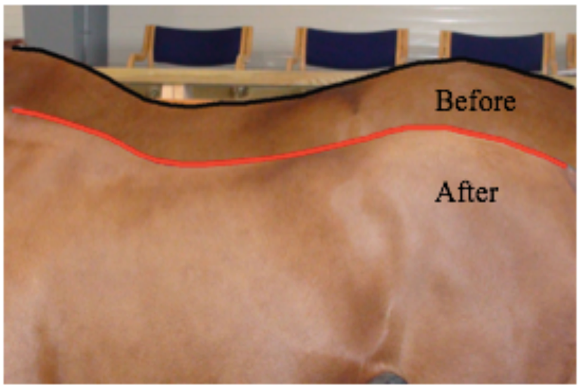

Before
After

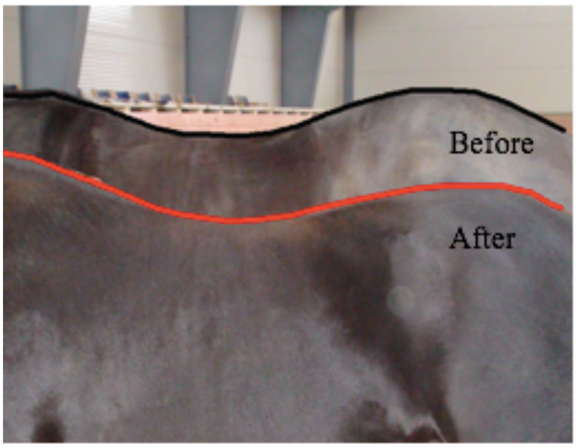

Before
After


Before
After


Before
After


Before
After


Before
After


Before
After

6 Discussion

6.1 Behaviour and gait quality

As predicted there was higher behavioural scores after treatment than before treatment. This shows that during a training regime which includes LSR there could be a positive effect on behaviour. For activities all scores were higher after treatment for R1 and R2, even for the control rider there was higher scores for all behaviours, except head and neck position. This shows that LSR has an effect on riding regardless of the rider. Head and neck position is influenced by the rider's hands and might explain the lower scores during control rider after treatment. However further research is needed, to find out if the effect could also be produced by other training methods. In future studies a control group could be used to investigate this.

Movement scores showed a significant improvement from week to week. This implies that LSR has an impact on movement. Even if it was the same person who did the evaluation of movement each week, test for reliability should have been conducted before the study. It would therefore be beneficial to use the same evaluation that are used during dressage competitions, this would also make the scores comparable to competition scores. It would then be easy to combine movement scores and gait quality into one category. Handling scores from before and after treatment were not significant, but there was a small trend to higher scores after treatment. If this is caused by LSR or by general handling during this period is unclear.

All behavioural scores were done on a scale from 1-6, but it could be easier and more practical to use the scale if it had fewer scores. For example, a score of 1-5, would have been a middle score that could be used when it is hard to evaluate if the behaviour is negative or positive.

It is necessary to consider the effect equipment can have on behaviour, especially facial expressions. For example, a tight noseband or ill-fitted bit will affect and restrict the cues around the mouth. A saddle that is incorrectly fitted for the horse's back will make it more difficult for the horse to use the back correctly and might decrease development of back muscles (Dyson et al. 2015).

6.1.1 Behavioural scores during the different activities

Not all behavioural scores were significant during different activities. For facial expressions only the ear and mouth were significant. The effect on ear position was only significant between L1 and LSR (both R1 and R2). Highest scores were found during R1 and R2, which could be an effect of a lower head and neck position that was found during these two sessions. Lowest scores were found during the first lunging and might be because it was the beginning of the training session, and the horse had not yet become focused enough. Time is also important for the horse to warm up and for the muscles to work. For tension in the mouth area there was a significant difference between lunging and riding. Higher scores were seen during lunging. During lunging the influence of the rider's/trainer's hands is smaller than during riding and may be the cause for the difference.

Willingness to collaborate was significant between L1 and all the other activities. This could be explained since it was in the beginning of the training session and that the cooperation between rider and horse needs some time to align when training is started. All of the horses had previous experience with being ridden, and this could cause for no significant difference between the riding sessions. Earlier experience has taught the horse to collaborate with the rider.

The total score of the behavioural observations were only significant for L1 and all the other activities. As mentioned before, L1 is the first activity, therefore it could explain why lower scores are seen here. LSR (R1 and R2) have the highest difference between before and after training, which mean that LSR has a positive impact on behaviours during riding.

Gait quality had higher scores for all activities after treatment, for both walk and trot, which support the predictions that the scores would increase both for the experimental rider and control rider. This could mean that LSR affected gait quality not only during LSR, but also during other training and riding methods. There is a trend towards improved gait quality for all activities after treatment. Gait quality is important for all riders, especially in dressage. It would therefore be interesting to investigate the difference over an extended period of time (more than one month) to see if the gait quality improved even more, and also to investigate the effect of training method.

Eyes and willingness to work were not significantly affect by different activities. Scores for eyes were relatively high throughout all activities, and indicates that none of the activities were fearful or stressful for the horses. Earlier experience could explain for why willingness to work was not significant, but there was a trend to higher scores after treatment than before since there was an effect of time.

6.1.2 Correlations

It is expected that behaviours will influence each other. As the results show head and neck position have a noticeable impact on ear position, willingness to collaborate and work. Since studies (Álvarez et al. 2006; Rhodin et al. 2005; Waldern et al. 2009) show that a high head and neck position affect the horse negatively, the ear position is expected to change as a sign of discomfort or pain; the same applies for willingness to collaborate and work. A horse that feels discomfort will try to signal the rider normally by working against the rider. There was a moderate correlation between both eyes and ears on willingness to collaborate and work. Signals from the eyes and ears could therefore be a good sign to evaluate collaboration and willingness to work. The correlation between willingness to collaborate and work are strong. Since these two are often difficult to separate, it might be beneficial to have them as one behavioural measurement to make evaluation easier.

6.2 Head and neck positions

When observing head and neck positions the only statistical significance was between the different gaits. Even if head and neck position were affected by time, and scores increased from before treatment to after treatment this was not significant. Measurements in walk showed higher scores than for trot. This means that the horse had a lower head and neck position during walk than during trot. A study received the same result, where horses raised their head higher when speed increased (McGreevy et al. 2010). The rider's hands have an observable influence on the head and neck position and consistence in movement and position of the hands will reduce the influence. This might be the reason that there was a difference between activities during riding; scores were higher for R1 and R2 than for R0, but there was no difference between R1 and R2 (same rider in R1 and R2). This also shows that the hand consistency of the experimental rider is even across the LSR sessions. Activities with a rider had higher scores then those during lunging, and could explain why horses choose to have a higher head and neck position when they could and that it was the influence of the rider's hands that affected the position during riding. During training sessions where the head and neck are held in a high position, horses will normally seek downward and forward when the reins are long enough. This can often be seen after dressage competitions when the horse is leaving the arena. Just because a horse is lowering its head it will not automatically start to use the hind and back correctly, therefore during training it is important that even if the head and neck is lowered, that the back remains engaged and strong.

6.3 Mechanical nociceptive threshold and pain sensitivity

In most muscular locations across the topline, MNT measurements changed as a consequence of treatment. This demonstrate that LSR has an effect on MNT, but it is difficult to determine if this is positive or negative. Tense muscles might become more sensitive after training due to increased activity, but then tolerate more pressure after regular training sessions. Horses that are "muscle dead" may not react at all, but after LSR training which loosen the muscle it is likely that muscle sensitivity increase A horse with normal muscles might tolerate a higher pressure after training, the horse might not show an increased pressure tolerance after regular training. We only tested 8 different locations, and results might be different if more or other locations were used and more measurements taken. Some locations were different for each side, but others did not differ.

Pain sensitivity did not differ from before and after LSR, both before and after treatment. All scores were low and is a sign that none of the horses had pain in the locations tested. It is significant to be aware that some of the locations are trigger points, and that there might be an increased reaction, or in some cases less reaction because of muscle problems.

The back muscles are largely influenced by the saddle and a poorly fitted saddle might make the muscle more or less sensitive to pressure. If this is the case, the loin area (lumbar vertebra) of the back is often affected, and it might be beneficial to include locations in this area in future studies. Back problems might also lead to problems in different part of the body since they are connected to each other. In future studies it might be good to have a professional examine the equipment to minimize the influence on performance, and are fitted to the individual horse.

6.4 Topline

The topline or arch of the back shows how the muscles are developed. A strong back means that the horse will be strong enough to carry and balance itself with a rider. If the back is weak, the rider's weight will increase the influence it has on the back and produce a negative effect on head and neck position and gait. It is easy to make a subjective measurement of the topline, but a more reliable measurement is needed. Since the pictures of the horses in this study were not taken in the same way each time, getting a reliable measurement is difficult. The head and neck position will influence the arch of the back, therefore position should be the same during all measurements. In future studies that includes the topline, a more systematic approach to taking photos should be used. If photos are alike it will be easy to make a statistical result comparing the two curves to each other. Some pictures were taken from above, but because of inconsistency in photos it was impossible to investigate body symmetry from these. This would also be interesting in later studies, since people often refer to horses preferring one side over the other.

7 Conclusion

Conclusion is that longitudinal stretching has a positive impact on behaviour during riding, regardless of the rider. And that gait quality scores increased during all activities, both in walk and trot, and this shows that a positive mental state effects the gait quality. We also found a change in mechanical nociceptive threshold from the treatment, but not for pain sensitivity. Additional studies are needed to enhance the reliability of this training method.

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