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Factors affecting the behaviour of horses when ridden, with emphasis on bridles and other equipment used to control behaviour

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Abstract

The horse is usually controlled through use of some form of equipment and pressure. This thesis explores type and fit of riding equipment, especially bridles, and how they affect ridden horse behaviour. A review of relevant literature is presented, followed by an observational study of 60 privately-owned horses in Norway. The main aim of the observational study was to see if bridle tightness was associated with ridden horse behaviour, but other tack, and the horse's age, sex, and pain scale (facial grimace) score were also evaluated. The data collection included registration of different types of bridles, use of whip and spurs, a short questionnaire to riders, pain scale scoring and observation of the horse's behaviour before, during and after a riding session of 20 min. Noseband, headpiece and brow band tightness was also assessed before the riding session using a taper gauge to quantify the width of the gap between the tack and the horse's skin in ¼ finger units. The mean ± SE tightness was 1.68±0.06, 1.82±0.04 and 2.24± 0.01 fingers for the noseband, headpiece and browband respectively, based on n=57, n=58 and n=57 horses.

Horses with tighter headpieces had more wrinkles at the corner of the mouth (p=0.010). The horse's tongue was visible more often during riding when the headpiece was looser (p=0.033), and when wearing a noseband without rather than with a flash (p=0.039). No other significant associations were detected between bridle or other equipment variables and behaviour or facial grimace score. However, behavioural indicators of discomfort or conflict during riding were frequently observed, with the most common, mouth movement, being observed in an average of 22 15-s scans out of a total of 80 scans (28 % of scans). It was concluded that, while associations were lacking between most of the equipment variables and behaviour, tongue visibility was affected by the bridle and the amount of mouth-related behaviour is consistent with discomfort or conflict.

Sammendrag

Hesten kontrolleres vanligvis ved hjelp av ulike typer utstyr og trykk. Denne oppgaven utforsker både typer og tilpasning av rideutstyr, med fokus på hodelag, og hvordan dette påvirker hestens atferd under rytter. En gjennomgang av aktuell litteratur, etterfulgt av en observasjonsstudie av 60 privateide hester i Norge ble gjennomført. Hovedmålet med observasjonsstudien var å se om hvor stramt hodelaget var festet hadde noen assosiasjon med hestens atferd under rytter. Annet utstyr og hestens alder, kjønn og poeng på smerteskalaen ble også evaluert. Datainnsamlingen inkluderte registrering av ulike typer hodelag, bruken av pisk og sporer, en kort spørreundersøkelse, poenggiving på smerteskalaen og observasjon av hesten før, under og etter en rideøkt på 20 minutter. Nesereim, nakkestykke og pannereim ble også vurdert før rideøkten ved å bruke et måleinstrument for å tallfeste mellomrommet mellom utstyret og hestens hud i ¼ fingerenheter. Gjennomsnitt±SE stramhet var 1.68±0.06, 1.82±0.04 og 2.24± 0.01 fingre for henholdsvis nesereim, nakkestykke og pannereim basert på n=57, n=58, n=57 hester.

Hester med en strammere nakkereim hadde flere rynker i munnviken (p=0.010). Hestens tunge var oftere synlig når nakkereimen var løsere (p=0.033) og når den gikk med en nesereim uten mulereim (p=0.039). Ingen andre signifikante assosiasjoner ble funnet mellom hodelag eller annet utstyrs variabler, og atferd eller poeng på smerteskalaen. Det ble likevel ofte observert atferdsindikatorer på ubehag eller konflikt. Den mest vanlige var munnbevegelser, som ble i gjennomsnitt observert i 22 15-s skanner ut av 80 (28 % av skannene). Det ble konkludert med at selv om det var mangel på assosiasjoner mellom det meste av utstyrsvariabler og atferd, var tungesynlighet påvirket av hodelaget, og mengden munnrelaterte bevegelser er konsistent med ubehag eller konflikt.

Content

1. Introduction

The domestication of horses (*Equus caballus*) occurred around roughly 5500 years ago (Gaunitz et al., 2018; Outram et al., 2009) and there are now approximately 60.5 million domestic horses worldwide, with about half in the Americas (Food & Agriculture Organization, 2017) and about 125.000 in Norway (Vik & Farstad, 2012). A reason for success in domesticating horses lies in their behavioural flexibility (McGreevy, 2004, p. 7, 88-89) and ability to habituate to a human on their back (McGreevy et al., 2009).

Until the 1920's, the horse was a work animal used in the military, industry, urban life and agriculture but now horses are popular for recreation and sport, at least in Western countries (Derry, 2006, p. xi, 101). The ancient Greeks used both positive reinforcement and punishment methods to train horses (Goodwin et al., 2009). For example, Xenophon mentioned a "hard" or "bad" mouth in his treatise "*On Horsemanship*" written around 350 BC. He described some horses as being "disobedient" and asserted that the right amount of pressure must be applied to the mouth to get the right response. He also mentioned rewarding the horse for the right behaviour with rest and relaxation (Xenophon, 2010, p. 16-50). Riding masters in the Middle Ages emphasised punishment as a training tool (Podhajsky, 1979, p.63). Over the past millennium, various forms of riding equipment have been developed to aid the rider in training and controlling the horse's behaviour, mostly based on the positive punishment principle of adding uncomfortable pressure to reduce unwanted behaviour (Waran et al. 2007, p 153-162). These approaches to the training of horses persist in today's horsemanship traditions (Rees, 2017, p.143).

This thesis explores how horses respond behaviourally when exposed to different riding practices, with a focus on the type and fit of equipment used when riding and, especially, bridle equipment. This includes both equipment associated with application of discomfort, leading to conflict between the goals of horse and rider, and those associated with positive experiences for the horse, leading to positive collaboration between horse and rider. First, a literature review is presented regarding factors affecting pain and other negative affective states as well as those generating positive affective states, and their assessment in horses. This is followed by description of a research study conducted in Norway on effects of the rider's use of riding equipment on the behaviour of 60 horses when ridden.

2. Literature review

2.1 Pain, discomfort, and distress

The International Association for the Study of Pain (IASP) defines pain as "*An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage*" (IASP, 2019). Discomfort is defined as " a feeling of being uncomfortable physically or mentally, or something that causes this" (Cambridge Dictionary, 2020). This term is often used when referring to mild pain although it can also be applied to other negative feelings. The term distress refers to "the emotional content of noxious experiences that elicit physiological stress responses" (Mellor et al., 2000, p. 172) and is, thus, also a more general term that may be applied in the context of pain.

Pain is a feeling, or aversive sensation, that serves as a warning signal of potential or actual tissue damage (Broom, 2001). It provides an opportunity for learning to avoid such pain-causing circumstances through a change in behaviour (Mellor et al., 2000). Avoidance behaviour is, thus, expected of the individual when experiencing acute pain and learned avoidance is expected with repeated risk of pain (Broom, 2001).

Self-reporting painfulness has allowed identification of blood biomarkers associated with pain in humans (Niculescu et al., 2018). A problem with detecting pain in non-human animals such as horses is that they cannot tell you in spoken language if they are in pain or how much pain they are experiencing. Furthermore, connections between behaviour, mental state and physiological responses are complex (Ashley et al., 2005; Hall & Heleski, 2017; Morton & Griffiths, 1985). When relying on behavioural expressions to detect pain, the behaviours may be subtle and hard to detect, and may occur inconsistently (Mellor et al., 2000). Pain and discomfort are subjective experiences, and there may be a lack of correspondence between behavioural pain expression and the degree of tissue damage (Hausberger et al., 2016; Morton & Griffiths, 1985; Richardson & Flecknell, 2005). Emotions influence how the nervous system processes pain signals and, therefore, perceived pain varies in duration and intensity (Mellor et al., 2000). For example, if there is an urgent need to escape from danger, fear can overshadow pain, leading to escape rather than staying still to minimise pain. Although with more intense pain there may be less attention to anything else (Williams, 2002), the threshold for expressing pain varies depending on other behavioural priorities and pain can be present without behavioural signs specific to pain (Broom, 2001). Detecting mild, chronic, or intermittent pain is also be more difficult than detecting severe or acute pain (Ashley et al., 2005). Nevertheless, it is important to recognize pain, and associated discomfort and distress, as pain is one of the most compelling animal welfare concerns (Weary et al., 2006).

2.1.1 Neurobiology of pain

From a neurobiological perspective, receptor cells, peripheral and central neural pathways and neurotransmitters, are involved in the generation of pain feelings (Broom, 2001). Conscious feelings of pain arise with the involvement of the cerebral cortex (Xie et al., 2009). Pain can occur under three conditions: nociceptive, inflammatory, and pathological. Nociceptive pain occurs when a potentially dangerous or noxious (harmful or potentially harmful) stimulus stimulates nociceptive nerve cells. Input from these peripheral pain receptor cells, referred to as nociceptors, is converted to perceived pain when impulses transmitted along nerve pathways in the spinal cord reach higher brain regions (Mellor et al., 2000). Activation of nociceptors leads to a rapid withdrawal reflex at the spinal cord level that protects the tissue from further damage (e.g. withdrawing a limb when touching something hot; Woolf, 2010). While this reflex response occurs without immediate conscious awareness, milliseconds later, nociceptive pain is processed and experienced in the brain, thereby enabling learning to avoid that stimulus in the future. Inflammatory pain also has a protective role and is activated by the immune system (Woolf, 2010). Inflammatory processes occurring after an injury or infection lead to pain that discourages the organism from moving or having physical contact with the affected area. This pain guarding behaviour reduces further risk of damage. Pathological pain involves a dysfunctional, sensitised nervous system that generates chronic pain in the absence of painful stimuli, which can sometimes occur as a sequel to tissue damage (Woolf, 2010). In humans, this pain is associated with chronic stress-related diseases such as fibromyalgia and irritable bowel syndrome (Woolf, 2010).

2.1.2 Assessing pain

When assessing pain, one must consider potential differences pain expression due to species, breed, age, sex, and environment, as well as whether the pain is mild or severe, acute or chronic, and constant or intermittent (Morton & Griffiths, 1985; Robertson, 2006). A physical examination may be used to detect pain, and behavioural observations, made directly or via video recordings, can be useful for revealing subtle signs of discomfort (McDonnell, 2005). Assessing animal pain can involve evaluating general body functions (e.g. food and water intake, weight change), physiological responses (e.g. plasma cortisol concentrations, heart rate, blood pressure, temperature, respiratory rate) and behaviour (e.g. vocalizations, facial expressions, abnormal body postures, mobility, lack of grooming, change in personality) (Morales-Vallecilla et al., 2019; Weary et al., 2006). These factors will not necessarily tell you what the animal is feeling right now as, for example, weight change takes some days to develop (Weary et al, 2006). Physiological measures may be useful if altered behaviour is not evident until injuries are more advanced, but collecting these measurements can involve procedures which may be stressful in themselves and may, thus, provide erroneous results (Weary et al., 2006). There are differences in pain tolerance between species (Mellor et al., 2000) and breeds (e.g. dogs, Gruen et al., 2020), and individual horses may vary in pain tolerance (Evans & Lowder, 2012). Some horses may be stoic, and continue to work despite pain (McDonnell, 2005).

2.1.3 Behavioural expression of pain

When assessing pain, there are three categories of behaviour that can be of use (Weary et al., 2006).

1. Showing pain-specific behaviour, which includes injury-directed, defensive or escape behaviours (Weary et al., 2006). For example, pain may affect locomotion, such as producing a limping gait indicative of lameness (Dyson et al., 2018b).
2. Showing a decline in certain behaviours, both in frequency and magnitude, especially in behaviours that the animals would normally be highly motivated to perform (Weary et al., 2006). Thus, lethargy can be a sign of pain (Morton & Griffiths, 1985).
3. Showing altered behaviour in choice or preference tests (Weary et al., 2006). For example, sheep become harder to move down a path if they expect an aversive treatment in that direction (Rushen, 1986).

A behaviour that occurs only and reliably when the animal is in pain can be considered an honest signal if it benefits the animal by leading to help from others (Mellor et al., 2000; Weary & Fraser, 1995). For example, in social species where group members collaborate to drive away predators (e.g. dogs, pigs), a specific pain vocalization may be used by an injured individual to attract aid from the group. However, vocalizations signalling pain risk attracting predators and, in species where group members are unlikely to be able to fend off a predator but instead rely on running away or hiding for safety, there may be no pain cry given when injured (e.g. sheep, Broom, 2001). This does not mean that physiological responses are absent during pain. For example, sheep undergoing mulesing without anaesthetics have heightened cortisol and β-endorphin levels compared to sheep given anaesthetics (Shutt et al., 1987). It has been proposed that horses can learn to avoid work by limping (McDonnell, 2005) suggesting that limping may not always be an honest signal of pain.

Behaviour problems can result from physical and/or psychological pain or discomfort, and it can sometimes be hard to determine if the cause of the behaviour is physical or psychological. A change in performance or attitude may be misunderstood as misbehaviour (McDonnell, 2005), though the horse is trying to reduce pain or discomfort (McGreevy & McLean, 2010, p. 23). Horses "*push into pain*" (Scoggins, 2001, p. 138). For example, a horse with oral pain may lean on the tender side. The reaction of the rider may be to correct this "misbehaviour", which causes the horse to open its mouth and toss its head (Scoggins, 2001). People should not jump to the conclusion that limping is a sign that a horse is "misbehaving" to avoid work because, usually, pain is involved and when the pain is eliminated, horses return to their normal behaviour (McDonnell, 2005).

When in pain and avoidance is not possible, horses use active coping behaviour resembling behaviour used to avoid or remove predators. The horse may buck, rear or shy away (McLean & McGreevy, 2010). If the horse cannot relieve the pain using active coping behaviour, it will eventually adopt passive coping behaviours due to learned helplessness (McLean & McGreevy, 2010). Learned helplessness refers to a state were an animal no longer responds to pressure or pain and can also arise from prolonged incorrect use of negative reinforcement where the aversive pressure is not released (McGreevy et al., 2005). This does not mean the horse does not feel pain as physiological signs of chronic stress are likely to be present.

2.1.4 Challenges in detecting pain

Horses have found to decrease or cease expressing discomfort behaviour when people approach or interact with them (Torcivia & McDonnell, 2020). This is in accordance with prey behaviour, whereby the animal does not show signs of pain when in view of a potential predator (humans) and may contribute to a delay in recognizing pain in horses (Torcivia & McDonnell, 2020). Similarly, when chickens' attention was directed towards a novel environment, pain perception was suppressed (Gentle, 2001). Horse riders may not notice signs of discomfort, as found when riders groomed their horses (Lansade et al., 2019). Nor does the experience level of a caregiver guarantee recognition of pain, correct interpretation of behaviour or concern about animal welfare. A portion of horse owners seem to find it acceptable to train horses in ways that cause distress (Bell et al., 2019). However, if people do not know how to recognise absence of happiness, they would not know how a "happy athlete" behaves (Bell et al., 2019).

Identification of primary causes of pain or discomfort in horses is complicated by a novel environment, which may either worsen or reduce the expression of undesirable behaviour (McDonnell, 2005). Observing horses in the presence of their owners, or humans in general, can cause the horse to have more discomfort or distract them from apparent discomfort, and behaviour indicative of pain may only arise in certain situations (e.g. being tacked up; McDonnell, 2005).

Skill in recognising pain, and attitudes towards pain, are relevant when considering pain assessment. Richardson & Flecknell (2005) reviewed articles for analgesic use in laboratory rodents post-surgery. They found an increase in use of analgesics between the 1990's and early 2000's but still many animals not receiving enough pain relief. Though veterinarians may be concerned about pain, they may find it hard to recognize in practise and, therefore, provide insufficient analgesics (e.g. Morales-Vallecilla et al., 2019; Hugonnard et al., 2004). Although many say they have high confidence in recognizing pain, quantifying degree of pain seems to be much more difficult (e.g. Perret-Gentil et al.; 2014, Morales-Vallecilla et al., 2019). Furthermore, there may also be a link between assuming that animals feel pain less easily or intensely than people and providing them with poorer care, as has been reported in a study of dairy farmer attitudes (Kielland et al., 2010).

Quality of life (QOL) is a term often used by veterinary practitioners to assess their patients (Parker & Yates, 2012), which, along with health, includes evaluation for sources of negative experiences (e.g. discomfort, frustration, and fear). There is evidence suggesting that a vast majority of horse owners and caretakers accept that horses can have affective states such as pain and fear (Hötzel et al., 2019), but this may vary between countries.

2.1.5 Pain grimace scales

When in pain, mammals often show a facial expression referred to as a grimace. Grimace scales have been developed as an aid for recognising pain and quantifying the level of pain in a variety of species including horses (Costa et al., 2014), cattle (Gleerup et al., 2015), lambs (Guesgen et al., 2016), sheep (McLennan et al., 2016), ferrets (Reijgwart et al., 2017), rabbits (Keating et al., 2012) cats (Evangelista et al., 2018), piglets (Viscardi et al., 2017), mice (Langford et al., 2010) and rats (Sotocinal et al., 2011). These scales involve separate scoring of different components of a facial grimace, such as ear position and orbital tightening, usually as: not present (score 0), moderately present (score 1) or obviously present (score 2). The overall score is a sum of the scores for each component. Some authors have raised concerns about the limitations of such pain scoring. For example, McLennan et al. (2019) calls for more testing to ensure validity. The scales are often developed using only one or two sources of pain, and McLennan et al. (2019) calls for testing the scales on a wider range of sources of pain. In addition, animal age has not generally been a factor in developing the scales, and younger and older animals may respond differently.

2.2 Conflict behaviour in the ridden horse

The meaning of the term "conflict" is in ethology understood as a conflict between an animal's behavioural tendencies. The animal can have two motivations simultaneously (e.g. wanting to approach and avoid an object at the same time), or the original motivation (e.g. approach) can be thwarted by inaccessibility thus creating conflict (Wood-Gush, 1983). Displacement activity (an irrelevant behavioural pattern) is a common response to conflict (Wood-Gush, 1983). This can often be a grooming behaviour (Wood-Gush, 1983), but licking and chewing has also been suggested as a displacement activity (Goodwin, 2003).

Responses to conflict may be signs of discomfort (Górecka-Bruzda et al., 2015), and in horse studies, pain avoidance and escape behaviour that conflicts with what the rider wants is often referred to as conflict behaviour (Hall & Heleski, 2017). McGreevy et al. (2005) have described conflict behaviour somewhat differently, stating that these behaviours are usually characterized by hyper-reactivity and result from confusion. Hyper-ractive behaviour is associated with activation of the hypothalamic–pituitary–adrenal axis (HPA axis) and with a degree of arousal (McGreevy et al., 2005)

When ridden, confusion can arise because the horse does not understand the rider's cues, or they are conflicting (McGreevy & McLean, 2010, p. 276). For example, confusion can occur if the rider pulls the reins with the goal of flexing the horse's neck. Pulling on the reins creates pressure from the bit, and horses are trained to decelerate when feeling this pressure. The horse then decelerates rather than flexing the neck. If this confusion persists, it can lead to a slowed response and a detraining effect when asking the horse to decelerate (McLean & McGreevy, 2010). Detraining involves an applied stimulus without performance of the learned response and will cause "*reduction or extinction of the likelihood of the learned response arising from the stimulus*" (McGreevy & McLean, 2010, p. 277). Consequently, the rider elevates the rein tension to achieve deceleration (McLean & McGreevy, 2010). Similarly, a rider may demand that the horse bends its neck to one side without previously conditioning a turn-response. Some riders also give a cue to move forward while at the same time pulling on the reins, giving the horse cues to accelerate and decelerate at the same time. This does not allow the horse to give previously learned responses (McLean & McGreevy, 2010; McGreevy & McLean, 2010, p. 276). Also, if a horse is simultaneously motivated to stay with conspecifics and listen to the rider's signal, but is ridden away from other horses, conflict behaviour may arise in the form of delayed movement, "napping" (defined as "refusing to go forward, running sideways, spinning or running backwards" (McGreevy et al., 2005) or refusing to respond to the "go" signal (Hall & Heleski, 2017).

Two stimuli with different intensities presented at the same time can give rise to the effect know as overshadowing. The most salient stimulus will be the one that becomes the conditioned stimulus associated with the conditioned response (McLean, 2008). McLean (2008) argues that overshadowing leads to phenomena such as "dead sides" and "laziness". As a result of the horse's failure to learn the less salient cue, the rider may assume a need to apply greater stimulation to elicit the desired response, and so applies stronger pressure when giving rein and leg cues (McGreevy and McLean, 2010, p.75). For horses that become habituated to leg-pressure or that show unwanted deceleration, the rider may choose to use whips and/or spurs to stimulate locomotion (Hill et al., 2015). Riders explain their use of these aids as being needed to strengthen their cues or for use in an emergency (Williams et al., 2019). When simultaneously using a leg cue, whip and/or spurs to promote forward locomotion, it is likely that the horse will respond to either the whip or the spur as being more salient than the leg cue, causing the leg cue to be overshadowed (Baragli et al., 2015). On the other hand, use of overshadowing can help anxious horses to overcome fears (e.g. of clippers). For example, by overshadowing an initially frightening stimulus with another, more salient stimulus (e.g. well-trained in-hand signals of acceleration or deceleration), the horse will habituate to the initially frightening stimulus (McLean, 2008). Habituation refers to no longer responding to a stimulus that has been encountered repeatedly without being perceived to have a negative or positive consequence (McGreevy et al., 2005).

Ödberg & Bouissou (1999) regards side reins and draw reins as temporary help aids which must be discarded as soon as possible but notes that riders today often continue to use them regularly in daily training. Their prolonged use may lead to loss of forward impulsion with false collection (an apparently collected outline using legs and reins simultaneously or using gadgets or pulleys; McGreevy & McLean, 2010, p. 278), causing the rider to use harder and more persistent leg pressure. Also, riders often give repeated cues even if the horse is already responding correctly, such as "*kicking with the legs at every stride while the horse is in extended trot*", resulting in confusion and habituation in the horse (Ödberg & Bouissou, 1999). Some may then be tempted to apply even further pressure, such as by putting on a more severe bit. This may lead to further desensitisation (McGreevy & McLean, 2010, p. 183). Desensitisation refers to a decrease in response intensity (Starling et al., 2016).

Conflict behaviour may arise from improper training or misapplication of training methods (McLean & McGreevy, 2006), such as incorrect use of negative reinforcement (lack of removal of pressure) (McGreevy & McLean, 2010, p.276). Tail swishing (defined as lateral and dorsoventral tail movements) can be a sign of conflict behaviour in hyper-reactive horses (McGreevy et al., 2005), but is also suggested as a sign of higher effort and concentration (Hall & Heleski, 2017). It has also been suggested that there can be an increase in conflict, stress-related or irritation behaviours as a response to kicking or spurring by the rider (Waite et al., 2018). There are horses that will not respond with conflict behaviours when discomfort escalates, perhaps leading to the use of even stronger bits or other aids (McGreevy et al., 2014). A strong bit would apply more pressure to the mouth, and in some cases other parts of the head like the nose and/or poll in addition.

Predictability and control are important for resilience to stress (McLean, 2005). Low predictability and controllability can result in conflict behaviour and, if confusion is maintained over a long period, chronic stress may arise (McLean, 2005). Sources of stress and conflict behaviour in horse training include inconsistent reinforcement of responses, expecting the horse to give different responses from a single signal, giving opposing signals (stop and go signals given simultaneously) or intermittent or constant pain or discomfort (McLean, 2005).

In situations involving conflict between the horse and rider, horses may show agonistic behaviours such as bucking, rearing and bolting (McGreevy, 2012, p. 332). Bucking may follow shying, and shying is associated with other types of conflict behaviour (McGreevy et al., 2005). These behaviours may also be labelled hyper-reactive behavior. Horses that are hyper-reactive usually show a hollow posture and the legs move more rapidly but with shorter strides. These types of behavioural response are learned fast and are resistant to extinction (McGreevy & McLean, 2010, p. 279-280). A behaviour would be resistant to extinction if it is sometimes rewarded (McGreevy & McLean, 2010, p. 79), for example if the rider falls off when the horse rears or bucks (pressure from reins and legs instantly dissapears). Horses with a higher anxiety level may be more likely to develop these behaviours than calmer horses (Fenner et al., 2019). Horses showing the behaviours “swish tail when ridden/handled”, “pin ears” and “bucking under saddle” (labelled as defensiveness) required a longer time to learn a new task, and difficulty in learning the task was thought to lead to frustration or confusion (Fenner et al., 2019).

In a study on conflict behaviour in horses (Williams & Warren-Smith, 2010), observations were made on 72 horses divided over nine dressage competition levels. Conflict behaviours were seen at all levels. Of all the conflict responses shown, tail swishing was the most often exhibited. This was followed by ears back, being above the bit (raises the head high, McGreevy & McLean, 2010, p.241), tenseness, teeth visibility, pulling, hollowing of the back and short stiff strides. Competition level did influence the type of behaviour shown. For example, at the higher levels of competition, ears back and tail swishing were observed most frequently (Williams & Warren-Smith, 2010). Górecka-Bruzda et al. (2015) studied conflict behaviours in 100 show jumpers and 50 dressage horses competing in televised competition events (Fédération Équestre International TV). They looked for horses exhibiting any of the following behaviours: head shaking, pulling the reins out of the riders' hands, tail swishing and gaping. In show jumping, pulling the reins out of the riders' hands was the most observed conflict behaviour while, in dressage, tail swishing was the dominant conflict behaviour (with other behaviours occurring only sporadically). Overall, conflict behaviours were exhibited regularly during competition (on average, every 4 s in dressage and every 5 s in show jumping). In addition, behaviours increased in frequency with higher degrees of task complication or difficulty. In a similar study, Jastrzębska et al. (2017) looked at conflict behaviour in 19 show jumping horses during a competition. Behaviours observed included head shaking, pulling the reins, tail swishing, refusing to jump, bucking and bolting. No correlations between conflict behaviours and salivary cortisol concentration were found, although both are considered stress response indicators. Górecka-Bruzda et al. (2015) concluded that conflict behaviours increased with more demanding fences.

2.3 Fear

To preserve safety in handling and riding horses, it is important to avoid flight responses and minimise confusion and frustration (Starling et al., 2016). Fear is an innate behaviour which will motivate the horse to flee from potential threats (Hall & Heleski, 2017). If horses flee from a fear-inducing stimulus, this will reinforce the flight behaviour by negative reinforcement since the fearful stimulus is removed (McLean, 2008). Vigilance is a behaviour that occurs before escaping from predators, and how vigilant an animal is will have an impact on escape decisions (i.e. how close to let a predator approach before fleeing) (Cooper, 2015). There is a distinction between "routine vigilance" and "induced vigilance", where the former refers to monitoring surroundings periodically while the latter occurs as a response to a stimulus (Blanchard & Fritz, 2007). Vigilance has been defined as "the horse stands still, with elevated neck, intently oriented head and ears", and has been used (among other behaviours) to assess emotionality (Wolff et al., 1997). A high rate of defecating indicates fearfulness in horses as well (Visser et al., 2008).

Hockenhull & Creighton (2013) studied ridden horse behaviour as reported by their owner through an online survey that gathered information about equipment and training on 1326 horses and behavioural problems in 791 horses. The results showed that 91% of the horses had one or more ridden behaviour problems at the time of the study. The three behaviours most common were shying ("*sudden hyper-reactive sideways leaping*"; McGreevy et al.,

2005) (50%), not standing still when rider mounts (46%) and pull/lean on the bit (45%). The least common behaviour problems were stopping at jumps (13%), running out when jumping (13%), rearing (7%) and bolting (3%). The authors underline that although rearing and bolting only happened on few occasions, this was a high number considering it happened over the course of only one week. In addition, they refer to this, and the overall high number of problems reported, as a concern for both horse welfare and safety for the rider.

2.4 Learning theory and horse training

Evolutionarily, the ability to learn and gain insight through experience is favoured, and learning is therefore a trait of adaptive significance (i.e. has a selective advantage; Fraser, 2010, p.4). However, the earliest evidence of horse training depicts horses being coerced, through physical force and rough methods, to implement the desired behaviours (Ödberg & Bouissou, 1999). From around 16th century Europe, the usage of horses in the military gave rise to methods focusing on suppleness and obedience. Communication with the horse shifted from reins and heels to the seat. This was the start of the art of equitation within the "academies", which focused on slow development of desired responses. This philosophy reached its peak in the 18th century with the treatise L'Ecole de Cavalerie (The School of Horsemanship) by François Robichon de La Guérinière. In the 19th century, this academic equestrian tradition was reduced to a few locations in Europe (Ödberg & Bouissou, 1999) as the modern competition scene emerged, with its time limitations and a focus on rapid progress. Under these conditions, riders may use stronger aids to pressure the horse into movements it is not ready for (Ödberg & Bouissou, 1999). Overall, horse training outcomes are affected by training methods, the horse's temperament and health, the trainer's knowledge and skills, and the horse's learning processes and ability (McGreevy & McLean, 2010, p. 7).

Learning theory has its roots in human psychology, from which modern learning theory emerged in the 1970's (Illeris, 2018). The four quadrants of operant conditioning can be described as follows (reproduced from McLean & Christensen, 2017, p.23)

- *Negative reinforcement (R-): The removal of an aversive stimulus to reward a desired response (e.g. rein tension is applied until the horse stops and the removal of the tension rewards the correct response)*

- *Positive reinforcement (R+): The addition of a pleasant stimulus to reward a desired response (e.g. the horse approaches when called for and receives a carrot to reward the response)*
- *Negative punishment (P-): The removal of a desired stimulus to punish an undesired response (e.g. the horse tries to take food from the handler, but food is withheld until the behaviour ceases)*
- *Positive punishment (P-): The addition of an aversive stimulus to punish an undesired response (e.g. the horse bites and receives a slap on the muzzle)*

Reinforcement increases the likelihood of a behaviour being offered again, while punishment decreases this likelihood (McLean & Christensen, 2017).

Understanding the terminology associated with learning theory is important to apply it in the right way. Warren-Smith & McGreevy (2008) showed that, of the 206 equestrian coaches who replied to their questionnaire, only 2.8 % correctly explained how to apply positive reinforcement, and 11,9% correctly explained negative reinforcement. However, 79,5% and 19,3%, respectively, answered that they considered these forms of training very useful. This gap between practice and knowledge can represent a problem since trainers are often a source of information to riders.

Similarly, in a UK online survey, Brown & Connor (2017) asked participants (n=58) to define learning theory terms and to answer multiple-choice questions about learning theory principles. Although participants regarded themselves as professionals with higher understanding than amateurs, there was an overall lack of understanding and application of learning theory. They had problems understanding negative reinforcement and positive punishment, though over 80% were able to define pressure-release. The authors ascribe this to misunderstanding of the words “positive” and “negative”. The use of these terms in learning theory stems from mathematics and simply refers to something added, or something removed respectively, and not something “good” or “bad” (McLean, 2005). Horse trainers on the other hand seems to interpret this to mean for example that “*positive reinforcement was a favourable response by the trainer to reward a desirable behaviour, while negative reinforcement was seen as an aversive response to correct undesirable behaviour*” (Brown & Connor, 2017).

The use of punishment in horse training does not always bring the right response as horses can form wrong associations, leading to further unwanted behaviour (Mills, 1998). Horses that apparently do not want to cooperate may be regarded as “bad” (McLean, 2005). The term punishment is called “correction” by many (Rees, 2017, p.143). Some activities within horse training may have unfortunate consequences, like training methods or riding techniques that involve punishment, the use of tack with a high potential of causing pain or distress (e.g. crank nosebands) and misuse of aids such as whips and spurs (Jones & McGreevy, 2010). There has been some preliminary research into the use of whips in show jumping. Stronger whip strikes (as measured by distance between body and arm height of the rider) gave rise to evasive behaviours. It is unlikely that the horse can form an association between a behaviour the rider perceives as misbehaviour and a whip strike delivered after jumping. Also, using a whip before a fence may cause the horse to have negative associations with jumping (Spencer et al., 2019).

Incorrect behaviours are more likely to be a result of faulty training than the horse being wilfully disobedient (Starling et al., 2016). Since trainers train horses with desirable outcomes, it is possible that they understand in practical terms positive and negative reinforcement and punishment, but the lack of proper definitions may cause them to not utilise learning theory efficiently (McLean, 2005). Some may even agree with the assumption that cues to go forward are innately understood by the horse, rather than a result of training (McLean, 2005).

McLean (2005) suggests that incorrect use of negative reinforcement ultimately results in horse wastage, which refers to horses leaving the equine industry. These horses are often young (McLean & McGreevy, 2006; Thomson et al., 2014). Apart from reasons such as injuries/illness, poor performance or unsuitable temperament/behaviour (Thompson et al., 2014), McLean & McGreevy (2006) argue that both poor training methods and management contribute to this wastage. Where these horses end up is largely unknown (Thompson et al., 2014).

Negative reinforcement is characterized by pressure release. Use of a restrictive noseband, or other devices that apply pressure that cannot be released by the rider when training is in defiance of negative reinforcement principles. A constant pressure cannot be a reinforcer since it is not applied or removed in response to behaviour. When opening or crossing its jaw, any intensified pressure will be a punishment. If, on the other hand, the pressure is relieved by a relaxed jaw, negative reinforcement will occur (McGreevy et al., 2017). Riders depending on tight nosebands, for example, are training their horses to perform desired behaviours only when wearing such a device (Doherty, et al., 2017a). Weller et al. (2020) suggests that restrictive nosebands defy the Five Freedoms of animal welfare by hindering expression of normal behaviour (freedom number 4, see below).

The five freedoms:

1. Freedom from hunger and thirst
2. Freedom from discomfort
3. Freedom from pain, injury or disease
4. Freedom to express normal behaviour
5. Freedom from fear and distress

2.5 Positive affect and positive welfare indicators

The affective states experiences by an animal are an important aspect of animal welfare. An affective state is "*an intense but short-lived affective response to an event…and is materialised in specific body changes*" (Désiré et al., 2002, p.13). An affective response involves a neural autonomic response (emotional, sensory, visceral, or cognitive), a subjective response (feeling) and a behavioural response (e.g. a posture or activity) (Désiré et al., 2002; Panksepp, 2011).

According to the philosopher, Jeremy Bentham, happiness can be explained as "*the balance of pleasure over pain*" (Burns, 2005, p. 48) (known as the happiness principle), providing guidance for ethical decisions regarding animals (i.e. maximize pleasure and minimize pain). People who use horses should have this in mind (Jones & McGreevy, 2010). Research on affective states in horses has mainly focused on negative states, and especially pain and fear (Waran & Randle, 2017) but there is now increasing interest in addressing positive affective states and their behavioural expressions.

2.5.1 Positive behavioural expressions

One behaviour often considered to indicate a positive affective state is play behaviour, which has been studied in a variety of domestic animals including horses (e.g. in dairy calves (Jensen et al., 1998), piglets (Brown et al., 2015) and foals (Crowell-Davis et al., 1987;

Cameron et al., 2008). Young horses play with peers in their social group and may have preferred play partners (Sigurjónsdóttir et al., 2003; Van Dierendonck et al., 2009). Play declines in adulthood, especially in mares (Hausberger et al., 2016; Sigurjónsdóttir et al., 2003). Adult play may even be associated with poor welfare and occur as mechanism for relieving stress (Hausberger et al., 2012). Locomotor play, including behaviours such as bucking, running, or frolicking (McDonnell & Poulin, 2002), is considered undesirable when horses are being handled or ridden.

Vocal behaviour is thought to reflect the affective state of the animal, in addition to transmitting information to other individuals (Watts & Stookey, 2000). Using separation and reunion as negative and positive situations respectively, Briefer et al. (2015) found that whinnies (neighs) varied in their expressions. Positive situations produced whinnies that were shorter in duration and had a lower frequency at the start of the whinny. Stomp et al. (2018a) explored the possibility that the snort, a non-vocal sound made when air passes through the nostrils, is an indicator of positive emotion in horses. They found that horses snorted more when on pasture than in individual housing, and more when feeding or grazing. When snorting, horses were unlikely to have their ears backwards (a sign of negative affective states). Comparing horses in three different management conditions varying in time spent on pasture, horses in the group given 100% pasture time emitted snorts more often than horses with less pasture time. The authors discarded the idea of the snort having merely a hygienic function, since horses with less pasture time spent more time in a dusty environment. They concluded that snorting might be an indicator of positive emotion, though they emphasized that snorts indicate a transient rather than chronic state (Stomp et al., 2018a). Consistent with this interpretation, high rein tension has been associated with lower levels of snorting, flattened ears and higher levels of potential conflict or discomfort behaviours (e.g. horse-induced change in gait or open mouth) (König von Borstel & Glißman, 2014; Ludewig et al., 2013). On the other hand, Visser et al. (2008) has related snorting to stress. In their study, naïve and not previously housed horses that were stabled individually had a significantly higher rate of snorting (and other stress related behaviours) in the first three weeks than horses housed in pairs. Snorting may also indicate frustration (Lesimple et al., 2012).

Relaxation has been mentioned as sign of positive affect (Bell et al., 2019). Bell et al. (2019) speculate that having a relaxed horse is potentially something desirable in horse owners, but also highlight the risk of confusing relaxation with other less welcome states such as learned helplessness or depression (Furiex et al., 2015). A unresponsive and lethargic horse may be distressed rather that “calm” or “relaxed” (Hall et al., 2008). Studies on imposed head lowering have not produced calmness in horses, as assessed by heart rate and heart rate variability. Neither has a connection between licking and chewing and calmness or that these behaviours are associated with lead lowering (Warren-Smith & McGreevy, 2005; Warren-Smith et al., 2007). For non-ridden horses, behaviours like chewing/licking and head tossing have been described as stress related behaviours (Padalino & Raidal, 2020). Yarnell et al. (2013) showed that calm horses had a rise in the stress hormone cortisol just as in horses expressing anxiety-related behaviour when exposed to a sham clipping procedure.

The use of facial expressions, as used in EquiFACS (Facial Action Coding Systems) may have the potential to reveal both positive and negative emotions in horses (Wathan et al., 2015). FACSs is adapted for many animal species (e.g. dogs, Waller et al., 2013; cats, Caeiro et al., 2017). Eye wrinkles on their own have also been proposed as a potential indicator of emotional response, where a reduction of eye wrinkles may indicate positive emotion (Hintze et al., 2016). The horse’s ears can act as a visual cue of attention (Wathan & McComb, 2014), especially when they flick alternately in different directions (McGreevy & McLean, 2010, p. 9). However, there is limited evidence about which position delivers the best information about relaxation or attentiveness (McGreevy & McLean, 2010, p. 10). In dairy cattle, half-closed eyes as opposed to eye white showing, along with ears hanging down or backwards, as opposed to pinned upright or forwards, have been associated with a positive rather than negative affective state (Battini et al., 2019; Lambert & Carder, 2019). In dairy cows, the more eye white showing, the more frustration/stress was present, with showing eye white resulting from withdrawal of the eyelids (Sandem et al., 2002). Comparing “gentle grooming” and “standard grooming”, Lansade et al. (2018) found significant differences in facial expressions. Horses in the “gentle grooming” treatment had their eyes half closed and their upper lip extended more often than those in the “standard grooming” treatment, whereas the latter had eyes wide open and showed the white of the eye more frequently. These authors suggested that facial expressions could be useful in assessing positive affect, at least in a grooming context (Lansade et al., 2018). In general, however, validated indicators of positive emotions are lacking for horses (Hall et al., 2018).

2.6 Bits

In Britain there is evidence for metal bit use as far back as the Iron Age (about 750 BCE - 43 CE; Bendrey, 2011), but the earliest evidence for bit use and, consequently, the use of horses for more than meat, dates back to 3500 - 3000 BCE in Botai, Kazakhstan (Anthony & Brown, 2000). Evidence of bit wearing by a donkey was found in Tell es-Sâfi/Gath in Israel, dating to 2700 BCE, probably using a non-metal bit (Greenfield et al., 2018). Of course, horses may have been ridden or used bitless before this (Brown & Anthony, 1998). Currently, the snaffle bit is the most popular bit used in Europe (both single and double jointed) and Australia (Engelke & Gasse, 2003; Hill et al., 2015).

Bits are often made of metal (stainless steel is the most popular) but can also be made of materials such as leather or rubber. There are three main types of bits: direct contact bits (e.g. snaffle bits), leverage bits (e.g. Weymouth, Pelham, Kimblewick) and gags (e.g. conventional gags, Pessoa/Dutch gag). The number of types of bits is huge. Even the most common bit, the snaffle, can come in a variety of types: loose rings (e.g. the "regular" snaffle), fixed rings (e.g. eggbutt or d-ring) or cheek (e.g. full check). These types can again have a mouthpiece that is straight, single jointed or double jointed, which all can come in different thicknesses, shapes (e.g. slightly curbed/ported) or have elements of other metals (e.g. copper or sweet iron). In double jointed bits, the mid link can have different designs as well (e.g. dog bone or bean) (Esterson, 2014).

2.6.1 Conformation of the mouth

The bit lies on the bridge of bone between the front and cheek teeth (the mandibular diastema) (Bendrey, 2011). When pressure is applied to the reins, the bit moves laterally and/or posteriorly causing soft tissue to move (Scoggins, 2001). The hard palate has a large range of depths unrelated to age, sex or breed in horses over three years of age (Evans & Lowder, 2012). Nor has the oral cavity size (as measured by length of interdental space, width of the lower jaw and width of the incisor arch) any relation to sex or age for horses grouped in either under or over 2,5 year age categories (Engelke & Gasse, 2003). There is uncertainty if a "high" or "low" hard palate relates to bit problems, but this should be considered when choosing a bit (Evans & Lowder, 2012). Manfredi et al. (2010) also suggest that this anatomical difference between horses will predispose some horses to bit-induced discomfort or trauma. Conformation of the bars also varies from thick and round to thin and narrow (Johnson, 2002), and the size of the head itself gives no reliable information about appropriate bit fit (Engelke & Gasse, 2003). In addition, there may be an asymmetry between the left and right side in distance between the upper and lower jaw (Engelke & Gasse, 2003). The mouth changes as the horse ages, and tongue shape, thickness, and relative mobility also varies between horses (Scoggins, 2001).

The composition of the mouth affects the action of the bit (Scoggins, 2001). Manfredi et al. (2010) theorize that horses push the tongue dorsum (upper surface) over the bit to provide "cushioning" to relieve bit pressure. This mechanism may also appear in horses with large tongues compared to oral cavity size, to relieve direct pressure on the tongue (Manfredi et al. 2010). Regardless, the tongue has to change shape and position when the bit is inserted (Engelke & Gasse, 2003). McGreevy et al. (2012) has suggested that a tight noseband may restrict tongue movement, depriving the horse of the opportunity to relieve pressure to the tongue, bars of the mouth and hard palate.

2.6.2 Bit damage to the oral cavity

Bits can cause damage to the lower second premolar anterior edge (e.g. exposing enamel), but not all damage in this area is due to the bit; this could also come from dietary wear (Bendrey, 2011). The bit also applies pressure to the commissures of the lips (corners of the mouth) and this can cause the cheeks to compress and rub against the upper and lower first cheek teeth. This action causes discomfort and potential damage (Dixon, 2000; Scoggins, 2001). In addition, bits can damage the tongue and cause mandibular periostitis (Scoggins, 2001; Johnson, 2002). If the horse has oral discomfort, this will lead it to focus on pain rather than performance (Scoggins, 2001). This may lead the horse to disregard bit cues, try to evade the action of the bit, or ignore it completely by running off (Scoggins, 2001). The tongue hanging out to one side when bitted may be a sign that the horse is trying to protect a side of the mouth that is painful (Johnson, 2002).

Using fluoroscopic images, Manfredi et al. (2010) showed that the horse uses its tongue to alleviate pressure from the bit. In this study, the (flash) noseband was tightened so that one finger could fit between the noseband and nasal bone. Bilateral rein tension was set at no tension or 25 ± 5 N. Since the horses stood still and did not try to back when rein tension was added, this amount of pressure was considered non-excessive. Five of the six horses in the study retracted the tongue when rein tension was added (Manfredi et al., 2010). The more rein tension, the less time the horse spent quiet and the more time was spent mouthing, retracting, and bulging the tongue. Manfredi et al. (2010) defines the term "mouthing the bit" as "*mandibular and/or tongue movements that occurred without separating the incisors by more than one centimetre and without retraction of the tongue*", while others have defined it as gently moving the bit (McGreevy et al., 2005). Horses tend to retract their tongue to prevent it from getting squeezed between the bit and the bone, which happens especially at the mandibular junction where the bony floor prevents the tongue from moving downwards (Engelke & Gasse, 2003). The bits used by Manfredi et al. (2010) were single- and double-jointed snaffle bits with loose rings and a straight eggbutt with a low port. Movements of the mouth (intra-oral behaviours) did not differ between the bit types.

Bridled and bitted ridden horses have a high risk of oral ulceration, even with dentistry upkeep (Tell et al., 2008). Oral bit-related lesions are considered a problem in Icelandic competition horses (Björnsdóttir et al., 2014). The snaffle bit has been reported to cause more oral damage than a gag bit, but the latter has the potential to be associated with tongue trauma (Mata et al., 2015). The use of curb bits with ports represents a risk for developing lesions on the bars of the mandible (Björnsdóttir et al., 2014).

2.6.3 The impact of rein tension

The risk of injury to the oral cavity increases with rein contact and complexity of the mouthpiece of the bit (Scoggins, 2001). Static rein tension causes an increase in tongue movements (Manfredi et al., 2010). High rein tension causes more conflict behaviours, but their performance might decline with punishment-based training (Christensen et al., 2011). High rein tension has been shown to reduce the frequency of head-tossing, perhaps by physically preventing the horse from demonstrating any discomfort or avoidance behaviour in fear of additional mouth pressure (von Borstel & Glißman, 2014). Lower and steadier rein tension is related to higher scores for rideability (von Borstel & Glißman, 2014), and voluntary rein tension is lower in horses exercised without a rider (Piccolo & Kienapfel, 2019).

Habituation to bit pressure may occur, leading to the horse to lean on the bit. The horse puts pressure on the rein(s) causing the rider to feel as though (s)he must support the weight of the horses' head. This may result in the horse being labelled "hard-mouthed" (McGreevy et al., 2005). Leaning on the bit has been reported as a problem behaviour (Hockenhull & Creighton, 2013).

2.6.4 Bit chewing

It has been suggested that the bit triggers digestive system responses and, since the bit is a foreign body (Cook, 2014), the horse may try to expel it (Ahern, 2019). Manfredi et al. (2010) argues that, since their study showed a quiet mouth when there was no rein tension, the horse becomes accustomed to the bit's presence and, subsequently, does not treat it as an object to eat. In contrast, Cook (2000) claims that bits activate digestive system responses when the lip seal is broken. These responses are reflex salivation and movements of the lips, jaw, and tongue. He concludes that, when ridden with a bit and asked to move forward, the horse experiences neurological confusion because eating and exercising are conflicting activities.

Chewing without food present can be a calming signal (Draaisma, 2018, p. 24), or a behavioural response after a stressful event (Lie & Newberry, 2018). This behaviour has also been referred to as "vacuum chewing", which has been considered a stereotypy (e.g. pigs, Zhang et al., 2017) associated with frustration (e.g. horses, Lesimple et al., 2012). Gentle chewing of the bit that causes light salivation has been seen as desirable as the mouth is softer and the horse may accept the bit more easily (Guzzo et al., 2018). On the other hand, chewing the bit has also been considered an abnormal behaviour and a sign of not accepting the bit (Cook,1999), and a wet mouth without food may be due to restricted ability to swallow (McGreevy et al., 2017). Horses do not usually produce saliva until food is in the mouth and chewing has started (Davies, 2009, p.15; Alexander, 1966), and saliva production stops when chewing stops (Alexander, 1966). The amount of saliva produced is influenced by the number of chewing movements (Luthersson, 2004, p.78).

2.6.5 Impact of the bit on ridden horse behaviour

Behavioural issues have often been attributed to type of bit as opposed to other parts of the bridle (Murray et al., 2015). An open mouth is anecdotally undesirable in performance horses (Quick & Warren-Smith, 2009). If the bit causes pain, the horse may try open its mouth to relieve the pressure (Hill et al., 2015). As an obligate nasal breather (Ahern, 2019), there is no reason a healthy horse with no discomfort or pain should go around with its mouth open except when vocalising, biting, drinking, or eating (Mellor & Beausoleil, 2017). Constant bit pressure can lead the horse to try evasions (McGreevy & McLean, 2010, p. 182). Evading the bit may lead to behaviours such as moving the tongue abnormally (outside of the mouth) or flexing the neck in an effort to reduce discomfort (McGreevy et al., 2005). Apart from bit discomfort, upper airway dysfunction may be a reason for opening the mouth under (heavy) exercise. Restricting mouth opening with a noseband with such dysfunction may be a source of anxiety for that individual. (Ahern, 2019). A pilot study showed that horses mainly exhibited mouth movements in the suspension phase (no limbs in contact with the ground). It was suggested that this was caused by hand movements by the rider (Eisersiö et al., 2013). Compared to naïve horses being ridden with bitless bridles, naïve bitted horses chew, open their mouths, paw the ground, and tail swish more. (Quick & Warren-Smith, 2009). There may also be behaviours occurring in the oral cavity that are not visible to the viewer (Manfredi et al., 2010). Eisersiö et al. (2013) demonstrated that mouth movements (defined as "slight opening of the mouth or slight lip movement") decreased when the horse were ridden with an elongated neck and vice versa with an increasing nose angle (i.e. nose closer to the body).

2.7 Nosebands

It is likely that, prior to use of bits, control over the horse was achieved using a simple noseband (Brown & Anthony, 1998). East European Middle Bronze Age cheekpieces included a narrow or broad nose strap (Priakhin & Besedin, 1999), although this may not have functioned in the same way as modern nosebands.

2.7.1 Common types of nosebands

The following descriptions of common noseband types are gleaned from websites (Miller, 2020; Hööks Academy, 2020, kapson.se, 2020, Horsefulness Training, 2020, Horse&Hound, 2016). An illustrated overview are shown in Appendix 1.

- A *plain cavesson* (also referred to as a plain, regular, or English noseband), runs around the nose and is placed about 2 cm below the end of the facial crest. Placing it too low may cause pinching between the bit and noseband. It is recommended for horses that accept the bit, but mildly limits crossing of the jaw, thus preventing the horse from avoiding the bit, depending tightness.
- A *crank* (or Swedish, cinch, adjustable) noseband is placed in a similar location on the nose, but the strap is threaded through rings or roller bars before closing, adding leverage that allows greater tightening. It is said to more evenly distribute pressure and is often padded over the nose and under the jaw.
- A *cavesson* can be used on its own or in combination with a bit (then often labelled semi cavesson and used with two reins) both for riding and groundwork. It acts on the nasal bone, and when used alone may prevent the horse from tilting its head.
- A *cavemore* is a bitless combination of a cavesson and a hackamore and used with two reins. The hackamore can be of varying types (e.g. flower wheel or shanks with different lengths). When it is engaged the cavemore acts on the nose.
- A *flash* (or Aachen) noseband is a narrow strap attached to the middle of a plain cavesson or crank noseband that runs under the chin below the bit. It is used to close the horse's mouth, as well as preventing crossing the jaw and placing the tongue over the bit. The noseband has to be tight enough to prevent the flash from pulling the noseband down and is, therefore, fastened before the flash.
- A *drop* (or Hanoverian) noseband is fitted below the bit and rests on the end of the nasal plane. This placement keeps the noseband from putting pressure on the teeth. It is used to aid in keeping the mouth closed and preventing jaw crossing. It is considered mild as the rider does not have to tighten it much to keep the mouth closed. Previously popular in dressage, today it is mostly used in training young horses, and when riding Icelandic horses.
- The *figure 8* (or crossed, Grackle, or Mexican) noseband has two straps crossing the nose on a diagonal. It is fastened by a buckle behind the upper jaw over the cheekbone and

another buckle at the chin groove. It is said to prevent jaw crossing without placing pressure on the teeth. Its placement on the nose allows good air intake. It is reccomended for young or “hot” horses.

- The *Micklem* bridle has a noseband that sits higher up on the nasal plane, and is fitted by one strap going below the bit and one on the lower part of the cheek. It is said to prevent pressure points that can arise using more traditional bridles.

Tradition within riding disciplines determines noseband use. In a questionnaire sent out by Hill et al. (2015), almost all dressage riders (94 %) used nosebands, mostly plain cavesson, crank or flash nosebands. Of riders in other categories, 53 % said they did not use nosebands but for those who did, the plain cavesson was the one most commonly used.

In another survey yielding 3236 respondents (White et al., 2020), 2332 answered that they used nosebands. Most used a plain cavesson (46.6 %) while few used a sheepskin noseband (0,4 %). Reasons for using a noseband varied (respondents could give several answers). A few of the most common responses included “to prevent the horse moving its tongue over the bit” (20.8 %), “to prevent the horse from opening its mouth” (17.7 %), “to improve the horse’s acceptance of the bit/contact” (18.2 %), “to improve the appearance of the horse” (20.4 %), “to align with the rules of sport” (30.2 %) and “the current noseband came with the bridle when I purchased it” (24.7 %). Regarding behavioural or physical complications with noseband use, 18,6 % reported at least one, with “hair loss in the area under the noseband” (39.9 %) being the most common. Most of these respondents rarely used a noseband while 28.9 % reported that their noseband had a crank tightening system.

2.7.2 Rules regarding noseband tightness

The Fédération Equestre Internationale (FEI, 2019a) has a code of conduct for the welfare of horses that applies to all disciplines. It says that the horse «…*must not be subjected to methods which are abusive or cause fear*» and that «*tack must be designed and fitted to avoid the risk of pain or injury*». In addition, it mentions that abusing a horse using natural or artificial aids (such as whips or spurs) will not be tolerated. The FEI rules for dressage (FEI, 2019a) mention creation of a “happy athlete” through “harmonious education”, so the horse is “calm, supple, loose and flexible” and “confident, attentive and keen”. Furthermore, the horse is expected to accept the bit through being submissive, without showing any tension or resistance (FEI, 2019a), although submission is difficult to score (Hawson et al., 2010).

Based on a study on noseband tightness by Uldahl & Clayton (2019), the Danish Equestrian Federation (2017) banned tight nosebands in all disciplines, starting 1.1.2018. The rule states that there should at least be enough space between the nasal plane and the noseband to fit a measuring unit equivalent to 1,5 cm in diameter. If stewards find that a noseband is too tight, they will ask the rider to loosen it and riders who do not comply are sanctioned through a reprimand or fine. Noseband rules have also been implemented in The Netherlands (Royal Dutch Equestrian Federation, 2019) and New Zealand (New Zealand Equestrian Federation, 2018). The Netherlands' rule is similar to that in Denmark, specifying a minimum of 1,5 cm between the noseband and the nasal plane, while in New Zealand, the rule requires that there is enough room to fit one finger comfortably between the noseband and the horse's nasal plane. The Stewards Manual of FEI (2019b) indicates that noseband tightness is measured at the cheek. It does not state any specific measurement to regulate noseband tightness, but states that it must not be fastened so tightly *"that it causes harm to the horse"* (FEI, 2019a). The tack control performed by the stewards is also completed after the horse has finished competing. The Norwegian Equestrian Federation (NRYF) general competition rules (Norges Rytterforbund, 2019a) and dressage rules (Norges Rytterforbund, 2019b) do not indicate any specific measurement other than stating that the tightness of the noseband must not cause any harm or discomfort to the horse.

In November 2019, the International Society for Equitation Science (ISES, 2019) released a position statement regarding restrictive nosebands. It states that a noseband is too tight if two adult fingers cannot fit between the noseband and the nasal plane. They suggest that governing bodies should enforce the "2-finger-rule", as measured on the nasal plane. The ISES taper gauge can be used as a standardised measuring tool. They also recommend that an open mouth should be recognized as behaviour indicating pain or discomfort, not a sign of resistance from the horse. This is a step towards better welfare for horses in equestrian sports.

2.7.3 Impact of the noseband

A reason used for tightening the noseband is to exercise greater control over the horse. Noseband tightness influences rein tension, and a looser noseband can cause the rider to apply more tension on the reins to decelerate. Indirectly, a tight noseband increases the horse's sensitivity to bit pressure (Pospisil et al., 2014; Randle & McGreevy, 2013). Thus, a problem with lack of responsiveness to bit pressure may lead riders to tighten the noseband (Doherty et al., 2017a; Hockenhull & Creighton, 2013). Another reason may relate to competition rules. In dressage, where an open mouth or any other sign of discomfort (i.e. behaviours that distort the impression of "submission") lowers the score (Crago et al., 2019; FEI 2019a).

2.7.1.1 Bone trauma

While nosebands can be ornamental fashion accessories (Paterson, 2011, p.43), they can deform the bridge of the nose, as found in horses wearing Mongolian and Altai bridles with a noseband connected directly to the reins (Taylor et al., 2016). Chronic bridling may contribute to this deformation. Deformation of this kind has also been found in skulls of Mongolian horses of the late Bronze Age, likely due to use of nosebands (Taylor et al., 2016). Casey et al. (2013) highlight evidence for chronic bone trauma at the site of nosebands, including formation of new bone. Using radiographs of 60 horses, Crago et al. (2019) looked for abnormal changes to the nasal bone in the area where the noseband usually sits. The specialists in the study disagreed on what they considered to be within the normal range in images of this region of the skull. They could only agree in one case of abnormality though, as a retrospective study, poor-quality images could not be retaken.

2.7.1.2 Soft tissue damage

Soft tissue responds to pressure by deforming to the degree possible until limited by hard tissue. For example, the cheek responds to pressure by expanding the area of contact until limited by the teeth whereas areas with little soft tissue do not have this possibility to expand in response to pressure (Doherty et al., 2017b). If the horse has dental abnormalities such as sharp edges to the rostral cheek teeth, pressure on the cheek can cause discomfort or buccal ulceration since the buccal lining of the mouth hits these sharp points (Scoggins, 2001; Dixon, 2000). Indeed, this can happen without abnormalities since the labial cutting edge of these teeth is naturally sharp (McGreevy et al., 2012). A preliminary study investigating soft tissue damage caused by nosebands indicated no significant relationship between noseband tightness and image score, but the author raised concern regarding the generally high level of soft tissue damage observed (Perruccio, 2017). Studies of compressive devices such as tourniquets used on humans and rabbits find compression injuries, such as neuromuscular injury, and Pedowitz (1991) records a threshold for injury at two hours. Although not causing damage to the buccal tissues, bitless bridles also apply pressure to the skin tissue (McGreevy et al., 2014). A case study of a dissected horse cadaver used duct tape as a noseband model. The tape was positioned at three locations (lower, regular and high), and facial nerves were pulled to record their movements under the restrictions of the model noseband. The results showed altered facial nerve movement when the noseband had tight contact with tissue, and the lowest position showed the most limited movement. The combination of a tight noseband and a high position also created movement dysfunction (Luomala et al., 2018).

2.7.1.3 Pressure

Pressure from the noseband varies from place to place (Doherty et al., 2017b), and is expected to be highest where the curvature is highest (Casey et al. 2013). Casey et at (2013) also argue that pressure over the transverse convex profile reduces the effective width of the noseband, making the pressure more severe than the noseband width would suggest. Wider nosebands may have a greater effect on blood circulation (Doherty et al., 2017b), but narrower nosebands exert higher pressure than wider ones (Doherty et al., 2017a). Due to negative curvature over the inter-nasal bone and inter-mandibular rami area, the noseband does not apply pressure in these areas, referred to as the “hammock-effect” (Casey et al., 2011; Doherty et al., 2017b). Nasal bones that anatomically produce a larger hammock effect result in the noseband applying more pressure to the left and right nasal bone, though this type of anatomy may be rare in the equine population (Doherty et al., 2017b).

Doherty et al. (2017b) studied the forces applied by the noseband by placing a digital pressure probe under a plain cavesson noseband at three different tightness settings (0.5 fingers, 1 finger and 2 fingers). At 2.0 finger tightness, pressure was 8 ± 2 N in Trial 1, 7 ± 1 N in Trial 2 whereas, at 0.5 fingers, it was 83 ± 5 N in Trial 1 and 95 ± 5 N in Trial 2. Three horses in Trial 1, and two horses in Trial 2, were excluded at the 0.5 finger setting due to difficulty fitting the probe, and pressure could not be measured at 0 fingers. These measurements did not account for curvature of the noseband or nasal bones, but maximum pressure is likely to arise on the highest parts of the nasal bone. Soft tissue assists in dispersing force but the nasal bones and mandible (jawbone) are areas with little soft tissue coverage (Doherty et al., 2017b). Doherty et al. (2019) performed pressure tests on a cadaver horse head, with six settings of noseband tightness based on the ISES taper gauge, ranging from 2 to 1 finger, with similar findings: N increased from 8 to 71 as the tightness setting increased from 2 fingers to 1 finger. They also measured the noseband tension (measured by a load cell), which also increased with tighter noseband settings, reaching 56 N at 0 fingers.

Some nosebands are designed to restrict jaw movement (Randle & McGreevy, 2013). Because of their lever action, crank nosebands can be tightened much more than other nosebands (McLean & McGreevy, 2010), and a severely tightened crank noseband will prevent virtually any jaw movement (Hill et al., 2015). Showing oral conflict behaviours is not possible when the noseband is tightened too hard (McGreevy et al., 2012), and if the bit is causing any pain, this restriction forces the horse to endure it (Hill et al., 2015). Overtight nosebands (with no space underneath them) can cause a physiological stress response (increased heart rate, decreased heart rate variability and increased eye temperature) even when stationary (Fenner et al., 2016). When tightened to this extent, the noseband may cause pain or discomfort. It also prevents the performance of natural behaviours like licking, chewing, yawning, and limits swallowing (Fenner et al., 2016). When possible, movements during chewing, yawning, and swallowing cause additional force against the noseband (Doherty et al., 2017b) whereas closing the jaw relieves tension from the noseband (Casey et al., 2013). To allow chewing, there needs to be about 17 mm between the incisors (depending on head size) (Kienapfel & Preuschoft, 2018).

McGreevy et al. (2012) studied the effect of tight nosebands on facial skin and eye temperature using infrared thermography. The preliminary results suggest that a tight noseband causes reduced vascular perfusion to facial skin distal to the noseband. Eye temperature also increased, indicating a stress response (McGreevy et al., 2012). Breathing restriction may also occur by applying a tight noseband (Doherty et al., 2017b).

Studies of the force needed to activate nociceptors by applying pressure (indicating the threshold for noxious mechanical stimulus) have been conducted in horses (forelegs) (Chambers et al., 1992), cattle (hindlegs) (Ley et al., 1995) and sheep (Welsh & Nolan, 1995). To activate nociceptors in sound horses, a mean force of 4.99 ± 0.59 N (right leg) and 5.43 ± 0.72 N (left leg) was needed (not differing significantly between legs), a mean of 6.82 N in sound cattle and a mean of 4.9 ± 2.1 N in sound sheep. Lame horses, cows and sheep all had lower thresholds, indicating hyperalgesia. The device used on cattle and the one used on horses had a cut-out force of 20 N, and 25 N, respectively (Ley et al., 1995; Chambers et al., 1992). Both studies cited prevention of tissue damage as the reason for setting a maximum limit. The sheep study imposed a maximum of 16 N (Welsh & Nolan, 1995).

2.7.1.4 Measuring noseband tightness

Traditionally, one would check if there was enough room for two fingers between the noseband and nasal plane as an indication that the noseband was fitted correctly (Crago et al., 2019). However, there are anatomical differences between fingers and different traditions as to where the fingers should be placed (Doherty et al. 2017a), on the nasal plane or the cheek (Kienapfel & Preuschoft, 2018). Checking tightness on the cheek provides a false impression of a looser noseband, since fingers may sink into the soft part of the anatomy (Kienapfel & Preuschoft, 2018). Doherty et al. (2017a) studied the prevalence of tight nosebands in 737 horses competing in dressage, eventing, or performance hunter events in Ireland, England and Belgium: 44 % of the nosebands were so tight that the ISES taper gauge would not fit under it (0 fingers), 7 % measured 0,5 fingers, 23 % measured 1 finger, 19 % measured 1,5 fingers and 7 % measured 2 fingers. The tightest nosebands were found in eventing classes, followed by dressage and then performance hunter classes (Doherty et al., 2017a) The space equivalent to 2 fingers allows horses to express conflict behaviour, but not all kinds of behaviour (e.g. yawning) (McGreevy et al., 2012). Out of 750 horses, the flash noseband turned out to be significantly tighter than other noseband types (plain cavesson, drop and Micklem), and was also the most popular type of noseband (43,4 %). The drop noseband was the least common (2,3%). This study did not differentiate between plain cavesson and crank nosebands. Doherty et al. (2017a) also used callipers to measure noseband width, which ranged from 10-50 mm, and the distance between the upper part of the noseband and the rostral margin of the facial crest, which ranged from 0-70 mm indicating a large variation in noseband placement.

The ISES taper gauge was used in a Dutch study measuring noseband tightness in 100 horses competing in either dressage or show jumping (Visser et al., 2019). The most used noseband type was a crank noseband with flash for dressage (n=34) and cavesson with flash for show jumping (n=36). Tightness was 2 fingers for 59 horses, while only two had a tightness of 0 fingers. Nosebands were looser in dressage than show jumping. In addition, Visser et al. (2019) conducted an online survey, mainly aimed at dressage riders and yielding 386 responses. Again, dressage riders usually rode with a crank noseband with flash (42,7%), while show jumpers usually used a plain cavesson (36,5%). Almost all respondents (98 %) were aware of the new Dutch regulations regarding noseband tightness implemented one month prior to the survey (Visser et al., 2019).

Out of 2312 respondents to an online study (White et al., 2020), 96,3 % stated that they always or usually checked the noseband and, out of 2295 respondents, 62,1 % said they checked for tightness at the bridge of the nose, 10,4 % at the cheek, 21,4 % under the chin and 6,1 % elsewhere.

2.7.1.5 Effects of different kinds of nosebands and effects of bridles on poll pressure

Flash and drop nosebands were found to exert a higher pressure on the nose than a plain cavesson, both in walk and trot and without a difference in rein tension (Peters & Brassington, 2019). Nosebands were fitted with a 2-finger setting using the ISES taper gauge. The authors suggest this difference in pressure was likely a result of oral movement (Peters & Brassington, 2019). The original Micklem™ bridle has been studied to evaluate the producer's claim that it is "more comfortable, more humane and more effective" (Bucknell & Randle, 2019). Horses wearing a Micklem™ bridle spent more time with a "correct" head carriage and ears pricked (often seen as a positive behaviour) than horses wearing a flash noseband (both fitted with two fingers under the noseband, Bucknell & Randle, 2019).

Murray et al. (2015) investigated pressure distribution under a double bridle, looking at both sub-headpiece and sub-(crank) noseband pressure. Noseband tightness was not standardized, as the rider adjusted the noseband as (s)he normally would. High peak pressure sites for headpieces were located at the far-end of the headpiece ventral to the ear base. This location overlies parotid salivary glands and some branches of facial nerves (including ear nerves). Other pressure sites varied with design. For example, when the noseband strap ran under the headpiece, this caused a pressure peak on the midline on the top of the head. For nosebands, peak pressure sites were immediately left and right of the nasal bone. Noseband stiffness influenced pressure distribution, with stiffer nosebands distributing pressure further from the nasal bone on each side (Murray et al., 2015). Since the bit is usually held in place by cheek pieces, the tension applies some pressure to the poll regardless of engagement of the bit via rein tension, and leverage or gag bits can add to pressure on the poll (Cross et al., 2017).

While the above review indicates what has been reported regarding effects of different features of bridles on the welfare of the horse, questions remain about how bridles and other riding aids are being used in practice in different countries, and the extent to which they affect horse behaviour when ridden.

3 Research study aims

The overall aim of this exploratory study was to describe the types and fit of bridles and other riding aids being used during routine horse training sessions in Norway, and to evaluate associations with behavioural indicators of welfare in horses during riding sessions. Some observations were also made to assess how horses behaved in anticipation of being ridden, and when tack was removed after riding.

The study was designed to investigate the following specific aims. Hypothesis and predictions were formulated where applicable.

1. To collect information about discipline and use of horses, and how often they are turned out, since these data are few in Norway.
2. To gather data about bridle tightness and bridle design used on Norwegian horses, which has not been previously investigated in Norway.
3. To assess information from riders on their choice and use of bridles and other riding aids, and their views on how to recognise positive behaviour in horses to reveal attitudes towards equipment is use and what is expected of horses during riding.
4. To observe horses before a riding session for behavioural signs of discomfort or conflict when being prepared for riding.
5. To determine wheter horses exhibit a facial grimace score when wearing a tight noseband.

   Hypothesis:

   A tighter noseband is associated with more discomfort/pain.

   Prediction:

   A tighter noseband is associated with a higher facial grimace pain scale score.

6. To determine whether bridle tightness has an effect on ridden horse behaviour.

Hypothesis:

A tighter bridle, as represented by tightness of the noseband and/or headpiece increases the performance of behaviours associated with discomfort/pain with the exception that a very tight bridle (noseband or headpiece less than 1 finger width) restricts mouth movement.

Predictions:

6a) Horses perform fewer mouth related behaviours (foam/saliva present, mouth open, mouth movement and tongue visible) when ridden if the noseband or headpiece is tighter than 1 finger, or if the average tightness of the noseband and headpiece combined is tighter than 1 finger.

6b) For nosebands and headpieces set at 1 finger or more, the tighter the noseband or headpiece, or average of both combined, the more mouth related behaviour (foam/saliva present, mouth open, mouth movement and tongue visible) is performed when ridden.

6c) Horses having a tighter noseband or headpiece, or average of both combined, show more ears back, tail movements (swish and lash) and head tossing laterally and vertically than horses with looser nosebands or headpieces.

6d) Headpiece tightness is correlated with the number of wrinkles at the corner of the mouth.

7. To assess the role of type of noseband on ridden horse behaviour.

Hypothesis:

Different types of noseband vary in their effect on ridden horse behaviour because they vary in the amount of pressure placed on different parts of the head affecting the degree of discomfort.

Predictions:

7a) Horses ridden with a crank noseband (with or without a flash) show more mouth related behaviours (foam/saliva, mouth open, mouth movement and tongue visible) than horses ridden without a crank noseband.

7b) Horses wearing a crank noseband with or without a flash have it fitted tighter than horses wearing a flash noseband, plan cavesson, drop noseband, Micklem or Micklem type noseband or “other”.

8. To assess whether a flash has an impact on ridden horse behaviour.

Hypothesis:

The presence of a flash on a cavesson, regardless of crank, increases the performance of behaviours associated with discomfort/pain.

Prediction:

Horses perform more mouth related behaviours (foam/saliva present, mouth open, mouth movement and tongue visible) and tail behaviours (swishing and ashing) when ridden with than without a flash.

9. To find out if the presence of whips and spurs or “help reins” (refers to draw reins and running martingales in this study) effects ridden horse behaviour.

Hypothesis:

Horses associate whips and/or spurs or use of “help reins” with discomfort or pain, causing them to express signs of discomfort as a response to the rider’s requests when ridden

Predictions:

9a) Horses perform more tail movements (swish and lash), bucking, ears backwards and head tossing (laterally and vertically) when the rider is carrying a whip and/or wearing spurs than when the rider is not wearing this type of equipment.

9b) Horses perform more tail movements (swish and lash), bucking, ears backwards and head tossing (laterally and vertically) when “help reins” (draw reins or running martingale) are used than when they are not used.

10. To evaluate whether type of bit has an impact on ridden horse behaviour.

Hypothesis:

The use of a snaffle with loose rings causes more instability than a bit with fixed rings (eggbutt) leading to more behaviours related to discomfort.

Prediction:

Horses wearing double jointed loose ring snaffle bits exhibit more mouth related behaviours (foam/saliva present, mouth open, mouth movement and tongue visible) than horses wearing a double fixed ring snaffle bit.

11. To determine if age or sex of the horse effects behaviour when ridden.

    Hypothesis:

    Age affects ridden horse behaviour, as younger horses are less used to being ridden.

    Prediction:

    11a) Younger horses show more behaviours associated with conflict or discomfort.

    11b) There is no difference between males and females in expressing behaviour associated with discomfort during riding.

12. To assess whether noseband tightness influences snorting.

    Hypothesis:

    Noseband tightness will influence the performance of snorting since a looser noseband is more comfortable

    Prediction:

    Horses snort more often with a looser noseband

13. To observe horses after a riding session to see if this reveals behaviour associated with signs of preceding discomfort when ridden

14. To look for rare or unexpected behaviours that could provide insights into horse's perception and other equipment used before, during or after riding.

4 Materials and methods

4.1 Recruitment of horses

A short informative study invitation text was written inviting horse owners to volunteer their horse for the study. The text (Appendix 2) contained a brief description of study aims and what the owner would be asked to do with their horse if willing to participate and provide contact information. Operators of private and public stables (n=21) in mid- and south Norway were contacted in the timespan 28.10.2019 – 26.02.2020 and asked to distribute the study invitation text to the horse owners at their stable. The text was then posted in closed Facebook groups open to horse boarders, or sent out to personally known boarders via e-mail, and those willing to volunteer their horse were invited to make contact via text message either by phone or on Facebook. This method yielded very few responses (five riders), leading to a new approach of asking stable owners and others in the horse community to provide contact information for riders perhaps willing to participate. These riders were then contacted directly. Some were given an oral or shortened version of the information text given the circumstance. This new approach started in mid-November 2019 and ended 19.03.2020.

When in contact with potential volunteers, they were asked to allow observation of their horse during preparation for riding, during riding, and when untacking. It was explained that the observations were about the behaviour of the horse, and not their own behaviour during riding. It was also explained that some measurements of the tack would be made, and that they would be asked some questions about the horse and the equipment they used. While it was initially considered to video the observation sessions, most riders were considered unwilling and so it was explained that data would be collected only by directly observing and recording the horse’s behaviour on record sheets. A total of 47 riders agreed to enrol their horse(s) in the study. An appointment was then made to meet the owner with their horse at their normal riding stable at a convenient time when they were planning to ride for at least 20 min.

Riders were asked to follow their usual procedures and were not given any directions about which type of tack to use, how to ride or which gaits to use. It was explained to riders that participation was voluntary. No riders chose to withdraw, resulting in data collection on a total of 60 horses.

4.2 Ethics statement

The study involved behavioural observations of horses, and no invasive procedures were used on the horses. All horses were observed in their typical environment under normal use, with rider consent. Therefore, no specific approval was required for animal use in this study (Forsøksdyrloven, 2015). The study was focused on behavioural responses of horses rather than on riders. Therefore, the research did not fall into the category of human research (Helseforskningsloven, 2008). No personal information about people was stored for this research. Horse data are presented anonymously, and no information was stored that could be used to identify horse owners or riders. Therefore, this research did not require approval from the Norwegian Centre for Research Data (NSD, 2019).

4.3 Study design and procedures

The study was divided into three parts: before riding session, riding session and after riding session. The riding session could take place in an indoor or outdoor arena.

Ethograms were developed and refined through practice observations prior to commencing data collection. Intra-observer reliability was checked through scoring of behaviour of horses in Youtube videos and self-recorded riding sessions.

4.4 Data collection

4.4.1 Before riding session

Information regarding the horse (age, sex, breed, use/discipline, hours turned out per day), tack, and behaviour when tack was being put on, was collected before the riding session started (see data sheet, Appendix 3).

Questions 1-3 of Table 1 were asked to obtain information about the context of the observed riding sessions.

Table 1. Questions 1 - 3 from the questionnarie

Question 1	Are you a beginner, intermediate or experienced rider?
Question 2	Is your ride today for pleasure or are you practicing for a specific type of competition or another event? If practicing, for what type of event?
Question 3	Is this the tack that you usually use? If not, why did you chose to use this tack today?

Behaviour was recorded using 1-0 sampling for the presence or absence of each behaviour in the ethogram shown in Table 2 and using the data sheet presented in Appendix 4. Behaviour occurring in each 15-s time interval was recorded starting when the rider was approximately 1 m from the horse and, approaching the horse with the bridle, and ending when all the buckles of the bridle were fastened. This period varied from 30 s to 2 min in duration. Due to a scheduling issue, one horse was not observed prior to the riding session.

Facial grimace scoring was performed using the horse grimace scale (Costa et al., 2014), based on direct observation starting about 3 s after the bridle was put on (Appendix 5). The number of wrinkles at the corner of the mouth when wearing the bridle was then noted.

Table 2. Ethogram for observations before and after the riding session

Behaviour	Description
Licking	Tongue extends out of the mouth and may move across the muzzle but is not in contact with object, own body or other (modified from Fenner et al., 2016)
Chewing, nutritive	The horse bites and softly grinds the teeth while eating (Fenner et al., 2016))
Chewing, non-nutritive	The horse bites and softly grinds the teeth in the absence of food (modified from Fenner et al., 2016)
Yawning	The horse separates the upper and lower jaw and opens the mouth. The tongue extends somewhat out of the mouth. A deep, long inhalation follows (modified from Fenner et al. 2016, and McDonnell, 2003)
Head shake	The horse shifts the head from side to side (Fenner et al., 2016)
Body shake	Rapid, rhythmic rotation of the head, neck and upper body along the long axis while standing with feet planted (McDonnell, 2003)
Scratching head with hind leg	One hind leg lifted off the ground and moved towards the head. Head reaches downwards and backwards to make contact with hind leg which then scrubs the desired area.
Scratching front leg with teeth	The muzzle moved downwards towards one of the front legs. Teeth are used to scrub the desired area.
Rubbing head against leg	Head is moved downwards towards one of the front legs, which is usually put forward. Head then scrubs the front leg.
Rubbing head against object	Head is scrubbed against an object
Rubbing head against person	Head is scrubbed against a person
Stretching	Rigid extension of the limbs and arching of the neck and back (McDonnell, 2003)
Paw	With an object or material as an apparent target, a foreleg is lifted off the ground slightly, extended quickly in a forward direction, and followed by a backward, toe-dragging movement as if digging (McDonnell, 2003)
Ears flat back	Both ears flat backwards for a bout lasting > 2 s
Bite rider	The jaws and teeth are opened and closed and then (quickly) released taking a small (nip) or large (bite) piece of the rider's clothes and/or flesh. Ears are flat backwards (modified from McDonnell, 2002)
Attempted bite rider	The jaws and teeth are opened and ears backwards coming towards the rider to bite, but the bite is interrupted by the rider's actions (modified from McDonnell, 2002)
Head tossing vertically - medium	The horse moves the head in a quick forward-upward motion. The nasal plane reaches a maximum 45-degree angle. Movement can be repeated in short succession (modified from Hall et al., 2014)
Head tossing vertically - high	The horse moves the head in a quick forward-upward motion. The nasal plane is moved beyond a 45-degree angle. Movement can be repeated in short succession (modified from Hall et al., 2014)
Head tossing laterally	The horse moves the head in a quick lateral motion (Hall et al., 2014)
Stepping away	The horse moves away from the rider with one or more steps as (s)he tries put on the bridle
Head turn	Head turns away from rider as (s)he tries to put on the bridle

Noseband, headpiece, and brow band tightness was measured using the ISES taper gauge (International Society for Equitation Science, https://equitationscience.com/store/taper-gauge, accessed 12.09.2019). The placement of the taper gauge for the different measures is shown in Figure 1. It was led under the relevant strap until it naturally stopped, not using force. In addition to the two marks for one and two fingers already present on the gauge, additional marks at quarter-finger intervals were added to increase measurement precision.

For two horses, tightness of headpiece could not be measured. One horse was very tall, and nervous about the gauge, so the measurement was omitted. The other horse had a type of headpiece that did not have any strap lying directly on the horse in the middle of the headpiece, that area was “open”. Another horse had two straps lying parallel to each other over the poll, and their combined width was measured. One horse had a sheepskin cover over the headpiece, and the width used in analyses was taken without the cover (25 cm without; 54 cm with the sheepskin). The number of mouth wrinkles could not be registered for 7 horses as they were covered by bit guards.

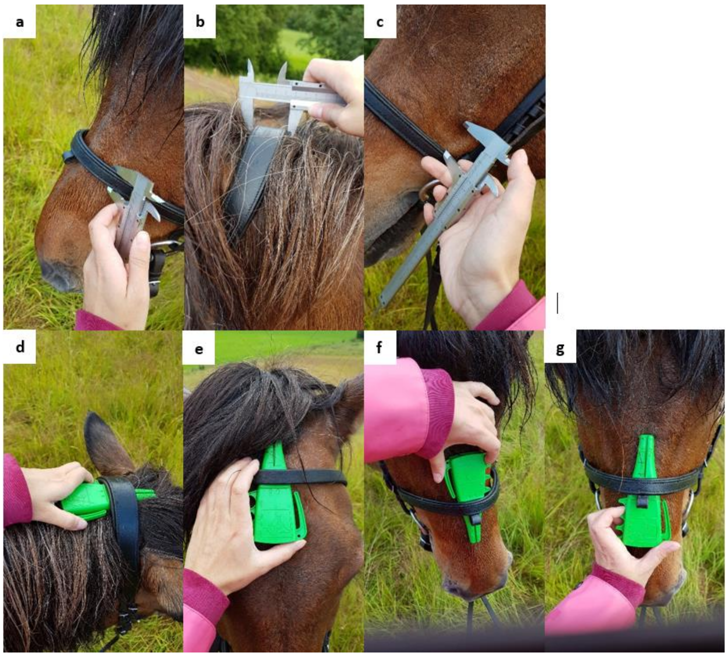

Figure 1. An illustration of the ISES taper gauge and calliper used in the study and their placements. a) width measure on noseband, b) width measure on headpiece, c) distance measure between noseband and facial crest, d) taper gauge measure on headpiece, e) taper gauge measure on brow band, f) taper gauge measure on noseband, g) taper gauge measure on noseband

The width of the headpiece and noseband were measured using callipers (Skyvelære (item number 40-8746), Clas Ohlsson, Insjön, SE) in the placements shown in Figure 1. In a few cases, the horse did not stand still long enough to get precise width measurements, and they were taken when the bridle was taken off after riding. On two horses, the headpiece of the noseband ran under the headpiece of the bridle and was not of the common "monocrown" type (where the hanger for the noseband is integrated with the head piece). In these cases, the upper strap width was measured. Width of the noseband was usually uniform but, if not, the measurement was taken at the widest point. "Anatomical" head pieces varying in width were measured both in the middle (widest point) and behind the ears (where narrower).

The distance between the upper margin of the noseband and rostral margin of the facial crest was also measured using the callipers. This measurement could not be made for horses without a noseband (n=3), those wearing a Micklem or Micklem-type noseband in which the position of the noseband was above the ventral edge of the facial crest (n=5), and those wearing a type of noseband in which the piece running directly over the nose was further down the nose than the piece closest to the facial crest, which would not give comparable information about nosepiece location ("other noseband", n=7).

4.4.2 Riding session

It was planned to observe each horse for 20 min, but riding ended before 20 min for 3 horses. The 20 min originally was originally planned to start after 5 min of warm-up in the saddle, but this approach was not followed as riders had different warm-up routines. Some riders warmed up their horses by riding on a short trail or just walking around with the horse in hand. On one occasion, there was no time for warm-up, and some riders only rode for the benefit of the study and did not warm-up (i.e. the whole riding session only lasted 20 min). Therefore, the 20 min of observation began as soon as the rider started riding in the arena. Riders were free to end then or continue riding for a longer period according to their normal routine. The start and end times were noted to give a measure of total riding time, rounded to the nearest 5 min.

Direct observations were made using 0-1 sampling at 15 s intervals using the ethogram in Table 3. All behaviours observed during each 15-s interval were recorded (see data sheet in Appendix 6). When a horse changed gaits within a 15s period, both gaits were registered in the data sheet, but only the new gait was entered in the data file. Head position was defined as before or behind the vertical, rather than attempting to estimate the angle in degrees.

Observations were made from the centre of the riding arena except for one horse observed from the long side of the arena and four horses observed from the end of the arena, in accordance with rider request. One horse was being lunged with a rider, and one young horse was led in addition to being ridden. On six occasions, riders were being instructed by a trainer.

Table 3. Ethogram used for the riding session

Behaviours	Description
Ears back	Both ears turned backwards (but not flattened) for bouts lasting > 2 s
Eye white	Sclera of the eye showing
Eyes – stare	Glazed, intense stare (Dyson et al. (2018a))
Nostrils – flared	Nostrils dilated to the maximum
Mouth – foam	Foam/saliva visible in any amount
Mouth open	Visible space between upper and lower jaw
Mouth movement	The horse bites and grinds the teeth without the presence of food (modified from Fenner et al. (2016), including lower lip movement with teeth closed or other behaviours that resemble mastication
Tongue visible	Tongue visible outside mouth
Tail swishing	Intense circular or lateral movement of caudal vertebrae; beyond gentle, rhythmic swaying of the tail (Heleski et al. (2009))
Tail lashing	Rapid, sharp dorsoventral movement (upwards - downwards) of caudal vertebrae (modified from Heleski et al. (2009))
Head in	Nose is angled inwards towards chest, with head behind the vertical for bouts lasting > 2 s
Head tossing vertically – medium	The horse moves the head in a quick forward-upward motion. The nasal plane reaches a maximum 45-degree angle. Movement can be repeated in short succession (modified from Hall et al. (2014))
Head tossing vertically – high	The horse moves the head in a quick forward-upward motion. The nasal plane is moved beyond a 45-degree angle. Movement can be repeated in short succession (modified from Hall et al. (2014))
Head tossing laterally	The horse moves the head in a quick lateral motion (Hall et al. (2014))
Height of poll – high	Poll is highest point of body, excluding the ears (Dyson et al. (2018a))
Height of poll – low	Poll is lower than third and fourth cervical vertebrae, neck stretched forwards and horse seems relaxed with loose reins (Dyson et at (2018a))
Nose up	Nose is held up above a 45 degree angle for bouts lasting >2 s
Snort	Sound produced upon forceful quick exhalation of less than 1 s duration (Hall et al. (2014))
Neigh	High pitch sound that appears to drop to a lower frequency at the end. Lasts about 1.5 s (Waring, 2003, p. 297)
Defecating	Expelling of faeces (Kaiser et al. (2006))
Bucking	Both hind feet kicked up off the ground (Dyson et al. (2018a))
Attempted buck	Suddenly arching of the back with an upward-forward jump, usually with ears laid backwards (modified from McGreevy et al. (2005)
Rearing	Both front feet lifted up off the ground while rising on the hind limbs (de Cartier d'Yves & Ödberg, 2005)
Halt	Horse standing still with all four limbs on the ground
Walk	All limbs move sequentially one after the other in a four-beat motion (Waring, 2003, p.42)
Tølt	As walk, but faster and often higher foreleg action (Waring, 2003, p. 47)
Trot	Two diagonal feet are lifted synchronously or on the ground simultaneously in a two-beat motion (Waring, 2003, p. 42)
Canter	A three-beat gait where the second and third leg is in contact with the ground simultaneously (Waring, 2003, p. 43)
Pace	The legs on the same side work in unison in a two-beat motion (Waring, 2003, p. 43)
Back up	As walk, but in reverse

4.4.3 After riding session

After the rider dismounted and took the horse to the usual place for tack removal, the horse was observed from the moment the rider started to open the first buckle of the bridle and for the next 2 min. A few riders loosened the noseband directly after dismounting. In this case, observations started once when tack removal began. The Table 2 ethogram was used, with 1-0 sampling in every 15 s interval (see data sheet, Appendix 4). The rider was asked Questions 4-6 of Table 4, and sometimes Questions 1-3 if there had been no time for this before the riding session.

Table 4. Questions 4 -6 from the questionnarie

Question 4	What do you like about the specific type of bridle you used today and the way it fits?
Question 5	How do you decide how loose or tight to make the different parts of the bridle you used today?
Question 6	What behaviour do you think is the most positive behaviour that a horse can show when being ridden?

On two occasions, the horse was led out to pasture with the bridle on and then the bridle was removed, and the horse was turned loose before the 2-min observation was completed. The horse would then go out of sight quickly behind a building. On three occasions, there were unforeseen events resulting in no observations being made after the riding session.

4.5 Data analysis

For analysis purposes, ISES taper finger measures <0.75 were converted to 0, and > 2.0 were converted to 2.25. Behavioural data on number of scans which each behaviour occurred were over-dispersed which led to analysis of associations between riding equipment and behaviour using negative binomial logistic regression performed in SPSS (version 23.0.0). An analysis of the association between headpiece tightness and number of wrinkles at the corner of the mouth (from now on “wrinkles” was conducted using ordinal logistic regression in R (version

4.0.2). An analysis of the association between noseband type and noseband tightness was conducted using linear regression in R (version 4.0.2). Spearman correlations were performed in SPSS (version 23.0.0). Significance level was set at 0.05 for all analysis.

5 Results

5.1 Horses and riders

Sixty horses from 21 stables participated in the study, which took place between 28.10.2019 and 19.03.2020 (Appendix 7). The average age of the horses was 12 with a median of 12, including 31 geldings, 28 mares and 1 stallion. The horses represented 28 breeds (Table 5). Full-time turnout accounted for 20 % (n=12) of the horses. For horses not on full-time turnout, the average number of hours turned out per day was 10, distributed as follows: over 10 hours 42 % (n=20), 5 - 10 hours 52 % (n=25), under 5 hours 6 % (n=3). The horses were used mainly used in jumping (n=14), dressage and hacking (n=9), dressage (n=8) or jumping and dressage (n=8), with the rest having other or other combinations of use.

The horses had 47 riders (36 riders riding 1 horse, 9 riders riding 2 horses and 2 riders riding 3 horses). Twenty-five horses were ridden with a whip (42 %), 13 (22 %) with spurs, 11 (18%) were ridden with a combination of both and 11 (18 %) were ridden with neither. Average riding time was 38 min (shortest time 12 min, longest 80 min, median 30 min). 42 horses were ridden in an indoor arena, while 15 were ridden in an outdoor arena and 3 on a field.

Table 5. Number of horses of different breed types

Breed	Number of horses within each breed
Danish Warmblood	n=9
Dutch Warmblood	n=8
Norwegian Warmblood	n=6
Icelandic Horse	n=5
English Thoroughbred, Oldenburger, Pura Raza Española, Swedish Warmblood, Welsh Cob, Holsteiner, Nordland Horse, Fjord Horse	n=2/breed
American Paint, Selle Français, Danish Sport Pony, Belgian Warmblood, Lusitano, Norwegian Coldblood Trotter, German Riding Pony, New Forest, Lippizan, Danish Palomino, Irish Warmblood, Standardbred, Mecklemburger, Huzule, North Swedish Horse, mixed breed	n=1/breed

5.2 Bridle information

The types of saddles, bit, nosebands, and other tack used are shown in Appendix 7. In addition, 29 horses had an "anatomical" type of headpiece meaning that the middle part was wider and the part behind the ears was narrower. Tables 6, 7 and 8 shows information gathered on tightness and width measurements. The mean ± SE tightness was 1.68±0.06, 1.82±0.04 and 2.24± 0.01 fingers for the noseband, headpiece and browband respectively, based on n=57, n=58 and n=57 horses.

Table 6. The average noseband tightness for each noseband type

Type of noseband	Average noseband tightness	
	Fingers	**Horses (n)**
Drop	2	5
Plain cavesson	1.9	10
"Other"	1.9	11
Crank without flash	1.8	7
Micklem or Micklem type	1.7	5
Cavemore	1.5	1
Crank with flash	1.4	6
Flash	1.3	12
Total average	1.7	57

Table 7. Number of horses within each noseband tightness category across all bridle types

Finger tightness	Tightness noseband		Tightness headpiece	
	Horses (n)	**%**	**Horses (n)**	**%**
Not applicable	3	5	2	3
0	1	2	0	0
1	6	10	2	3
1.25	7	12	4	7
1.5	10	17	7	12
1.75	10	17	13	22
2.0	14	23	27	45
2.25	9	15	5	8
Total	60	100	60	100

Table 8. Width of noseband, headpiece and distance from the noseband to the facial crest

Width	Noseband	Headpiece centre	Headpiece behind ears	Distance noseband to facial crest
Not applicable (n)	3	1	31	15
Average (mm)	28	40	32	30
Narrowest width (mm)	11	12	17	0
Widest width (mm)	48	81	43	119
Median (mm)	28	37	33	24

5.4 Responses to questions

No riders described themselves as beginners, 14 described themselves intermediate and 33 as experienced riders (Question 1). Ten of the 60 horses were being trained for competition (7 for dressage competitions and 3 for show jumping) when observed. (Question 2). Regarding choice of tack on the day of observation (Question 3), 21 horses were wearing the same tack they normally wore, 35 had one or more pieces of tack that varied depending on use of the horse, and 4 had new tack or the rider was not sure what was usually worn. Responses regarding what was liked about the bridle used and its fit (Question 4) were pooled into categories (Table 9). Several riders gave multiple reasons. If the same bridle was used when riding more than one horse, responses were counted once and not per horse. References to padding and “it fits the horse” were pooled under function.

Table 9. Number of responses to question 4: What do you like about the specific type of bridle you used today and the way it fits?

Category of responses	n	%
Reasons related to function	34	45
Reasons related to design/appearance	15	20
Reasons related to quality	10	13
Reasons related to horse preference	5	7
No reason/not riders' horse	3	4
Reasons related to competition rules	2	3
Other reasons or reasons just related to the bit	7	9
Total	**76**	**100**

Riders gave a variety of responses to Question 5 about how loose or tight to make different parts of the bridle. The most common answers (three or more with the same reply) are represented in Table 10. Riders usually did not have a "rule" for every part of the bridle. None mentioned the browband. Also, only 4 riders referred to mouth opening by the horse (3 wanting to allow the horse the opportunity to open its mouth or chew, and 1 wanting to prevent mouth opening). One rider considered a minimum of one finger between the noseband and horse to be sufficient. Riders measuring noseband tightness at more than one location were counted under both locations. Only one rider mentioned if the fingers were in an upright or downward position when measuring.

Table 10. Responses to question 5: How do you decide how loose or tight to make the different parts of the bridle you used today?

Category of responses	n	%
Refers to "not tight"/" loose" without having a specific way of measuring	13	23
One fist/hand under throatlatch	13	23
"Two finger rule" under the noseband on the nasal plane	11	20
Refers to horse preference	6	11
Refers to the "usual notch"	4	7
"Two finger rule" under the noseband without specifying where to measure	3	5
"Two finger rule" under the noseband on the side/cheek	3	5
Refers to a "feeling" of what is the right tightness	3	5
Total	56	100

When asked about the most positive behaviour that a horse can show when ridden (Question 6), riders often mentioned several behaviours they felt were positive, as well as personality traits that a horse could have and emotional states it could experience. Responses in these three categories that were given by at least two riders are shown in Table 11. The most common responses were not behaviours, but traits or states. Statements that closely resembled "likes his job" and "wants to work" were pooled under "willingness to work". Two riders mentioned movement of the mouth in relation to positive behaviour: one saw a quiet mouth as positive, while the other regarded playing with the bit as positive.

Table 11. Responses to question 6: What behaviour do you think is the most positive behaviour that a horse can show when being ridden?

	Responses (n)	% of category	% of total
States			
Relaxed	15	50	15
Positive	4	13	4
Happy	3	10	3
Satisfied	2	7	2
Awake	2	7	2
Energetic	2	7	2
Attentive	2	7	2
Category total	*30*	*100*	
Traits			
Willingness to go forward	15	38	15
Willingness to work	11	28	11
Obedient	7	18	7
Cooperative	3	8	3
Willingness to learn	2	5	2
Willingness to please	2	5	2
Category total	*40*	*100*	
Behaviours			
Ears pricked	9	29	9
Stretching neck/back/body	6	19	6
Head low/seeks down	5	16	5
Snort or snort-like vocalization[1]	4	13	4
Self-carriage/lifts back	3	10	3
Ears back ("to listen for messages")	2	6	2
Tossing head	2	6	2
Category total	*31*	*100*	
Total		**101**	**100**

[1] Included sound described as snorts by riders, but they did not use the word "snort"

5.5 Before riding session behavioural observations

Out of the behaviours described in the ethogram (Table 2) only behaviours “licking”, “chewing, non-nutritive” and “head turn” were observed. Total observations, mean and SE are presented in Table 12. Correlations between “licking” and “chewing, non-nutritive” were r=0.377, p=<0.01, “chewing, non-nutritive” and “head turn” were r=-0.190 and “head turn” and “head turn” and “licking” r=-0.201.

Table 12. Total number of 15-s scans, and mean and SE occurences of each behaviour before riding (n=59 horses, mean number of scans per horse: 6)

Behaviour	Total observations	Mean	SE
Licking	14	0.2	0.07
Chewing non-nutritive	114	1.9	0.17
Head turn	20	0.3	0.08

The horse not observed before the riding session were not included in the correlation analysis between pain score and ridden horse behaviour (n=59). There were no correlations between pain score and noseband tightness (Appendix 8). Correlations for pain score and a combined value for crank noseband, double jointed snaffle with loose rings, whip and spurs were not significant (r=-0.02, p=0.88).

5.5 Riding session observations

Behaviours “nostrils flared” and “eye white” were excluded from analysis, although some observations were made (119 and 126 observations respectively), due to uncertainty if the behaviours were clearly present. The behaviours “eyes stare” and “rearing” were never observed. Behaviours that were observed less than 20 times overall were not analysed due to their rarity. These behaviours were: “ head toss vertical high” (14 observations), “head toss lateral” (5 observations) “nose up” (16 observations), “neigh” (3 observations), “defecation” (13 observations), “bucking” (5 observations), and “attempted buck” (10 observations). “Head toss vertical high” and “head toss lateral” were pooled with “head toss vertical medium” (57 observations) creating the variable “head tossing”. Table 13 shows the mean and SE for all behaviours and horses (n=60). An overview over behavioural counts per horse for all behaviours is presented in Appendix 9.

Table 13. Mean and SE number and % of total scans of 15-s scans in which each behaviour occurred during 20 min riding sessions (n=57 horses, total numer of scans:4560).

Behaviour	**Mean**	**SE**	**% of total scans**
Ears back	15	2.02	18
Mouth foam	18	3.61	23
Mouth open	13	2.39	17
Mouth movement	22	2.48	28
Tongue visible	3	0.84	4
Tail swishing	3	0.86	4
Tail lashing	8	1.86	10
Head in	14	2.48	17
Head tossing	1	0.28	1
Poll high	12	2.43	16
Poll low	4	0.73	5
Snort	2	0.34	3

Browband tightness was excluded from analysis because 55 horses had a browband tightness of > 2 fingers, 2 had 2 fingers and 3 did not wear a browband (mean±SE: 2.24±0.01). On these grounds, browbands were considered too loose to influence behaviour.

The bridles PS of Sweden Nirak/Pinoneer/Jump off/High jump, Horse Vision or Horse Vision type noseband and Cavesson were pooled to create the group “other”. The number of horses wearing each of these types of bridle was too low for individual analysis.

There was only one horse with the noseband tightness value “less than 1 finger” and none for headpiece tightness. No horse had an average tightness of less than 1 finger. Consequently, there were not enough horses in these categories to perform any analysis on Prediction 6a. A comparison was made between the levels of mouth-related behaviour of the horse with the tightest noseband value and the average for the remaining horses wearing a noseband (Table 14). Three horses were excluded since they did not wear a noseband, leaving n=56.

Table 14. Total number of observations of mouth related behaviours for the horse with the tightest noseband value (Horse), and the mean and SE number for the remaining horses based on 1-0 samling ruding 15-s scans thoughout each 20-min riding session (n=56 horses)

Behaviour	**Horse**	**Mean**	**SE**
Mouth foam	16	18	3.68
Mouth open	2	13	2.42
Mouth movement	20	22	2.52
Tongue visible	0	3	0.77
Total mouth	38	56	5.85
Tightness of noseband (fingers)	0	1.71	0.05

There was a low significant correlation between noseband tightness and the behaviour "poll low" (r=0.279, p=<0.05) (Appendix 8). There were no significant associations between mouth-related behaviour and noseband tightness (Table 15).

Table 15. Estimated effect of noseband tightness on behaviour variables during riding (n=54 horses). Three horses were excluded since they did not wear a noseband and the analysis included only horses ridden for the full 20 mins.

Behaviour	**B**	**SE**	**P**	**95% CI**
Mouth foam	-0.86	1.35	0.522	0.42
Mouth open	0.04	0.55	0.946	1.04
Movement	0.43	0.34	0.201	1.54
Tongue visible	1.40	0.98	0.154	4.05
Total mouth	0.04	0.34	0.904	1.04

“Mouth movement” had the highest incidence of observations (n=1229) and Figure 2 shows the number of observations for this behaviour for each noseband tightness category.

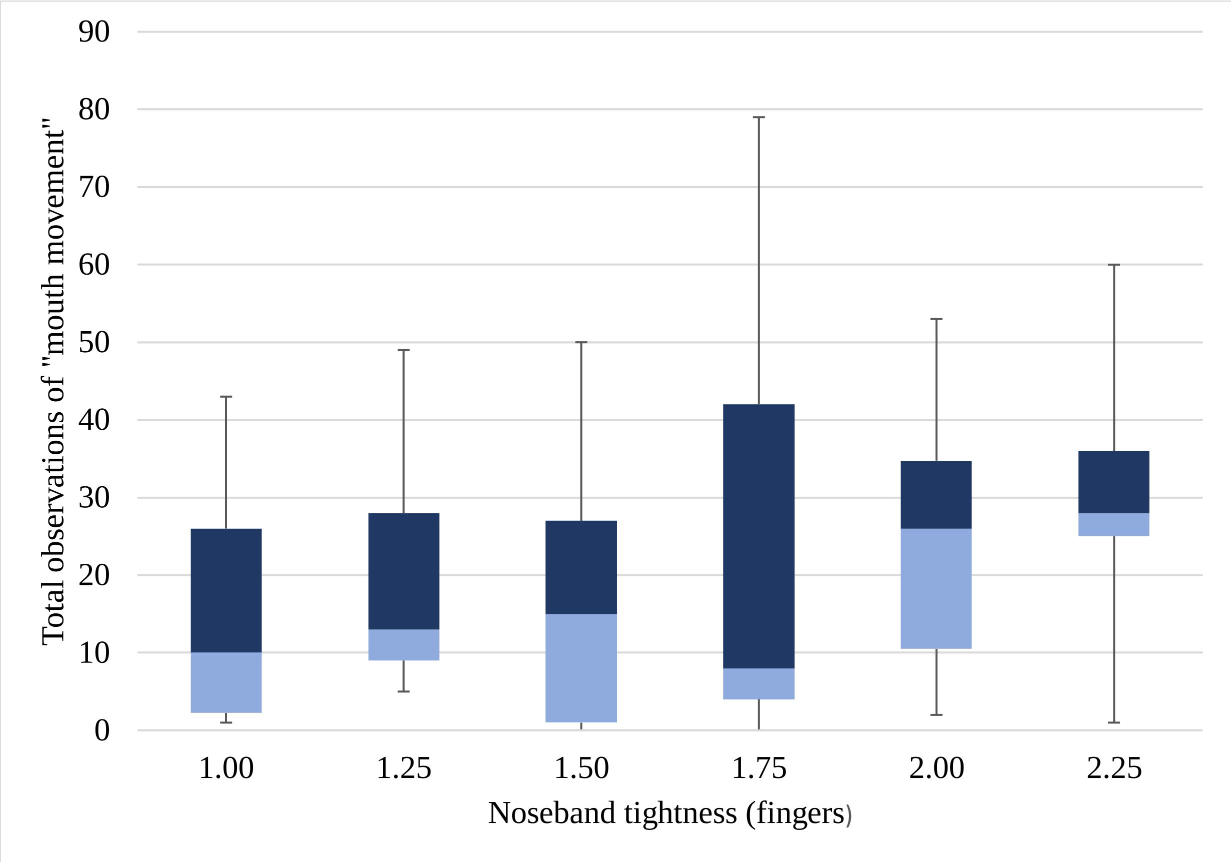

Figure 2. Median ± IQ number of 15-s scans in which the behaviour "mouth movement" occurred per 20-min riding session at each noseband tightness category (n=54 horses)

There was a low, significant positive correlation (r=0.296, p=<0.05), and a significant association between the behaviour “Tongue visible” and headpiece tightness (p=0.033) (Table 16; Appendix 8).

Table 16. The estimated effect of headpiece tightness on behavioural variables (n=55 horses). Two horses did not have a measurable headpiece and the analysis only included horses ridden for the full 20 mins.

Behaviour	**B**	**SE**	**P**	**95% CI**
Mouth foam	-0.40	2.03	0.846	0.67
Mouth open	-0.61	0.78	0.435	0.54
Movement	-0.27	0.43	0.535	0.77
Tongue visible	2.50	1.17	**0.033***	12.22
Total mouth	-0.25	0.44	0.576	0.78

"Mouth movement" had the highest incidence of observations (n=1151) and Figure 3 shows the number of observations for this behaviour for each headpiece tightness category.

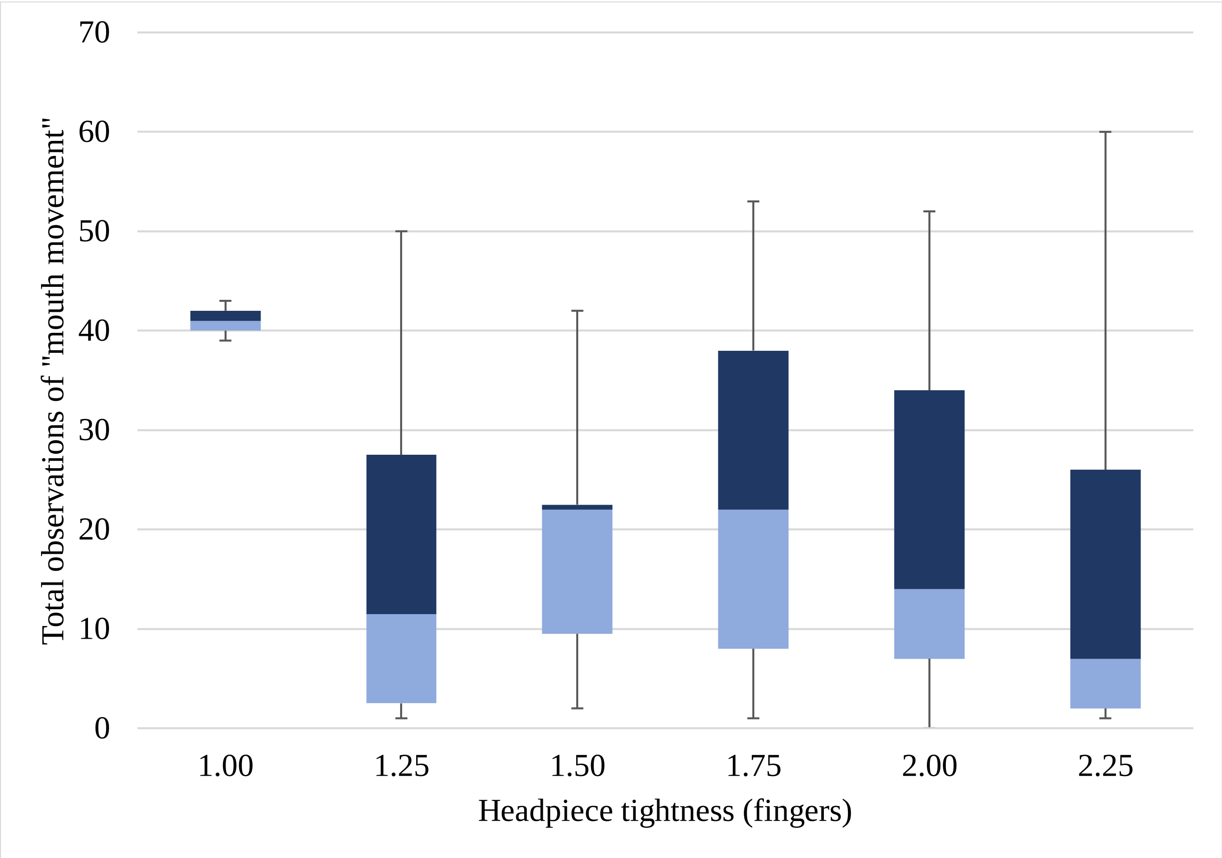

Figure 3. Median ± IQ number of 15-s scans per 20 min in which the behaviour "mouth movement" occurred at each headpiece tightness category

There were no significant associations between mouth-related behaviour and combined average bridle tightness (Table 17; Appendix 8).

Table 17. Estimated effect of combined average bridle tightness (noseband and headpiece) on predicted variables during riding (n=53 horses). Five horses were excluded since they did not wear a noseband or did not have a measurable headpiece. Only horses ridden for the full 20 mins were included in the analysis

	B	**SE**	**P**	**95% CI**
Behaviour				
Mouth foam	-1.11	2.03	0.586	0.33
Mouth open	-0.22	0.70	0.759	0.81
Movement	0.26	0.42	0.542	1.29
Tongue visible	2.92	1.59	0.066	18.51
Total mouth	-0.07	0.44	0.875	0.93

There were no significant associations between the behaviour "ears", tail-related behaviour or "head tossing" and noseband tightness (Table 18; Appendix 8).

Table 18. Estimated effect of noseband tightness on behavioural variables during riding (n=55 horses). Three horses were excluded since they did not wear a noseband and the analysis included only horses ridden for the full 20 mins.

	B	**SE**	**P**	**95% CI**
Behaviour				
Ears back	0.33	0.39	0.405	1.38
Tail swishing	-1.07	1.04	0.304	0.34
Tail lashing	-0.29	0.58	0.510	0.75
Tail movements total	-0.38	0.51	0.460	0.68
Head tossing	0.70	0.69	0.305	2.02

"Ears back" had the highest incidence of observations (n=817) and Figure 4 shows the number of observations for this behaviour for each noseband tightness category.

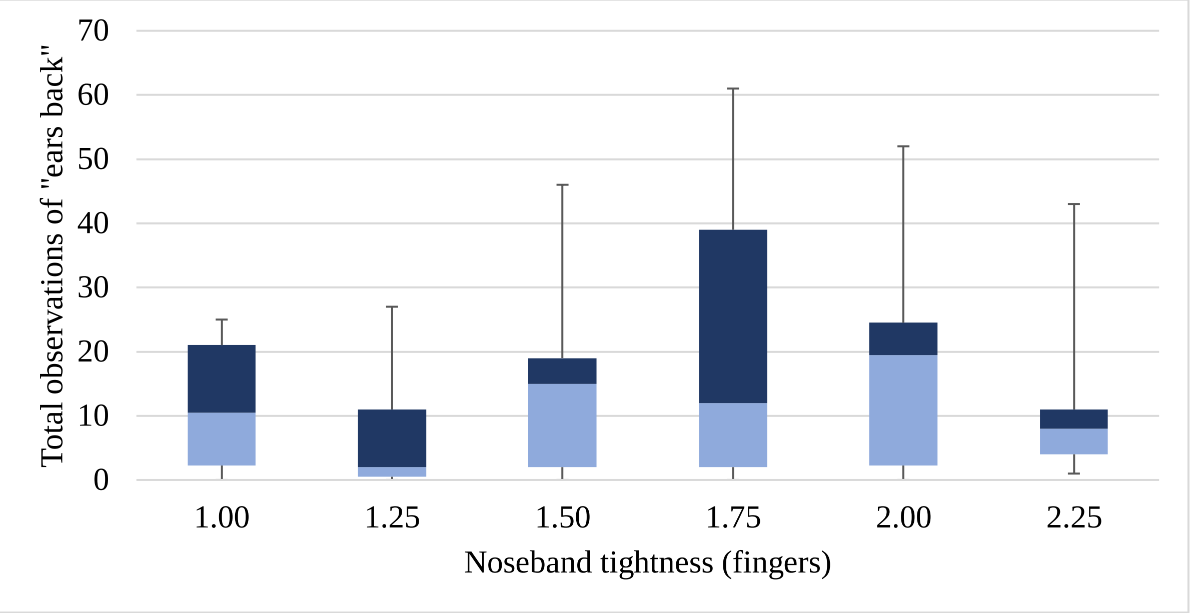

Figure 4. Median ± IQ number of 15-s scans in which the behaviour "ears back" occurred per 20 min riding session at each noseband category

There were no significant associations between the behaviour "ears back", tail-related behaviour or "head tossing" and headpiece tightness (Table 19; Appendix 8).

Table 19. Estimated effect of headpiece tightness on behavioural variables during riding (n=55 horses). Two horses were excluded since they did not have a measurable headpiece and the analysis included only horses ridden for the full 20 mins

Behaviour	**B**	**SE**	**P**	**95% CI**
Ears back	0.20	0.57	0.723	1.22
Tail swishing	1.91	1.70	0.263	6.73
Tail lashing	0.33	0.85	0.698	1.39
Tail movements total	0.53	0.92	0.565	1.70
Head tossing	-0.27	0.91	0.771	0.77

“Ears back” had the highest incidence of observations (n=769) and Figure 5 shows the number of observations for this behaviour for each tightness category.

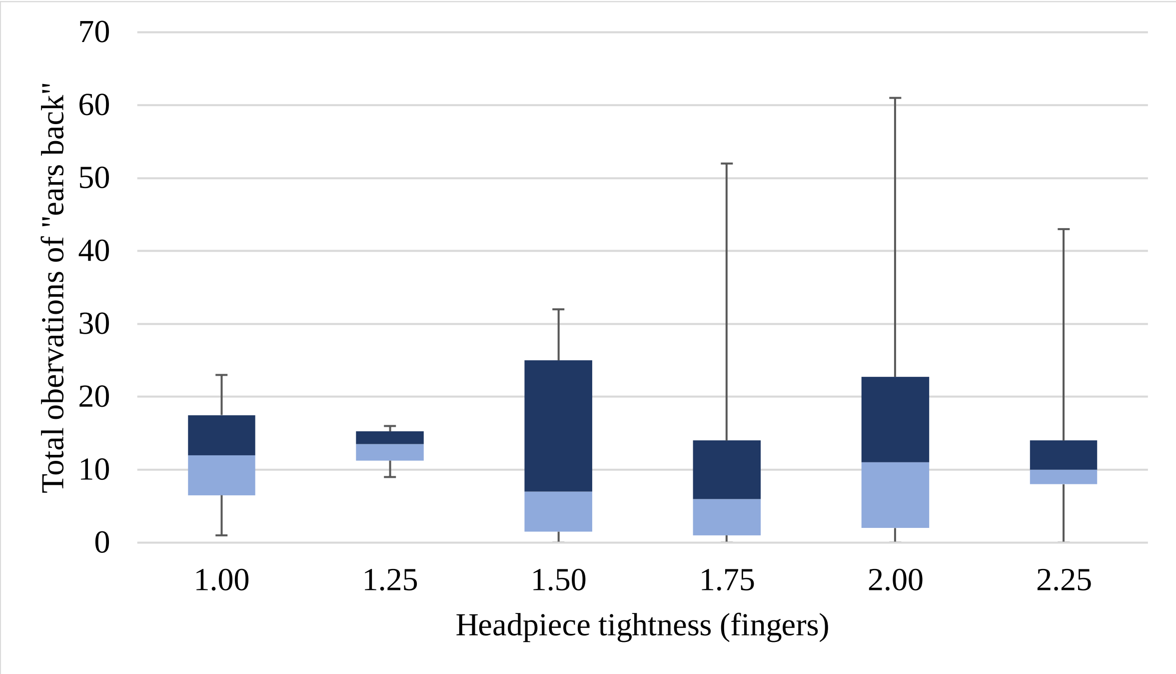

Figure 5. Median ± IQ number of 15-s scans in which the behaviour "ears back" occurred per 20 min riding session at each headpiece tightness category

There were no significant associations between the behaviour “ears back”, tail-related behaviour or “head tossing” and combined average tightness (Table 20; Appendix 8).

Table 20. Estimated effect of headpiece tightness on behavioural variables during riding (n=55 horses). Five horses were excluded since they did not wear a noseband or did not have a measurable headpiece and the analysis included only horses ridden for the full 20 mins

Behaviour	**B**	**SE**	**P**	**95% CI**
Ears back	0.23	0.34	0.498	1.26
Tail swishing	0.33	1.21	0.786	1.39
Tail lashing	-0.14	0.38	0.705	0.87
Tail movements total	-0.11	0.43	0.790	0.89
Head tossing	0.23	0.65	0.720	1.26

There was a low significant negative correlation (r=-0.312, p=<0.05), and a significant (p=0.01) association between wrinkles and headpiece tightness (Table 21; Appendix 8).

Table 21. Estimated effect of headpiece tightness (fingers) and number of wrinkles at the corner of the mouth (n=53). Seven horses were excluded since they used bit guards

	Value	SE	T	P	OR	r
Headpiece tightness x wrinkles	-2.46	0.96	-2.57	**0.010****	0.085	-0.45

The number of horses with 0, 1 or 2 wrinkles and their corresponding headpiece tightness are presented in Figure 6.

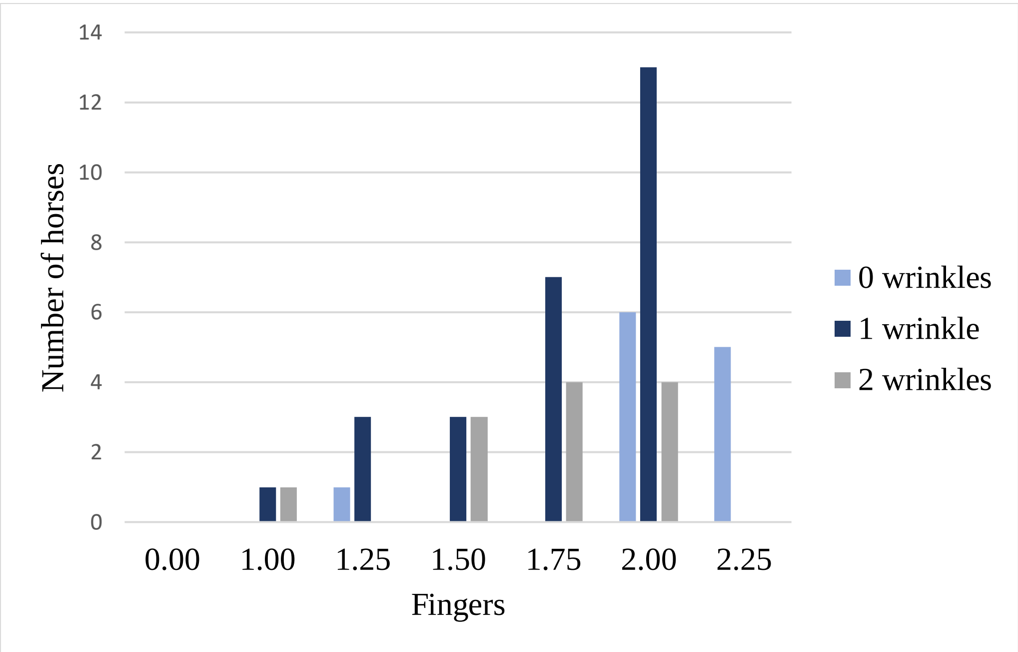

Figure 6. Number of horses with 0, 1 or 2 wrinkles at the corner of the mouth with the associated headpiece tightness

There was a low significant positive correlation between the behaviours “mouth foam” and “total mouth” and wearing a crank with a flash (r=0.254, p=<0.05, r=0.350, p=<0.01 respectively) (Appendix 8). There were no significant associations between the behaviour “ears”, tail-related behaviour or “head tossing” and wearing a crank noseband (Table 22).

Table 22. Estimated effect of horses wearing a crank noseband and behavioural variables during riding (n=57). Only horses who were ridden for the full 20 mins were included in the analysis. Crank noseband with/without flash=1, all other nosebands or no noseband=0

Behaviour	**B**	**SE**	**P**	**95% CI**
Mouth foam	0.39	1.00	0.694	1.48
Mouth open	0.05	0.53	0.926	1.05
Mouth movement	-0.41	0.32	0.195	0.66
Tongue visible	-0.13	0.82	0.874	0.88
Total mouth	0.00	0.30	0.994	1.00

“Mouth movement” had the highest incidence of observations (n=769) and Figure 7 shows the number of observations of this behaviour for each noseband category.

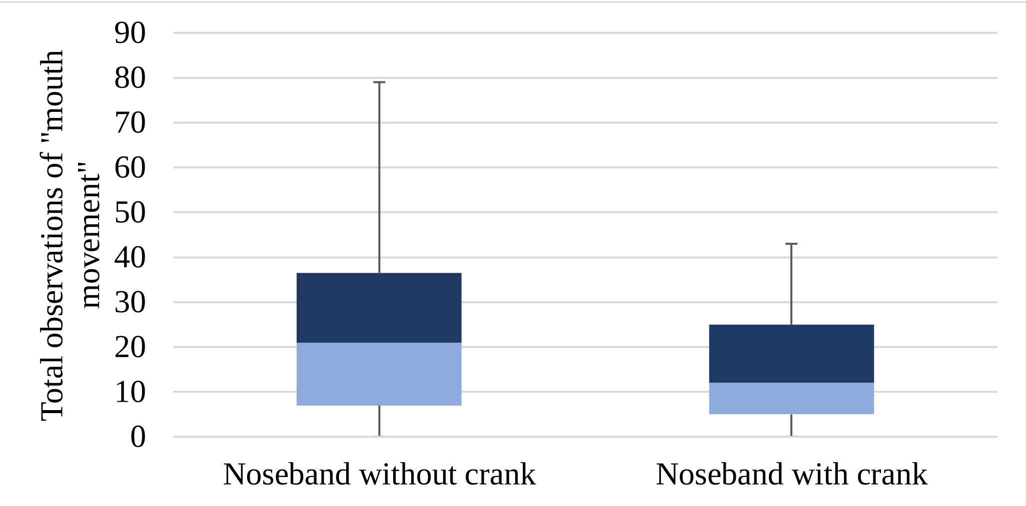

Figure 7. Median ± IQ number of 15-s scans for the behaviour "mouth movement" per 20 min in each noseband type category

There was no significant association between noseband type (crank noseband with/without flash or all other nosebands) and noseband tightness (Table 23). The correlation between noseband type and tightness of noseband was r=0.21 (p=0.12).

Table 23. The relationship between noseband type and noseband tightness (n=57). Horses not wearing a noseband were not included (n=3). Crank noseband with/without flash=1, all other nosebands=0

	B	**SE**	**P**	**95% CI**
Noseband type	-0.15	0.12	0.220	0.86

Figure 8 shows the number of horses with nosebands with or without crank in each of the noseband tightness categories.

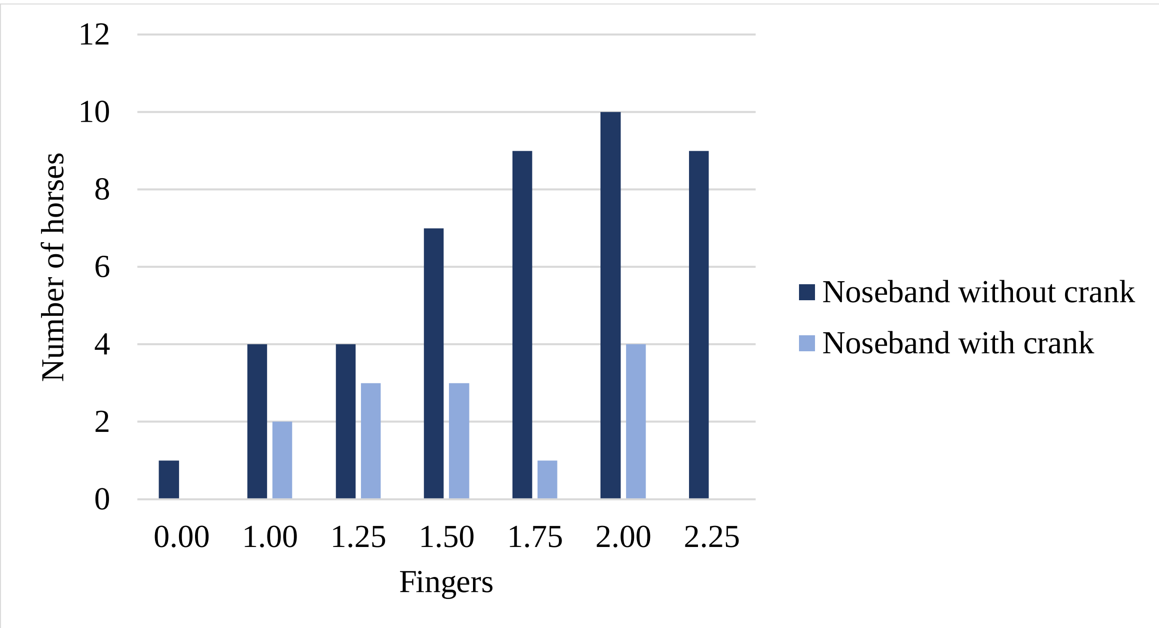

Figure 8. Number of horses within each noseband type and noseband tightness category

There was a significant association between not wearing a flash and the behaviour "tongue visible" (p=0.039; Table 24).

Table 24. Estimated effect of horses wearing a flash and behavioural variables during riding (n=35). Only horses wearing plain cavessons, flash nosebands and crank noseband with or without flash, and horses who were ridden for the full 20 mins were included in the analysis. With flash=1, without flash=0

	B	SE	P	95% CI
Behaviour				
Mouth foam	1.17	0.93	0.207	3.23
Mouth open	0.06	0.59	0.920	1.06
Mouth movement	-0.22	0.34	0.511	0.80
Tongue visible	-1.82	0.88	**0.039***	0.16
Total mouth	0.28	0.34	0.408	1.33
Tail swishing	1.47	0.80	0.067	4.35
Tail lashing	0.06	0.66	0.929	1.06
Total tail	0.34	0.66	0.606	1.40

There were low significant correlations between the presence of a whip and the behaviours "mouth foam" (r=-0.257, p=<0.05), "mouth open" (r=-0.354, p=<0.01), "mouth movement" (r=-0.260, p=<0.05), "tail lashing" (r=0.279, p=<0.05), "head in" (r=-0.259, p=<0.05) and "poll low" (r=0.315, p=<0.05), and a moderate significant correlation between the presence of a whip and "total mouth" (r=-0.406, p=<0.01). There was a low significant correlation between the presence of spurs and the behaviour "mouth foam" (r=0.362, p=<0.01) (Appendix 8).

There were no significant associations between the behaviour "ears back", tail-related behaviour or "head tossing" and the presence of whip, spurs, or both (Table 25).

Table 25. Estimated effect of the presence of whip, spurs or both on behaviour variables during riding (n=57). Only horses who were ridden for the full 20 mins were included in the anlysis. Present=1, absent=0. W=whip, S=spurs

	B			**SE**			**P**			**95% CI**		
Behaviour	***W***	***S***	***WS***	***W***	***S***	***WS***	***W***	***S***	***WS***	***W***	***S***	***WS***
Ears back	-0.07	-0.33	-0.76	0.34	0.34	0.43	0.829	0.339	0.077	0.93	0.72	0.47
Tail swishing	-0.15	0.32	0.19	0.75	0.75	0.94	0.838	0.671	0.843	0.86	1.38	1.20
Tail lashing	0.91	0.60	0.88	0.52	0.53	0.65	0.082	0.255	0.174	2.48	1.82	2.42
Tail total	0.59	0.52	0.72	0.54	0.54	0.67	0.280	0.333	0.287	1.80	1.69	2.05
Head tossing	-0.35	0.05	-0.43	0.53	0.54	0.69	0.514	0.929	0.534	0.71	1.05	0.65

“Ears back” had the highest incidence of observations (n=831) and Figure 9 shows the number of observations for this behaviour for each whip and/ or spurs category.

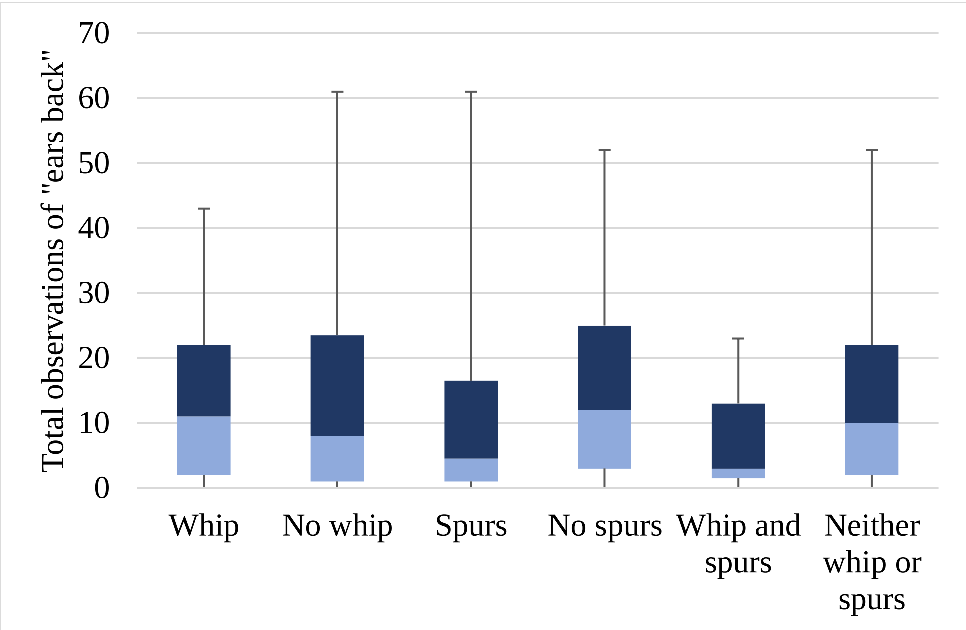

Figure 9. Median ± IQ number of 15-s scans in which the behaviour "ears back" occurred per 20 min for each whip and/or spurs category

There was a moderate significant correlation between the use of a running martingale and the behaviour “tail swishing” (r=0.442, p=<0.01) and a low significant correlation for “tail total” (r=0.260, p=<0.05). There were low significant correlations between the use of draw reins and the behaviours “mouth open” (r=0.357, p=<0.01), “mouth movement” (r=0.278, p =<0.05) and “poll low” (r=-0.264, p=<0.05) (Appendix 8).

There were no significant association between the behaviour “ears”, tail-related behaviour” or head tossing and the use of “help reins” (Table 26).

Table 26. Estimated effect of “help reins” on behavioural variables during riding (n=57). Only horses who were ridden for the full 20 mins were included in the analysis. Present=1, absent=0

Behaviour	**B**	**SE**	**P**	**95% CI**
Ears back	0.34	0.51	0.514	1.40
Head tossing	-1.52	1.00	0.128	0.22
Tail lashing	-0.56	0.81	0.490	0.57
Tail swishing	1.39	1.07	0.196	4.00
Tail movements total	0.23	0.82	0.782	1.26

“Ears back” and “tail movements total” had the highest incidence of observations (n=831 and n=642 respectively; Figure 10).

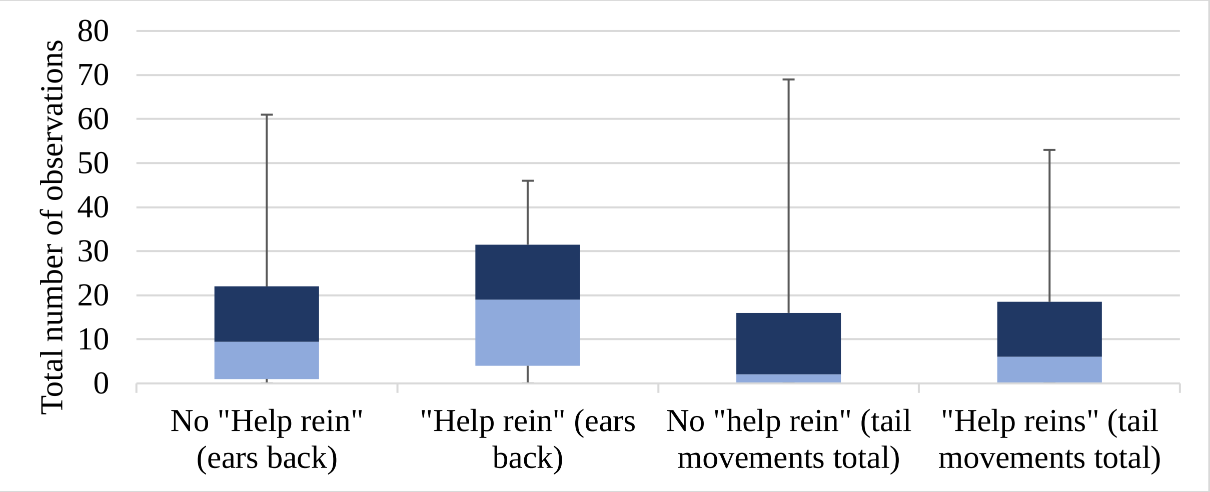

Figure 10. Median ± IQ number of 15-s scans in which the behaviours "ears back" and "tail movements total"occurred per 20 min riding session for the categories "help rein" and "no help rein"

There was a low significant correlation between double jointed snaffles with loose rings and the behaviour “head in” (r=-0.257, p=<0.05) (Appendix 8).

There were no significant associations between mouth-related behaviours and bit type (Table 27). No differentiation was made between type of fixed ring (e.g. eggbutt or D-ring).

Table 27. Estimated effect of bit type on behavioural variables during riding (n=35). Only horses wearing a double-jointed snaffle with loose or fixed rings and that completed the full 20-min riding session were included in the analysis. Loose rings=1, fixed rings=0

Behaviour	**B**	**SE**	**P**	**95% CI**
Mouth foam	-0.44	1.17	0.706	0.64
Mouth open	0.42	0.59	0.472	1.52
Mouth movement	-0.29	0.36	0.417	0.75
Tongue visible	0.67	0.85	0.433	1.95
Total mouth	-0.15	0.33	0.655	0.86

“Mouth movement” and “mouth open” had two of the highest incidences during riding with different bit types (n=675 and n=433 respectively; Figure 11).

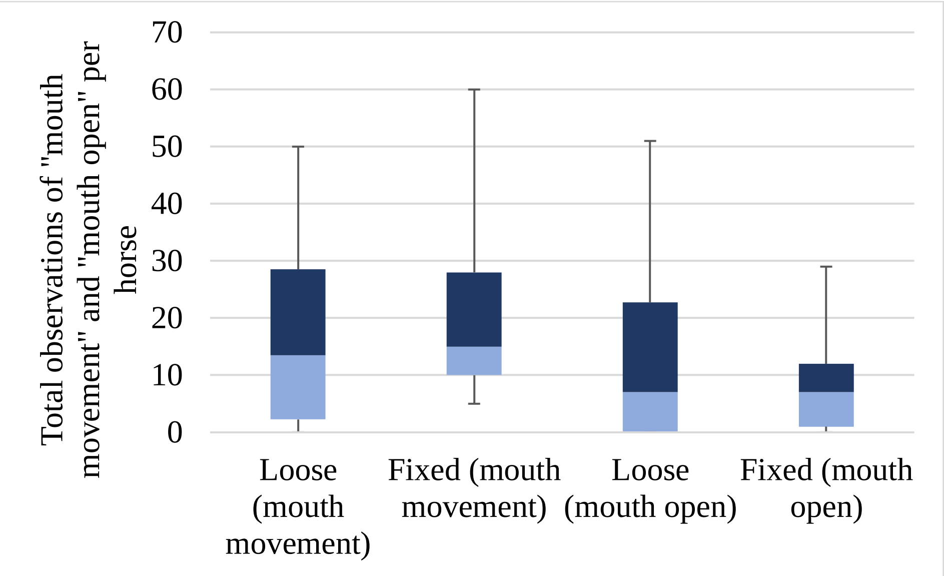

Figure 11. Median ± IQ number of 15-s scans in which the behaviours "mouth movement" and "mouth open"occurred per 20 min in each bit category

There was only one stallion. The results for the stallion in comparison with the mean for geldings and mares are listed in Table 28.

Table 28. Number of 15-s scans in which behaviour was performed by a stallion (total) (n=1), and mean and range for geldings (n=31) and mares (n=28) per 20-min riding session

	Stallion	**Geldings**		**Mares**	
Behaviour		***Mean***	***Range***	***Mean***	***Range***
Ears back	52	16	61	12	43
Mouth foam	0	20	76	15	80
Mouth open	29	12	50	13	80
Mouth movement	53	20	52	21	28
Tongue visible	0	4	28	3	28
Total mouth	29	56	127	52	189
Tail swishing	0	3	24	3	28
Tail lashing	2	9	59	7	57
Tail movements total	2	12	69	10	57
Head in	16	15	75	13	71
Head tossing	0	1	7	2	11
Poll high	0	12	56	13	67
Poll low	2	5	22	3	16
Snort	5	2	7	3	10
Age	7	12	18	12	18

The stallion was pooled with the rest of the males. There were no significant associations between age or sex and the behaviour variables observed during riding (Table 29).

Table 29. Estimated effect of age and sex on behaviour (n=57). Only horses ridden for the full 20 mins were included in the analysis. Male=1, female=2

	B		**SE**		**P**		**95% CI**	
Behaviour	***Age***	***Sex***	***Age***	***Sex***	***Age***	***Sex***	***Age***	***Sex***
Ears back	0.01	-0.42	0.03	0.34	0.779	0.211	1.01	0.66
Mouth foam	-0.01	-0.22	0.10	0.84	0.888	0.795	0.99	0.80
Mouth open	0.04	0.08	0.04	0.44	0.383	0.856	1.04	1.08
Mouth movement	-0.00	0.05	0.03	0.27	0.888	0.857	1.00	1.05
Tongue visible	-0.06	-0.44	0.07	0.68	0.403	0.522	0.95	0.65
Total mouth	0.00	-0.06	0.03	0.25	0.937	0.828	1.00	0.95
Tail swishing	-0.04	0.25	0.08	0.74	0.580	0.740	0.96	1.28
Tail lashing	0.01	-0.24	0.06	0.53	0.812	0.655	1.01	0.79
Tail movements total	-0.00	-0.11	0.06	0.54	0.976	0.845	1.00	0.90
Head in	0.01	-0.12	0.05	0.47	0.871	0.800	1.01	0.89
Head tossing	-0.11	0.27	0.06	0.53	0.057	0.618	0.90	1.30
Poll high	0.01	0.17	0.05	0.55	0.893	0.762	1.01	1.18
Poll low	0.02	-0.46	0.04	0.40	0.687	0.248	1.02	0.63
Snort	-0.03	0.15	0.03	0.32	0.300	0.646	0.97	1.16

There were a low significant correlation between "snort" and the combined average bridle tightness (r=0.304, p=<0.05) (Appendix 8).

There were no significant associations between noseband tightness and the behaviour "snort" (Table 30).

Table 30 Estimated effect of noseband tightness on snorting (n=57). Only horses who completed the 20 min riding session were included in the analysis

	B	**SE**	**P**	**95% CI**
Snort	0.43	0.37	0.24	1.54

5.7 After riding session behavioural observations

Out of the behaviours described in the ethogram in Table 2, only behaviours “Licking”, “Chewing non-nutritive”, “Chewing nutritive” and “Rub head on object” were observed. Total observations for all horses, mean and SE are presented in Table 31.

Table 31. Total number of 15-s scans, and mean and SE number of scans in which each behaviour occurred per 2-min post-riding session (n=57 horses). Three horses did not have observations after the riding session

Behaviour	Total observations	Mean	SE
Licking	79	1.4	0.22
Chewing non-nutritive	134	2.4	0.20
Chewing nutritive	56	1.0	0.28
Rub head on object	17	0.3	0.10

6. Discussion

6.1 Horses and riders

Mean hours turned out for horses not on full time turnout was 10. Many riders stressed the fact that turnout time depended heavily on season, weather, and other random conditions and that the number of hours stated was just an estimate. This is in line with previous findings in Norway, where an online survey (n=2075 respondents) found varying hours of turnout over the seasons (Bøe et al., 2014). However, the current study found more horses to belong in the "over 10 hours turnout" group (42 % vs 35 %), and less in the "under 5 hours" group (6 % vs 11,9 %). This would be explained by the simple fact that several riders in the current study were boarders at the same stable, whereas the respondents in Bøe et al. (2014)'s study were respondents from the whole country.

There were several combinations of uses and disciplines for the horses in this study (35 % had some combination of use other than the ones cited below), which may suggest that riders cherish a versatile horse rather than specializing in a specific discipline (although this also occurred). Whereas this study found horses to be mainly used in jumping (23%, n=14), dressage and hacking (15%, n=9), dressage (13%, n=8) or jumping and dressage (13%, n=8), Bøe et al. (2014) found a greater percent of use in dressage (20.3 %) and a lower percent of jumping (8.9 %).

6.2 Bridle information

When measuring tightness for flash nosebands, the strap that was checked was strictly speaking just the cavesson strap. There was not an isolated measure for the flash strap, which may have given a different result. Uldahl & Clayton (2019) used a different kind of device to measure noseband tightness and they used this to measure the tightness of the flash as well. This measurement was taken lateral to the nasal bones. It is a bit unclear if the authors had any troubles getting accurate results. From the illustrations of this measure one would think they would hit the cavesson strap when inserting the measuring devise under the flash (i.e. they would not get accurate measures for the looser fittings). And measuring further down would lead to measuring over soft tissue. Kienapfel & Preuschoft (2018) concludes in their study that either one of the cavesson or flash strap can be tighten enough to hinder the mouth from opening, and that both should be measured to prevent misleading results. This should be taken into account in future studies.

Of the 60 horses in this study, 57 (95 %) horses wore nosebands. The two most popular nosebands were the flash noseband (20 %) and the plain cavesson (17%). Other studies have also found these two types to be the most often used, although some studies did not differentiate between nosebands with or without crank (e.g. Uldahl & Clayton, 2019). Disregarding type of closing mechanism, the prevalence of these two types are even higher (with flash 30 % and without 28 %). More variation of noseband types would perhaps be expected due to the large range of types available. In reality, riders perhaps choose nosebands based on tradition. Of the 60 horses, 23 (38 %) horses had a noseband tightness of 2 fingers or more (Table 7), which is less than a study conducted in The Netherlands by Visser et al. (2019), where 59 % had a noseband tightness of 2 fingers (also using the ISES taper gauge). Perhaps the variety of different ways of measuring noseband tightness by the riders (Table 10, discussed in section 6.3) might have caused riders to tighten more that they thought they did.

6.3 Questionnaire

The study included six questions where the riders could answer freely. These were open to subjective interpretation by the rider. The possibility for self-report bias and for giving the "most socially acceptable answer" was present (Bertrand & Mullainathan, 2001). Asking the questions directly to the riders also meant that they did not have much time to think about their answers. It may be possible that being given more time would have provided different or more elaborated answers. On the other hand, very few answered that they did not know or did not have any opinion (n=3). This can be related to the fact that people might not want to admit to not having an opinion when asked (Bertrand & Mullainathan, 2001), maybe especially when asked directly by someone they do not know. Overall, the impression was that people, despite having to answer quickly, had some opinion on the questions asked.

Asking riders how many years they have been riding would have been better than asking them to rank themselves as a beginner, intermediate or experienced rider, which is subjective, without a definition for each level. The scale could also have been a ranking between, amateur, semi-professional or professional, but the likelihood of any (or very few) volunteers being professional or even semi-professional was predicted to be low to none. Most riders were not comfortable answering the experience question. They wanted to know the classification for the different categories. Nonetheless, there is reason to believe that rider experience would not have influenced horse behaviour in any great extent either way (see e.g. Strunk et al, 2018).

There was diversity of different ways riders checked for bridle tightness, including "a feeling" of the right tightness and using "the usual notch". Some mentioned the "two finger rule", but most had some idea of what was the "appropriate amount" regardless (see Table 10). A few (n=3) did measure noseband tightness at the cheek, which would not provide the correct tightness (Kienapfel & Preuschoft, 2018).

The apparent misunderstanding regarding positive behaviours, personality traits and emotional states may tell us something about how riders think regarding behaviour (i.e. when asked about behaviour answers something else). Of the 47 riders, 11 riders mentioned "willingness to work" as a positive trait. In horse temperament tests this trait may not have been considered adequately (König von Borstel et al., 2011), and have a vague definition including a large variation of behaviours (König von Borstel & Glißman, 2014). In a questionnaire responded to by 23 participants (judges and test riders), 23% named willingness to work when asked to define horse personality and 20% responded willingness to learn (König von Borstel et al. 2013). Willingness to work was also listed as a component of rideability (König von Borstel et al. 2013). In fact, all the different traits mentioned in the current study (see Table 12) could influence willingness to work and underlining the fact that this is a poorly defined term. Köing von Borstel et al. (2011) found a negative association between stumbling and the trait willingness to work, suggesting that judges knowingly (or unknowingly) blame the horses' attitude or willingness to work, when in fact stumbling is a sign of lacking physical ability (e.g. be fatigued). In performance tests, König von Borstel et al. (2011) suggests that judges perceive head-tossing as an indicator of poor temperament or unwillingness to co-operate and work. In the current study, he most answered positive state was "relaxed" (n=15) and four riders mentioned both "relaxed" and some form of willingness to work or going forward. Perhaps they meant relaxed as in not stressing or relaxing after a bout of training.

The term "willingness to please" may be appealing to some people handling horses. This would perhaps imply that the horse has an inherent understanding of what humans want of them, and that it wants to comply with these demands (McGreevy et. al, 2009). As McGreevy et al (2009) argue, the horse would have to have a high cognitive ability for this to happen. They also question the horse's motivation to please humans and gives the example of why a horse would wish to please a human by jumping a fence when its natural response would be to avoid it. In addition, they emphasize the point of cooperation and that this would further call for the need for complex cognitive skills. The horse would have to understand that it is, for example competing in a sport and want the same end result as the rider (i.e. to win) (McGreevy et. al, 2009). Trained responses are more likely than the horse having a willingness to please (McGreevy, 2011). Willingness to please and cooperation had two and three mentions respectively as a positive trait.

6.4 Before riding session observations

There were very few types of behaviour registered at the observation session before riding ("licking", "chewing non-nutritive" and "head turn"). Non-nutritive chewing was observed on some occasions (15-s scans=114) in the before riding session. Since the observation period included time after the bridle was put on and stopped when all the buckles were fastened, there was no differentiation between right before the bit was put on and after. The chewing motions then recorded may simply have been a response to the bit, and not an anticipatory (positive or negative) behaviour preceding riding.

Although not registered, some horses were cross tied, and that may have prevented potential desired movements away from the rider. But there were not many head turns registered (total n=20) either and the horses would have had the opportunity to do this once the halter was off and before the bridle was put on. This may indicate that most horses did not oppose the bridle being put on or had been trained to stop.

6.5 Pain scale

There were no correlations between the pain score and any of the behaviours observed during the riding session. A combined category of crank noseband, whip, spurs and the double-jointed snaffle with loose rings and pain score did not correlate either. This was an observation taken in a short moment of time, just by looking at the horse for a few seconds.

After the data collection finished, it might have been better to have photos to look at to be more sure of the results. Although, one would need permission from the owner and there was a risk that people would say no if they were told the reason for the photo. Even with a photo, horses may not have shown pain signals in the presence of an unfamiliar person (Torcivia & McDonnell, 2020). In addition to the observer and the rider, some horses were observed in stables with other people and/or horses present which would most likely have caught the horse's attention as well. This would probably have interfered with any potential pain expressions. The background for the Horse Grimace Scale (HGS) was based on video still photos (Costa et al., 2014), but the study had no mention of humans being close by the horses or not when being videotaped. Costa et al. (2014) suggests that "live" observation would be better than photos (e.g. dark coat colour in combination with poorer image quality interfered with scoring) (Costa et al., 2014), but these kinds of observations would perhaps be best if one can be concealed from the horse's view or assess live video feed. In addition, a short direct observation like the one in the current study is probably not long enough to score correctly. It is also worth noting that the three horses not wearing a noseband all did get a score above 0 on the pain scale. In addition, pain scales are based on few sources of pain (e.g. castration; Costa et al, 2014). Although it is difficult to gauge pain, it is likely that pain arising from these types of intervention is more severe than pain or discomfort from tack, hence making it even more difficult to detect subtle signs of pain in the latter situation. Also, behaviours such as stepping away when being tacked up might be perceived as misbehaviour rather that a sign of pain.

6.6 Bridle tightness and behaviour

Since only one horse fell into the category of having room for less than one finger under the noseband or headpiece, no analysis was performed. But the horse did have mouth related behaviour observed, meaning that horses can to an extent perform some oral movement even with tight nosebands. However, no visible tongue was observed and the number of "mouth open" observations was under the average of the other horses (2 observations versus 13 observations respectively). Mouth movement and presence of foam was in line with the average. It is likely that given more space under the noseband, this horse would perhaps have shown more "mouth open" and perhaps "tongue visible" as well.

The current study found no effects on behaviour from noseband tightness, headpiece tightness or the combined average, except that a tighter headpiece tightness reduced the behaviour variable “tongue visible” ($p=< 0.05$, Table 15-20). While a tight noseband might restrict tongue movement (McGreevy et al, 2012), a tight headpiece implies a bit that is seated higher up in the mouth, placing more pressure on the mouth as indicated by more wrinkles at the corner of the mouth. Since horses tend to retract their tongue to prevent squeezing it between the bit and the bone (Engelke & Gasse, 2003), a bit that is placed higher in the mouth might cause the horse to have the tongue outside of the mouth instead since there is no space for it to retract. However, in the current study, there were found no evidence for this as the tongue was less rather than more likely to be visible. No horses were seen with their tongues out continuously, suggesting that they are continuously trying to find ways to be more comfortable and maybe have been alternating different methods, but a tight headpiece reduced their ability to put their tongue out.

Mouth movements were observed in almost all horses (n=57) to variable degrees during riding. Although lower lip movement on its own was included in the present definition, the observations were mainly of non-nutritive chewing. Non-nutritive chewing can be a self-comforting behaviour that follows a period of anxiety (Goodwin, 2003) or a period of stress (Lie & Newberry, 2018). When being ridden with a bit it may be hard to distinguish chewing that could arise as a stress response from the training itself, discomfort from the bit, tight noseband/bridle or any other impact caused by the rider (like rein tension or use of spurs). Since there was only one horse ridden bitless, there were not enough data to perform any comparison between bitted and bitless horses. Mouth movement was in fact the most observed behaviour in the riding sessions (total of 1258 observations, 28 % of total scans). “Mouth open” was also relatively common (n=756, 17 % of total scans), and these two behaviours were positively correlated ($r=0.617$, $p=< 0.01$). Although noseband or headpiece tightness had no effect on these behaviours, they were clearly present. Including all mouth related behaviours, total observations reached 3217 during riding sessions (71 % of total scans). Studies regarding nociceptive activation were done on other parts of the animals body (mostly legs, e.g. Chambers et al., 1992), and it is therefore not clear if the same amount of pressure would apply to the nasal plane on the usual site of nosebands. A preliminary study has shown that a horse would endure noseband pressure of up to 50 N while eating hay with a noseband tightness of 2 fingers, and produce peaks of pressure in excess of 200 N during head tossing (Casey et al., 2013). That study did not concern itself with nociceptor activation.

The presence of these mouth related behaviours in the current study would suggest that at least some discomfort was present and that they represented a coping behaviour. It is difficult to say if there is pain directly involved since, under a riding situation, the horse would perhaps be distracted by both rider and the environment (e.g. other horses and riders in view). This distraction may contribute to suppression of pain behaviour or perception (see Torcivia & McDonnell, 2020). An open mouth has also been suggested as a conflict behaviour (Górecka-Bruzda et al., 2015).

Tail movements were observed in 35 out of 60 horses in varying degree. Since the study was conducted in winter, one can exclude flies as a cause for these behaviours. In this study there was a distinction between two types of tail movements: swishing (lateral movement) and lashing (dorsoventral movement). Others have not made this distinction, defining swishing as both lateral and dorsoventral movements (see McGreevy et al., 2005). Although the movements are different, perhaps in practical use there is no need for this division, since it is their deviance from the normal swaying of the tail that is of interest. This behaviour has been suggested as both a sign of conflict and of concentration and higher effort (Hall & Heleski, 2017; McGreevy et al., 2005), which may seem mutually exclusive. It is difficult to imagine a horse experiencing conflicting motivations between, for example, which rider cue to follow and at the same time giving its highest effort if it is not sure what the rider asks of it.

Wrinkles at the corner of the mouth (Table 21) was counted as brief direct observation. There is the possibility that the horse moved / held the bit in its mouth in a way that changed the wrinkles. It has been said that there should not be any wrinkles at the corner of the mouth (Hayes, 2011, p. 56), but there is not a definite answer as to how many wrinkles are considered “correct”. There was a negative correlation between number of wrinkles and the headpiece tightness ($r=-0.45$, $p=<0.01$). Since a higher number of “fingers” means a looser bridle, this result is probably what you would expect since the headpiece holds the cheek pieces that hold the bit. A tighter fit would therefore pull the bit higher up to the commissures and produce more wrinkles. With the diversity of conformation of the horse’s mouth between individuals (e.g. Evans & Lowder, 2012 and Engelke & Gasse, 2003), a correct fitting of the bit and type of bit (thickness etc.) would seem more important than having a standard number of wrinkles.

6.7. Type of noseband and effect on behaviour

The current study indicated no effects from the presence of a crank noseband on behaviour (Table 22 and 23). Neither was there a relationship between nosebands with or without crank versus all other types of nosebands and noseband tightness. The reasoning for testing this was that, with the pulley system of the crank noseband it was expected that riders would unintentionally tighten the noseband more and therefore produce more of the behaviours of interest. This was not the case in this study. There were, however, low but significant positive correlations between crank nosebands with flash (vs without) and the behaviours “mouth foam” and “total mouth”, suggesting an effect of the crank on behaviour.

6.8 The presence or absence of a flash and behaviour

Not wearing a flash was significantly associated with the behaviour “tongue visible” (p=0.039; Table 24). As mentioned in section 6.2, tightness of the flash was not measured. The analysis did not take into account noseband tightness, but only the presence of a flash or not. The results indicate that, regardless of noseband tightness, wearing a flash restricts the ability to extend the tongue.

6.9 Presence of whip, spurs or “help reins” and behaviour

The presence of whip, spurs or both did not have any effect on horse behaviour (Table 25). Out of the 47 riders, 40 % used spurs, under half of what has been found in competitions (77 % of 3143 horses; Uldahl & Clayton, 2019). Although some have suggested that spurs will increase conflict, stress-related behaviour or irritation behaviours (Waite et al., 2018), no such association was found in the current study.

Out of the 47 riders, 82 % rode with a whip, spurs, or a combination of both. The use of whips may be detrimental if used excessive or inappropriately (Jones & McGreevy, 2010). Since rider behaviour was systematically recorded it is not possible to say anything about frequency of use, and its impact on horse behaviour. The riders were not asked about how often they used these aids either. Most people asked in an online survey regularly rode with a whip (60%, n=2047) and 12% (n=412) sometimes did (Williams et al., 2019). Simply carrying a whip or spurs can be part of tradition but, if not actively used or rarely used, this would explain why this equipment did not affect behaviour in this study.

There were no effects of “help reins” on the predicted behavioural variables (Table 25). There were a few low, but significant, correlations between the presence of draw reins and the behaviours “mouth open” (positive correlation), “mouth movement” (positive correlation) and “poll low” (negative correlation), indicating that the two former behaviours happen more often when draw reins are present. There was a moderate, significant positive correlation between the use of the running martingale and tail swishing ($r=0.44$, $p=< 0.01$). Since there were few horses using this kind of tack the correlations must be interpreted with caution but may indicate that the presence of them may influence ridden horse behaviour. How the riders seat influence the horse via the seat is hard to observe and evaluate (Blokhuis et al., 2008), and rein use by the rider was not recorded in the current study.

6.10 Type of bit and effect on behaviour

No association between bit type (double jointed snaffles with loose rings and double jointed snaffles with fixed rings) on behaviour were detected. There was a low, but significant, negative correlation between the use of double-jointed snaffles with loose rings and the behaviour “head in”. “Head in” is most likely a result of rein tension since the horse’s natural or free head carriage is in front of the vertical (Rhodin et al., 2009). Perhaps there is too little difference in the function of these two bits to affect the behaviours recorded.

Since there were several types of bits in combination with different types of nosebands and tightness’s in this study, it is unlikely that one isolated variable affects behaviour on its own. The rider also has an effect, perhaps especially by manipulating rein tension. Because there was only one horse ridden without a bit and only three horses without a noseband, these groups were too small to analyse. A larger sample of horses with each combination of equipment would be required to explore interactions between the many combinations of equipment observed. Given the potential harm that a bit can cause (e.g. Scoggins, 2001), a tight bitless bridle would probably do less harm than a tight noseband and with a bit, but the risk of tissue damage would still be present even if bitless. Also, some bitless alternatives such as rope halters often have a narrow noseband. This would likely produce damaging pressure if strongly engaged. Studies of bits and mouth conformation are based on the most used types of bits (like the snaffle; Manfredi et al., 2010), but it is unclear if such results apply across the large range of bits used, and variations within the use of each type. Different bit types can, for instance, cause differences in heart rate variability, tongue colour and saliva production (Vanderhorst et al., 2013). In the current study, all quantities of foam/saliva present around the mouth were recorded simply as “present”, and 21 out of 60 horses had some amount present during the riding session. Foam present was not correlated with mouth movements, which is perhaps something one would expect since chewing promotes salivation.

6.11 Associations of age and sex with behaviour

No significant associations between age or sex and behaviour were detected. Both age and sex have been suggested as factors affecting how an animal expresses pain (McLennan et al., 2019; Robertson, 2006), but exactly in what way this would affect ridden horse behaviour is unclear. Dyson & Pollard (2020) found no effect of age on a ridden horse pain score but did find that mares had higher scores than geldings. In contrast, Aune et al. (2020) found no effect of sex on ridden horse behaviour, although that study did not focus on pain related behaviour specifically.

6.12 Noseband tightness and positive welfare

Two behaviours were chosen to represent positive welfare states: “Snort” and “Height of poll-low”. Head lowering has been suggested as a positive behaviour (e.g. Warren-Smith & McGreevy, 2005 and Warren-Smith et al., 2007). The head lowering in these studies was imposed on the horse. In the current study, the behaviour “poll low” was almost always a result of the rider letting go of the reins. Most likely, this was to give the horse a chance to stretch between training bouts. In other words, this was not a behaviour the horse had the opportunity to do on its own. In this sense it is hard to call this a positive behaviour since there is no way of telling how the horse would have chosen to carry its head if it was free to do so throughout riding.

The study by Visser et al. (2008) defined snorting somewhat differently than in the current study (“closed mouth, wide open nostrils, raspy noise”). Differences in definitions and perhaps different perceptions of what a snort is may contribute to differences in results.

Unless there is a standardised “vocalization library” with agreed upon sound samples, studies of vocalization will be difficult to compare. Also, two subtypes of snorting have been identified (pulsed and non-pulsed; Stomp et al., 2018b). In the current study, snorting was not correlated with any of the registered behaviours. Snorting was observed (total n=143), and a low, but significant, positive correlation between snorts and the combined noseband tightness was present (r=0.30, p=< 0.05), suggesting that a looser bridle was associated with more snorting, consistent with the interpretation of snorting as a positive behaviour. A a link between snorting and riding techniques that allowed more comfort for the horse, like long, loose reins and a low neck posture and especially in walk, has been reported (Stomp et al., 2020). On the other hand, there is uncertainty regarding the extent that horses enjoy being ridden, if at all (König von Borstel & Keil, 2012), so there should be caution in interpreting snorting in a riding situation.

6.13 After riding session observations

Non-nutritive chewing was often observed (n=55 of the 57 horses observed) when the bridle was removed and was highly correlated with licking (p=< 0.01) which was observed in 36 of 57 horses. This could be a natural response to having the bridle taken off and the bit removed from the mouth. Alternatively, it may indicate a response to a preceding stressful event (Lie & Newberry, 2018), in this case riding. Licking has also been observed in horses being denied access to a food source (motivation is thwarted) either by the presence of a dominant horse or when watching as a meal is prepared (Houpt et al., 1978), but when performed in combination with non-nutritive chewing may not be a sign of conflict or a displacement activity. There was no correlation between non-nutritive chewing/licking and noseband/headpiece/combined tightness.

6.14 Other behaviours observed

In two separate occasions rearing was observed after the observation period was over, but before the focal horse was done with its training. One case happened in a corner some metres before a fence with a non-observed horse. The other case involved an observed horse, but this was after the observation period was over. This horse reared before a fence on the long side of the arena. Refusing to jump is considered a result of conflict behaviour (McGreevy et al., 2005).

One observed horse grinded his teeth. This behaviour started about ten minutes into the observation period. Teeth grinding (bruxism) is a behaviour that can be caused by physical discomfort even if there is not a clearly visible source (McDonnell, 2005). McDonnell (2005) also suggests that this behaviour could stem from extreme physical pain perhaps caused by gastric ulcers. When dental and other health problems can be excluded, bruxism may be a response to stressors during training or related to general management (McGreevy et al., 2005; Fraser, 2010, p. 196). To be termed an abnormal condition it must be an established habit (Fraser, 2010, p. 196).

Tightening of the girth was observed to cause some horses to react in a negative way (e.g. flattening ears, swishing tail, lifting back foot). Some horses also were unwilling to be led by their rider, often stopping, and refusing to move (for shorter or longer durations but all approximately less than one minute). When a horse stopped its forward motion, either when being led or ridden, it was usually a temporary situation, and the horse was rather quickly urged to move forward again. Sometimes this behaviour could lead to into baulking, where the horse refuses move at all despite any sort of encouragement both physical (e.g. pushing) or psychological (e.g. food offerings) (Fraser, 2010, p.207-208). Baulking was not observed in the current study.

6.15 Limitations and future research

6.15.1 Volunteers

Many recruits to the study were suggested by others who had already participated, and riders from different stables were found to be communicating with each other about the study. This may have resulted in riders not tightening the noseband as tightly as they usually would. This could also have occurred anyway due to being observed by a stranger, and it is possible that those volunteering to participate the study were not those using tight nosebands in the first place whereas others may do so. People may have ridden a little differently and, perhaps, applied less pressure to the horse than usual due to being observed by an outsider. It may also be that people willing to participate were the kind of riders that are most concerned with horse welfare. Thus, results may not fully reflect overall ridden horse behaviour within Norway. Alternatively, recent rules on bridle fit in Denmark and The Netherlands (Danish Equestrian Federation (2017); Royal Dutch Equestrian Federation, 2019) might have reduced the problem of overly tight bridles in Norway also, or perhaps this has not been an issue in Norway, where there is more attention to animal welfare in legislation than many countries.

Giving riders more instructions on what to do would have led to more comparable results (e.g. specifying how long to warm up and to ride for a standard duration in each gait). Having a more rigid riding sequence, however, would have reduced the sample size of horses in the study, since some of them could only walk (e.g. because of their training scheme or start up after injury). Also, the fact that some riders rode more than one horse could have rendered these results more similar than when comparing horses ridden by different riders.

6.15.2 Number of horses

Up to 2017, studies using a ridden horse ethogram involved no more than 69 horses per study, some as few as 4 horses. These low numbers may represent a problem in interpreting the results (Hall & Heleski, 2017). The number of horses in the current study is in line with other studies but was lower than desired given the variation in types of equipment observed. For example, when comparing types of nosebands or bits, the number of animals within each category becomes even lower. A greater number of horses would have facilitated the use of more sophisticated statistical models including multiple variables and interactions between variables.

6.15.3 Method

The observation method (1-0 sampling) used in this study only tells us if a behaviour happened or not during the sample interval and not duration or frequency (Simpson & Simpson, 1977; Altman, 1974). Measures of actual durations and frequencies would have been more sensitive for measuring relatively frequent or longer lasting behaviours (e.g. “ears back”, “mouth open” and “head in”).

Any longer intervals than 15 s would have given less precise results (Simpson & Simpson, 1977). The 1-0 method was used for feasibility in the current study as it would have been difficult to accurately record frequencies and durations of a relatively large number of behaviours by direct observation.

Videotaping and analysing horse behaviour and interactions between horse and rider afterwards, would allow for use of a larger ethogram and more precise behaviour scoring. However, riders were considered reluctant to be video-recorded, and including rider behaviour in the study would have likely reduced the sample size of willing participants. Also, when observing directly, recording the time of a behaviour would have meant reducing the ethogram down to one or perhaps two behaviours. From that perspective, 1-0 sampling was selected as the most feasible method, since a larger set of behaviours can be recorded per interval and it is an easy way of scoring behaviour correctly (Crockett & Ha, 2010). This method produces high interobserver reliability for studies involving more than one observer (Crockett & Ha, 2010), though it gives limited precision (Lehner, 1992).

While physiological measures were not part of the current study, these would be useful for assessing welfare when combined with behavioural results, especially when evaluating pain. Physiological measures also have limitations (Weary et al., 2006). In the current study, behavioural measures were considered more feasible within the available time and budget.

The taper gauge was chosen to measure tightness beyond its original use (nosebands). The study conducted by Murray et al. (2015) used pressure mats under the noseband and headpiece. This would produce more precise results in terms of pressure applied to the horse. Although the ISES taper gauge is based on an average of the circumference of human fingers (McGreevy et al., 2012), it is possible to push it to little or too much under the noseband. This would perhaps not produce any great difference in the worst cases since an overtight noseband would not allow any measuring device to pass under. The Danish Equestrian Federation has also produced a similar measuring tool (Rasmussen, 2018), indicating increased awareness of avoiding overly tight nosebands in equine sports. In practice such devices are user friendly and easy to handle.

Measuring the brow band tightness at the middle of the forehead may not have been ideal, noting that pressure points for the brow band have been found on each side below the ears (Murray et al., 2015). That study did not measure at the middle part of the brow band, but a too small brow band would perhaps still be loose at the front but have heightened pressure at the attachments at the head piece. The authors also suggested that this pressure may involve muscles (the hyoid apparatus) associated with tongue movement and swallowing.

7 Conclusion

Headpiece tightness as represented by number of fingers using the ISES taper gauge, and use of a flash with the noseband, were associated with “tongue visible”. Other behaviours consistent with discomfort/pain or conflict were observed, though not associated with the riding equipment evaluated under the conditions of this study in which extremely tight bridles were not observed.

8 Literature

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7.1 Picture references

Figure 1: photo: Cecilie B. Løkken

Appendix 1 - Common types of nosebands

Plain cavesson

https://www.kieffer.net/en/bridles/snaffle-bridles/3142-kieffer-ultrasoft-sue.html

Crank noseband

https://www.premierequine.co.uk/favoloso-anatomic-bridle-with-crank-noseband-c2x25252804

Cavesson

https://www.horze.eu/lunging/f.r.a.-wendy-b-cavesson%2C-bitless-bridle%2C-leather-reins-w%2F-clip/322942.html

Cavemore

https://gramho.com/media/1891084904840337674

Flash noseband

https://www.kieffer.net/en/bridles/snaffle-bridles/216-belinda.html

Drop

https://www.kieffer.net/en/bridles/snaffle-bridles/250-olivia.html

Figure 8

http://www.sunshinecoastsaddlery.com.au/products/horze-mexican-figure-8-bridle.html

Micklem

https://www.stallhoymyr.no/products/rambo-micklem-competition-bridle

Appendix 2 - Information text provided to potential study recruits

Hei,

Jeg studerer ved NMBU og holder nå på å skrive masteroppgaven min innen dyrebiologi. Jeg er interessert i utstyr brukt under ridning, og hvordan disse påvirker hestens atferd under ridning. Jeg er på utkikk etter ryttere som vil være villige til å delta i studien. Som frivillig saler du opp hesten med det utstyret som den vanligvis bruker og trener hesten slik du normalt gjør mens jeg observerer. Mitt fokus er på hesten, og jeg vil ikke registrere noe av det du gjør.

Før du starter å ri, ønsker jeg å observere mens du tar på utstyr. Jeg har også noen korte spørsmål som jeg ønsker at du svarer på og jeg vil ta noen mål av hodelaget. Mens du rir vil jeg bruke et skjema der jeg registrerer informasjon om hestens atferd i omtrent 20 minutter. Fortrinnsvis ønsker jeg å stå i midten av ridebanen for å få sett mest mulig. Om dette ikke lar seg gjøre kan jeg stå på utsiden. Etter rideøkten er ferdig, ønsker jeg å observere når du tar av utstyret. For observasjonsperiodene før og etter ridning, bruker jeg et eget registreringsskjema for å notere atferd.

Jeg trenger mange frivillige, jo flere jo bedre! Mange observasjoner betyr et sterkere statistisk resultat. Ditt bidrag er derfor viktig for meg, og jeg setter stor pris på alle som ønsker å bli med. Hvilket nivå du rir på er uvesentlig, men du må være over 18 år.

Studien er anonym. Om du ønsker, er det mulig å motta oppgaven på e-post når den er ferdig.

Om du er villig til å være frivillig i denne studien, kontakt meg på mobil: 99 22 86 55, send meg en melding på Messenger eller e-post: cecilie.blakstad@nmbu.no

Med vennlig hilsen

Cecilie Blakstad Løkken

Appendix 3 - Data sheet used for questions and measurements

Horse information

Age: ________ Use/discipline: __________

Sex: __________ Hours turned out per day: ________

Breed: __________

Tack information

Type of bit: ________________________

Type of bitless	Sidepull	Cross under	English hackamore
	German hackamore		Other: ____________________
Type of noseband	Figure 8	Drop	Crank with flash
	Micklem	Flash	Crank without flash
	Kineton	Combination	Plain cavesson
	Other: ____________________		Double H
Type of saddle	Jump	Dressage	All-round
	Other: ____________________		Western
Rider aids	Whip (dressage)	Whip (jump)	Spurs
	Other: ____________________		
Help reins	Standing martingale	Running martingale	Side reins

	Draw reins	Elastic neck stretcher/extender	
	Chambon	Thiedemann	Gogue
	Other: ____________________		
Other tack	Double bridle	Double reins	Curb chain
	Double bits: ______________________		Pelham strap

Measures

Tightness of noseband:	< 0,75	1,0	1,25	1,50	1,75	2,0	> 2,0
Tightness of headpiece:	< 0,75	1,0	1,25	1,50	1,75	2,0	> 2,0
Tightness of brow band:	< 0,75	1,0	1,25	1,50	1,75	2,0	> 2,0

Width of noseband in millimetres ____________

Width of centre headpiece in millimetres ____________

Width of headpiece behind the ears in millimetres (where applicable) ____________

Distance between the noseband and the facial crest in millimetres ____________

Number of wrinkles at the corner of the mouth ____________

Other information

1. Are you an beginner, intermediate or experienced rider? Circle correct answer.
2. Is your ride today for pleasure or are you practicing for a specific type of competition or other event? If practicing, for what type of event?

____

3. Is this the tack that you usually use? If not, why did you chose to use this tack today?

____

4. What do you like about the specific type of bridle you used today and the way it fits?

---

5. How do you decide how loose or tight to make the different parts of the bridle you used today?

---

6. What behaviour do you think is the most positive behaviour that a horse can show when being ridden?

Do you want to receive a copy of the master thesis when it is completed? If yes, note e-mail.

Appendix 4 - Data recording sheet used for before and after riding session

Before riding session

		Lick	N-chew	Chew	Yaw	H-S	B-S	S-leg	S-mouth	R-leg	R-ob	R-per	Stre	Paw	E-flat	B-R	A-B-R	H-V-M	H-V-H	H-L	Step	Turn	Action
0 - 15																							
15 - 30																							
30 - 45																							
45 - 60																							
60 - 75																							
75 - 90																							
90 - 105																							
105 - 120																							

After riding session

		Lick	N-chew	Chew	Yaw	H-S	B-S	S-leg	S-mouth	R-leg	R-ob	R-per	Stre	Paw	E-flat	B-R	A-B-R	H-V-M	H-V-H	H-L	Step	Turn	Action
0 - 15																							
15 - 30																							
30 - 45																							
45 - 60																							
60 - 75																							
75 - 90																							
90 - 105																							
105 - 120																							

Action:
T = tied up
G = groomed
L = lead
LS = loose in stall
LP = loose in pasture
LO = loose outdoor

Appendix 5 – Facial grimace score data sheet and the horse grimace pain scale (HGS) (Costa et al., 2014)

	Not present	**Moderately present**	**Obviously present**
Stiffly backwards ears			
Orbital tightening			
Tension above the eyes			
Prominent strained chewing muscles			
Mouth strained and pronounced			
Strained nostrils and flattening of the profile			

Appendix 6 - Data recording sheet used for the riding session

			Eyes			Mouth				Tail		Head				Poll					Buck			
		Ear	Scl	Stare	Nos	Foam	Open	Che	Tou	Swish	Lash	H-P	H-V-M	H-V-H	H-L	P-H	P-L	N-up	Snort	Def	B	A-B	Rear	Gait
0 - 15																								
15 - 30																								
30 - 45																								
45 - 60																								
60 - 75																								
75 - 90																								
90 - 105																								
105 - 120																								
120 - 135																								
135 - 150																								
150 - 165																								
165 - 180																								
180 - 195																								
195 - 210																								
210 - 225																								
225 - 240																								
240 - 255																								
255 - 270																								
270 - 285																								
285 - 300																								

H=halt **Other riders present at 0 -15 (y/n):** **Indoor or outdoor arena:**

W = walk R= Reversing

T = trot **Total riding time:**

C = canter

TØ = tolt

P = pace

Appendix 7 - Overview of information gathered per horse

WL=warmblood, CL=coldblood, TH=Thoroughbred, M=mare, G=gelding, ST=stallion, H=hacking, HO=hobby, D=driving, AC=academic, CD=classic dressage, RS=riding school, GR=gait riding, BA=backed, HR=hours turned out per day, DJ Snaffle Loose=Double jointed snaffle with loose rings, DJ Snaffle Fixed=Double jointed snaffle fixed rings, Crank w/o F=Crank noseband without flash, Crank w F=Crank noseband with flash, Micklem=Micklem or Micklem type noseband, Plain=Plain cavesson, Drop=Drop noseband, Flash=Flash noseband, D=dressage, J=jump, A=All-round, B=bareback pad, W=whip, S=spurs, OT=other tack or aids, SA=saddle, DB=Double bridle, DR=Double reins, CC=Curb chain, PS=Pelham strap, RM=Running martingale, DW=Draw reins, DG=De Gauge, NO=Noseband, HP=Headpiece, BB=Brow band, CHP=Center headpiece, EHP=Headpiece behind ears, NO-FC=Distance from noseband to facial crest, WR=number of wrinkles at the corner of the mouth

	Horse information				Tack			Aids		Tightness			Width (mm)				
Breed	**Age**	**Sex**	**Use**	**HR**	**Bit type**	**Noseband**	**SA**	**W/S**	**OT**	**NO**	**HP**	**BB**	**NO**	**CHP**	**EHP**	**NO-FC (mm)**	**WR**
American Paint	12	M	D/H	12	Weymouth & bradoon	Crank w/o F	D	-	DB/DR/CC	1,25	1,0	>2,0	40	56	-	26	2
Belgian WL	17	G	J	8	DJ Snaffle Loose	Plain	J	W/S	-	2,0	2,0	>2,0	18	30	-	36	1
CL Trotter	22	M	AC/H	24	Straight snaffle with fixed rings	-	B	W	-	-	2,0	>2,0	-	33	-	-	0
Danish Sport Pony	22	G	D/H	12	DJ Snaffle Loose	Other	D	W	-	2,0	2,0	>2,0	41	81	40	14	1
Danish WL	12	M	J/D	12	DJ Snaffle Fixed	Flash	D	W/S	-	0	1,25	> 2.0	19	21	-	10	1
Danish WL	21	G	D/H	9	DJ Snaffle Loose	Crank w F	D	S	-	1,50	1,25	>2,0	35	42	33	3	0
Danish WL	12	M	D	11	Weymouth & bradoon	Crank w/o F	D	S	DB/DR/CC	2,0	1,75	>2,0	48	27	-	37	1
Danish WL	9	M	J/D	10	DJ Snaffle Loose	Flash	D	W/S	-	1,5	2,0	>2,0	27	37	25	18	2
Danish WL	6	M	D	14	Western snaffle double rein	Other	D	W	DR	1,75	1,75	>2,0	31	47	33	13	1
Danish WL	11	G	D	24	DJ Snaffle Loose	-	D	W	-	-	2,25	>2,0	-	44	28	-	0
Danish WL	20	G	J	4	DJ Snaffle Loose	Flash	J	S	RM	1,5	1,75	>2,0	21	26	-	15	1
Danish WL	17	M	D/H	12	Single jointed 3 ring Pessoa	Crank w F	D	W/S	-	1,25	1,5	>2,0	38	42	25	14	2

Danish WL	13	G	D/J	12	DJ Snaffle Loose	Micklem	D	S	-	1,5	2,0	>2,0	20	40	19	-	1
Dutch WL	7	G	J/D	13	DJ Snaffle Fixed	Plain	D	W	-	2,0	-	>2,0	22	27	-	47	1
Dutch WL	9	M	J	5	Straight snaffle with loose rings	Micklem	J	W	RM	1,75	2,0	>2,0	19	44	17	-	-
Dutch WL	16	G	J	12	Straight baby Pelham	Flash	J	W/S	DG/PS	1,75	1,5	>2,0	22	22	-	31	-
Dutch WL	18	M	J	7	DJ Snaffle Loose	Flash	J	S	DW	1,0	1,75	>2,0	34	56	36	35	2
Dutch WL	12	G	J	7	DJ Snaffle Loose	Flash	J	S	-	1,75	2,0	>2,0	28	30	22	29	1
English TH	18	G	D/H	12	DJ Snaffle Loose	Crank w F	D	S	DW	1,0	1,0	>2,0	36	28	-	23	1
Fjord Horse	8	M	RS	24	DJ Snaffle Loose	Plain	A	W	-	1,25	1,75	>2,0	22	27	-	24	1
Fjord Horse	15	G	H/D	24	Weymouth	Plain	B	W	CC	2,25	1,5	>2,0	25	30	-	0	1
German Riding Pony	12	G	CD	14	Cavemore	Cavemore	D	W	DR	1,5	1,75	NA	28	12	-	52	-
Holsteiner	10	G	J	8	Straight snaffle with loose rings	Other	J	W	-	2,0	2,0	>2,0	38	76	41	23	-
Holsteiner	8	G	J	12	DJ Snaffle Fixed	Flash	D	S	-	1,5	1,5	>2,0	15	27	-	9	2
Huzule	19	M	HO	8	Single jointed snaffle with fixed rings	Other	A	W/S	-	1,5	2,0	>2,0	35	77	42	0	1
Icelandic Horse	8	M	H	24	DJ Snaffle Loose	-	B	W	-	-	2,25	2,0	-	13	-	-	0
Icelandic Horse	6	G	H	24	Kimblewick	Plain	D	W	CC	2,25	2,0	>2,0	16	59	33	36	1
Icelandic Horse	5	G	GR	24	DJ Snaffle Loose	Other	D	-	-	2,25	2,0	>2,0	32	67	41	23	0
Icelandic Horse	7	G	H/D	9	DJ Snaffle Fixed	Other	D	W	DR	2,0	2,0	NA	32	27	-	24	1
Icelandic Horse	5	G	H	24	DJ Snaffle Fixed	Drop	D	W	-	2,25	2,0	>2,0	32	23	-	83	0
Irish WL	7	M	J	6	Straight snaffle with loose rings	Other	J	-	-	1,25	2,0	>2,0’	37	77	43	32	-
KWPN	14	G	D	12	Kimblewick	Crank w/o F	D	S	CC	1,75	1,50	>2,0	45	56	36	8	2
KWPN	19	M	J/D	8	Straight snaffle with loose rings	Flash	J	W/S	-	1,0	1,25	>2,0	20	30	-	10	1
KWPN	19	G	D	8	DJ Snaffle Loose	Crank w F	D	W/S	-	1,25	2,0	>2,0	45	24	-	15	1
Lippizan	23	M	D/H	8	DJ Snaffle Loose	Crank w/o F	D	W	-	1,5	1,75	>2,0	38	27	-	24	-
Lusitano	8	G	CD	24	Western snaffle double rein	Other	B	W	DR/CC	1,75	2,0	>2,0	31	47	33	7	0
Mecklemburger	15	M	J/D	9	Double jointed Baucher	Plain	J	W	-	2,0	2,0	>2,0	20	55	30	27	0

Mixed Breed	19	G	H	8	DJ Snaffle Loose	Other	J	W/S	-	2,0	2,0	>2,0	32	65	42	42	1
New Forest	14	G	J/D	14	DJ Snaffle Fixed	Plain	D	W	-	2,25	2,0	>2,0	22	37	-	35	0
Nordland Horse	12	G	RS	13	DJ Snaffle Fixed	Crank w/o F	J	S	-	2,0	2,0	2,0	25	23	-	17	-
Nordland Horse	4	G	D/H	24	DJ Snaffle Fixed	Plain	J	W	-	2,0	1,5	>2,0	21	33	19	7	1
North Swedish Horse	6	M	H/D	10	Kimblewick	Drop	B	-	-	1,25	2,0	>2,0	21	37	-	119	1
Norwegian WL	5	M	J	8	Single jointed snaffle with loose rings	Flash	J	W	-	1,75	1,25	>2,0	30	64	42	6	1
Norwegian WL	13	G	J/D	8	DJ Snaffle Loose	Flash	J	W/S	-	1,0	1,75	>2,0	27	45	-	21	1
Norwegian WL	11	M	H/D	8	DJ Snaffle Loose	Other	D	W/S	-	2,0	2,0	>2,0	35	74	41	25	2
Norwegian WL	13	M	J	4	DJ Snaffle Loose	Flash	J	S	-	1,5	1,75	>2,0	19	23	-	28	2
Norwegian WL	8	M	J	4	DJ Snaffle Fixed	Crank w F	D	-	RM	1,5	1,75	>2,0	34	28	-	40	1
Norwegian WL	6	G	J	7	DJ Snaffle Loose	Flash	J	-	RM	1,0	1,75	>2,0	11	53	34	18	2
Oldenburger	9	G	HO	9	DJ Snaffle Fixed	Crank w/o F	D	W	-	1,75	2,0	>2,0	34	44	25	37	2
Oldenburger	18	G	D	7	DJ Snaffle Loose	Drop noseband	D	-	-	2,0	2,0	>2,0	27	27	-	110	1
Palomino	9	M	HO	8	DJ Snaffle Loose	Micklem	D	-	-	1,25	2,0	>2,0	19	42	21	-	1
PRE	5	M	BA	14	DJ Snaffle Fixed	Drop noseband	D	-	-	2,25	2,25	>2,0	32	23	-	110	0
PRE	7	ST	D/H	14	Single jointed snaffle with fixed rings	Drop noseband	D	-	-	2,0	1,75	>2,0	26	58	28	85	2
Selle Francais	11	M	J	8	DJ Snaffle Fixed	Micklem	J	S	-	2,0	1,75	>2,0	24	43	-	-	1
Swedish WL	13	M	D	7	Double jointed Baucher	Plain cavesson	D	-	-	1,0	1,5	>2,0	20	55	31	6	1
Swedish WL	21	M	CD	14	Western snaffle double rein	Other	B	W	DR	2,25	2,25	>2,0	31	47	33	13	0
Thoroughbred	7	G	HO	12	Double jointed full check snaffle	Crank w F	D	S	-	1,75	2,0	>2,0	40	25	-	7	2
WL Trotter	9	M	D/J/H	13	Double jointed Baucher	Micklem	D	W	DW	1,75	-	>2,0	23	-	21	-	2
Welsh Cob	13	M	AC/J	24	DJ Snaffle Fixed	Plain cavesson	D	W	-	2,25	2,0	>2,0	14	22	-	27	1
Welsh Cob	8	G	D	24	Double jointed full check snaffle	Crank w/o F	D	W	-	2,25	2,25	-	29	27	-	27	0

Appendix 8 - Correlations (Spearman) between variables

Before riding session	Riding session	After riding session

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1 Licking	1,000																																						
2 Chew non nutr.	**,377****	1,000																																					
3 Head turn	-,201	-,190	1,000																																				
4 Ears	-,053	-,165	-,100	1,000																																			
5 Mouth foam	-,150	,014	,162	-,007	1,000																																		
6 Mouth open	,148	-,007	-,193	,011	-,045	1,000																																	
7 Mouth movement	-,005	-,053	-,059	,118	,159	**,617****	1,000																																
8 Tonge	,163	,126	,042	-,141	-,106	-,049	,013	1,000																															
9 Total mouth	-,012	,035	-,024	,043	**,674****	**,538****	**,750****	,012	1,000																														
10 Tail swishing	,014	,236	,176	-,232	,253	,007	,010	,092	,194	1,000																													
11 Tail lashing	,028	,071	,047	-,126	,057	-,036	,015	,108	,044	**,645****	1,000																												
12 Tail total	,018	,105	,081	-,158	,141	-,051	,014	,103	,095	**,754****	**,973****	1,000																											
13 Head in	,191	-,050	-,024	-,022	**,454****	**,280***	**,278***	-,041	**,504****	,015	-,011	,027	1,000																										
14 Head tossing	-,019	,014	-,074	,083	,040	-,032	,019	-,006	,013	-,102	-,097	-,116	,091	1,000																									
15 Poll high	,009	,037	-,177	-,028	-,099	-,044	**-,326***	-,151	-,207	-,113	-,221	-,209	-,210	**,268***	1,000																								
16 Poll low	,025	-,093	-,044	-,017	**-,269***	-,125	-,147	**,343****	-,249	-,152	-,069	-,123	**-,265***	-,184	,062	1,000																							
17 Snort	,037	,084	,032	,068	-,077	,004	-,024	,122	-,037	-,121	-,169	-,166	-,055	,124	,127	,169	1,000																						
18 Licking	,136	,005	,003	-,053	-,018	,153	-,129	-,019	-,068	-,027	,039	,009	,244	-,057	-,073	,087	,042	1,000																					
19 Chew non nutr.	-,018	,112	-,108	,117	-,082	,141	,076	-,054	,000	-,064	-,020	-,025	,090	-,064	-,008	,120	-,167	**,616****	1,000																				
20 Chew nutr.	-,101	-,091	,191	,036	**,292***	-,022	-,044	,011	,144	,061	-,025	,031	,253	,234	,033	-,014	,180	-,211	**-,326***	1,000																			
21 Rub head object	,002	-,038	-,054	,050	-,148	**,362****	,220	,012	,189	,138	,078	,070	-,005	,007	,053	-,158	-,124	-,221	-,109	-,086	1,000																		
22 Noseband tightn.	-,073	-,028	-,021	,119	-,143	,045	,225	,195	,032	-,100	,109	,054	-,088	,043	-,143	**,279***	,152	,082	,184	,072	-,265	1,000																	
23 Headpiece tightn.	-,081	,045	,110	,018	-,116	-,075	-,106	**,296***	-,117	,046	,088	,085	-,118	-,077	,053	,232	,248	-,005	-,057	,052	-,204	**,527****	1,000																
24 Conbined tightn.	-,038	,071	,092	,256	-,075	,066	,155	,226	,074	,092	,135	,125	-,024	-,120	-,113	,102	**,304***	,022	,093	,092	-,149	**,669****	**,780****	1,000															
25 Wrinkles	-,143	-,036	,077	-,109	,251	,093	,021	**-,312***	,178	,088	-,090	-,037	,082	-,186	-,064	**-,321***	-,096	,030	,097	,133	,070	**-,422****	**-,446****	-,226	1,000														
26 Whip	,038	,018	,008	,048	**-,257***	**-,354****	**-,260***	,176	**-,406****	,087	**,279***	,216	**-,259***	-,114	-,116	**,315***	,052	,186	,133	-,076	**-,384****	,252	,210	**,308***	-,256	1,000													
27 Spurs	,066	,137	,116	-,212	**,362****	,117	-,088	-,219	,212	,121	,059	,066	,119	-,053	,013	-,223	-,156	-,001	-,086	,123	,122	**-,333***	**-,296***	**-,275***	**,366****	-,236	1,000												
28 Whip & spurs	,009	,020	,099	-,189	,060	-,034	-,193	-,077	-,118	,155	,178	,164	-,129	-,105	-,035	,019	-,105	,214	,091	-,030	-,199	-,258	-,099	-,098	,196	**,387****	**,580****	1,000											
29 Running maringale	,038	,124	,018	,072	,111	,092	,073	,024	,116	**,442****	,152	**,260***	,022	-,093	,036	-,126	-,179	-,174	,063	,121	,230	-,182	-,078	-,080	,112	-,191	-,082	-,127	1,000										
30 Draw reins	,080	,254	-,140	,064	-,029	**,357****	**,278***	-,174	,232	-,153	-,241	-,241	,043	-,174	-,096	**-,264***	,083	-,172	-,109	-,145	**,274***	-,235	-,225	-,058	,232	-,125	,125	-,109	-,061	1,000									
31 DeGouge	-,063	,028	,193	-,075	,247	-,015	-,019	-,099	,154	-,087	-,137	-,137	,180	,168	,132	,104	,127	,161	,088	,226	-,061	,004	-,164	-,048		,106	,159	**,275***	-,035	-,030	1,000								
32 Double bridle	-,089	-,218	-,113	-,199	,041	,224	,220	-,141	,156	,039	,047	,045	,191	,049	-,200	-,214	-,153	,006	-,009	,132	,144	-,032	-,225	-,071	,139	-,227	,038	-,088	-,050	-,043	-,024	1,000							
33 Double reins	,107	-,065	-,004	,107	,033	-,187	,103	,183	,033	-,060	,020	-,008	,154	,089	**-,318***	,097	,055	,109	,069	,119	-,042	,074	-,030	,121	-,096	,085	-,191	-,172	-,097	-,083	-,047	**,511****	1,000						
34 Hours turnout/day	-,043	-,037	-,094	,013	-,087	-,210	,125	,214	-,024	-,253	,041	-,043	,050	,071	-,210	,135	,233	-,013	-,047	-,203	-,216	**,487****	,182	,191	**-,400****	**,345****	**-,362****	-,224	**-,414****	-,036	,030	,014	,199	1,000					
35 Snaffle fixed dbl j	,050	,089	-,042	,160	,170	,013	,109	,017	,084	-,102	-,192	-,165	,110	,111	-,004	-,090	,032	,007	,237	,050	-,148	**,289***	,018	,189	-,081	,017	-,099	-,145	,022	-,121	-,068	-,098	-,065	,181	1,000				
36 Snaffle loose dbl j	,084	,188	,013	-,087	-,131	,021	-,173	-,067	-,057	,103	,057	,078	**-,257***	-,155	,124	,060	-,099	-,186	-,182	-,172	,247	**-,277***	,111	-,137	,033	-,155	**,297***	,176	,074	,143	-,099	-,141	**-,277***	**-,295***	**-,400****	1,000			
37 Crank with flash	**,338****	,168	-,021	-,080	**,254***	,209	,181	,040	**,350****	,140	,153	,145	,173	-,064	,058	-,199	-,177	-,083	-,207	,077	**,289***	**-,279***	-,219	-,205	,077	-,181	**,295***	,129	,134	,178	-,043	-,062	-,121	-,118	-,040	,092	1,000		
38 Crank w/o flash	,084	-,095	-,113	-,204	,028	,091	-,015	-,005	-,031	-,151	-,048	-,065	,093	-,170	-,064	-,063	-,199	,048	,035	,023	-,042	,074	-,064	-,068	,181	-,127	,021	-,172	-,097	-,083	-,047	**,511****	,191	,064	,061	-,169	-,121	1,000	
39 Pain score	-,093	,076	-,186	-,122	-,099	,003	-,070	,097	-,090	-,124	-,150	-,162	-,023	,312*	,124	,110	,142	,053	-,043	**,409****	,002	,050	,191	,030	-,015	,037	-,037	-,013	-,110	-,110	-,063	,142	,084	,020	,050	-,021	,005	-,045	1,000

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Appendix 9 - Behavioural counts per horse

Horse ID	Ears	Mouth foam	Mouth open	Mouth movement	Tongue	Tail swishing	Tail lashing	Head in	Head tossing	Poll high	Poll low	Snort
1	9	16	2	20	0	0	57	71	0	0	0	0
2	1	0	13	39	0	0	0	14	3	0	0	0
3	23	0	40	43	0	0	0	37	0	0	0	0
4	0	4	28	42	14	0	0	18	0	0	3	0
5	0	0	0	6	0	1	8	0	0	0	8	0
6	25	0	10	2	0	0	1	0	2	67	1	1
7	7	0	0	28	0	0	12	0	0	0	8	0
8	6	47	5	10	0	0	0	13	11	38	2	0
9	15	0	0	1	0	0	0	14	1	0	1	0
10	0	0	0	7	28	0	0	7	2	1	0	0
11	16	0	44	50	1	0	7	2	1	7	6	2
12	2	72	25	12	6	10	59	75	0	1	3	1
13	1	0	41	25	0	7	13	21	0	1	4	0
14	12	0	0	3	0	3	10	0	3	22	1	3
15	4	0	5	34	28	10	32	2	0	1	5	2
16	1	0	23	36	0	0	0	8	2	2	19	7
17	38	0	50	38	0	0	4	23	0	2	4	6
18	1	46	80	47	0	2	32	69	0	0	0	1

19	21	0	0	7	0	0	0	0	0	0	9	3
20	52	0	29	53	0	0	2	16	0	0	2	5
21	2	0	1	0	0	8	19	0	0	0	0	3
22	11	0	22	35	9	4	12	0	0	0	13	0
23	1	0	2	3	0	0	0	0	0	41	6	5
24	18	0	12	27	0	0	14	0	5	0	0	1
25	23	0	1	2	0	0	0	0	0	26	8	0
26	31	55	0	52	23	2	22	7	7	0	17	2
27	2	0	0	25	5	0	1	0	0	5	9	9
28	4	0	1	2	0	0	1	2	5	16	3	5
29	7	0	0	4	6	0	0	22	0	4	7	6
30	43	29	0	26	3	0	2	7	0	0	15	2
31	25	0	0	6	17	0	5	29	4	0	0	2
32	8	0	2	1	1	0	27	0	0	2	1	1
33	14	0	0	2	3	0	1	0	0	11	22	2
34	22	46	11	28	1	0	0	25	4	5	2	3
35	40	45	66	79	0	0	0	13	0	0	0	8
36	2	0	15	4	2	28	25	25	0	0	16	2
37	1	39	0	7	0	0	4	32	3	56	0	3
38	32	67	17	15	0	0	0	60	2	11	4	1
39	3	76	3	14	0	0	0	33	3	26	6	4

40	22	16	9	43	0	1	27	7	3	0	0	1
41	39	0	1	8	0	0	0	2	0	41	5	0
42	9	0	0	1	0	0	3	1	0	47	5	1
43	19	0	17	5	8	0	0	0	3	52	15	8
44	46	0	12	27	0	2	4	0	2	50	0	1
45	1	76	0	22	0	23	2	21	1	0	0	2
46	19	47	29	50	4	7	2	12	0	0	0	0
47	6	74	0	17	0	24	4	9	0	27	0	0
48	10	0	28	60	0	0	0	22	1	20	0	2
49	11	0	12	15	4	11	5	3	5	41	0	6
50	3	0	6	13	1	0	0	15	3	33	1	2
51	0	0	12	15	11	0	2	5	0	1	8	0
52	0	0	51	29	0	0	0	0	0	22	0	3
53	61	55	0	0	0	0	0	0	0	1	1	2
54	0	64	7	12	1	0	0	25	0	0	2	5
55	25	0	0	5	5	0	0	0	0	0	2	3
56	0	80	2	17	0	6	6	0	0	32	0	0
57	15	53	0	0	0	20	47	40	0	2	0	1
58	31	0	15	34	0	0	0	14	0	11	3	0
59	0	0	3	13	7	10	6	0	0	2	8	10
60	27	31	5	49	0	0	0	17	0	0	0	6

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