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The effects of a variation in noseband tightness on the rein tension of the ridden horse.

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The effects of a variation in noseband tightness on the rein
tension of the ridden horse.

by

Deborah M. Duke

A thesis submitted to the University of Plymouth in partial
fulfilment for the degree of

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Finally, the research was undertaken as an opportunity to investigate a contemporary equine issue, with the hope that it will be a small part of the drive to improve welfare for the ridden horse.

Debbie Duke

Author's Declaration

At no time during the registration for the degree of Research Masters has the author been registered for any other University award without prior agreement of the Graduate Sub-Committee.

Work submitted for this research degree at the Plymouth University has not formed part of any other degree either at Plymouth University or at another establishment.

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Deborah M Duke

The effects of a variation in noseband tightness on the rein tension of the ridden horse.

Abstract

The noseband has been the topic of much recent attention from many within the equitation science field concerned with the welfare of the ridden horse. Nosebands have adapted over the years and are now used specifically for different purposes most being linked to increased control of the horse by either closing the mouth, placing additional pressure on the horse's head in certain areas and preventing the horse avoid the pressure of the bit in their mouth. However, objective data do not exist on the consequences of tightening the noseband on the horse's head. The possibilities are physical pain, skin and nerve pressure at an unacceptable level and an increased stress response as a result of the noseband pressure. The aim of this study was to compare the rein tension variations associated with a range of noseband fittings and the behaviours exhibited by a small sample of horses whilst wearing a cavesson noseband on three different levels of tightness. Fifteen horses were ridden around a predetermined route in a 25x45m arena, the rein tension was recorded with the ReinCheck™ during all observational periods. There were three replicates per horse covering loose, tight and normal noseband fittings. Data collated using SignalScribe™ were statistically analysed using a series of Friedman's analyses and post-hoc Wilcoxon tests. There was a significant

effect of noseband fitting on rein tension for the left rein: loose to normal ($P < 0.03$; 17% increase in rein tension), loose to tight ($P < 0.01$; 28% increase in rein tension) but not between normal and tight ($P > 0.05$). For the right rein, rein tension only significantly increased between the loose and tight fitting ($P < 0.006$; 24% increase in rein tension). Rein tension on the left rein in all conditions exceeded that on the right hand ($P < 0.001$). No significant differences in rein tensions were associated with horse age ($P > 0.05$). The results suggest that noseband fit and the associated increase in pressure does alter the rein tension recorded for that horse. Higher rein tensions were reported on the left rein, which could be related to rider or horse laterality. Further studies are required to fully elucidate the effect of noseband fit on rein tension and to inform industry guidelines.

Chapter 1. Introduction	10
1.1 Equitation Science and the improvement of welfare.....	10
1.2 The relationship between rein tension and noseband pressure	11
1.3 Purpose of the study	13
1.4 Literature review	15
1.5 Control of the horse.....	15
1.6 The bridle and associated tack	22
1.7 Horse behaviour associated with tack	26
1.8 Noseband fit and welfare	27
<i>1.8.1: Post inhibitory rebound effect on behaviours.</i>	30
<i>1.8.2 Implications of perceived 'poor' behaviour.</i>	32
1.9 Physiological assessment of equine welfare	33
1.10 Rein tension.....	35
1.11 Bit Pressure	39
1.12 Welfare considerations.....	41
1.13 Helplessness / Learned Acceptance	45
1.14 Solutions for improved welfare in modern equestrianism	46
1.15 Progression following this trial	48
Chapter 2 - Materials and Methods	49
2.1 Equine subjects.....	49
2.2 Location of data collection.....	51
2.3 Riders	52
2.4 Tack.....	53
2.5 The Noseband.....	54
2.6 The Experimental Route	54

2.7 The Procedure	55
2.9 Data collection method	58
2.10 Data analysis	60
CHAPTER 3. Results.....	62
3.1 Descriptive results.....	62
3.2 Differences in rein tension between noseband conditions and reins.....	66
3.3 Effect of age on rein tension	68
Chapter 4. Discussion and Conclusion	69
4.1 The fitting of the noseband.....	69
4.2 Variations in left and right rein tensions	73
4.3 Effect of age on rein tension	74
4.4 Use of the findings in industry	75
4.4 Conclusions	76
References	78
Appendix One: different bridles and how they are fitted.....	100

List of tables

Table 2.1	Information about the equine subjects and their associated individual details.	p.50
Table 2.2	The questions asked of each rider commencing the data collection.	P.53
Table 2.3	Noseband fittings.	p.56
Table 2.4	The order each horse wore the range of fitting nosebands.	p.57
Table 3.1	Mean rein tensions for the left and right reins across the different noseband conditions.	p.65
Table 3.2	Variation between the combination of noseband pressure and the rein tension on the left rein.	p.67
Table 3.3	Variation between the combination of noseband pressure and the rein tension on the right rein.	p.67
Table 3.4	Wilcoxon signed rank within subjects left versus right rein for all horses across the noseband conditions.	p.67

List of figures

Figure 1.1	Example of using the ‘two finger’ measurement guide for the cavesson noseband	p.24
Figure 1.2	The ISES taper gauge inserted underneath the noseband and indicating the spacing between the noseband and the horse’s face.	p.25
Figures 1.3-1.11	Range of bridles (Appendix 1)	p.100
Figure 2.1	Diagrammatic representation of the school used for the trial	p.55
Figure 2.2	The measurement used to reach the normal fitting of the noseband	p.56
Figure 2.3	The positioning of the Rein Check measuring equipment.	p. 59
Figure 3.1	The effect of noseband fitting on rein tension (N) across the cohort	p.62
Figure 3.2	Right vs left rein cohort mean value for all noseband conditions	p.63
Figure 3.3	Left and right rein tension (Newtons: N) in relation to noseband fitting	p.64
Figure 3.4	Mean and standard deviation for rein tension for the left rein across all noseband conditions.	p.64
Figure 3.5	Mean and standard deviation for rein tension for the right rein across all noseband conditions.	p.65
Figure 3.6	Mean rein tension values for the cohort in relation to the applied noseband conditions for the left and right reins.	p.68

Chapter 1. Introduction

1.1 Equitation Science and the improvement of welfare

Equitation science is defined as the application of scientific methods to assess objectively the welfare of horses undergoing training; it promotes an evidence-based understanding of horse-rider interactions (ISES, 2017). The horse's preferred 'way of being' would be to live in herds and not to be requested to produce technical movements, jump higher fences or gallop as fast as they can on command by riders. The development of equitation science and the desire by the majority of horse owners to meet the highest standards of welfare is leading to the emergence of more accurate methods of measuring and ensuring high welfare standards for *Equidae*. Equestrianism's senior governing body the Fédération Équestre Internationale (FEI) (FEI, 2016) currently states that:

“In ensuring that the highest welfare standards are maintained, we must continue to improve our understanding of environmental and scientific factors surrounding the care of sports horses, both in and out of competition”

which is a development to improve welfare and therefore a step in the right direction and an acceptance of change in the equitation science world. However to support their statement and place actions alongside the statements such as this, the FEI and other prestigious governing bodies in the equine world need to now take action. The FEI needs to incorporate new guidelines, adapt rules and

regulations that reduce certain procedures, introduce modifications to tack, restrict certain methods of training and educate the lay person as to why these changes have been implemented. Currently the FEI statements seem to support the developments but provide no actual real guidance to riders on how to access evidence-based findings about these areas that could be argued to directly impact on the welfare of the horse. Equitation science research offers a potential tool, which can bring industry and researchers together to develop new and test traditional equitation practices to optimise the welfare of the horse (Waran and Randle, 2016).

The next role of the equitation science community is to translate the emerging scientific knowledge to the horse owner; measurements, adaptations and changes need to be explained and their benefits must be obvious and understandable and if possible visual (Williams, 2013). The results of research studies need to be delivered to the horse owner in a user friendly way allowing them to make informed choices with scientific backing and evidence to support the decisions on how to manage their equine partners.

1.2 The relationship between rein tension and noseband pressure

Evidence suggests that the horse was domesticated at around the end of the second millennium BC (Levine, 2005). Since then the human and horse relationship has adapted for economical needs, pleasure and adaptation in

breeding management. Today horses are utilised all over the world for a range of varying activities (Hobbs *et al.* 1994). To facilitate the functions humans require horses to undertake, control mechanisms have been developed. Horses have worn a bit for many years, 4000 BC (Levine, 2005), with the use of the bit documented as far back as the 14th Century (Anthony and Brown, 1991). The bit sits in the horse's mouth and acts as an interface between the horse and the rider, aiding control (Clayton, 2011). The noseband is the piece of tack that forms part of the bridle, its main function is to 'complete' the look of the bridle on the horses' head and to assist in aiding the rider to control the horse by accentuating the action of the bit (Holderness-Roddam and Vincer, 1987). The noseband can be used to help keep the horse's top and bottom jaws together and to reduce the resistance to the bit shown through an open mouth. There are a large range of nosebands available; some function simply to be a decorative feature of the horses' tack and provide little pressure or resistance to the jaw or enhance the control of the rider. Whilst others provide severe pressure to the horses' sensitive nose and may have a detrimental impact on both welfare and performance of the horse.

Equine welfare is a key strategic priority for global equestrian federations and the individual responsibility of horse owners, trainers and riders to adhere to animal welfare legislation (Williams and Tabor, 2017). The future of equestrianism relies on the positive perception of the sport (Lemon, 2016; Fletcher and Daspher, 2013), therefore decision makers within the equine industry are required to cultivate techniques which minimise risks to sport horses and maximise efforts to ensure equine welfare is a top priority in sporting

and training environments (Campbell, 2013; International Society for Equitation Science, 2015). Within equestrianism, the application of 'excessive' rein tension and the impact on equine welfare has been heavily debated amongst equine professionals (McLean and McGreevy, 2010). Standard equipment worn by horses such as bits and nosebands, are designed to reduce the extent that horses can physically exhibit resistance behaviours potentially masking conflict behaviours associated with uncomfortable or excessive bit pressure and increased rein tension (McGreevy *et al.*, 2005; Randle and McGreevy, 2013). Despite this limited research has explored the impact of the bridle and nosebands specifically on bit position in the horse's mouth (Clayton, 2011) or rein tension (Randle and McGreevy, 2013).

1.3 Purpose of the study

Research aims:

The aim of this study was to observe the reaction of the horse by recording the rein tension in response to varying pressures applied by a noseband applied at three different levels of tightness. If there are variations identified it can lead to further research to ascertain an acceptable level of noseband pressure.

Research objectives:

The study aims were achieved through the following objectives:

- to design an experimental protocol to examine the impact of noseband fit on rein tension,

- to measure rein tension associated with differing fits of a cavesson noseband in experienced horses and riders,
- to identify if differences in rein tension occurred with noseband fit, between the left and right reins, or were related to horse age, and,
- to make recommendations for optimal noseband fit to prevent excessive rein tensions in the horse.

Hypotheses:

The following hypotheses were proposed to determine the effect of the experimental variable noseband fitting on rein tension (N):

H¹: There will be a significant effect of noseband tightness on the rein tension (N)

H₀: There will be no significant effect of noseband tightness on the rein tension (N)

H²: There will be a significant difference in the median rein tension (N) recorded for young (ie. ≤14 years old) and the median rein tension (N) recorded for older (ie ≥15 years old)

H₀: There will be no significant difference in the median rein tension (N) recorded for young (ie. ≤14 years old) and the median rein tension (N) recorded for older (ie ≥15 years old)

1.4 Literature review

Horses are ridden for a range of different reasons ranging from non-competitive hacking, racing at top speeds to competing for Olympic Gold medals jumping large obstacles and performing intricate, complex movements to gain prestige and achieve financial rewards for doing so. All riders of horses need to establish control for safety reasons and the initial control centre is normally the bridle via the bit and reins combined with the application of aids such as the voice, seat, leg, pressure, physical signs and commands form the basis of establishing control and ensuring the horse performs as required by the rider (Clayton, 2011).

1.5 Control of the horse

Historic equestrian training practices have been designed using the dominance-submission model (Randle, 2015). However, the use of submission has been questioned by trainers who base their methodologies on the ability of horses to learn and operate (be trained) within their cognitive abilities also known as Learning Theory (McLean, 2014). The application of learning theory for individual horse-rider combinations requires due consideration to horse-human relationships, equine personality, management and training regimes linked to the ultimate purpose or targeted goal to achieve success (Randle, 2015). Therefore, learning theory as a training paradigm requires riders, owners and trainers to be fully conversant with its principles, to understand equine

behaviour and apply these principles correctly to maximise welfare and performance (Randle, 2015). The majority of riders are aiming for 'connection' with their horse and in particular to achieve these goals with the minimal force and through appropriate training (Williams, 2015). Most practitioners would aim to reduce pressure applied to their horse to meet these goals. The aids given to the horse from the rider work on the application of the aid to achieve the goal and then the release of the aid or pressure once the desired outcome has been achieved (McGreevy and McLean, 2010). Over time this form of training can lead to the pressure requirements being less and less to achieve the desired outcome as the horse learns to avoid the pressure by performing the required action (McGreevy and McLean, 2006). Training and education will influence human interaction with the horse (Randle, 2015) therefore whilst an ethical equitation training approach through the use of learning theory is advocated (McLean and McGreevy, 2008). The influence of management including tack selection and fitting will also contribute to how a horse interprets the signals given by the rider (Murray *et al.*, 2015).

The range of techniques used to control the horse often varies with the skill of the rider and the knowledge they have of the application and release of the pressure and identifying the correct signals and reading the responses of the horse, which then determine the outcome (Williams and Tabor, 2017; Randle, 2015). However, as Robinson (1999) and McGreevey (2004) have identified, the shift from horses being 'used for work' to owned for leisure purposes has increased substantially (Leckie, 2001). The increase in leisure horse ownership means the understanding of equine learning theory and how to optimise horse

welfare must be disseminated from equitation professionals to every day horse owners. The increase in UK horse ownership noted by Leckie (2001) indicates an increase in inexperienced persons applying training and tack to their horses, therefore the potential to cause discomfort, pain and negatively affect the welfare of the horse is also likely to increase.

The use of the tack is intended to provide assistance to the rider to apply the pressure needed to maintain control of the horse and themselves whilst riding and the combination of pressure can come from the bridle, saddle or other equipment during the formative stages of training such as the lunge line. Tack must be designed to provide only a measured, agreed and acceptable amount of pressure to a horse, or it must be able to provide release of pressure to reinforce correct rider aids. However, some tack cannot allow the required release (following the correct response being given). If the pressure continues the horse either accepts this and may begin displaying resistance or conflict behaviour or may select the 'fight' reaction to the on-going pressure (McGreevy and McLean, 2006). Pressure that a horse cannot escape from often results in the cases where horses are labelled 'problem horses' and can create the horse reacting negatively to tack, riders, people and certain situations. For example if the horse's teeth press into its cheeks when the noseband is tightened, this can lead to a pain related association being formed with the bridle and its application. The horse may then become difficult to catch, reluctant to have the bridle placed on its head or it may demonstrate 'conflict' behaviours such as kicking, biting or aggression in other forms.

The pressures applied by the bridle alone are at the poll, the brow, on the outside of the cheeks, around the nose, in the mouth on the bars of the mouth, the tongue, the inside of the cheeks, the chin and the lips (Murray *et al.*, 2015). All of these areas having pressure applied will generate a response and each area needs to be investigated to determine if the control provided by the application of pressure is outweighed by possible negative associations caused by pressure (McGreevy and McLean, 2006). For example, Cronin *et al.* (2003) concluded that muzzled dogs displayed increased submissive behaviour and a substantial decrease in vocalisation behaviour compared to non-muzzled dogs. Riders need to be aware of how their actions and the tack they apply can affect the welfare of the horse and of the consequences of applying pressure for control to achieve their training goals. If riders are ignorant to the outcomes of the application of pressure or force to their horses and are unable to identify the signs of stress, as Cronin (2003) identified, the animal receiving the pressure often becomes more submissive and less responsive as the restrictions are applied. This may lead to a possible reduction in performance, preventing horses reaching their potential which can have financial implications to the owner as well as reducing welfare.

The welfare and performance related issues associated with poorly fitting tack can be eliminated through the application of research findings following the continued development of equitation science. Limited research has explored the impact of tack design on equine performance and welfare. Murray *et al.* (2015) identified an increase in pressure under the headpiece of the bridle as horses extended the front leg during the movement of 'taking a stride'. This increase in

pressure when asking the horse to increase the stride length could encourage the horse to avoid 'stretching' and increasing the stride length to avoid the pressure if it is excessive. These pressures may, through the nature of the horse to avoid pressure, result in reduced performance (Murray *et al.* 2015). The horse's association with negative experiences can also have a long lasting effect on its future training and welfare. Górecka-Bruzda *et al.* (2015) in a study of 150 elite show jumpers identified in competitions that conflict behaviours were commonplace and that the dismissal of these behaviours by the FEI and other governing bodies had to be reviewed if the welfare of the ridden horse was going to be improved. Therefore, the correct application of tack is essential to the production of a quiet, contented horse willing and able to produce the desired results in competitions.

More research has been conducted on the impact of saddle fit on the horse's tolerance and adaptation to pain and discomfort, indicating that even though there is a negative impact on the horse the adaptations the horse makes to tolerate the discomfort may go unnoticed, particularly by a novice rider or horse owner. For example a study by Dyson, (2017) highlighted that a poor fitting saddle can affect the horses' lateral movement and has been shown to impair the regular and consistent pattern of movement. The pressure can force the horse to 'search' for a more pain relieving movement pattern (Peham, *et al.* 2004). A similar study investigating the pressure of harnesses on dogs, equivalent to saddles or other pieces of tack, concluded that the correct selection and adaptation of fit of the harness to the dog and to the handler is essential to reduce the load / pressure applied to the animals. (Penham, 2013).

Interestingly in dogs, higher pressures resulted in reduced interaction which could limit performance if the same behaviour is found to occur in horses. Hawson (2011) has suggested that if the pressure applied to a horse is not forgiving this can result in the horse becoming tense. Furthermore, if this tension is not managed through removal after a correct behavioural response, it can lead to the horse ceasing to offer a response and eventually becoming unresponsive, or producing an incorrect and potentially unwanted response. Fowler (2008) suggests that any intervention that restricts an animal's activity or restrains an animal in anyway is an action and responsibility that should not be considered lightly, and that restrictions applied to animals can impact on behaviour, life or other activities of that animal. Restrictions are a normal part of equine domestication and are accepted within the equine community as necessary. However, the restrictions vary greatly from a simple head collar and lead rope to guide the horse in a direction from the ground to more severe restraints. Understanding the impact of common practices is essential to ensure equine welfare is prioritised.

The effect of noseband fit on nasal pressure, rein tension and equine behaviour has been investigated in some preliminary studies. Fenner *et al.* (2016) examined the effects of nosebands fitted at a range of tightness combined with the application of a double bridle. All of the horses monitored displayed a range of signs of stress, in the form of increased cortisol, raised thermographic eye temperature and a display of reduced mouthing / oral movement behaviours as noseband tightness increased. Fenner *et al.* (2016) demonstrated that the increasing tightness of the noseband also had a significant impact on the

occurrence of normal oral activities such as swallowing and chewing, whilst licking and yawning behaviours were eliminated. These findings show that the increasingly tight nosebands do have the capacity to prevent normal oral behaviours of horses, as mandibular movement is almost completely restricted (McGreevey *et al.* 2012). Keinapfel *et al.* (2014) observed behaviours indicative of conflict within competition horse but could not assess mouthing behaviours in many subjects, as the nosebands were often too tight to allow even one finger to be inserted between the noseband and the horse's face. The rider's desire for horses to work on the vertical, coupled with the restrictions placed on exhibiting of normal oral behaviours such as swallowing, do not create an environment to observe acceptance of the bit or the contact or to be able to see if the horse is balanced and compliant whilst being ridden.

Murray *et al.* (2015) reviewed the link between rein tension, noseband tightness and the increased intranasal pressure during exhalation by designing and using a more flexible bridle that reduced pressure in these areas compared to the horse's normal bridle. These three areas combine to provide pressure cues during riding to the horse. Murray *et al.* (2015) identified the flexible bridle reduced pressures at the poll and under the noseband whilst simultaneously resulting in increased carpal, tarsal and forelimb protraction suggesting reduced pressures generate enhanced performance. The restrictions placed on the horse both at the poll, around the nasal cavities and through the mouth through the use of normal bridles combined with tight nosebands could not only be a welfare concern but could also therefore be decreasing the animal's ability to 'perform', which is a key success measure across equestrian sport (Williams,

2015). Further research is needed to explore the impact of different tack including noseband fit and how associated pressures influence performance in the competition horse.

Further studies are warranted to examine and understand the potentially negative implications of poorly fitting tack. The findings from the current study have the potential to add to this knowledge base and inform future practice on noseband use to promote positive equine welfare.

1.6 The bridle and associated tack

The fundamental aspect of the control process in the horse/rider relationship is the bridle, this is a combination of leather or similar strong materials that are combined together around the horse's head to achieve certain desirable traits and provide control and attachment from the rider to the horse. The head piece travels behind the horse's ears and supports the cheek pieces on either side of the horse's face that attach and hold the bit in the horse's mouth. The head piece is prevented from slipping backwards down the horse's neck by the brow band which passes from one side of the head piece to the other around the horse's brow, this passes close to the base of the ears. Under the head piece is the strap passing behind the ears of the nose band, this is attached to whichever nose band is used that passes around the horse's face normally above the bit. To prevent the head piece travelling over the ears and coming off there is a throat latch that branches from the headpiece and passes loosely under the throat of the horse.

The use of the noseband as part of the basic bridle is common amongst ridden horses all over the world. An introduction to the different types of noseband available is provided in Appendix One. In general, the noseband is an aid to improve the control of the horse for the rider and this is achieved by the restriction placed on the jaws of the horse. By assisting in keeping the jaws closed, the horse is less able to open its mouth avoiding the pressure of the bit. Nosebands are regularly discussed as part of day to day tack in guidance books (for example Edwards 1992 and Muir and Houghton 2002) and in competition rule books such as the FEI Rule Book (2016) and The Pony Club Dressage Rule Book (2016). Despite the common use of nosebands, there are no definitive guidelines for its correct fitting. The FEI (2016) states that “*all tack must be designed and fitted to avoid the risk of pain and injury*”. The Pony Club (2016) reports that the fitting of the noseband should “allow the ‘*two finger guide*” (that nosebands should be fitted so two human fingers can fit between the leather of the noseband and the horse’s nose) but a generic and clear interpretation of these descriptions does not currently exist.

McGreevy *et al.* (2012) completed a small survey to investigate the assumption of the measurement called the ‘two finger’ rule and found that this spacing guide is not a reliable tool for standard nose band fastening as the measurement and application of this spacing can vary considerably amongst individual riders/handlers (Figures 1.1). Further work by Doherty *et al.* (2013) examined the fit of nosebands of 147 horses at an affiliated cross country competition and found only 12% of horses examined had nosebands fastened with sufficient

space to fit the recommended two fingers under them. Whilst 47% had nosebands fastened so tight that there was no room for anything to pass underneath. The two finger rule is found in many tack guide books and is an accepted measurement tool across the equestrian industry. McGreevy concluded that a standardised measuring system was required to prevent over-tight nosebands and the potential detrimental affect these could have on equine behaviour and welfare. The International Society for Equitation Science (ISES) have since developed a universal Taper Gauge (Figure 1.2) designed to be used by governing bodies and leisure owners to ensure consistent follow guidelines can be applied across equestrianism. The Australian Pony Club has embraced the ISES taper gauge. The inclusion of the taper gauge at this level will begin to demonstrate that this procedure is the normal and accepted manner in which to fit a noseband. This acceptance from an establishment such as the Australian Pony Club is a forward thinking development that can start the inclusion of science into the reality of the horse world (Randle, 2016 personal communication and McLean 2016 personal communication).



Figure 1.1: Example of using the 'two finger' measurement guide for the cavesson noseband (chronofhorse, 2016)



Figure 1.2 The ISES taper gauge inserted underneath the noseband and indicating the spacing between the noseband and the horse's face. (ISES, 2016)

The lack of objective data on the effects of nosebands and on their correct fitting can have far reaching implications to the horse as can the poor or incorrect fitting of any piece of tack / equipment (Dyson, 2017). Muir and Houghton (2002) state that the cavesson noseband is purely aesthetic and should therefore be fitted to allow two fingers room to pass between the fitted noseband and the horses' face. However, variations of the cavesson noseband exist, for example the cinchback or crank cavesson that are padded to allow for tighter application (McGreevy and Mclean, 2010 and Casey *et al.* 2013). The ability to tighten and apply higher pressures within the cavesson design confirms that not all types of cavesson are purely aesthetic as was commonly thought (McGreevy and McLean, 2010) and support the need for increased research to understand the impact of different types of noseband and how they are fitted.

1.7 Horse behaviour associated with tack

Poorly fitting or incorrect use of tack has been associated with an increase in conflict behaviours in the horse (McGreevy *et al.*, 2012). Therefore, incorrect fit and use of tack can also influence rider safety. Hendriksen (2013) investigated riders' interpretation of horse behaviour, those who took part in the study and felt they were 'experts' in the field of equine behaviour scored an average of 76.2% compared to those who felt they had a high or average knowledge and ability to interpret horse behaviours, who scored 75% and 72.4% respectively. However, interestingly only 54% of participants were able to speak confidently about and identify 'conflict' behaviours in horses. If a rider is not able to interpret horse behaviour and demonstrate understanding of why it is occurring then it is unlikely they will be able to identify a horse being in discomfort or becoming stressed, especially if the pressure or restraint causes the horse to withdraw. In this case, a horse may begin to display undesirable behaviours and the rider may not identify the link or association with the tack and therefore the issue or cause is not able to be removed. The horse's behaviour then can deteriorate and lead to the horse being punished, 'sorted out', or sold as a labelled problem horse if the behaviours are indicative of conflict. It is acknowledge that there is a need to develop validated, agreed indicators of good and bad welfare that can be used in assessing the impact that training and management practices, including the use of tack, have on horses (Hall *et al.*, 2008).

1.8 Noseband fit and welfare

The Animal Welfare Act (2006) states all animals should be allowed the freedom to express natural behaviour and freedom from pain and distress. Therefore, if equine sport is to adhere to the requirements of animal welfare legislation and allow the display of natural behaviour and not cause pain to horses, then restriction and restraint should be kept to a minimum to be able to remain morally acceptable and be classed as humane treatment (Ödberg and Bouissou, 1999). Overall (2015) states that if the concept of stress can actually be identified, and measured it would be a beneficial place to start. Furthermore without 'good' and 'clear' markers in place that are fundamentally easy to use for a range of people across a wide range of disciplines, then conflict behaviours and other markers of poor welfare will be increasingly difficult to measure.

Despite the potential links between noseband fit and equine welfare, limited research has occurred in this field. Following on from their research conducted in 2013, Doherty *et al.* (2016) reviewed the tightness of 750 horse's nosebands and found 44% of horses surveyed had nosebands that were classed as extremely tight and were tighter than the taper gauge representing the '2 finger rule'. The pressure from tightly fastened crank nosebands has been likened to pressures that are comparable to those applied when using tourniquets in humans (Casey *et al.*, 2013). In humans, these pressures are associated with permanent tissue and nerve damage. Doherty *et al.* (2013) identified that the measurement of noseband pressure in many cases is also high enough to

induce tissue and nerve damage. This severe pressure indicates that the welfare issue is actually higher than simply a restriction. It is potentially causing physical damage to the skin and body of the horse and this coupled with increased rein tension drives the horse to either fight, where he'll encounter more restrictions, or to submit, and become helpless to the pressure, which is not the object of horse ownership and training in any sphere.

Tight nosebands have also been shown to increase the pressure of the cheeks against the horse's teeth, which can in some cases increase the compliance of the horse and the responsiveness to the pressure of the reins, by masking the natural comfort seeking responses of the horse by restricting the movement of the jaw and the tongue (McGreevy and Randle, 2011). However, Eisersiö *et al.* (2013) found that mouth movements decreased almost linearly with a long relaxed rein compared to that of a more collected position of the horse maintained through the use of a more collected, tighter rein and contact, and that the frequency of mouth movements increased with a larger nose angle. The large nose angle correlates to the horse having a much more natural position, which would link to a more relaxed mentality. These observations could indicate that more 'mouthing' or the movement of the bit in a gentle fashion within the oral cavity and the movement of the lips, jaws and other oral behaviours could actually be associated with relaxed behaviour. Normal oral activities such as swallowing and gentle chewing are not necessarily signs of resistance but are in fact normal behaviour when there is a bit in a horse's mouth (Manfredi *et al.*, 2010). In many elite competitions, these oral movements are currently considered signs that the horse is uncomfortable and is under pressure and is

avoiding or resisting the bit in their mouth. The inclusion of restrictions on the tightness of the noseband could allow the horse to show both acceptance and resistance and therefore display 'normal behaviour' in response to the stimuli applied via the bit and bridle. This would then keep elite equine sport in line with basic fundamental animal welfare legislation, and consequently mean riders would have less desire to clamp the horses jaws closed in order to occlude/hide this movement (McGreevy *et al.* 2012).

Waran and Randle (2016) have rather controversially posed the difficult question of whether a horse needs in fact to even be 'happy' to achieve competition success and question if welfare is a priority within equestrian sport. Poorly-fitted or inappropriate tack can have a detrimental impact on the welfare of the horse. However making a horse uncomfortable would be a counterintuitive approach to take at elite level and would be unlikely to lead to success in competition (Davis, 2016; Mountford, 2016). The British Equine Veterinary Association (BEVA) state that all riding equipment should be checked for fit at all levels of competition but also acknowledge that inexperienced riders can cause discomfort with any bridle regardless of its fit and therefore that training is the key to improved equine welfare. Equestrian bodies must be encouraged to take into account new findings and use them to make an assessment of current practices that will ultimately improve the welfare of the horse (Randle, 2010). Therefore further studies are required to provide quantifiable evidence of the impact of common training practices including the use of tack to enable objective measures to be integrated into equestrian

federation guidelines to ultimately enhance equine welfare (Williams and Tabor, 2017; Williams, 2013).

Recent studies of the application of learning theory within equitation have begun to show how the most simple and discrete variations in applications of horse training can assist in removing misunderstandings between horse and handler / rider and welfare can be improved. Through using the observation of varying behaviour the simplest adjustment of a traditional method can improve welfare for the horse and reduce conflict between horse and human, and this includes adaptation of tack and how it is used (Goodwin *et al.* 2009).

1.8.1: Post inhibitory rebound effect on behaviours.

Post-inhibitory rebound behaviour is shown where the frequency of the behaviour increases to higher than it was before, after a period of prevention (Freire *et al.* 2010). For example, if a behaviour is drastically restricted for a period of time and then the restrictions are released the behaviour is then excessively demonstrated by an individual, it can be concluded that this behaviour is necessary for that individual. Freire *et al.* (2010) used this restrictive rebound assessment on behaviour of stabled horses to see if planned exercise reduced the unwanted behaviours sometimes seen in stabled horses after long periods of stable confinement, the findings indicated that exercise reduced the amount of unwanted behaviour, supporting the view that reducing the time in the stable improves obedience and reduces reactivity. A similar experiment was conducted by McGreevy and Nicol (1998) looking at the

consequences of preventing crib biting for a set period of time and then to review the incidence of crib biting following the restrictions, which was shown to increase significantly. These results are then defined as 'post inhibitory rebound', it is determined that the period of restriction leads to a peak in the activity following the restriction period. McGreevy and Nicol (1998) conclude that behaviours that follow are characterised by an increase in the prevented behaviour often at an increased rate compared to the behaviour being observed before the restrictions were put in place. This pattern of motivation was considered functional and necessary for the well-being of the animal and that prevention of these behaviours may impact negatively on welfare of individuals. A similar reaction could be observed when loosening a noseband with horses excessively mouthing and displaying behaviours, which could be misinterpreted by riders as evasive, leading to the continued use of tight nosebands.

Fenner *et al.* (2016) warn that the absence of actual visual evidence of a physiological stress response during any given treatment should not devalue post-inhibitory rebound as a behavioural indicator of compromised welfare. Therefore monitoring of the horse and the welfare of the individual must continue post applied restrictions to be sure that the post reaction to the pressures can be observed in the individual as well, even if the conflict behaviours were not obvious with the restrictions in place. If post inhibitory rebound is caused then the behaviours associated with this action must be seen as 'necessary' or 'desired' for that horse. However these behaviours may not be what people would always want to see their horses doing such as wind sucking or weaving. However, if basic oral behaviours are restricted such as swallowing

and are causing post inhibitory rebound then the restriction cannot be seen as acceptable welfare (Fenner *et al.* 2016). Therefore to restrict them is impacting on not only a basic need but also non-compliance with the basic animal welfare legislation (Animal Welfare Act 2006; Fenner *et al.* 2016).

1.8.2 Implications of perceived 'poor' behaviour.

The distortion and lack of clarity surrounding the definition of 'normal behaviour' within equestrianism has resulted in a broad misunderstanding of some aspects of what should be classed as 'poor' behaviour. Often displays of 'poor' behaviour are directly linked to the horse and their apparent 'unwillingness' or their 'problem' area and it is often suggested that the individual horse is at fault (McLean and McGreevy, 2010). In reality, these behaviours often represent the horse's response to the given environment and situation the horse finds itself in. For example, a horse may spook at an unfamiliar object, which is uncomfortable for the rider, can be dangerous if on the road and yet is only a horse acting in a very natural way to a potential threat (McLean and McGreevy, 2010). These changes in behaviour are simply adaptations to the stimuli and the environment. In a non-domestic situation if a horse felt pain it would move away from the stimulus, however in the ridden the option to move away from pain can be removed through the use of tack such as a tight noseband, therefore it can only resist the pressure by displaying behaviours labelled as 'poor' (Williams and Warren-Smith 2010). Wastage among the ridden horse population is often attributed to general 'poor' behavioural problems (Odberg and Bouissou, 1999). These apparent problems among horses and the consequential wastage can

possibly be reduced through a better and more thorough understanding of the causes of these behaviours.

1.9 Physiological assessment of equine welfare

The use of the heart rate monitor allows the initial signs of stress to be identified in the equine subject (von Borell *et al.* 2007). Heart rate variability (HRV) is frequently used in equitation science to assess stress in horses as it differs from the regular measurement of the 'heart rate' by measuring variation within inter-beat intervals. In healthy horses, the intervals between each of the heart beats are expected to be irregular. This irregularity is a result of rhythmic oscillation of the normal cardiac activity in the animal in response to its exposure to stimuli and the body's attempt to maintain homeostasis. Variation from this pattern can facilitate a physiological measure of distress (von Borell *et al.* 2007).

Heart rate variability (HRV) has been used to investigate occurrence of disease, psychological stress, environmental stress and individual temperament and coping strategies in farm animals. There are strong correlations between behaviour and emotional states and the heart rate variability in animals (von Borell, *et al.* 2007). The use of the heart rate monitor within equitation science is relevant as heart rate and heart rate variability (HRV) analysis for the equine appears to be a sensitive measure of the physical and emotional state of the horse (von Borell *et al.* 2007). HRV has been used to assess potential in endurance horses and although it provides potentially valid information it appears to be effected by environmental factors, therefore requires subject to

be in the same place at the same time. These limitations reduce the validity of HRV and HR as a stand alone assessment. (Younes *et al.* 2016).

Fenner *et al.* (2016) examined a range of naïve horses and the impact that noseband tightness had on a range of physical parameters. The results found that naïve horses, wearing a noseband applied tightly with no space between the skin and the noseband, demonstrated an increased heart rate, decreased heart rate variability and increased eye temperature compared to when wearing a noseband fitted with the conventional recommended area underneath, indicating that the pressure increased possible stress responses in these horses. There can be a range of factors that could cause this response, such as pain, discomfort, restriction of normal movement of the jaw and mouth. Or alternatively the horse could be reacting to a change in circumstance such as being simply tacked up or the anticipation of what may be about to happen. These horses would need to be assessed again with the bridle minus the noseband to see if the tightness and pressure associated with the noseband were the fundamental reason for the rise in the physiological parameters mentioned and measured.

Psychological states may have an impact on both the heart rate and the respiration without there being any obvious reasons for these changes, such as an increase in exercise or change of environment. Therefore, in these instances heart rate variability is a good indicator of psychophysiological stress, be it positive or negative and can be a useful tool for assessing stress that otherwise may not be noted or able to be observed, (von Borstel *et al.* 2016).

However, the assumption the change in HRV or HR is related to any one variable cannot be guaranteed. (Younes *et al.* 2016). Visser *et al.* (2002) reinforced the role of individual response and horse temperament in determining HRV and this influence suggests horses who aren't naturally calm would not be good subject for HRV measurement (Coelho *et al.*, 2017). Therefore implying the measurement would not be representative on unpredictable or on horses with unknown temperaments.

1.10 Rein tension

The bit and the rein tension applied via it is fundamental in horse-rider communication during ridden and in-hand training (Hawson *et al.*, 2014). Rein tension is defined as the force exerted along the reins via a mouthpiece or 'bit' in the horse's mouth, as an aid to control direction, speed and head position of the horse and is measured in Newtons (N) (Clayton *et al.* 2003). Rein tension has been shown to vary depending on additional factors such as the rider's dominant hand, the preferred 'side' of the horse, the perception of grip pressure by the rider and the laterality of the horse (Kuhnke *et al.*, 2010; Von Borstel and Glibman, 2014; Eisersiö *et al.*, 2015). Rein tension data have been used to identify the horses' contact with the bit in association with the tightness of the noseband (Randle and McGreevy, 2013), with rein tension increasing as noseband pressure tightens. To date, many studies investigating rein tension have used different types of nosebands, which are not fitted using a standardised and consistent method (Lemon, 2016). For example, Eisersiö *et*

al. (2013) reported horses wore standard bridles, however participating horses wore a mix of cavesson nosebands and flash nosebands. To date, the effect of flash nosebands on rein tension have not been investigated. Flash nosebands are designed to restrict the horse from opening the mouth (Casey *et al.*, 2013) comparing horses subjected to different noseband conditions is likely to yield incomparable rein tension data (Lemon, 2016). Future research evaluating rein tension should include descriptions of noseband type and tightness (Lemon, 2016). However to fully evaluate the impact of noseband type and tightness, studies which evaluate the effect of this piece of equipment on rein tension are also needed.

Rein tension devices are based on a gauge consisting of two sensors attached between the bit and the rein (Clayton *et al.*, 2005). Via a data logger, the information is then sent to a computer, then using bespoke software the rein tension is displayed in a real time graph. Through telemetric assessment, pressures can be visualised instantly and the resulting graph can show the amount of contact, any obvious unevenness of the contact and can be directly linked to the horses' way of going at that moment in time, as well as being linked to behaviours that can be recorded via video for further linked analysis. Commonly rein tension devices weigh around 20g and are integrated into the reins and are small enough to be considered unobtrusive and can be applied with no consequence to the rider or the horse (Lemon, 2016). This subtlety is a rare occurrence when physical data are being collected and in many circumstances the application of the recording devices can alter the operating conditions for the horse and rider even before the data collection has started.

The production of a cumulative pressure measurement is a complication in existing rein tension systems and further development is required to identify the horse and riders individual contributions to the tension measured (Lemon, 2016). Tension can also be influenced by the movement of the horse's head and neck and depends on the rhythm and the gait of the horse. Clayton *et al.* (2003) noted that the pattern of the horse's head rise and fall within the gait corresponds to the rhythmic pattern of the gait, and this correlates to the peaks in measured tension. Egenvall *et al.* (2015) examining stride variations in rein tension in walk and trot showed that biphasic patterns were found mainly in trot. The highest rein tension was found in the suspension phase in trot, and the lowest observed in the stance phase. In walk, the highest rein tension was found at hind limb stance. This study also highlighted substantial between-rider variation in walk and trot and between-horse variation in walk (Egenvall, *et al.* 2015). Studies of rein tension therefore need to consider many factors including the gait and the stride position and inter-horse variability.

Rein tension data and its interpretation encourages much debate as the simple term learnt by the majority of horse riders is to have a 'contact' with the horse's mouth via the rein and hand connection. However, this concept is vague and difficult to describe. Randle *et al.* (2015) looked at pressure and perception of rider's pressure on a dummy horse, they looked at perceived rein tension and actual rein tension across a wide range of participants. The results identified that the majority of participants had a greater rein tension in the right hand / rein than the left and that the perception and the reality were often not as riders perceived them to be. Similarly, Hawson *et al.* (2014) identified higher rein

tensions in riders' left reins during walk to halt transitions. Whilst Keinapfel *et al.* (2014) found that rein tension increased in many dressage competitions and warm ups, associated with increased collection. Additional studies have shown that rein tension varies between riding sessions, riders, horses, reins and other equipment, gait, exercises and also between- and within-strides (von Borstel and Glißman, 2014 and Clayton *et al.*, 2003, Clayton *et al.*, 2005, Clayton *et al.*, 2011, Egenvall *et al.*, 2012, Egenvall *et al.*, 2015, Egenvall *et al.*, 2016 and Eisersjö *et al.*, 2013; Eisersjö *et al.*, 2015, Heleski *et al.*, 2009, Kuhnke *et al.*, 2010, Warren-Smith *et al.*, 2007), indicating the range of variables that all need careful consideration before determining a guide for the horse owner or rider.

Rein tension relies on many factors such as the rider, the horse, the external factors such as the environment and the tack being worn. The current lack of standardisation of rein tension monitoring and the low sample sizes used within studies, prevent results providing a definitive measure of equine welfare (Lemon, 2016). Assessment of rein tension is relevant to equine welfare because it is assumed that excessive tension may be deleterious to the horse's welfare (Ödberg and Bouissou, 1999). However, until there can be an actual method to measure and identify a 'good contact' this discrepancy will mean that the measurement is reliant on both the interpretation of the rider and the physical responses of the horse (Egenvall *et al.* 2015).

1.11 Bit Pressure

Bits are often blamed for poor performance and the demonstration of conflict behaviours in horses (Murray *et al.*, 2015). However, noseband fit will influence bit position and rein tension, and the potential cumulative effect on equine welfare should also be considered (Clayton, 2011). Overall (2016) argues that as humans use reins as tools for communicating and controlling horses and these are often harsh and applied with force then this must be a welfare issue. Horses are trained to allow bits attached to reins to be put into their mouths, but bits interfere with the full range of tongue motions, indicating the mixed opinions of pressure and welfare measurements and controls. Manfredi *et al.* (2010) found that there was significant increase in tongue movement when rein tension was applied to a range of different bits, but importantly that the oral movement did not alter with the use of different bits, only in response to the additional tension applied. During the study, the occurrence of mouthing of all the bits rose with increasing pressure (Manfredi *et al.*, 2010). This is not surprising and in practice is commonly seen as a desirable behaviour of the horse, indicating acceptance of the bit by the horse, although one that could not actually occur with a restrictive noseband fitted. The retraction of the tongue away from the bit was linked to the increase in rein tension and again did not differ between bit type and their varying actions, only rein tension. The retraction of the tongue was in response to pressure and it was sensibly the horse removing the sensitive tissues away from the pressure being generated from the bit as the rein tension increased – this movement however is not an option for the horse wearing a restrictive noseband.

Horses are ridden by humans who are unable to determine their behaviour signals (Hendriksen, 2013), but are also subjected to the humans' poor knowledge of which bit design applies which pressure and how. A range of bits tested by Hendriksen (2013) were x rayed when *in situ* in the horse's mouths with a range of rein tensions applied. The range of identified areas of pressure and the variation and movement of the bits and therefore the application of pressure was substantial, and this combined with restrictions of horse behaviour caused by the use of other tack such as nosebands, creates a significant amount of largely non understood pressures on a horse when a 'good contact' was applied. Clayton (2011) reviewed the pressure applied by tack to many areas of the horses head and speaking at ISES (2011) described how the soft tissues such as the tongue were more able to withstand pressures than the harder tissues such as the hard palate, the nose, jaw and the poll. Clayton (2011) discussed the possible implications of the pressure being removed from the oral cavity and applied elsewhere and discussed that this would not necessarily remove the problem but may simply move it to an area of the horse less able to tolerate the pressure than the mouth is. Clayton (2011) argued without a full understanding of the impact of this rearranged pressure the alteration would not necessarily improve welfare for the horse in anyway. If the tongue is able to move it is able to withstand more pressure than the solid, fixed harder tissues with a less mobility than the oral cavity. Many of the actions of the bit create pain and resistance behaviours from the horse and these actions of a bit when pressure is applied need to be carefully considered especially if the horse cannot open his mouth to avoid them (Clayton, 2011).

To address these concerns, some welfare campaigners have focused on moving towards the use of bitless bridles. However Clayton (2011) suggests that caution should be expressed in moving immediately to bitless bridles as this change from a bitted to a bitless bridle may simply be a case of moving the problem of the pressure and worryingly possibly to an area less able to withstand it. Studies by Quick and Warren-Smith (2009) have identified equal or improved performance of horses wearing bitless bridles in comparison to bitted bridles. The equine subjects wearing the bitted bridles displayed more conflict behaviours, such as tail swishing, opening of the mouth, more chewing and pawing the ground than those in the bitless bridles. The designer of the Dr Cook bitless bridle, Cook (2012) refutes all of Clayton's claims and argues that bitless bridles remove the majority of the negative pressures and therefore the sources of conflict behaviour. This dispute highlights the need for science to provide an evidence base for practice and the potential confusion, which could result in the lay audience, if they have to judge arguments made from reputable and respected equestrian researchers who would both appear to hold welfare at the heart of what they do.

1.12 Welfare considerations

The welfare of the equine subject has been highlighted over the past decade. Increasing numbers of people now keep horses for leisure and sport but many lack the correct knowledge, beliefs and experience to ensure welfare is fully considered in their care regime. There are also the 'older generation' horse

owners who are reluctant to accept any new developments especially through equitation science or new information that would improve welfare for the horse. Equine industry professionals have a responsibility to improve communication to ensure the important emerging messages are being passed to all horse owners about simple methods and basic alterations in day to day care, such as the fitting of a noseband, or the determination of a light contact to improve horse welfare (Visser *et al.* 2011).

Training methods can be varied and adapted to accommodate the welfare implications of the horse. However, Rushen (1986) identified that a major issue in the interpretation and measurement of welfare is that stress can be altered by so many variables and factors and can be the normal reaction of an animal 'learning'. Reviews of equestrian training methods and the use of positive and negative reinforcement have increased and tend to show that the use of positive reinforcement combined with occasional negative reinforcement had preferable results compared to the use of only negative reinforcement (Warren-Smith and McGreevy, 2007). The simple implementation of pressure release in training such as removal of pressure from aids such as the rein, spurs, nosebands and the contact at the correct time and at the correct moment can help reinforce positive behaviour. However if these pressures remain, even when the horse responds, such as would occur with a fixed tight noseband, then this can inadvertently reinforce unwanted behaviours (McGreevy and Mclean, 2010).

Christensen *et al.* (2010) used a range of naïve, young horses to see if their own pressure application of rein tension for a food reward would indicate how

much pressure they would willingly apply to gain their reward. They had to place themselves under increasingly hard rein tension to reach the food rewards and initially they placed themselves under quite high rein tension to get the reward (day 1). However as the study progressed the horses all avoided the rein tension and selected to not reach for the reward to avoid the tension on the reins as they could predict what was coming. This indicates that the application of tension with no option for the horse to take themselves away or release is a welfare issue, demonstrating horses will chose to avoid rein tension and pressure if at all possible. As rein pressure is applied to the ridden horse the positioning of the head behind the vertical is achieved as he tries to move away and seek relief from the bridle pressure (Murray *et al.* 2015). Lee *et al.* (2011) suggest not all horses are strongly motivated to exercise, especially alone and will choose not to endure forced exercise on a treadmill, even for rewards. Rather they will exercise and select to move with their 'herd' or company as the predominant driving force. Horses choose to stay with their herd for safety, security and as a response to their natural instincts. In no circumstances do free horses force themselves to participate in prolonged exercise, it is not a favoured option but used to escape, to seek food, to locate water or to keep up with a moving herd. Warren-Smith *et al.* (2005) showed that a large proportion of people involved with handling of horses continue to apply excessive amounts of pressure on the horses' mouth that results in the horse ignoring the pressure, in the form of non-performance and non-responsiveness, both identified as learned helplessness. This then escalates to a harder bit being utilised by the rider and the cycle continuing.

The developments currently associated within equitation science have begun to highlight some of the key issues and misconceptions associated with traditional horse training and the development of top class competition horses. There is a shift emerging which is permitting more scientific evidence to support theories associated with welfare and the performance of the horse and to view issues from the horses' perspective. This evidence is paving the way for improved welfare in equestrianism (Jones, 2009).

The awareness and consciousness of animal welfare can come across dilemmas such as if to improve welfare in a given situation increases stress or suffering in another area, for example the use of head restraint to attempt to improve the stunning procedure for cattle increases the time before the animal is stunned. In this instance and because of this delay and the additional restraint the cortisol levels in the blood are over double that if cattle are stunned without the head restraint. So in this instance in an attempt to improve welfare for cattle at slaughter, the cattle were placed under prolonged and greater stress (Ewbank *et al.* 1992). In the example of cattle at slaughter, the only viable option to improve welfare would be if the cattle can be calmly and quietly placed into the head restraints before stunning. However as ultimately this is a business and time is important it is unlikely to be accepted as achievable by the owners of slaughter houses as it will not have any positive impacts on profit, quality of the meat or the utilisation of their staff. Equestrianism is positioned between pet owners having a horse and professionals owning horses requiring performance to complete a job. Therefore for the professional the success will often be the goal and the requirement and for the recreational horse owner

welfare may outweigh competition success (Williams, 2015). Ensuring that any developments of welfare indicators, assessment measures, guidelines or recommended changes are user friendly, non-invasive, cheap, readily available and achievable realistically for all users to implement is essential if they are to be accepted into the equine market and fully utilised. If they are to be accepted and utilised, they must be easily integrated into every day equine life and not remain just for the elite or the researchers who believe in and understand the product.

1.13 Helplessness / Learned Acceptance

It has been suggested that some horses may suffer from depression-like conditions (Fureix *et al.*, 2012; Fureix *et al.*, 2015), which may be related to the psychological condition of learned helplessness. This is where the horse attempts on repeated occasions to 'escape' from a pressure or restraint so much so that when the restraint is removed the horse is still unable to show or display these behaviours. Increased levels of conflict behaviour appears to be a sensitive parameter for stress in horses, but the reversed conclusion that the absence of conflict behaviour is indicative of good welfare is not always valid (Waran and Randle, 2013). The application of tack and its incorrect/inappropriate use where it prevents the display of natural behaviours and creates the need for the horse to show adverse behaviours such as opening the mouth to remove the pain or pressure of the bit, have the potential to lead to learned helplessness in the horse (McLean and McGreevy, 2006). An absence of the display of resistance or conflict behaviours indicative of

resistance does not mean that the resistance, distress or pressure is acceptable or that the horse is coping. This inward containment of stress can be much more difficult to measure and evaluate for riders, trainers and judges alike (McGreevy, 2007).

1.14 Solutions for improved welfare in modern equestrianism

Identification of traditional equestrian techniques that may be inadvertently associated with resistance behaviours should lead to alterations in the guidance distributed to riders from governing bodies and influential societies associated with horse ownership (Randle, 2015). For example, Clayton *et al.* (2011) found that horses are more willing to accept elastic side reins than fixed ones and that the length of the side reins can impact on the rein tension and the forward movement that results. This is a simple development that could lead to many horses having a more pleasant and less stressful experience while undergoing training. Establishing clear guidelines for horse owners and riders and not just vague terms that are open to interpretation is essential for the improvement of equine welfare. Areas such as 'a good contact' need clarification and this is essential to ensure standardisation of the developments throughout the equestrian community. For example determining what exactly is meant by a 'tight' rein contact, 'medium' contact and a 'sensitive' contact and the differences between them. These are definitions that without clarification can vary unintentionally through an ignorance of the exact requirements or the

definition can be misinterpreted by readers, practitioners and scientists, researchers and coaches alike.

The ultimate aim for equitation scientists should be to define and quantify as many scientifically identified features that can improve welfare as possible and disseminate this information to all areas of horse ownership in an understandable context. Alongside the physical actions applied to horses through training processes McGreevy *et al.* (2005), identify and advocate the need for a description of commonly used terms within equestrian training, coaching and basic care circles that define for all a quantifiable and exact guide so everyone associated can be aware of the implications of simple and every day terms such as 'contact'. A study that highlighted this misinterpretation of information was carried out by Warren-Smith *et al.* (2007) who identified that riders and judges perception of rein tension was vastly different from the rein tension data collected. This study highlighted that education amongst persons associated with horses at all levels is vital for the emerging developments in equitation science to be correctly interpreted and implemented in the equestrian world.

Equitation science allows the development of scientific methods to be studied and to be able to measure impacts between horse and rider and assist in promoting the welfare of the horse through identifying simple alterations or variations that can be adapted to improve the overall experience of a situation for both the horse and the rider / handler (Goodwin *et al.* 2009). This is clearly

needed in the debate associated with nosebands, competition guidelines and identifying acceptable rein tensions during riding.

1.15 Progression following this trial

This study aimed to identify variations in the horses' rein tension and behaviour in response to different fittings of a noseband, enabling the preliminary basis of identification of a 'best fit' for horse and rider. If the noseband can be fitted at the level identified to reduce rein tension this can improve the ridden welfare for the horse and the experience for the rider.

Professional personnel within the equestrian industry must be encouraged and supported to integrate the findings of equitation scientists into their own practice and to disseminate them to the horse owning population. Warren-Smith *et al.* (2005) reported a distinct lack of understanding among accredited coaches about positive reinforcement to the horse during training. There appears to be a clear need to educate people to enhance the welfare of horses and reduce the behavioural conflict and resistance that may provide the rider with an unsatisfactory experience and may lead to horses being replaced and rejected because of the occurrence of behavioural problems (Odberg and Bouissou, 1999).

Chapter 2 - Materials and Methods

2.1 Equine subjects.

This study involved 15 horses (Table 2.1) of variable sex (mares: n=6; geldings: n=9), age (range: 6-22 years; mean: 11.1 years) , height (range: 15hh – 16.3hh) with in excess of 3 years ridden experience, and which were currently working at pony club or riding club level. No novice horses were included in the study. All horses had been ridden regularly over the last three years with no time off for injury or any other reasons. All of the group were ridden on average a minimum of three times, and were subject to the same management protocols. All horses were up to date with vaccinations as they were kept on a public yard and all had received routine dental care within the last 6 months.

Table 2.1 Information about the equine subjects and their associated individual details.

Horse	Age	Gender G= Gelding M=Mare	Normal Bit	Normal Noseband	Main Use **	Rein Type *	Pattern followed (1=LOOSE, 2=NORMAL, 3=TIGHT)	Age and Gender of Rider M=male F=Female	Martingale worn on a day to day basis ***
1	9	G	lozenge double- jointed loose ring snaffle	Flash	C	R	1,2,3	23 F	R
2	11	G	Eggbutt snaffle	Cavesson	RC	R	3,1,2	17 F	NM
3	14	G	Dutch Gag happy mouth	Flash	RC	R	2,3,1	35 F	NM
4	7	G	Pelham	Grackle	RC	OS	1,2,3	47 F	R
5	20	G	Loose ring snaffle	Flash	RC	W	3,1,2	58 F	NM
6	22	M	Happy mouth loose ring snaffle	Flash	H	Le	2,3,1	49 M	NM
7	13	M	Loose ring snaffle	Drop	H	La	1,2,3	35 F	NM
8	10	G	Full Cheek Snaffle	Flash	RC	R	3,1,2	22 F	R
9	9	M	Eggbutt snaffle	Cavesson	RC	R	2,3,1	52 F	R
10	9	M	French link, loose ring snaffle	Flash	RC	R	1,2,3	27 F	NM
11	12	G	Half cheek snaffle	Grackle	RC	W	3,1,2	56 F	NM
12	11	G	Loose ring snaffle	Flash	RC	R	2,3,1	30 F	NM
13	7	M	Universal bit	Flash	C	La	1,2,3	18 F	NM
14	15	G	Loose ring snaffle	Flash	H	La	3,1,2,	51 M	R
15	6	M	Fulmer snaffle	Flash	RC	R	2,3,1	31 F	NM

**

RC – riding club, local shows and competitions, range of jumping, flat work and hacking, some lessons

H – just hacking, may visit other locations in transport but only to complete ‘rides’ can be in large groups as part of clubs, but no planned jumping or competitions

C - regular competitions, competed above local level

*

R – rubber covered

La- laced leather

Le – plain leather

W – webbing with leather markers part way along

OS – one sided rubber reins

R – Running martingale

S – Standing martingale

NM - No martingale worn on a day to day basis

2.2 Location of data collection

The trial took place at a privately owned livery yard, in the South West of England, adjacent to Dartmoor in a very rural location. All horses were looked after by the same owner, on a DIY livery basis, but on the odd occasion may be fed, led in from the field or turned out by the owners of the yard. The horses in the trial were ridden predominately by their owner, but 9 of the 15 were also regularly ridden by friends of the owners or other family members. The remaining six were rarely ridden by any person other than their owner.

Ridden trials were undertaken in a 25 x 45m outdoor arena, covered in a sand and rubber surface, flanked by tall fir trees on two sides, the other sides are surrounded by high banks. The surface was harrowed 2/3 times per week by the yard owners. All of the horses in the study were acclimatised to working in the arena therefore the environment can be considered a 'familiar setting' to all of the horses. All horses were also accustomed to their rider, the majority of their tack, the time of day for the trial, the noise, the people being present outside the school fence and the presence of the 'helper' in the school prior to data collection.

2.3 Riders

Fifteen riders of variable age (range: 17-58 years), and sex (female: n=13; male: n=2) participated in the study. Riders were required to have ridden for a minimum of four years but many had ridden for much longer than this. Ten of the horse-rider combinations used competed locally; undertaking fun rides, and attend rallies and local riding club events. Two of the combinations have competed in the last twelve months at County level; three of the sample only hacked currently but did travel to local beach rides, moor rides and fun rides. Riders were asked to complete a questionnaire to ensure they met the inclusion and exclusion criteria for the study and to gather demographic information (Table 2.2). Each rider also completed a ParQ fitness (Physical Activity Readiness Questionnaire) prior to being in the study, to ensure they were physically able to complete the required ridden route.

Table 2.2: The Questions asked of each rider commencing the data collection.

Question	Question
How old is your horse?	How long has he / she worn this bit?
How big is your horse?	How old are you?
How long have you owned him/her?	What other tack does your horse wear on a day to day basis?
How long has he been at this yard?	When did you horse last have his / her teeth checked?
What is his / her normal ridden schedule in a week?	How long have you ridden horses?
What do you do with him? (Level)	What type of reins do you have on your bridle?
How often do you ride him / her in the school on site?	Is your horse ridden alone on occasion?
What bit does he / she wear?	What gender is your horse?

2.4 Tack

A range of bits were used normally for the horses in the sample (Table 2.1). No riders were asked to alter their horses bit for the trial to ensure changes observed could be directly related to noseband pressure and to maximise

equine welfare. Riders were requested to remove martingales prior to participation as martingales have been shown to impact noseband pressure and influence rein tension (Heleski *et al.*, 2012).

2.5 The Noseband

The noseband used for all of the horses was a plain cavesson noseband; numerous extra holes were punched into it to ensure the fit was the same for each horse. Noseband fit was conducted by one consistent experimenter using anatomical landmarks. Nosebands were positioned on a central measured area between the base of the prominent cheekbone and the corner of the horse's mouth, centrally to this measurement. This adjustment meant the noseband was positioned to the size of the horse's head and to allow for size variation between horses in the trial.

2.6 The Experimental Route

Horse and rider combinations were required to complete a set route in the arena (Figure 2.1). Rein tension data collection began as the rider turned off the outside track to commence the course at 'A'. It ceased when the horse and rider combination halted at X following the completion of the set route.

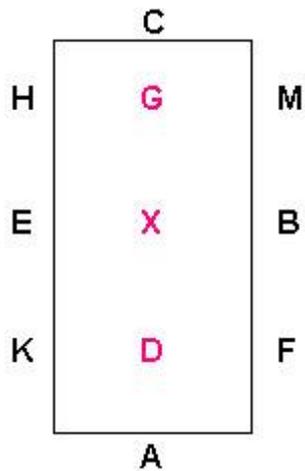


Figure 2.1 Diagrammatic representation of the school used for the trial
(Localriding, 2016)

2.7 The Procedure

Each horse completed the experimental route three times; once with the noseband on 'tight', once with it 'loose' and once with it 'normal':

- Enter at A in walk
- At X working trot
- Proceed in trot at C track right 20 m circle in trot
- Change rein MXK
- At A 20m circle in working trot
- Change the rein FXH
- Between H and C walk
- At C track right

At X halt

Noseband fit for each condition was adapted from the International Society for Equitation Science guidelines (ISES, 2017) and previous research (REFS) (Table 2.3; Figure 2.2).

Table 2.3: Noseband fittings

Tight noseband fitting	This was defined as firm contact between the noseband and the skin all the way around the horse's face, with no room for fingers or the taper gauge. No indentation of the skin was caused.
Loose noseband fitting	this was defines as one hole less than this horse's 'Normal' fitting
Normal noseband fitting	This was achieved using a finger measurement on the nasal plane of the horse concerned and measured using two fingers to ensure these could fit between the bridge of the noseband and the horse's rostral plane. Measurement was confirmed using the Taper Gauge.



Figure 2.2 The measurement used to reach the normal fitting of the noseband.

Table 2.4 shows the order the noseband fittings were applied to each horse in the trial. Riders' vision and awareness of the adjustment were not restricted while the noseband was being fitted and the application of the tightness was adjusted, however the riders were not told which setting their noseband was on, for each of the three trials. The noseband was in view of the rider and although they were asked to ride without consciously looking or altering their riding, this was a factor that could have influenced rein tension due to associated changes in rider behaviour. It was considered to remove the noseband from the sight of the rider to ensure the rider was not able to be aware of the setting, however this would have required a form of nose net or coverage of the horses' nasal area. This would have added another variable that would have been unfamiliar to the horse and that could have influenced the results.

Table 2.4: The order each horse wore the range of fitting nosebands.

Noseband Fitting	Horse No. 1, 4, 7, 10, 13	Horse No. 2, 5, 8, 11, 14	Horse No. 3, 6, 9, 12, 15
Loose	1	3	2
Normal	2	1	3
Tight	3	2	1

2.8 Data collection method

Rein tension is considered a good indicator to demonstrate the impact of tack on the ridden equine (Lemon, 2016). For example, if the noseband is tighter this could cause the horse to avoid bit contact or to take a stronger contact in response to the change in noseband pressure (Randle and McGreevy, 2013). Therefore, rein tension measurement can provide an objective and repeatable measure to enable assessment of different nosebands and their fit.

The cavesson noseband and the rein tension equipment were fitted to the horse's bridle in their stable or outside their stable while they were being tacked up, with the noseband set to the 'loose' setting. This simply replaced their own noseband so no habituation period was required. The horse then had their remaining tack put on; the only variation would be the variation in noseband and removal of the martingale. The rein tension attachments are designed to be unobtrusive, weighing 21g only and therefore once attached the horse and rider are able to complete normal activities without interference from the equipment (Figure 2.3).



Figure 2.3 The positioning of the Rein Check measuring equipment.

Each horse entered the arena and completed a warm-up walking around at least once, on their choice of rein. All riders selected the left rein to do this initial circuit of the school. Rein tension readings were checked to be working during this initial circuit of the school (Kuhnke *et al.*, 2010; Clayton *et al.*, 2005). In all cases, the equipment appeared to be picking up the rein tension and the relevant graphical representation of the rein tension appeared on the screen therefore no further adjustments had to be made. The horse and rider then were approached by the handler and had the noseband adjusted as indicated in Table 2.4. The horse was then monitored visually, and the rein tension readings were recorded by Rein Check™ and a laptop using SignalScribe™ on the outside of the arena and recorded by the horse number (Warren-Smith *et al.*, 2007; Kuhnke *et al.*, 2010; Christensen *et al.*, 2011; Egenvall *et al.*, 2012); von Borstel *et al.*, 2014; Hawson *et al.*, 2014); Christensen *et al.*, 2014). Each horse had the data recorded and the data set was labelled sequentially: horse number: loose, horse number: normal and horse number: tight. The defined route was called out for the rider by the

handler. On completion of the exercise route, the horse and rider approached the handler for the second and third adjustments of the noseband, and the route was repeated until all three noseband conditions had been completed successfully (Randle and McGreevy, 2013).

2.9 Data analysis

Rein tension data were collected on a laptop and downloaded and collated into a Microsoft Excel (version 2013) spreadsheet. The mean and standard deviation and median rein tension for each horse was calculated for each rein and for each noseband condition (Heleski *et al.*, 2009; Kuhnke *et al.*, 2010; Egenvall *et al.*, 2012; Chistensen *et al.*, 2011). Data were then transferred to Minitab version 17 for further statistical analysis.

Rein tension data were split further by the horse's age to see if there were any differences in the rein tensions with the variations in noseband fittings. The age of the horse was considered as a potential influencing factor as experience, acceptance and possibly learned avoidance may be more established in the older horse. Horse age was categorised at 14 years and below and 15 years and above as this is the age approximately where horses are at the end of their 'prime' and are then becoming the older generation.

Rein tension data were found to be non-parametric (Left Rein AD = 158.2; $P < 0.005$), (Right Rein AD = 77.0; $P < 0.005$), therefore a series of Friedman's Repeated measures tests were calculated to analyse if differences occurred in

rein tension with horse age and between the nose band conditions for each rein (Field, 2009). Subsequent post-hoc Wilcoxon matched pairs analyses identified where significant differences occurred between the noseband conditions (Field, 2009).

CHAPTER 3. Results

3.1 Descriptive results

The mean rein tension data for both reins demonstrate variation occurred between the noseband tensions applied (Figure 3.1). Interestingly, variation was also found between left and right rein tension indicating variability in rein contact and potential 'sidedness' of the riders and / or horses. (Figure 3.2). A wide range of standard deviation was found within each rein tension reading demonstrating individual variability occurred within the horses sampled across all conditions (Figures 3.3-3.5; Table 3.1).

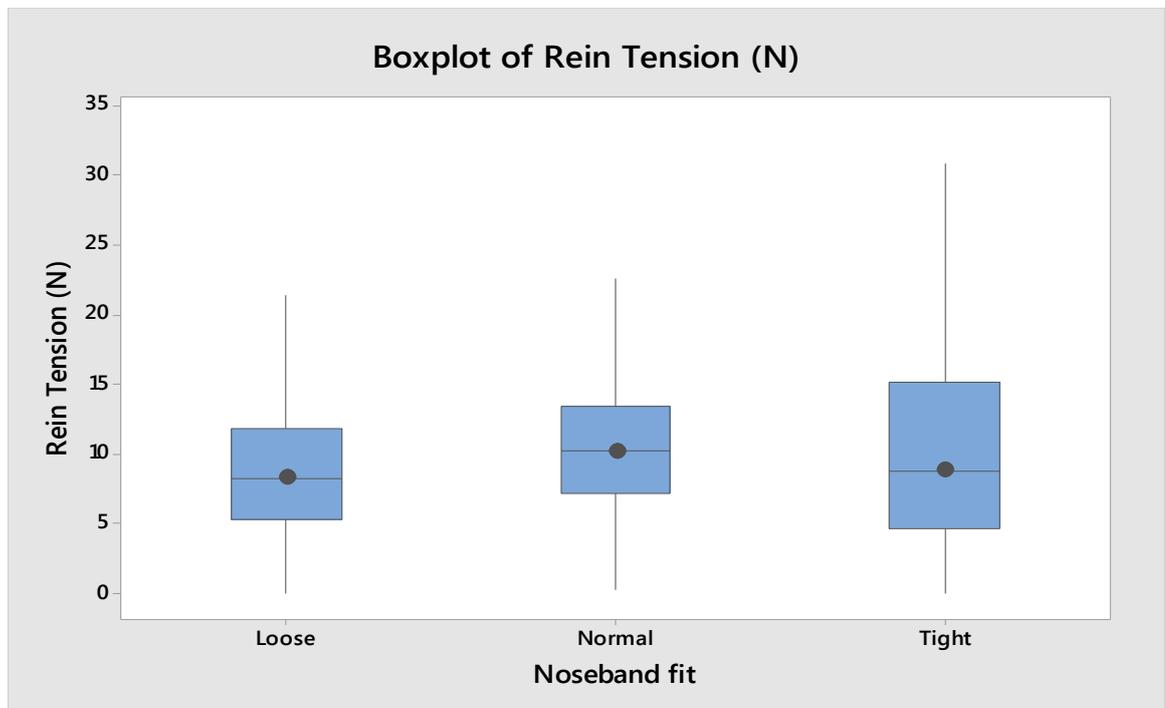


Figure 3.1 The effect of noseband fitting on rein tension (N) across the cohort

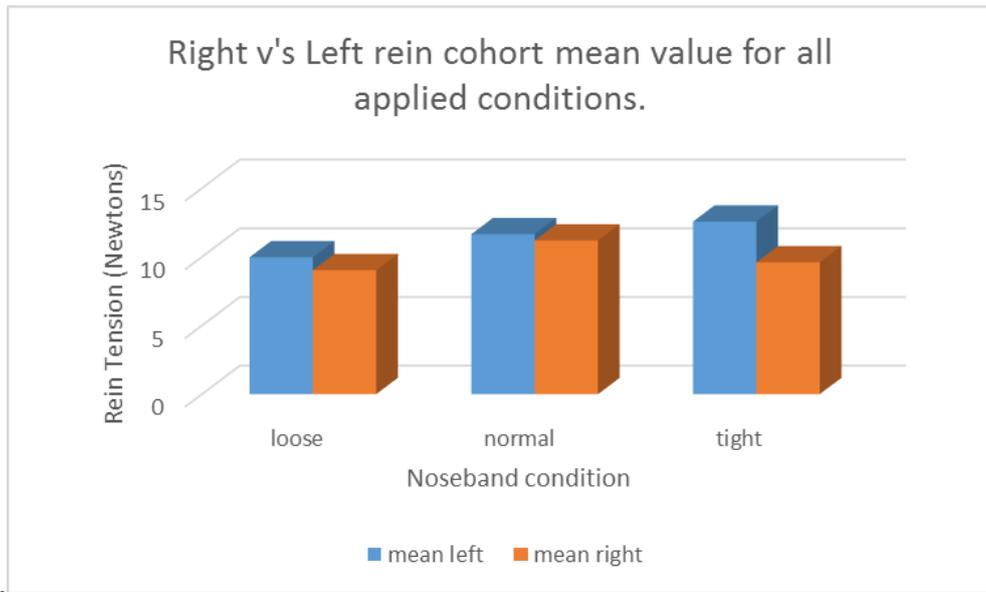


Figure 3.2: Right vs left rein cohort mean value for all noseband conditions

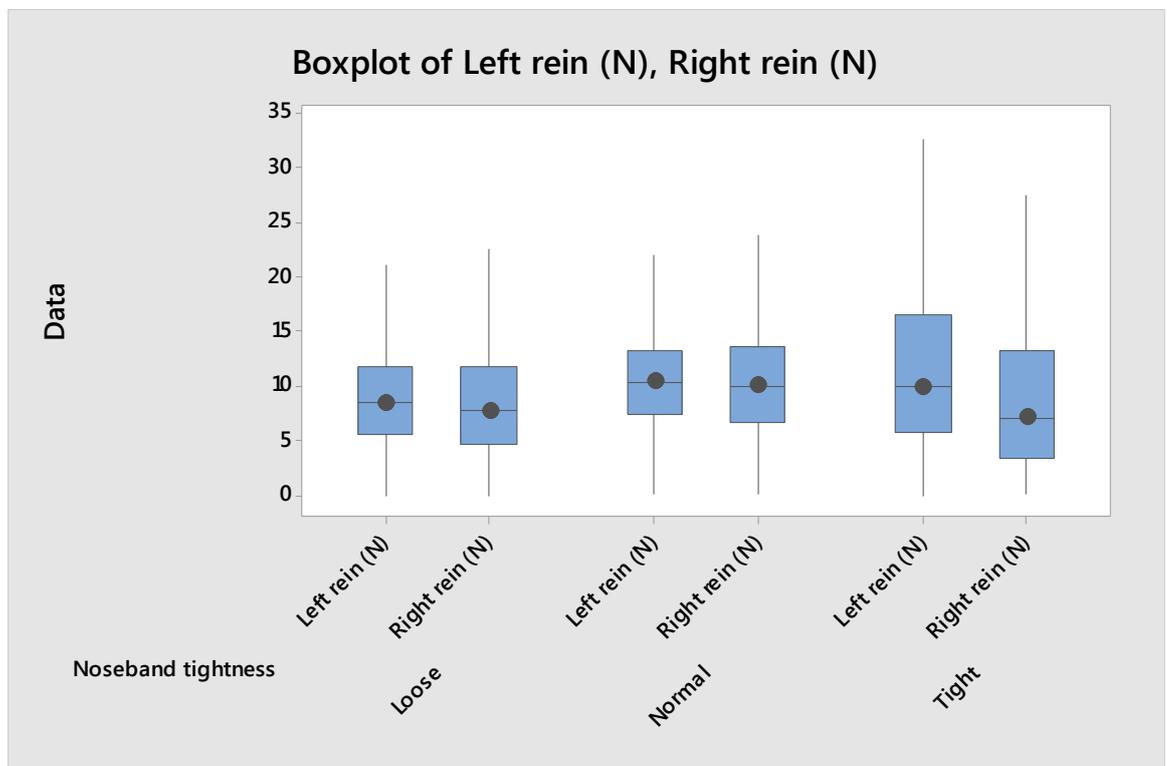


Figure 3.3 Left and right rein tension (Newtons: N) in relation to noseband fitting

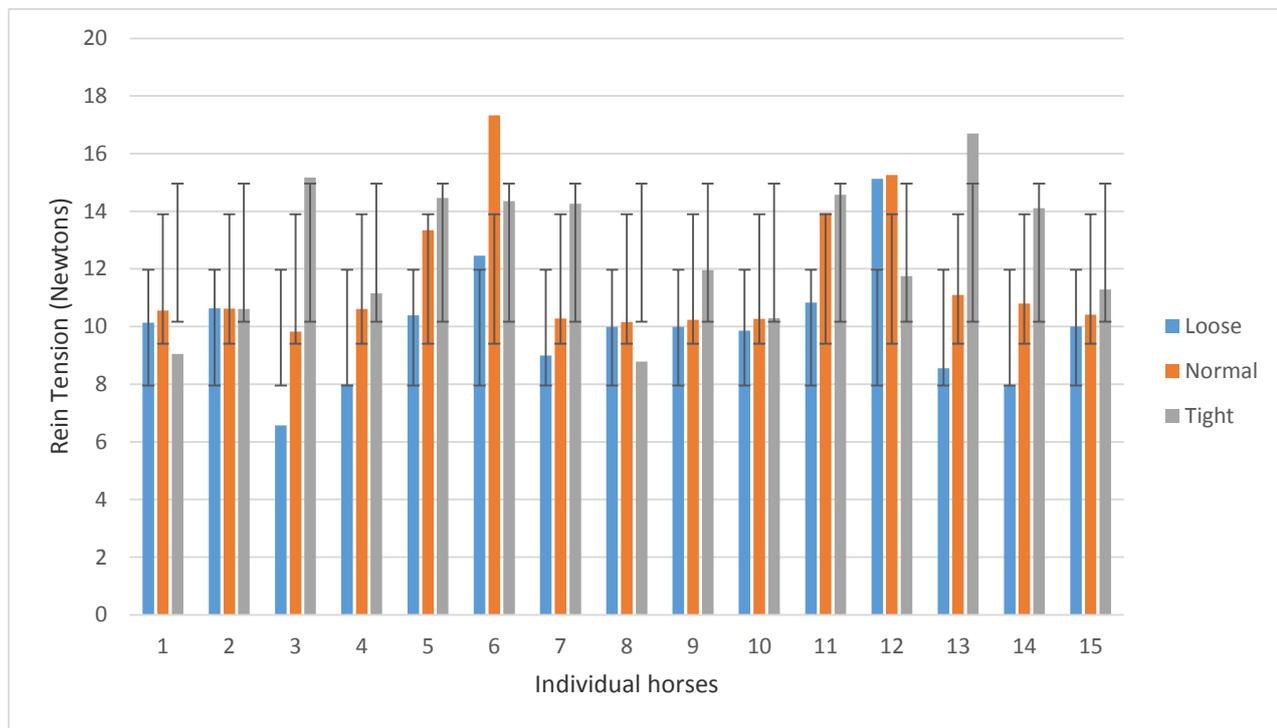


Figure 3.4: Mean and standard deviation for rein tension for the left rein across all noseband conditions.

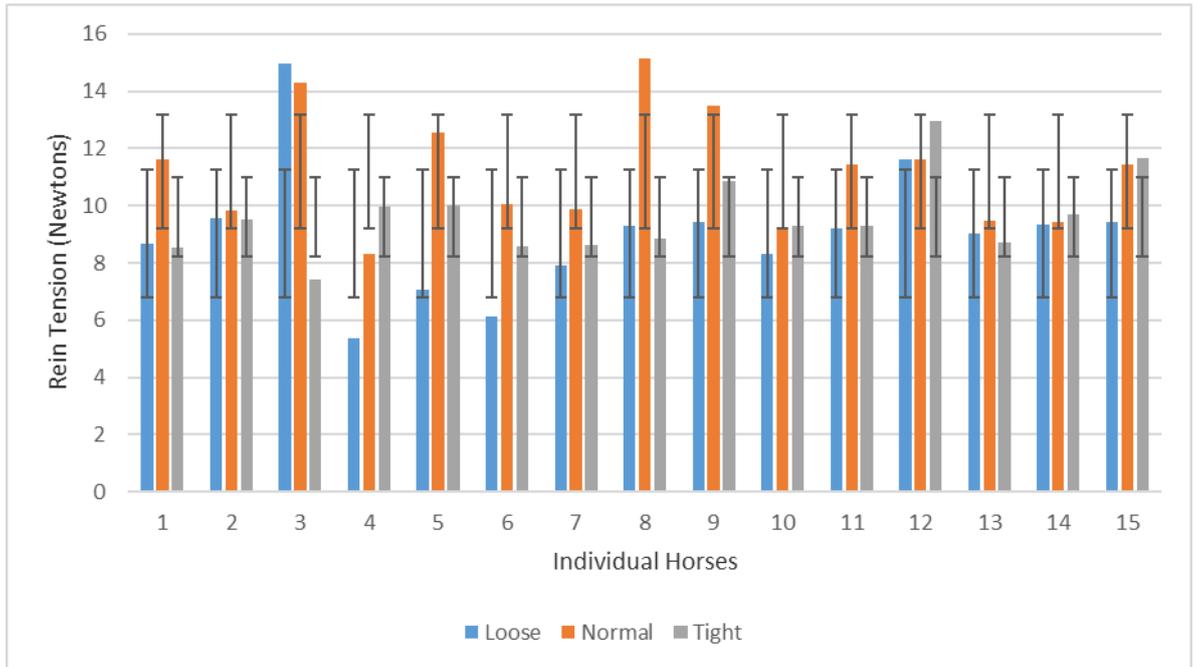


Figure 3.5: Mean and standard deviation for rein tension for the right rein across all noseband conditions.

Table 3.1 Mean rein tensions for the left and right reins across the different noseband conditions.

Rein tension (Newtons)	Left Rein			Right Rein		
	Loose	Normal	Tight	Loose	Normal	Tight
Horse						
1	10.13	10.56	9.05	8.68	11.61	8.54
2	10.63	10.62	10.61	9.56	9.85	9.5
3	15.13	15.26	11.75	14.95	14.28	7.42
4	6.57	9.83	15.17	5.35	8.31	9.95
5	8.55	11.1	16.7	7.04	12.55	10
6	7.95	10.8	14.11	6.12	10.06	8.58
7	7.99	10.61	11.15	7.92	9.87	8.63
8	10.39	13.35	14.46	9.28	15.14	8.85

9	12.46	17.33	14.35	9.45	13.48	10.86
10	9	10.28	14.26	8.33	9.22	9.3
11	9.99	10.16	8.78	9.21	11.46	9.31
12	9.99	10.23	11.96	11.63	11.63	12.95
13	9.86	10.27	10.29	9.04	9.49	8.73
14	10	10.41	11.29	9.35	9.42	9.71
15	10.83	13.94	14.57	9.45	11.45	11.65
Cohort	9.96	11.65	12.57	9.02	11.19	9.60
Standard deviation	2.01	2.25	2.39	2.24	2.00	1.38

3.2 Differences in rein tension between noseband conditions and reins

Significant differences in rein tension were found between the noseband conditions on the left rein (Friedman's: $P=0.006$) and the right rein (Friedman's: $P=0.05$). Post hoc analyses revealed rein tension increased with noseband tightness from the baseline loose condition on the left rein (Table 3.2) and between the baseline loose and normal condition for the right rein (Table 3.3). Therefore, hypothesis 1 that there would be a significant effect of noseband tightness on rein tension can only be partially accepted.

Table 3.2 **Variation between the combination of noseband pressure and the rein tension on the left rein.**

Noseband fittings	P; significance	Percentage variation
Loose – Normal	P=0.032; significant	17% increase
Loose-tight	P=0.010; significant	26% increase
Normal - tight	P>0.05	

Table 3.3 **Variation between the combination of noseband pressure and the rein tension on the right rein.**

Noseband fittings	P; significance	Percentage variation
Loose – Normal	P=0.006; significant	24% increase

The two reins (left and right) and the relevant conditions (loose, normal and tight noseband) for each horse were compared (Table 3.4; Figure 3.6). Interestingly, significant differences were reported in rein tensions recorded in riders' left and right hands but only for the loose and tight noseband conditions, with riders in this sample using higher pressures in their left compared with their right hand.

Table 3.4 **Wilcoxon signed rank within subjects left versus right rein for all horses across the noseband conditions**

Condition	P; Significance	Percentage variation in rein tension (Newtons)
Loose	P=0.008; significant	Left rein 9% higher than right rein
Normal	P>0.05; Non-significant	n/a
Tight	P=0.002; significant	Left rein is 24% higher than right rein

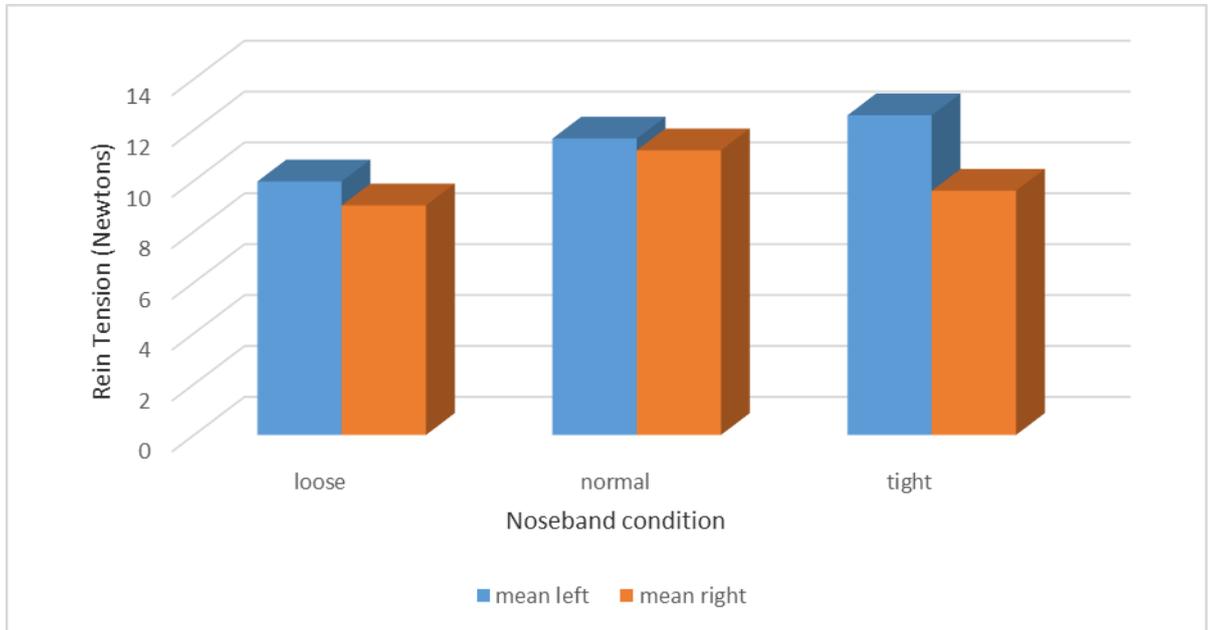


Figure 3.6: Mean rein tension values for the cohort in relation to the applied noseband conditions for the left and right reins.

3.3 Effect of age on rein tension

No significant differences related to horses' age were found in rein tension in either rein across all conditions (Mann Whitney U: $P > 0.05$). Therefore hypothesis 2 that there would be a significant difference in the median rein tension (N) recorded for young (ie. ≤ 14 years old) and the median rein tension (N) recorded for older (ie ≥ 15 years old) horses was rejected.

Chapter 4. Discussion and Conclusion

The results of the study suggest that a relationship between noseband fit and rein tension does exist, however further work in more horse and considering rider laterality is required to substantiate this.

4.1 *The fitting of the noseband*

The fitting of a noseband is currently subject to much discussion. Contemporary rein tension research currently indicates that more tightly fitted nosebands may apply unacceptable pressure to the horse's skin, face head and oral cavity, and impede the desired effect of the bit (Casey *et al.* 2013; Doherty *et al.* 2016). Excessively tight nosebands may also may mask undesirable behaviours that should not be exhibited by accepting, willing and well-trained horses, such as avoidance of the bit through opening the mouth, raising the head to avoid a contact and snatching the bit from the rider (McGreevy and McLean 2010). The varying types of noseband and their implications for the horse need to be fully understood through scientific research to ascertain the acceptable pressures and to ensure welfare is maintained. Without this legislation to control and provide limitations and evidence from research there is the potential to impact not only on welfare but also to reduce the horse's performance through the application of a noseband that is restricting the horse's way of going (Waran and Randle, 2016; FEI, 2016; Pony Club Rule Book, 2016).

The results show an increase in rein tension when the noseband pressure increases from loose upwards, to a higher tension. Rein tension increased from the baseline loose fit to the normal and tight fit on the left rein but only for the normal fit on the right rein. Previous research reported higher rein tension with loose cavesson nosebands compared to tight ones (Randle and McGreevy, 2013). The variation observed here could be due to limitations in the research design to ensure the welfare of equine participants. The tight noseband condition used did not restrict oral movement or indent nasal tissues. Therefore, tight noseband fit may not have exerted a measurable difference in pressure from the normal fit used. Interestingly, rein tension data recorded on the tight fitting reported a wider range of tensions (Figure 3.4) which indicate a more unstable and varying contact and possibly more conflict between the rider's hand and the horse's bit. This could relate to the experience of the rider or the experience of the horse. Lemon (2016) has suggested that variability in rein tension can be associated with rider and / or horse experience and the lack of standardised methodologies used currently within the field prevents effect evaluation across studies. Evaluation of individual horse's rein tension profiles within each condition could also prove useful to assess how rein tension varies with gait and rider performance, as these factors could have influenced the median pressures obtained (Clayton, 2011). Further research combining rein tension and noseband pressure assessment is warranted to fully explore the influence of noseband fit.

When the noseband is on a loose fitting there appears to be less rein tension (Randle and McGreevy, 2013). This could be because the horse is not fighting

any restriction or feeling any pressure associated with the bridle application. It has been identified that the action of the bit can be affected by noseband tightness (Manfredi *et al.* 2010; Hendriksen, 2013). Therefore in the baseline condition, for a rider who maintained a steady contact with a loose noseband the bit would be working as desired producing a consistent contact and rein tension. Once the noseband is tighter even by a smaller amount, then there is the added change of additional pressure from the bit. This will vary as bits have different actions, therefore without reducing the variation of bits used in a trial this would need further investigation associated with links between specific bit type to the noseband fittings and rein tensions observed. Limited studies have investigated the effect of bit type on rein tension (Manfredi *et al.*, 2005; Manfredi *et al.*, 2010; Cross *et al.*, 2016). Interestingly, Manfredi *et al.* (2010) found a significant increase in conflict behaviour when rein tension was applied vs. loose reins using six bits, but individual bit type had no effect. The opportunity to have all horses wearing the same bit to be able to monitor the varying response would demonstrate further how the application of a tighter noseband can impact on the action and subsequent pressure from the bit. However changing a horse's bit may instigate rider apprehension and change the way an individual rides a horse, adding another potentially confounding variable which could influence rein tension measurements.

If the increase in noseband pressure from loose to normal, or to tight, or to any tighter setting applies pressure to the nose area and causes disruption in the oral cavity this can be linked to the horse trying to remove themselves from this pressure. Horses avoid pressure, (McGreevy and Mclean, 2010; Christensen *et al.* 2010; Murray *et al.* 2015), and this has been established as an effective

method of learning, apply pressure, release pressure, (Murray *et al.* 2015), once action is performed to provide a reward in the form of released pressure. If the horse is seeking to resist the pressure of either the bit or the noseband this links to the increase in rein tension as the horse tries to remove the pressure. The wide range of standard deviation observed in rein tension across all horses and trials could suggest that horses were taking and releasing the bit during ridden work. The noseband conditions used in this study did not result in any horses exhibiting avoidance responses (Williams and Warren-Smith, 2010) or displaying unresponsive behaviour indicative of learned helplessness (Cronin *et al.* 2003, Doherty, *et al.* 2013). The horses in this trial were all well behaved horses that were used to the application of a noseband and the bit, they had all been ridden for many years and shown no conflict behaviours and therefore it can be concluded that these horses are aware of the pressures and chose to 'accept' them. This could explain the rise in rein tension from loose to normal, where the horse feels the pressure and resists initially, but then through learned acceptance or awareness of this pressure, the horse accepts the situation. The use of experienced, established ridden horses does not allow for the unsuppressed emotions, perceptions or reactions of the horse to a new pressure and repetition of the current study within naïve horses before learned behaviours are established could provide valuable data on the true effect of noseband tightness on rein tension.

4.2 Variations in left and right rein tensions

Both horses and riders have been shown to have a specific 'handedness' or lateral dominance (Randle *et al.* 2011). A common term in a schooling session is 'he's stiffer on the left rein' or 'he prefers the right rein' indicating as with people, horses have a preferred side. (Randle *et al.*, 2015). The results suggest rein tension is affected by laterality with consistently higher pressures recorded on the left rein compared to the right. Interestingly the magnitude of left lateral preferences increased as noseband fit became tighter again suggesting that some form of relationship exists between noseband fit and rein tension. The majority of riders in the study were right handed and this would naturally be assumed to be their stronger hand. However, in practice lateral dominance can vary as there is sometimes an increase in pressure in the non-dominant hand as it has to work harder to compensate (Randle *et al.*, 2015). Previous rein tension studies have found rider's non-dominant hand applies higher rein tension compared to the dominant hand (Kuhnke *et al.*, 2010; Hawson *et al.*, 2014). These findings are surprising as laterality preferences are reported to increase grip strength, by up to 10% on the dominant side of the body, in the majority of the general population (Lemon, 2016; Oppewal *et al.*, 2013). The participant effect (Nichols and Maner, 2008) i.e. the subconscious knowledge of the riders that rein tension is being observed, may have also impacted on the results gained. Riders were observed during the trials and may have consciously tried to achieve evenness in their rein tension. Awareness of the trials was unavoidable and although riders were requested to ignore the trial taking place this was not always possible.

Rein tension is the combined pressure on the rein from the horse and the rider. Randle (2015) reported differences in what riders perceive as a light contact and the impact of rein type on perceived rein tension. Therefore it is recommended that future studies should determine both horse and rider laterality before the trial. The integration of a pre-ridden assessment using a dummy or mechanical horse and the taking up of a 'perceived contact' by the riders could be used to ascertain the pressure being applied from the rider without the influence of the live horse present.

An observation during implementation of the trial was that all horses on entering the school, to begin the trial did their initial 'walk around the arena' on the left rein. This was not requested, suggested or influenced in anyway. The riders were asked to walk around the arena once before the noseband fittings were adjusted and the trial began and all of the 15 riders entered the arena and had a free choice to decide which way to walk around the perimeter but all chose the left rein. Further investigation prior to the rein tension tests would need to be undertaken to eliminate or document the variation before the results were collated and analysed.

4.3 Effect of age on rein tension

Surprisingly no significant effect of horse age on rein tension was observed for the cohort studied. Older horses were expected to display different rein tension profiles compared to younger ones, due to their increased experience. Previous rein tension studies have used horses with a wide range of experience, from

those naïve to bridles (Christensen *et al.*, 2011) to elite level equine athletes (Eisersiö *et al.*, 2013). The training level of both horse and rider are thought to influence rein tension readings (Lemon, 2016). Rein tension measurements in work to date do not display a consistent pattern for horses naïve to ridden work compared to their more experienced peers (Lemon, 2016), but other factors associated with training have been shown to influence pressures recorded. For example, the head and neck position of the horse and the associated shortening of rein length generally results in increased rein tension and a higher frequency of evasive behaviour being observed (Clayton *et al.*, 2011; Eisersiö *et al.*, 2013; Christensen *et al.*, 2014). Inclusion criteria were applied to ensure equine participants used in the current study were of comparable experience and this could explain the lack of significant differences in rein tension observed.

4.4 Use of the findings in industry

For the inexperienced owner guidelines relating to welfare, safety and control need to be created so an informed decision can be made about their choice of tack and its application. If the guidelines from the research link to welfare then the majority of horse owners would want to utilise this information. For the more experienced riders and competitors the guidelines need to become rules and if these are integrated to all the governing bodies then the horse's welfare will improve as restrictions will be removed from such severe and damaging levels to an acceptable tension that the horse can better tolerate. The development of recommendations for riders of all levels about rein tension and the

establishment of a contact can be developed as well and should be integrated within riding theory and learning.

4.5 Conclusions

The fit of a cavesson noseband did have an impact on the rein tension recorded for experienced horses. Generally rein tension increased when the noseband was tighter than a loose fit in contrast to previous research. Higher rein tensions were reported on the left rein, which could be related to rider or horse laterality. This study was completed on leisure horses with day to day riders; further research using professional riders and experienced horse and naïve horses and more inexperienced riders are required to fully explore the impact of noseband fit on rein tension.

Increased noseband pressure resulted in associated increases in rein tension recorded for these horses, increasing the pressure the horses feel on the bit and the nose. No signs of detrimental welfare were observed throughout the study. Going forwards, it is the establishment of when pressure related to noseband fit results in excessive rein tension and becomes a welfare issue that are needed. Further studies are also needed for clarification of external variables and their impact on the results, however the rise in rein tension in this trial may be indicative of the widespread implications of incorrectly fitting tack. To ensure all horses are not subjects of unacceptable pressure, guidelines need to be developed and then integrated into equine competition and legislation that are fully developed and explained with a transparency that the

whole riding population can understand. Ensuring that horses are not subject to unacceptable pressures in the name of pleasure riding or equine competition. These processes must be put into action sooner rather than later if the riders and trainers involved with riding horses can be confident that the welfare of the animal is at the heart of riding horses at any level.

References

Abbey, A. and Randle, H. (2016) Equitation pedagogic practice: use of a ridden horse ethogram to effect change. *Journal of Veterinary Behaviour: Clinical Applications and Research*. Vol (): pp-pp (in press)

Anthony, D.W. and Brown, D.R. (1991) The origins of horse back riding. *Antiquity*. Vol: 65, Issue: 246, p.22-38

Bachmann, P., Bernasconi, R., Weishaupt, M.A. and Stauffacher, M. (2003) Behavioural and Physiological response to an active stressor in crib-biting and control horses. *Applied Animal Behaviour Science*. Vol: 82, Issue 4, p.297-311

Becker-Birck, M., Schmidt, A., Wulf, M., Aurich, J., von der Wense, A., Möstl, E., Berz, R., Aurich, C. (2013) Cortisol release, heart rate and heart rate variability, and superficial body temperature, in horses lunged either with hyperflexion of the neck or with an extended head and neck position. *Journal of Animal Physiology and Animal Nutrition*. Vol: 97, Issue 2, p. 322–330

British Dressage Rule Book: (2010)

<https://www.britishdressage.co.uk/uploads/File/Equipment%20and%20Dress%20Rules.pdf>

British Horse Society (BHS) Rule Book : (pdf)

www.bhs.org.uk/~media/BHS/Files

Casey, V. McGreevy, P.D., O'Muiris, E., Doherty, O. (2013) Journal of Veterinary Behaviour Clinical Applications and Research. A preliminary report on estimating the pressures exerted by a crank noseband in the horse. Vol: 8, Issue 6, p. 479–484

Christensen, J.W., Zharkikh, T.L. and Malmkvist, J. (2010) Rein tension acceptance in young horses in a voluntary test situation. Equine Veterinary Journal. Vol: 43, p.223-228

Christensen, J.W., Zharkikh, T.L., Antoine, A. and Malmkvist, J. (2011) Rein tension acceptance in young horses in a voluntary test situation. Equine Veterinary Journal, 43 (2), pp. 223–228.

Christensen, J.W., Beekmans, M., van Dalum, M., and VanDierendonck, M. (2014) Effects of hyperflexion on acute stress responses in ridden dressage horses. Physiology and Behaviour. Vol: 128, p.39-45

Clayton, H.M., Larson, B., Kaiser, L.J., Lavagnino, M. Length and elasticity of side reins affect rein tension at trot. (2011) Vol: 188, Issue: 3, p.291-294

Clayton, H. (2011) Video fluoroscopy in order to show a horse's response to different bits and the effect of rein tension. (2011) International Society for

Equitation Science Conference, held Oct. 26-29 in Hooge Mierde, The Netherlands.

Clayton, H.M., Larson, B., Kaiser, L.J., Lavagnino, M. (2011) Length and elasticity of side reins affect rein tension at trot. *Veterinary Journal*. Vol:188 p.291-294

Clayton, H.M., Singleton, W.H., Lanovaz, J., Cloud, G.L. (2003) Measurement of rein tension during horseback riding using strain gage transducers *Experimental Techniques*. Vol: 27 p. 34–36

Clayton, H.M., Singleton, W.H., Lanovaz, J.L., Cloud, G.L. (2005) Strain gauge measurement of rein tension during riding: a pilot study. *Equine Comparative Exercise Physiology*. Vol: 2 p. 203–205

Coelho, C.S., Frederico, D., Oliveira, L.A.T., Binda, M.B., Conti, L.M. and Champion, T. (2017) Heart rate variability in Mangalarga Marchador horses after physical exercise. *Veterinarni Medicina*, Vol: 62 p.239–244

Cook, R. (2012) Horse-rider interaction via the reins. by Dr Hilary Clayton: A Rebuttal. academialiberti.blogspot.com

Cronin, G.M., Hemsworth, P.H., Barnett, J.L., Jongman, E.C., Newman, E.A., McCauley, I. (2003) An anti-barking muzzle for dogs and its short term effects on

behaviour and saliva cortisol concentrations. *Applied Animal Behaviour Science*. Vol: 83, Issue:3, p.215-226.

Cross, G.H., Cheung, M.K.P., Honey, T.J., Pau, M.K. and Senior, K.-J. (2016) Application of a dual force sensor system to Characterise the intrinsic operation of horse Bridles and bits. *Journal of Equine Veterinary Science* [online].

Dai, F., Cogi, N.H., Heinzl, E.U.L., Costa. E.D., Canali, E., Minero, M. (2015) Validation of a fear test in sport horses using infrared thermography. *Journal of Veterinary Behaviour – Clinical Applications and Research*. Vol: 10, Issue 2, p.128-136

Davis, N. (2016) New rules on horse nosebands needed to prevent distress. *Veterinary Medicine*. The Guardian, www.theguardian.com/science (03.05.16)

De Cartier d'Yves,A. and Ödberg, F.O. (2005) A preliminary study on the relation between subjectively assessing dressage performances and objective welfare parameters. *Proceedings of the 1st International Equitation Science Symposium 2005*. Australian Equine Behaviour Centre, Melbourne, Australia.

Doherty O, Casey V, McGreevy P, Conwa R, O'Muiris E., (2013) Two methods of measuring in- vivo pressures applied by a cavesson noseband. In: Heleski C, Wickens

Heleski, C. editor. 9th International Equitation Science Conference Proceedings.
Newark: University of Delaware. p. 38.

Dawkins, M.S. (2007) Observing animal behaviour: design and analysis of
quantitative data. Oxford University Press, UK.

Doherty, O., Casey, V., McGreevy, P., Arkins, S. (2016) An investigation into
noseband tightness levels on competition horses ISES Proceedings 12th
International Equitation Science Conference (2016)

Dyson, S (2017) Equine performance and equitation science: Clinical issues.
Applied Animal Behaviour Science. Vol: 190, p.5-17)

Eddy, A.L., Van Hoogmoed, L.M., and Snyder, J.R. (2001) The role of
thermography in the management of equine lameness. Veterinary Journal. Vol:
162, p. 172–181

Egenvall, A., Eisersiö, M., Rhodin, M., Van Weeren, R., Roepstorff, L. (2015a)
Rein tension during canter Comparative Exercise Physiology. Vol:11 p. 107–
117

Egenvall, A., Roepstorff, L., Eisersiö, M., Rhodin, M., Van Weeren, R. (2016)
Rein tension in walk and trot. Acta Veterinaria Scandinavica. Vol: 57 p. 89

Egenvall, A., Eisersjö, M., Roepstorff, L. (2012) Pilot study of behaviour responses in young riding horses using 2 methods of making transitions from trot to walk. *Journal of Veterinary Behaviour*. Vol 7 p. 157–168

Egenvall, A., Roepstorff, L., Eisersjö, M., Rhodin, M., Van Weeren, R. (2015 b) Stride-related rein tension patterns in walk and trot in the ridden horse. *Acta Veterinaria Scandinavica*. Vol: 57 p.89

Eisersjö, M., Roepstorff, L., Rhodin, M., Egenvall, A. (2015) Rein tension in eight professional riders during regular training sessions *Journal of Veterinary Behaviour*. Vol:10 p. 419–426

Eisersjö, M., Roepstorff, L., Weishaupt, M.A., Egenvall, A. (2013) Movements of the horse's mouth in relation to the horse-rider kinematic variables *Veterinary Journal*. Vol:198 p. 33–38

Edwards, E.H. (1992) *Saddlery*. J.A.Allen Publishers, UK p.46-51

Ewbank, R., Parker, M.J. and Mason, C.W. Reactions of cattle to head restraint at stunning: A practical dilemma. *Animal Welfare*. Vol:1, No:1, p.55-64

Farm Animal Welfare Council, (FAWC) (2009)

<https://www.gov.uk/government/groups/farm-animal-welfare-committee-fawc>

Animal Welfare Act.

Fenner, K., Yoon, S., White, P., Starling, M., and McGreevy, P. (2016) The Effect of Noseband Tightening on Horses' Behaviour, Eye Temperature, and Cardiac Responses. Vol: 11(5):

Field, A. Discovering statistics using IBM SPSS Statistics. London: Sage Publications Ltd; 2013. p. 249-257.

FEI (2014) — Rules for Dressage Events Fédération Équestre Internationale (25th Edition) FEI, Lausanne, Switzerland.

Fowler, M. (2008) Restraint and Handling of Wild and Domesticated Animals. 3rd Edition. Wiley-Blackwell, Oxfordshire, UK

Freire, R, Cooper, J.J. (2010) Effects of different forms of exercise on post-inhibitory rebound and unwanted behaviour in stabled horses. Journal of Veterinary Behaviour: Clinical Applications and Research. Vol: 5, Issue 4, p.218

Fureix C, Gorecka-Bruzda A, Gautier E, Hausberger M. (2011) Cooccurrence of yawning and stereotypic behaviour in horses (*Equus caballus*). ISRN Zoology. Article ID 271209, 10 pages

Fireix, C., Beaulieu, C., Argaud, S., Rochais, C., Quinton, M., Henry, S., Hausberger, M., and Mason, G., (2015) Investigating anhedonia in a non-

conventional species: Do some riding horses *Equus caballus* display symptoms of depression? *Applied Animal Behaviour Science*

Vol: 162, p.26-36

Gerber, V. (2014) Heads-up on head position: The need for equestrian reality.

The Veterinary Journal. Vol: 202, Issue 1, p. 5–6

Górecka-Bruzda, A., Kosińska, I., Jaworski, Z., Jezierski, T., Murphy, J. © 2014?

Conflict behavior in elite show jumping and dressage horses. *Journal of Veterinary Behaviour: Clinical Applications and Research*. Vol 10, Issue 2, p.137-146

Goodwin, D., McGreevy, P., Waran, N. and McLean, A., 2009. How equitation science can elucidate and refine horsemanship techniques. *The Veterinary Journal*, 181(1), pp.5-11.

Hall C., Goodwin, D., Heleski, C., Randle, H. & Waran, N. (2008) Is There Evidence of Learned Helplessness in Horses? *Journal of Applied Animal Welfare Science* Vol: 11, Issue 3, p.5-11

Vol: 11, Issue 3, p.5-11

Hall, C., Burton, K., Maycock, E., Wragg, E., (2010). A preliminary study into the use of infrared thermography as a means of assessing the horse's response to different training methods. In: Hartmann, E., Blokhuis, M.Z., Fransson, C., Dalin, G. (Eds.), *Proceedings of the 6th International Equitation Science Symposium*, 31 July to 2 August 2010, Uppsala, Sweden, p. 64.

Hall., C., Huws, N., White, C., Taylor, E., Owen, H., McGreevey, P. (2013)
Assessment of ridden horse behaviour. *Journal of Veterinary Behaviour: Clinical Applications and Research* Vol: 8 Issue 2, p .62-73

Hawson, L.A., Mclean, A.N. and McGreevy, P.D. (2010) The roles of equine ethology and applied learning theory in horse-related human injuries. *Journal of Veterinary Behaviour: Clinical Applications and Research*. Vol:5, p.324-338.

Hawson, L.A., Salvin, H.E., Mclean, A.N. and McGreevy, P.D. (2014) Riders' application of rein tension for walk-to-halt transitions on a model horse. *Journal of Veterinary Behaviour: Clinical Applications and Research*: Vol: 9 p.164-

168

Hawson, L.A. (2011) Welfare (and safety) implications for applying learning theory in horse training. *The Equine Head*. The Proceedings of the 2011 Equine Chapter Meeting of the ACVSC Science Week. Australia.

Heleski, C.R., McGreevy, P.D., Kaiser, L.J., Lavagnino, M., Tans, E., Bello, N. and Clayton, H.M. (2009) The effects on behaviour and rein tension on horses ridden with or without martingales and rein inserts. *The Veterinary Journal*. Vol:181, Issue:1, p.56-62

Hendriksen, P. (2013) Is there a need for improving the understanding of horse behaviour? Danish Animal Welfare Society, Frederiksberg, Denmark.

Proceedings of the 9th International Conference of the International Society for Equitation Science. Delaware, Newark, DE, USA . p.29

Hobbs, G.D., Yealy,D. and Rivas, J. (1994) Equestrian Injuries: A five year review. The Journal of Emergency Medicine. Vol:12, Issue:21, p.143-145

Hockenull, J. Creighton, E. A brief note on the information-seeking behaviour of UK leisure horse owners (2013) Journal of Veterinary Behaviour: Clinical Applications and Research. Vol: 8, Issue 2, p.106–110

Holderness-Roddam, J. and Vincer, C. (1987) Fitting Tack. Threshold Books Ltd. Kenilworth Press Ltd, London, United Kingdom p.8-12

International Society for Equitation Science, (ISES) Newsletter: Position Statement on Restrictive Nosebands. (27th June 2016)

International Society for Equitation Science (ISES) Newsletter: The Noseband Debate. No. 9 March 2012

Jones, B. (2009) Ethical Equitation – what’s in it for the horse? Proceedings of the 5th International Conference of the International Society for Equitation Science. Sydney, Australia. P.33

Jodkowska, E., and Dudek, K. (2003) Significance of body surface temperature measurements in exploitation of horses. Medycyna Weterynaryjna. Vol: 59 p. 584–587

Kienapfel , K., Link, Y., Von. Borstel, U. K., (2014) Prevalence of Different Head-Neck Positions in Horses Shown at Dressage Competitions and Their Relation to Conflict Behaviour and Performance Marks. Plos.One.

Kiley-Worthington, M. (1999) Equine Welfare. J.A.Allen, Newton Abbot, UK p.328

Kienapfel, K. and Preuschoft, H. (2010) Much too tight! On the effect of nosebands. *Pferdehilfkunde*. Vol:26, Issue:2, p.178-185

Kienapfel, K., Link, Y., König von Borstel, U. (2014) Prevalence of different head-neck positions in horses shown at dressage competitions and their relation to conflict behaviour and performance marks. Vol: 9 (2014),

Kuhnke, S., Johnson, J.L., Gaulty, M., Borstel, U.K. von, Dumbell, L. and McDonald, K. (2010) A comparison of rein tension of the rider's dominant and nondominant hand and the influence of the horse's laterality. *Comparative Exercise Physiology* [online]. 7 (02), pp. 57–63.

Lee, J., Floyd, T., Erb, H., Haupt, K. (2011) Preference and demand for exercise in stabled horses. Applied Animal Behaviour Science. Vol: 130, Issues 3–4, p. 91–100

Leckie, E.J., (2001) The equine population in the UK. A report for the International League for the Protection of Horses (ILPH). World Horse Welfare, Anne Colvin House, Ada Cole Avenue, Snetterton, Norfolk, NR16 2LR, UK.

Lemon, C. (2016). Systematic review on rein tension. Undergraduate thesis University of the West of England.

Levine, M.A. Mills, D. and McDonnell, S.M. (eds) (2005) The Domestic Horse. Cambridge University Press, Cambridge. p.5-22

Ludwig, N., Gargano, M., Luzi, E., Carezzi, C., and Verga, M. (2007) Technical note: applicability of infrared thermography as a non-invasive measurement of stress in rabbit. World Rabbit Science. Vol:15 p. 199–205

Ludewig, A.K., Gaulty, M., von Borstel, U.K., (2013) Effect of shortened reins on rein tension, stress and discomfort behaviour in dressage horses. Journal of Veterinary Behaviour: Clinical Applications and Research Vol: 8, Issue 2, p. 15–16

Manfredi, J.M., Clayton, H., Rosenstein, D. (2005) Radiographic study of bit position within the horse's oral cavity. *Equine and Comparative Exercise Physiology*. Vol: 2 p.195-201

Manfredi, J., Rosenstein, D., Lanovaz, J.L., Clayton, H. (2010) Fluoroscopic study of oral behaviours in response to the presence of a bit and the effects of rein tension. *Comparative Exercise Physiology*. Vol:6 p.143 – 148

Marlin, D. and Nankervis, K.J. (2013) *Equine exercise physiology* John Wiley and Sons, Oxford, UK (2013)

McGreevy, P.D., Nicol, C.J., The effect of short term prevention on the subsequent rate of crib-biting in Thoroughbred horses. *Equine Veterinary Journal*. Vol: 30 Issue S27. p.30-34

McGreevy, P.D. (2004) *Equine Behaviour: A Guide for Veterinarians and Equine Scientists* Saunders, Edinburgh, UK

McGreevy, P.D., Mclean, A.M., Warren-Smith, A.K., Goodwin, D. and Waran, N. (2005) (eds.) Defining the terms and processes associated with equitation. A low cost device for measuring the pressures exerted on domestic horses by riders and handlers. *Proceedings of the 1st International Equitation Science Symposium 2005*. Australian Equine Behaviour Centre, Melbourne, Australia.

McGreevy, P. and Mclean, A. (2010) *Equitation Science*. Wiley-Blackwell, Oxfordshire, UK

McGreevy, P., Warren-Smith, A. and Guisard, Y. (2012) The effect of double bridles and jaw clamping crank nosebands on temperature of eyes and facial skin of horses. *Journal of Veterinary Behaviour: Clinical Applications and Research*. Online 16.01.12

McGreevy, P.D. (2007) The advent of equitation science. *The Veterinary Journal*, Vol: 174 p. 492–500

McGreevy, P.D., Harman, A., McLean, A.N., Hawson, .A. (2010) Over-flexing the horse's neck: A modern equestrian obsession? *Journal of Veterinary Behaviour : Clinical Applications and Research : Official Journal of : Australian Veterinary Behaviour Interest Group, International Working Dog Breeding Association*, Vol:5 p. 180–186

Muir, S. and Houghton, K. (2002) *Saddlery and Horse Equipment: The Complete Illustrated Guide to Riding Tack Select Editions*. Anness Publishing, UK. p.49-52

Murray, R., Guire, R., Fisher, M., Fairfax, V. (2015) A Bridle Designed to Avoid Peak Pressure Locations Under the Headpiece and Noseband Is Associated With More Uniform Pressure and Increased Carpal and Tarsal Flexion,

Compared With the Horse's Usual Bridle. *Journal of Equine Veterinary Science*.
Vol: 35 p.947-955

Odberg, F.O. and Bouissou, M.F. (1999) The development of equestrianism from the baroque period to the present day and its consequences for the welfare of the horse. The role of the horse in Europe. *The Equine Veterinary Journal (Supplement 28)* (1999) p.26-30.

Oppewal, A., Hilgenkamp, T.I.M., van Wijck, R. and Evenhuis, H.M. (2013) The effect of handedness on grip strength in older adults with intellectual disabilities. *Research in Developmental Disabilities* [online]. 34 (5), pp. 1623–1629.

Overall, K. (2015) Stress and emotionality: Which definitions, which measures, which species? *Journal of Veterinary Behaviour: Clinical Applications and Research* Vol: 10, Issue 2, p. 91–93

Overall, K. (2016) A dog is not a mink is not a goat but they all can benefit from behavioural measures that tell us who they are. *Journal of Veterinary Behaviour: Clinical Applications and Research* Vol: 13, p. vi–viii

Peham, C., Licka, H., Schobesberger, H., Meshan, E. (2004) Influence of the rider on the variability of the equine gait. *Human Movement Science*. Vol:23, Issue:5, p. 663-671.

Peham, C., Limbeck, S., Galla, K., Bockstahler, B., (2013) Pressure distribution under three different types of harnesses used for guide dogs The Veterinary Journal Vol: 198, Supplement 1, p. 93– 98 e-Supplement: 7th International Conference on Canine and Equine Locomotion — Strömsholm, Sweden 25-28 June 2012

Pony Club Dressage Rule Book, (2012) Stoneleigh, UK p.8

Quick, J.S. and Warren-Smith,A.K. (2009) Preliminary investigations of horses' (Equus caballus) responses to different bridles during foundation training. Journal of Veterinary Behaviour: Clinical Applications and Research. Vol:4, Issue:4, p.169-176

Randle, H. (2016). Personality and performance: the influence of behaviour. in Williams, J.M. and Evans, D. (Eds) (2015) Training for Equestrian Performance, Holland: Wageningen Press.

Randle H, Abbey A, K S (2013) Qualitative (perceived) versus quantitative (actual) assessment of rein tension: What lessons can be learnt? 9th International Equitation Science Conference 2013 July 17th-20th Delaware, USA. 37.

Randle,H., Abbey, A. and Button,L. (2011) The effect of different rein types on the rein tension applied when taking up a 'medium contact'. Journal of

Veterinary Behaviour: Clinical Applications and Research. Vol:6, Issue:5, September –October. p.295

Randle, H., McGreevy, P.D. (2011). The effect of noseband tightness on rein tension in the ridden horse. Proceedings of the 7th International Equitation Science Conference, Eds: M. van Dierendonck, P. de Cocq, K. Visser, Wageningen Academic Publishers, Wageningen. 84.

Randle, H. (2010) Ethical Equitation – A Sustainable Approach. Journal of Veterinary Behaviour: Clinical Applications and Research. Vol:5, Issue:4, July – August 2010. p. 167-169.

Randle, H. and McGreevy, P. (2013) The effect of noseband tightness on rein tension in the ridden horse. Journal of Veterinary Behavior: Clinical Applications and Research [online]. 8 (2), pp. e18–e19.

Robinson, I.H. (1999) The horse-human relationship: how much do we know? Equine Veterinary Journal Supplement (28) p. 42–45

Rushen, J. (1986) Some problems with the physiological concept of “stress”. The Australian Veterinary Journal. Vol: 63, Issue 13, p.359-361

Stewart, M., Schaefer, A., Hale, D.B., Colyn, J., Cook, N.J., Stafford, K.J., Webster, J.R. (2008) Infrared thermography as a non-invasive method for

detecting fear-related responses of cattle to handling procedures. *Animal Welfare*. Vol: 17 p. 387–393

Tattersall, G.J., and Cadena, V. (2010) Insights into animal temperature adaptations revealed through thermal imaging. *Imaging Science Journal* Vol:58 p. 261–268

Tunley, B.V., and Henson, F.M.D. (2004) Reliability and repeatability of thermographic examination and the normal thermographic image of the thoracolumbar region in the horse. *Equine Veterinary Journal* Vol:36 p. 306–312

United States Equestrian Federation, (2016) Rule Book. Dressage Division. Available at: http://www.usef.org/_IFrames/RuleBook/2016.aspx.

Visser, K., Van Reenen, C.G., Van der Werf, J.T., Schilder, M.B., Knaap, J.H., Barneveld, A., Blokhuis, H.J. (2002): Heart rate and heart rate variability during a novel object test and a handling test in young horses. *Physiology and Behavior* Vol:76, p.289–296.

Visser, K., Van Reenan, M., Rundgrn, M., Zellerqrist, K., Morgan, K., and Blokhuis, H.J. (2003). Responses of horses in behavioral tests correlate with temperament assessed by riders. *Equine Veterinary Journal*. Vol:35 p.176-183

Visser, K., Vanwijk, E., Kortstee, H. and Verstegen, J. (2011) Passion for Horses: Improving horse welfare communication through identifying information search patterns, knowledge levels, benefits and daily practices of horse enthusiasts. *Journal of Veterinary Behaviour*. Vol:6, Issue:5, p.297

Von Borell, E., Langbein, J., Despres, G., Hansen, S., Leterrier, C., Marchant-Forde, J., Marchant-Forde, R., Minero, M., Mohr, E., Prunier, A., Valance, D. and Valance, I. (2007) Heart rate variability as a measure of autonomic regulation of cardiac activity for assessing stress and welfare in farm animals – A review. *Physiology and Behaviour*. Vol:92, Issue:3, p.293-316

Von Borstel, C. Glißman (2014) Alternatives to conventional evaluation of rideability in horse performance tests: suitability of rein tension and behavioural parameters , *PLoS One*, 1, pp. 1–9

Von Borstel, U., and McGreevy, P.D. (2014) Behind the vertical and behind the times. *The Veterinary Journal*. Vol: 202, Issue 3, p. 403–404

Von Borstel, U., Pasing, S., Gauly, M. (2011) Towards a more objective assessment of equine personality using behavioural and physiological observations from performance test training. *Applied Animal Behaviour Science*, Vol; 135 p. 277–285

Von Borstel, U., Heatly Duncan, I.J., Shoveller, A.K., Merkies. K., Keeling, L.J., Millman, S.T. (2009) Impact of riding in a coercively obtained Rollkur posture on

welfare and fear of performance horses. *Journal of Applied Animal Behaviour Science*. Vol:116, Issue 2-4, p.228-236

Von Borstel, U., Visser, K. and Hall, C. 2016. Stress. *Applied Animal Behaviour Science*. In press.

Von PEINEN, K., WIESTNER, T., Von RECHENBERG, B., WEISHAUPT, M.A. (2010) Relationship between saddle pressure measurements and clinical signs of saddle soreness at the withers. *Equine Veterinary Journal*. Vol: 42, Issue 38, p.650-653.

Waran, N. and Randle, H. (2016) What we can measure, we can manage: the importance of developing robust welfare indicators for use in Equitation. *Applied Animal Behaviour Science*. In press.

Warren-Smith, A.K., Curtis, R.A. and McGreevy, P.D. (2005) A low cost device for measuring the pressures exerted on domestic horses by riders and handlers. *Proceedings of the 1st International Equitation Science Symposium 2005*. Australian Equine Behaviour Centre, Melbourne, Australia.

Warren-Smith, A.K., Curtis, R.A., Greetham, L. and McGreevy, P.D. (2007) Rein contact between horse and handler during specific equitation movements. *Applied Animal Behavioural Science*. Vol:108, Issue:1-2, p.157-169

Warren-Smith,A.K. and McGreevy, P.D. (2008) Anthrozoos: A multidisciplinary Journal of the Interactions of People and Animals. Vol:12, Issue:2, p.153-162

Warren-Smith,A.K. and McGreevy, P.D. (2007) Use of blended positive and negative reinforcement in shaping the halt response of horses (*Equus caballus*). Animal Welfare. Vol:16, Issue:4, November. p.481-488

Williams, J.M. The application of science to training – why bother? in Williams, J.M. and Evans, D. (Eds) (2015) Training for Equestrian Performance, Holland: Wageningen Press.

Williams, J.M. Defining performance and measuring success, in Williams, J.M. and Evans, D. (Eds) (2015) Training for Equestrian Performance, Holland: Wageningen Press.

Williams, J.M. and Tabor, G. (2017) Rider impacts on equitation. Applied Animal Behaviour Science, 190, pp.28-42.

Williams, L.R. and Warren-Smith, A.K. (2010) Conflict Responses exhibited by dressage horses during competition. Journal of Veterinary Behaviour: Clinical Applications and Research. Vol:5, Issue:4, p.215

Yanmaz, L.E., Okumus, Z., and Dogan, E. (2007) Instrumentation of thermography and its applications in horses. Journal of Animal Veterinary Advances. Vol:6 p. 858–862

Younes, M., Robert, C., Barrey, E. and Cottin, F. (2016) Effects of Age, Exercise Duration, and Test Conditions on Heart Rate Variability in Young Endurance Horses. *Frontiers in Physiology*. Vol: 7 p.155

Appendix One: Different bridles and how they are fitted

There are a wide range of nosebands on the market and the preference seems to fluctuate in line with almost 'equine fashion', this can be seen at a local competition, a pony club rally and in professional competition horses. There are too many variations to usefully describe them all but the general groupings are the aesthetic nosebands, traditionally used as 'part of the bridle' and a piece of the tack that improves the overall image of the horse for the show ring or in competition and then there are the nose bands that are used to restrain. Besides aesthetics, the function of the majority of nosebands is to close the horses' jaws in order to prevent resistance to the bit achieved by opening the mouth, and assist the rider in controlling the horse. The noseband can be used for a variety of reasons such as to prevent the horse crossing their jaws, teeth grinding, placing their tongue over the bit, pulling in general, grasping hold of the bit with their teeth and the manipulation of the bit within the mouth to avoid the pressure being applied.

Some of the nosebands that are seen today are depicted (Figures 1.3, 1.4, 1.5, 1.6 and 1.7) and their function briefly explained, their purpose for the rider and the horse is identified. The range of nosebands varies in popularity across the disciplines and are often adapted for the type of horse. There are differences in noseband and tack used in different countries and all of the nosebands vary in severity.



Figure 1.3 The cavesson noseband. (www.robinsonsequestrian.co.uk)



Figure 1.4 The Grackle noseband. (www.millbryhill.co.uk)



Figure 1.5 The Flash noseband (www.robinsonsequestrian.com)



Figure 1.6 The Drop noseband. (www.shop.sabreleather.co.uk)



Figure 1.7 The Kineton noseband (www.trotonline.co.uk)

Nosebands are constantly being adapted and updated and often reflect fashion trends, however the largest change in noseband development seems to have occurred around the late 1960's and early 1970's where nosebands became tighter, this coincides with the development of many equine sports. Up until this time loose cavesson nosebands, which were largely aesthetic in purpose, were typical. The drop noseband became increasingly popular in the 1960's / 1970's and this was followed by the increase in popularity of the grackles and flash based nosebands. The 1980's saw the introduction of the "crank" noseband, coinciding in time with the regular appearance of rollkür/hyperflexion in the international dressage warm up arena (ISES, 2012).

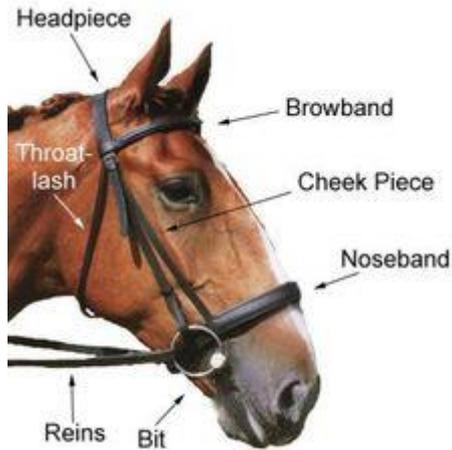


Figure 1.8 A plain cavesson bridle and its associated elements.
(www.pinterest.com)

The Cavesson nose band is a piece of leather or rope passed around the horses' face (Figure 1.3). The general guidelines for fitting the cavesson are to allow 'two fingers' width of space between the nose band and the horses' cheek and / or nose (McGreevy *et al.* 2012). Although it is not particularly clear exactly how this measurement can be confirmed as correct by everyday horse owners it has become an unofficial industry guide.

Edwards (1992) maintains that if control of the horse in question is limited the cavesson can be tightened a 'few' holes and that the entire noseband can be lowered a 'few' holes to keep the mouth closed. This guidance implies that a variation of a 'few' holes can substantially alter the effect of the noseband on the horse, as it's implied it will 'alter the control', therefore the assumption that the cavesson nose band is purely aesthetic and has little impact on the way of going or control solely depends on how tightly its applied. This confirms the

requirement for and the importance of stringent and wide-spread guidelines associated with nose band use.

The Grackle noseband. Another nose band whose use is widespread is the grackle, this is a noseband comprising of two crossing straps that both are done up at the back of the horses' jaws and cross on the front of the face (Figure 1.4). The design is specifically intended to prevent the crossing of the lower jaw to evade the bit contact (Edwards, 1992). The grackle is being seen more regularly at the present time and is a piece of tack that needs to be further studied in order to determine the impact of the pressure on the horse's face, as it covers a wider area of the horse's face than other nosebands and exerts pressure on different and additional areas of the horse's head.

The Flash noseband

This was designed to combine the action of the drop noseband and allow the attachment of a standing martingale to the traditional cavesson (Figure 1.5). It's design was an adaptation of the cavesson which could have the standing martingale attached to it, this martingale is a piece of leather attached to the nose band at one of the strap ends and this is a continuous piece of leather that then joins to the girth of the horse, the idea being that the horse receives pressure onto the noseband if he raises his head above the desired point (Figure 1.9). The standing martingale is much less popular now in comparison to the running martingale (Figure 1.10), which uses the same principle but the girth attachment splits and either end is then joined to both reins. Pressure is applied to the mouth if the horse raises its head and not the nose.

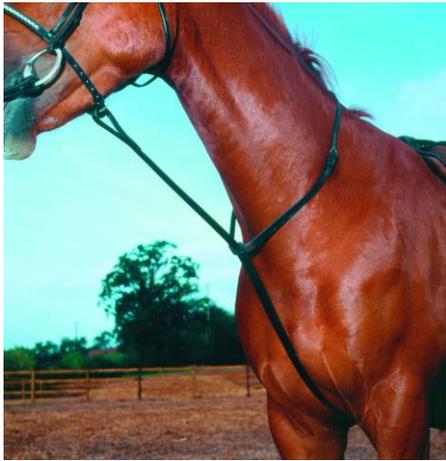


Figure 1.9. The standing martingale attached to the cavesson noseband.
(equineink.com)



Figure 1.10 The running martingale attached to the reins.
(horselifeandlove.blogspot.com)

The flash nose band is designed to keep the mouth closed, as it has the original cavesson section and an additional strap attached to the front of the noseband that passes below the bit and applies pressure around the horse's mouth at a lower point, to apply more closure to the jaws. To enable this strap to remain stable the cavesson section is often fitted tighter than a traditional stand-alone cavesson would be (Muir and Houghton, 2002).

The Drop noseband

This is a noseband that is also used to assist in closing the horse's mouth and although less popular at the moment was previously a regularly seen piece of tack. The drop noseband is fitted just below the bit much lower than a normal cavesson and assists in keeping the horse's mouth closed, if fitted incorrectly it can affect the horse's breathing (Muir and Houghton, 2002) as it can reduce the nasal passage circumference. The drop nose band is designed in such a way that it exerts pressure on the nose making the horse respond by closing the jaws. If it is used with the snaffle bit it alters the action of the bit which consequently increases the pressure applied to the lower jaw when tension is applied to the reins by the rider. The altered pressure from the bit produces a more severe downward and inward force in the horse's mouth.

Edwards (1992) suggests the drop nose band allows more flexion at the poll and greater relaxation of the lower jaw, the drop nose band applies pressure in the chin groove as would a curb chain or curb strap and the relaxation caused to the lower jaw impacts on the poll and the neck of the horse as the tension in the mouth / jaw are released. However, Edwards (1992) also suggests this

relaxation is partly achieved by the momentary disruption to the horse's breathing, causing the horse to drop his nose and improve rider control. In this case most horse owners would agree gaining additional control by temporarily impacting on breathing is not a desired method of control.

Drop nose bands are not currently in fashion and are not readily discussed in equine tack forums and do not often appear in current equine publications. However older tack books advise positively about the use of drop nosebands, specifically and the related relaxed jaw and improved contact that the use of a drop nose band was considered to promote. However there are no scientific studies to support this analysis and it could be argued to be based largely on personal subjective opinion.

There are unverified links to the impact of horse's completing fast work where the drop noseband has been unscientifically linked to possible restrictions on the extension of the nostrils, and the consequential intake of oxygen, although there is no known scientific evidence to support this. If this is the case then it could reasonably be argued that the use of flash nosebands or grackle nosebands could have the same impact on breathing? Yet these are fully accepted and used in top end competitions where speed, endurance and oxygen intake would be crucial to success and achieving the best results.

The Kineton noseband is known for its severity, unlike previously described nosebands it does not act to close the mouth instead it applies pressure to the top of the horse's nose when the rider exerts pressure onto the reins. This

causes the horse to lower its head in response to avoid the pressure applied to the top of the nose. The kineton consists of two metal loops with a connecting nose strap. The centre of the nose piece is often a strip of metal covered in leather. Its severity is recognised by Edwards (1992) who refers to it as the “*blunt instrument’ of all biting arrangements* and should only be used with *confirmed tearaways*”.

The Double Bridle

The double bridle (Figure 1.11) is required in higher end dressage (above Prix St. George level) and is often the choice for show riders and dressage riders as it provides the correct ‘formal’ image where tack and turnout are part of a competition and historically the double bridle is associated with ‘correct’ dress. It comprises of two bits and four reins. One bit is the snaffle bit that is often smaller in diameter and has smaller rings than a traditional snaffle, this bit sits above and behind the curb bit in the horse’s mouth. The biting arrangement associated with the double bridle can be a very harsh piece of equipment in the horse’s mouth in inexperienced hands as the application of pressure is at the chin groove, the tongue, the bars of the mouth, the lips, the poll and the mouth if the curb bit is used. To avoid this pressure a horse’s response would be to open his mouth to relieve or to attempt to get away from the pressure. If however the horse is wearing a crank cavesson noseband that is specifically designed to prevent the horse opening its mouth this is not an option.



Figure 1.11 A horse wearing a double bridle.