ISES position statement on alterations of the horses' head and neck posture in equitation

Background

Horses have long mobile necks that evolved to facilitate efficient feeding and drinking. In many horse sports head and neck posture resulting from the relative positioning of the cervical (neck) vertebrae and the atlanto-occipital joint (the poll) is given high priority and is typically manipulated via rein tension (see Figure 1). It is common to see the horse's neck either extremely flexed (see Figure 1c) or extended (see Figure 1d) in a wide range of disciplines including (but not limited to) cross country, dressage, driving, reining and showjumping. In many cases, these positions cannot be self-maintained by the horse either at all or for any length of time. There is substantial evidence that head and neck postures such as these have a negative impact on horse welfare.

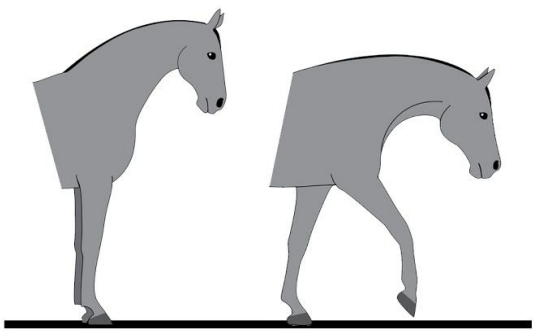

Fig 1a. HNP 'in front of the vertical'

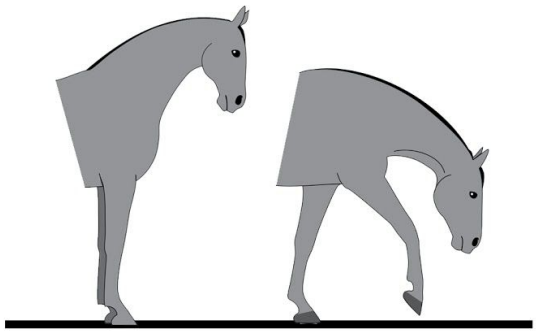

Fig 1b. HNP 'on the vertical'

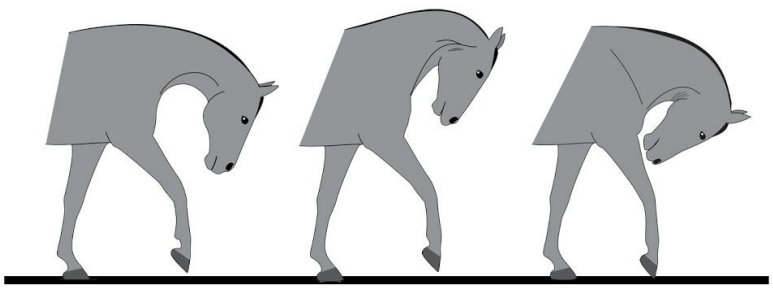

Fig 1c. HNP 'behind the vertical'

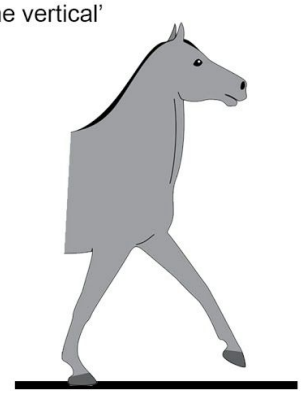

Fig 1d. HNP 'inverted'

Figure 1a-d: Head and neck postures (HNP) with different dorso-ventral flexions. Illustrations by Cristina Wilkins, courtesy of ISES.

Head and neck posture and, therefore, dorso-ventral flexion of the atlanto-occipital joint (the poll) and distal cervical vertebrae (see Figure 2) in the ridden and driven horse is typically integrated in the training of the horse's mobility responses. Because negative reinforcement depends on the release of pressure, the ability of the horse to maintain a particular head and neck posture that is appropriate for the stage of training without continuous or high rein

tension, is fundamental to maintaining welfare. In Western trail and pleasure riders, mean rein tensions of 14.7 Newton (approx. 1.5 kg-force) have been recorded (König von Borstel et al., 2011a). In dressage, mean rein tensions as high as 49 Newton (approx. 5 kg-force) have been recorded while tensions appear to be even higher in driving (29 – 196 Newton or approx. 3-20 kg-force; Preuschoft et al., 1999). These figures suggest that, in equitation, horse head and neck posture is often deliberately enforced by the rider instead of being self-maintained by the horse.

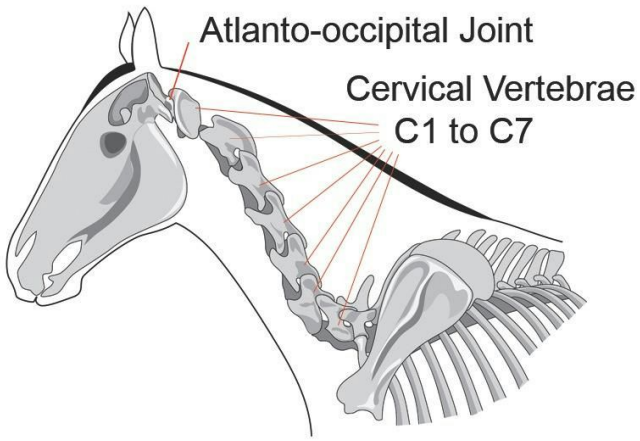

Figure 2. Location of the atlanto-occipital joint and the cervical vertebrae. Illustration by Cristina Wilkins, courtesy of ISES.

In terms of welfare, it is important to identify the various aspects that, in isolation and when combined, determine the head and neck posture.

As shown in Figure 3 there are a variety of anatomic landmarks that can be referenced to determine head and neck posture:

a) The angle of the cranio-facial profile (the frontal bones and nasal planum) relative to the vertical (Figure 3a)
b) The degree of flexion of the intersection of the mandible and the ventral surface of the neck (commonly referred to as ‘gullet’) (Figure 3b)
c) The angle between the shoulder and the neck (the height of the poll relative to the shoulder) (Figure 3c)
d) The lateral displacement of the head in relation to the body (Figure 3d)
e) The lateral flexion of the neck (Figure 3e)

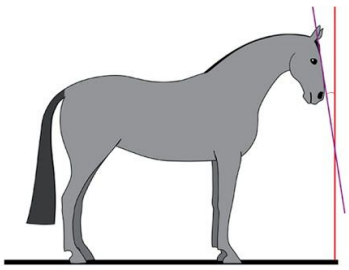

Figure 3a

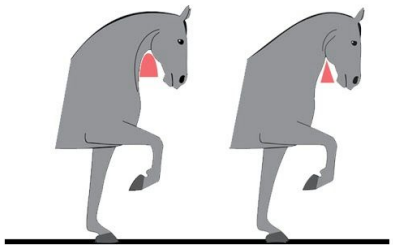

Figure 3b

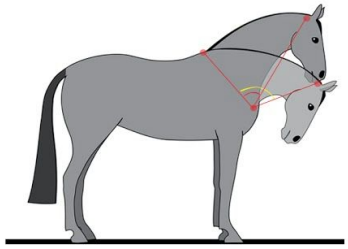

Figure 3c

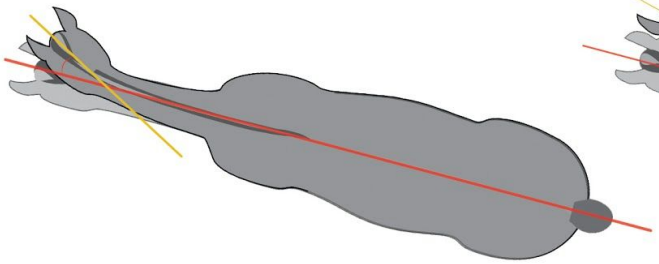

Figure 3d

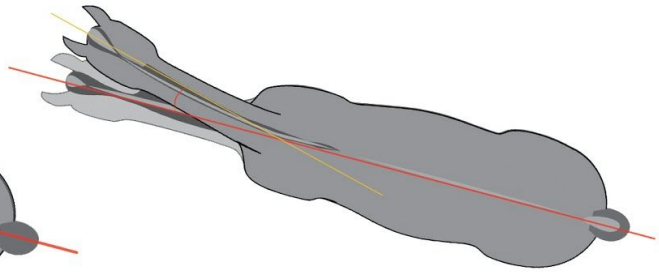

Figure 3e

Figure 3a-e. Anatomic landmarks that can be used to determine head and neck posture. Illustrations by Cristina Wilkins, courtesy of ISES.

In addition to the type and degree of flexion, several other factors have also been suggested to be potentially important with regard to horse welfare:

- Individual horse conformation
- Duration of the maintenance of the head and neck posture
- Horses' familiarity with the head and neck posture
- The way the posture is achieved, i.e. enforced (via unyielding or high rein tension and/or equipment), trained (e.g. via correct application of negative and/or positive reinforcement) or spontaneously (without human intervention)

Research and public concern have mainly focused on the effect of the angle between cranio-facial profile relative to the vertical (Figure 3a), and the angle between the shoulder and the neck (Figure 3c), and the effects these may have on welfare. However, it is important to note that the impact of head and neck postures on the horse differs by where the change in angulation between anatomic structures occurs. Alterations to the angle between the cranio-facial profile relative to the vertical (Figure 3a) may affect the horses' vision, whilst flexion in the mandible and the ventral surface of the neck (the gullet) (Figure 3b) may affect airway functioning. All extreme alterations of head and neck postures (a, b and c either alone or together) result in behaviour dysfunction.

For example, when the horse begins with its poll at the highest point (as per FEI Dressage Rules; FEI, 2015) and its cranio-facial profile in front of the vertical and then the horse's poll is lowered but without increasing the angle of the mandible and ventral profile of the neck, its cranio-facial profile will be behind the vertical axis (Figure 3c). In this case, depending on the individual horse's conformation and the way the posture is achieved, there may be

negligible or no physiological compromise. Nevertheless, there may be vision impairment and potential psychological consequences for the horse. It is suggested that the degree of flexion relative to individual horse conformation can be judged in practice by assessing the shape of the gullet (Figure 3b).

Extreme flexion in any of the head and neck planes can result in soft tissue damage and skeletal pathology. Also, with any of the alterations to head and neck posture (a-e), the effect of flexion is a gradual one, such that extreme flexion will have strong effects on physiological functioning while less extreme forms may have a less pronounced effect (see literature review below for details).

It is obvious that judgment of horse welfare in relation to head and neck posture in a given situation is not trivial. There is substantial evidence (see literature review below in the section “effects on welfare”) that significant welfare issues result when there are extreme alterations of the angle of the atlanto-occipital joint and uneven separation of the cervical vertebrae.

Consequences of alterations to head and neck posture

The physiological consequences of flexion or extension of cervical vertebrae have been suggested to include (see below literature review):

- upper airway impairment (particularly if the angle between mandible and ventral aspect of the neck [the gullet] is acute)
- pathological changes in the structures of the neck
- impaired vision
- physical and psychological stress due to physiological compromise
- stress due to rider intervention, in particular if the posture is enforced (e.g. rider applies high or maintains relentless rein tension and/or equipment is used to maintain the posture)

The degree of the cranio-facial profile relative to the vertical is a good indicator of the degree of cervical flexion and, consequently, the degree of compromise to equine welfare. However, the angle of the mandible in relation to the ventral surface of the neck should be considered as the key indicator of welfare as this more closely relates to the effects on airway functioning and soft and skeletal tissues. In addition to the degree of this flexion, individual head and neck conformation largely determines the severity of welfare impacts of head and neck flexions. The combined effect of individual conformation and the angle of the cranio-facial profile and the neck is suggested to be best reflected by the shape of the gullet.

Therefore, based on the varying physiological and psychological effects of the different types of flexion, there are two anatomical aspects that can be used as a guide to determine the effects of the different head and neck postures:

- The angle of the cranio-facial profile relative to the vertical (Figure 3a).
- The shape of the caudal corner of the mandible (the gullet). When the angle between the mandible and the ventral surface of the neck is acute it appears as an inverted ‘V’, and the curve of the caudal border of the rams of the mandible (the jaw) will no longer be clearly defined. The shape of the gullet may be a better indicator of physiological

compromise due to airway obstruction and skeletal insults. In contrast, when the angle is less acute it resembles an inverted 'U' and represents fewer concerns for welfare (Figure 3b).

Definition of extreme or hyperflexed head and neck posture:

A head and neck posture is considered to be hyperflexed or extremely flexed when cervical flexion or extension of the atlanto-occipital joint and cervical vertebrae compromises physiological function.

History of head and neck postures in equitation

In recent years, horse training techniques have emerged that involve extreme flexion of the horse's neck for various lengths of time. Although extreme head and neck postures can occur in free-ranging horses, they last for only brief periods, for example during bucking (Meyer, 2008) or self-grooming. In contrast, since the rise of modern horse sports, sustained, hyperflexed head and neck postures have become increasingly common in equestrian contexts.

While training techniques involving various degrees of cervical flexion have been described in the horse training literature dating back several centuries, texts do not recommend deliberately positioning the horse's cranio-facial profile behind the vertical (Cavendish, 1667; Baucher, 1842; Fillis, 1890). In recent decades, however, cervical flexion ranging from postures with the cranio-facial profile slightly behind the vertical to extreme flexion (where the horse's chin may touch its pectoral region) have become common in many equestrian disciplines, not just at elite sport level but also at grass roots (Kienapfel et al., 2014).

Throughout history a variety of equipment has been specifically designed to influence and, in some cases maintain, the horse's head and neck posture. Lever bits with port mouthpieces and curb chains multiply the amount of pressure applied by the rider through the reins as well as pressing on various parts of the horse's head. Other combination bits, training reins and pulley systems (e.g., side reins, draw reins, chambon, de Gogue, the Pessoa lunging system) are also designed to enforce and maintain a lowering of the atlanto-occipital joint and cervical flexion.

Although dropping the poll and coming behind the vertical should attract penalty if seen in dressage competitions, the criteria that the judges use to interpret the FEI rules for the desired head and neck position appears to have changed and, rather than being considered a fault, head positions behind the vertical are being rewarded, especially at the elite level (Lashley et al., 2014). Furthermore, steward guidelines issued in 2010 detailing permitted pre- and post-competition training techniques allow the practice of cervical flexion of varying degrees ranging up to deliberate extreme flexions of the neck including either high, low or lateral head carriages (FEI, 2010).

Historically (see Table 1 in the Appendix), there has been a lack of comprehensive and universally descriptive definitions. Head and neck positions which result in the horse's cranio-facial profile being behind the vertical have been generalised as 'over-bending' but have received a variety of labels including:

- over bending (also overbending)
- going deep
- riding deep
- very deep
- deep and round including the versions: long, deep and round (LDR), and low, deep and round (also LDR)
- a narrow frame
- 'biting the chest'
- Rollkur / rollkür
- hyperflexion
- extreme flexion
- deliberate extreme flexion

In 1992, Heinz Meyer introduced the term Roll-Kur - a composite German term that derives from "rolling [the neck]" and "cure" (Meyer, 1992). Following an article in StGeorg magazine (Pochhammer, 2005), the term became internationally known as Rollkur. In 2006, the FEI adopted the term hyperflexion and definition (refer to Table 1 in the Appendix: FEI, 2006), however, in 2010 they re-defined the term to reflect how it is achieved and now refer to the actual head and neck posture as 'extreme flexion'. Certain variations of flexion (such as, LDR) are considered by some to be gymnastically advantageous (Denoix, 2014).

Literature review - effects of head and neck flexion on welfare

In the following paragraphs, the terms "hyperflexed" and "hyperflexion" are used to refer to all degrees of neck flexion that result in a cranio-facial profile behind the vertical, as this is the denominator common to the vast majority of studies on head and neck postures.

A review of the literature (as at May 2015) reveals a total of 55 published studies dealing with horses' head and neck posture, 42 of which evaluated impact on welfare. Eighty-eight % of these studies concluded that hyperflexed head and neck postures negatively affect equine welfare. Notably, there is only one study (van Breda, 2006) that suggested evidence of improved welfare when training horses using hyperflexion. However, in this study treatment (i.e. riding in hyperflexion vs. no hyperflexion) was confounded with training level and horse management factors and, since stress related measurements were only taken 30 min after training, it is unclear if the differences reported were caused by hyperflexion. The remaining studies did not detect significant treatment differences.

In particular, hyperflexed head and neck postures have been shown to cause:

- upper airway obstruction (van Erck-Westergren, 2011; Sleutjens et al., 2012; Zebisch et al., 2014b); note that airway obstruction is a serious welfare concern as it leads to shortness in breath which is known to be highly aversive to animals due to the associated respiratory effort as well as the distinct sensations of air hunger and chest tightness (Beausoleil and Mellor, 2014).

- pathological changes in the structures of the neck (flexion of the neck leads to changes in neck length (Kienapfel and Preuschoft, 2011) and intersegmental angles of cervical and thoracic vertebrae (Clayton et al., 2010; Fjordbakk et al., 2013). Pronounced flexion leads to an increase in intervertebral foramina dimensions, which according to Sleutjens

et al. (2010) potentially leads to interference with nerve functioning. Furthermore, flexion leads to an increase in lamella sheet width resulting in increased tensions in elastic structures (Nestadt and Davies, 2014) such as the nuchal ligament origin (Elgersma et al., 2010). According to Weiler (2002), these increased tensions result in insertion desmopathies, which he observed in all examined dressage horses (commonly trained in flexed and hyperflexed head and neck postures), but in none of the horses who had not been trained in such postures.

- impaired vision (Harman et al., 1999; McGreevy et al., 2010); inability to see the ground toward which the horse is moving may lead to anxiety (von Borstel et al., 2009) and/or attempts to achieve frontal vision by turning of the eyeball (Bartos et al., 2008; von Borstel et al., 2009) although horses' ability to do so has only been demonstrated up to a vertical cranio-facial profile (Bartos et al., 2008).

- stress and anxiety due to physiological compromise and rider intervention necessary to achieve the hyperflexed head and neck posture (von Borstel et al., 2009, Christensen et al., 2014) and due to confusion caused by conflicting signals and inability to escape pressure (McLean and McGreevy, 2010). These negative effects are expressed through behaviours indicative of conflict (Caanitz, 1996; von Borstel et al., 2009; Kienapfel, 2011; Ludewig et al., 2013; Hall et al., 2014; Kienapfel et al., 2014; Zebisch et al., 2014a), avoidance behaviour/responses (von Borstel et al., 2009), enhanced/stronger fear reactions (indicative of heightened states of anxiety; von Borstel et al., 2009) and reluctance to move forward (Gomez Alvarez et al., 2006; von Borstel et al., 2009). As a consequence of the latter, higher levels of rider interventions are necessary (von Borstel et al., 2009; Christensen et al., 2014; Smiet et al., 2014), which, in turn, further increase discomfort as evident from increased levels of behaviour indicative of conflict. Depending on the study design, changes in physiological stress parameters such as cortisol (Christensen et al., 2014; Zebisch et al., 2014a), eye temperature (Hall et al., 2014), heart rate (Sloet van Oldruitenborgh-Oosterbaan et al., 2006; von Borstel et al., 2009) and heart rate variability (Smiet et al., 2014) also indicate higher levels of stress during hyperflexion.

A cross-study comparison (König v. Borstel et al., 2015) revealed that welfare concerns were detected regardless of the following aspects: the duration the posture is applied, the method used to achieve the posture, the horses' level of dressage training, horses' prior experience with hyperflexion and horses' breed (a factor closely related to head-neck conformation). Thus, the cross-study comparison suggests that the posture compromises equine welfare even if the horses are accustomed to it/its application and even when they are exposed to it only for a short duration.

Literature review - gymnastic effects (defined as aspects including e.g. performance, kinematics and workload)

Of the 55 reviewed studies, 35 investigated aspects related to gymnastics. Approximately one quarter (26%) of these studies concluded that training in hyperflexed head and neck postures has beneficial effects on gymnastics, while another 23% concluded that it has detrimental effects on gymnastics. The results within the remaining studies were inconclusive.

Investigated gymnastic effects relate to:

- Breathing: A number of studies showed evidence of airway obstruction during hyperflexion (van Erck-Westergren, 2011; Go et al., 2014a; b; Go et al., 2014c; Zebisch et al., 2014b), leading e.g. to increased inspiratory pressure but not to arterial hypoxemia (Sleutjens et al., 2012).

- Workload in specific muscles: The brachiocephalicus is more active, while the trapezius, splenius and rectus are less active in a hyperflexed head and neck posture, indicating that horses' neck muscles are being trained in a way undesirable for riding, i.e. strengthening the ventral (commonly known as underline) rather than dorsal (commonly known as topline) neck muscles (Kienapfel and Preuschoft, 2014; Kienapfel, 2015).

- Overall workload: based on measurements of lactate concentration and heart rate, some studies suggest that overall workload is increased by a hyperflexed head and neck posture (Sloet van Oldruitenborgh-Oosterbaan et al., 2006; Wijnberg et al., 2010).

- Kinematics: according to some studies, range of movement in the back (Rhodin et al., 2005; Gomez Alvarez et al., 2006; Kattelans, 2012) and limbs (Rhodin et al., 2009; Kattelans, 2012) increased while step length decreased (Weishaupt et al., 2006; Waldern et al., 2009; Ludewig et al., 2013) and stride duration increased (Weishaupt et al., 2006). While some of these effects are considered desirable in the interest of more expressive movements, they may also put the horse at a higher risk of injury (Rhodin et al., 2009). Also, with most studies, significant differences were limited to specific situations (e.g., one but not the other gaits, Weishaupt et al., 2006), and other studies failed to find significant changes in these parameters when investigating horses with rather than without a rider (Rhodin et al., 2009).

- Performance marks and submission: depending on the level of competition, performance marks were either lower, not different or higher when horses were ridden or warmed-up in hyperflexed head and neck postures (Kienapfel et al., 2014; Lashley et al., 2014). Rideability in young horses was judged to be superior when horses were ridden with the horse's cranio-facial profile behind the vertical (König von Borstel et al., 2011b), potentially because these horses were considered to be more submissive.

Conclusion

When balancing the gymnastic effects with the evident costs of impairing equine welfare, there remains little reason why the use of extreme/hyperflexed head and neck postures in equine training should be considered an acceptable practice.

Recommendation

ISES recommends that: Riders, trainers and sports officials must be aware of the gradual effect of flexion on welfare and ensure that head and neck postures do not compromise physiological or psychological function. Maintaining an open airway and ensuring the horse is self-maintaining the posture (rather than it being enforced by the rider/trainer and/or tack or equipment) are essential. Extreme or hyperflexed head and neck postures are not acceptable.

ISES recommends that: Riders, trainers and sports officials must be aware that psychological compromise (due to perceived vulnerability as a result of vision impairment and/or stress as a result of enforcing head and neck posture) occurs well before physiological compromise.

ISES recommends that: The FEI dressage rules emphasising the maintenance of a cranio-facial profile at or in front of the vertical at all times are prioritised (in FEI- and non-FEI- regulated disciplines).

Based on the substantial number of scientific studies on the impact of hyperflexed head and neck postures on horse welfare, the knowledge gained from these studies and the physiological and psychological compromise they cause, ISES does not call for additional research on hyperflexion. Further research may be warranted on the physiological and psychological effects of lesser degrees of flexion and extension (inverted head and neck postures).

ISES recommends that: Researchers who wish to study additional aspects related to head and neck posture should distinguish between the various postures by clearly defining the following aspects:

a) The shape of the gullet (to account for differences in individual conformation)
b) The angle of the cranio-facial profile relative to the ground (or the vertical)
c) The angle between cranio-facial profile and neck (degree of flexion in the atlanto-occipital joint), i.e. the 'openness' of the head/neck junction (intersection of mandible and ventral surface of the neck)
d) The angle between neck and withers
e) The lateral displacement of the head in relation to the body
f) Lateral flexion of the neck

Since it is unlikely that some or all of these factors can be standardised, appropriate measures of central tendency (e.g., mean or median) and variability of these angles as well as the shape of the gullet should be reported.

References

Bartos, L., Bartosova, J., Starostova, L., 2008. Position of head is not associated with changes in horse vision. Equine Veterinary Journal 40, 599-601.

Baucher, F., 1842. Méthode d'équitation basée sur de nouveaux principes Paris: Impr de Ve Dondey-Dupré, 33-36.

Beausoleil, N.J., Mellor, D.J., 2014. Introducing breathlessness as a significant animal welfare issue. New Zealand Veterinary Journal 63, 44-51.

Caanitz, H., 1996. Ausdrucksverhalten von Pferden und Interaktion zwischen Pferd und Reiter zu Beginn der Ausbildung. DVM-thesis, Klinik für Pferde der Tierärtzlichen Hochschule Hannover und dem Tierhygienischen Institut Freiburg.

Cavendish, W., 1667. A new method, and extraordinary invention, to dress horses, and work them according to nature. Tho. Milbourn, London.

Christensen, J.W., Beekmans, M., van Dalum, M., VanDierendonck, M., 2014. Effects of hyperflexion on acute stress responses in ridden dressage horses. Physiology & Behavior 128, 39-45.

Clayton, H.M., Kaiser, L.J., Lavagnino, M., Stubbs, N.C., 2010. Dynamic mobilisations in cervical flexion: Effects on intervertebral angulations. Equine Veterinary Journal 42, 688-694.

Denoix, J.M., 2006. Functional anatomy and diagnostic imaging of the cervical spine. In: Report of the FEI Veterinary and Dressage Committee's Workshop. The use of over-bending ('Rollkur') in FEI Competition. FEI Veterinary Committee meeting at the Olympic Museum, 31 January, Lausanne, Switzerland.

Elgersma, A., Wijnberg, I., Sleutjens, J., van der Kolk, J., van Weeren, R., Back, W., 2010. A pilot study on objective quantification and anatomical modelling of in vivo head and neck positions commonly applied in training and competition of sport horses. Equine Veterinary Journal 42, 436 - 443.

FEI, 2006. Report of the FEI Veterinary and Dressage Committees' Workshop. The use of over bending ("Rollkur") in FEI Competition.

FEI, 2010. FEI stewards manual dressage. New annex XIII.

FEI, 2014. Dressage Rules 2014. Rules for Dressage.

Fillis, J. 1891. Principes de dressage et d'équitation Paris: C. Marpon et E. Flammarion, 66-83.

Fjordbakk, C.T., Chalmers, H.J., Holcombe, S.J., Strand, E., 2013. Results of upper airway radiography and ultrasonography predict dynamic laryngeal collapse in affected horses. Equine Veterinary Journal 45, 705-710.

Go, L.-m., Barton, A., Ohnesorge, B., 2014a. Objective classification of different head and neck positions and their influence on the radiographic pharyngeal diameter in sport horses. BMC Veterinary Research 10, 118.

Go, L.-m., Barton, A., Ohnesorge, B., 2014b. Pharyngeal diameter in various head and neck positions during exercise in sport horses. BMC Veterinary Research 10, 117.

Go, L., Barton, A.K., Ohnesorge, B., 2014c. Evaluation of laryngeal function under the influence of various head and neck positions during exercise in 58 performance horses. Equine Veterinary Education 26, 41-47.

Gomez Alvarez, C.B., Rhodin, M., Bobber, M.F., Meyer, H., Weishaupt, M.A., Johnston, C., Van Weeren, P.R., 2006. The effect of head and neck position on the thoracolumbar kinematics in the unridden horse. Equine Veterinary Journal, Suppl 36, 445-451.

Hall, C., Kay, R., Yarnell, K., 2014. Assessing ridden horse behavior: Professional judgment and physiological measures. Journal of Veterinary Behavior: Clinical Applications and Research 9, 22-29.

Harman, A.M., Moore, S., Hoskins, R., Keller, P., 1999. Horse vision and an explanation for the visual behaviour originally explained by the 'ramp retina'. Equine Veterinary Journal 31, 384-390.

Kattelans, A., 2012. Eine Untersuchung zum Einfluss der Kopf-Hals-Haltungen auf Gelenkwinkel der Hintergliedmaße mit dem Bewegungsanalysesystem Simi und dem Tekscan®-HoofTM-System. DVM-thesis, University of Veterinary Medicine Hanover.

Kienapfel, K., 2011. And what are the opinions of the horses? - On the expressive behaviour of horses in different neck positions. Pferdeheilkunde 27, 372-380.

Kienapfel, K., 2015. The effect of three different head–neck positions on the average EMG activity of three important neck muscles in the horse. Journal of Animal Physiology and Animal Nutrition 99, 132-138.

Kienapfel, K., Link, Y., König v. Borstel, U., 2014. Prevalence of different head-neck positions in horses shown at dressage competitions and their relation to conflict Behaviour and performance marks. PLoS ONE 9, e103140.

Kienapfel, K., Preuschoft, H., 2011. What effects hyperflexion of the neck? The influence of the head-neck position on stretching of the soft tissue. Pferdeheilkunde 27, 358-+?.

Kienapfel, K., Preuschoft, H., 2014. Activity patterns of trunk muscles in walk, trot and canter and their relation to different head-and-neck-positions, Proceedings of the 10th International Equitation Science Conference, Vejle, Denmark, p. 45.

König von Borstel, U., Kassebaum, L., Gauly, M. 2011a Effect of discipline (Western vs Dressage) and skill level on learning and discomfort behaviour of riding horses. Proceedings of the 7th International Equitation Science Conference, Hooge Mierde, The Netherlands, p. 75.

König von Borstel, U., Pasing, S., Gauly, M., 2011b. Towards a more objective assessment of equine personality using behavioural and physiological observations from performance test training. Applied Animal Behaviour Science 135, 277-285.

König von Borstel, U., Kienapfel, K., Wilkins, C., Evans, D., McLean, A., McGreevy, P.,2015.Hyperflexing horses' necks: a meta-analysis and cost-benefit evaluation. Proceedings of the 11th International Equitation Science Conference, Vancouver, Canada, accepted.

Lashley, M.J., Nauwelaerts, S., Vernooij, J.C., Back, W., Clayton, H.M., 2014. Comparison of the head and neck position of elite dressage horses during top-level competitions in 1992 versus 2008. Veterinary Journal 202, 462-465.

Ludewig, A.K., Gauly, M., König von Borstel, U., 2013. Effect of shortened reins on rein tension, stress and discomfort behavior in dressage horses. Journal of Veterinary Behavior: Clinical Applications and Research 8, 15-16.

McGreevy, P.D., Harman, A., McLean, A., Hawson, L., 2010. Over-flexing the horse's neck: A modern equestrian obsession? Journal of Veterinary Behavior: Clinical Applications and Research 5, 180-186.

McLean, A.N., McGreevy, P.D., 2010. Horse-training techniques that may defy the principles of learning theory and compromise welfare. Journal of Veterinary Behavior: Clinical Applications and Research 5, 187-195.

Meyer, H., 1992. Roll-Kur. StGeorg 11, 70-73.

Meyer, H., 2008. Roll-Kur – Die Überzäumung des Pferdes. WuWei, Germany, p. 284.

Nestadt, C., Davies, H., 2014. Effects of thoracic posture on the nuchal ligament in foetal foals. Equine Veterinary Journal Suppl. 46, 44.

Pochhammer, G. 2005. Dressur pervers. StGeorg 8, 14-20.

Preuschoft, H., Witte, H., Recknagel, S., Bar, H., Lesch, C., Wuthrich, M., 1999. Effect of common head gear on horses. DTW. Deutsche Tierarztliche Wochenschrift 106, 169-175.

Rhodin, M., Gomez Alvarez, C.B., Bystrom, A., Johnston, C., van Weeren, P.R., Roepstorff, L., Weishaupt, M.A., 2009. The effect of different head and neck positions on the caudal back and hindlimb kinematics in the elite dressage horse at trot. Equine Veterinary Journal 41, 274-279.

Rhodin, M., Johnston, C., Holm, K.R., Wennerstrand, J., Drevemo, S., 2005. The influence of head and neck position on kinematics of the back in riding horses at the walk and trot. Equine Veterinary Journal 37, 7-11.

Sleutjens, J., Smiet, E., van Weeren, R., van der Kolk, J., Back, W., Wijnberg, I.D., 2012. Effect of head and neck position on intrathoracic pressure and arterial blood gas values in Dutch Warmblood riding horses during moderate exercise. American Journal of Veterinary Research 73, 522-528.

Sleutjens, J., Voorhout, G., Van Der Kolk, J.H., Wijnberg, I.D., Back, W., 2010. The effect of ex vivo flexion and extension on intervertebral foramina dimensions in the equine cervical spine. Equine Veterinary Journal 42, 425-430.

Sloet van Oldruitenborgh-Oosterbaan, M.M., Blok, M.B., Begeman, L., Kamphuis, M.C.D., Lameris, M.C., Spierenburg, A.J., Lashley, M.J.J.O., 2006. Workload and stress in horses: comparison in horses ridden deep and round ('rollkur') with a draw rein and horses ridden in a natural frame with only light rein contact. Tijdschrift voor Diergeneeskunde 131, 114-119.

Smiet, E., Van Dierendonck, M.C., Sleutjens, J., Menheere, P.P.C.A., van Breda, E., de Boer, D., Back, W., Wijnberg, I.D., van der Kolk, J.H., 2014. Effect of different head and neck positions on behaviour, heart rate variability and cortisol levels in lunged Royal Dutch Sport horses. The Veterinary Journal 202, 26-32.

van Breda, E., 2006. A nonnatural head-neck position (Rollkur) during training results in less acute stress in elite, trained, dressage horses. Journal Applied Animal Welfare Science 9, 59 - 64.

van Erck-Westergren, E., 2011. Dynamic respiratory videoendoscopy in ridden sport horses: effect of head flexion, riding and airway inflammation in 129 cases. Equine Vet J 43, 18 - 24.

von Borstel, U., Duncan, I., Shoveller, A., Merkies, K., Keeling, L., Millman, S., 2009. Impact of riding in a coercively obtained Rollkur posture on welfare and fear of performance horses. Applied Animal Behaviour Science 116, 228 - 236.

Waldern, N.M., Wiestner, T., von Peinen, K., Álvarez, C.G.G., Roepstorff, L., Johnston, C., Meyer, H., Weishaupt, M.A., 2009. Influence of different head-neck positions on vertical ground reaction forces, linear and time parameters in the unridden horse walking and trotting on a treadmill. Equine Veterinary Journal 41, 268-273.

Weiler, H., 2002. Insertionsdesmopathien beim Pferd. FN-Verlag, Warendorf, Germany. pp 168.

Weishaupt, M.A., Wiestner, T., von Peinen, K., Waldern, N., Roepstorff, L., Van Weeren, R., Meyer, H., Johnston, C., 2006. Effect of head and neck position on vertical ground reaction forces and interlimb coordination in the dressage horse ridden at walk and trot on a treadmill. Equine Veterinary Journal 38, 387-392.

Wijnberg, I.D., Sleutjens, J., Van Der Kolk, J.H., Back, W., 2010. Effect of head and neck position on outcome of quantitative neuromuscular diagnostic techniques in Warmblood riding horses directly following moderate exercise. Equine Veterinary Journal 42, 261-267.

Zebisch, A., May, A., Reese, S., Gehlen, H., 2014a. Effect of different head-neck positions on physical and psychological stress parameters in the ridden horse. J Anim Physiol Anim Nutr (Berl) 98, 901-907.

Zebisch, A., May, A., Reese, S., Gehlen, H., 2014b. Effects of different head–neck positions on the larynges of ridden horses. Journal of Animal Physiology and Animal Nutrition 98, 894-900.

Appendix

Table 1. Overview of history and definitions of head and neck postures

Year	Term	Activity	Definition	Duration	Source
16th-17th Century	*Blindfolding*	*Impairing vision with a cloth blindfold*	*"Horses learn better when they cannot see and are [...] less inclined to be distracted"*	*Not defined*	*Pluvinel's Maneige Royal, 1623, translation by Hilda Nelson J.A. Allen,1989*
17th Century	*Fexions*	*Invented draw reins, described extreme longitudinal and lateral flexions, especially at resistence of the horse bending in vertical way as much as possible*	*Definition of lateral flexions explained in detail, did not describe flexions longitudinal flexions that resulted in a nasal plane behind the vertical.*	*Not defined*	*William Cavendish (Duke of Newcastle), 1667 "A new method and extraordinary invention to dress horses"*
19th Century	*No specific term mentioned*	*Flexions said to "eradicate all resistance in the horse", mostly practiced at the halt, hyperflexion as by product often achieved, but not as desired HNP described*	*Extreme Flexions with a lowered poll and head positions behind the vertical are shown in the book's illustrations, however, the desired posture described in the text is a head and neck posture with the nasal plane on the vertical.*	*Not defined*	*Baucher, F 1842. Méthode d'équitation basée sur de nouveaux principes Paris: Impr de Ve Dondey-Dupré, 33-36.*
19th Century	*No specific term mentioned*	*Started practicing the Baucher flexions in motion, theoretical again no noseline behind the vertical*	*Extreme Flexion with a high poll considered correct. Going behind the vertical and lowering of the poll is specifically mentioned as incorrect flexion.*	*Not defined*	*Fillis, J. 1891. Principes de dressage et d'équitation Paris: C. Marpon et E. Flammarion, 66-83.*
Early 20th Century	*No specific term mentioned*	*Overbending using curb bits described as a technique developed to aid the German emperor who was disabled - as a means of control*	*Head strongly flexed with the nose towards the chest*	*Not defined*	*Paul Plinznerei*
1970s	*Overbending / riding deep / deep and round*	*Extreme flexions usually achieved using draw reins*		*Not defined*	*Paul and Alwin Schockemohle*
1990s	*Deep / Very deep*	*Extreme flexions during competition warm up*	*"horses with their nose on their chest"*	*Not defined*	*Uwe Schulten Baumer / Nicole Uphoff http://horsesinternational.com/articles/rollkur-looks-like-near-rape/ (translation of an article in the Dutch Bit magazine)*
2005	*'Set Deep', "biting chest", 'rolling the nose' Coined the term "Rollkur"*	*Nose to chest and nose to point of shoulder*	*"shoving the head back and forth", "the nose is rolled almost 45 degrees behind the vertical", "too narrow, too deep" and, "biting the chest"*	*Reported as 'systematic and consistent' (by Dutch riders but 'not yet' by German riders)*	*Dressur Pervers' article by Gabrielle Pochhammer, St Georg magazine http://home.comcast.net/~timpano/Images/DressurPervers.pdf*

2006	*Hyperflexion of the neck*	*Nose to chest and nose to point of shoulder*	*1st Proposed Draft Deffinition: ''Hyperflexion of the neck is a technique of working/training to provide a degree of longitudinal flexion of the mid-region of the neck that cannot be self-maintained by the horse for a prolonged time without welfare implications. There must be an understanding that hyperflexion as a training aid must be used correctly, as the technique can be an abuse when attempted by an inexperienced/unskilled rider/trainer."*	*To be defined*	*2006 FEI Veterinary and Dressage Committees Workshop, Laussanne: http://www.fei.org/fei/your-role/veterinarians/welfare/research* *FEI adopted the use of the term hyperflexion (email communication to Horses and People Magazine).*
2008	*Hyperflexion (Rollkur)*		*"There are no known clinical side effects specifically arising from the use of hyperflexion, however there are serious concerns for a horse's well-being if the technique is not practiced correctly.''*	*The FEI condemns hyperflexion in any equestrian sport as an example of mental abuse. The FEI states that it does not support the practice.''*	*FEI Welfare Sub-Commmittee Statement issued 11 April 2008 distributed to fei_prnews list by Malina Gueorguiev. (pdf copy of original press release distributed by FEI press office).*
February 2010	*Hyperflexion and rollkur (redefined)*		*New definition: ''Flexion of the horse's neck achieved through aggressive force.''*	*Unacceptable*	*http://www.fei.org/news/fei-round-table-conference-resolves-rollkur-controversy*
September 2010	*Extreme flexion, stretching*	*Deliberate extreme flexions of the neck involving either a high, low or lateral head carriage.*	*Correctly executed stretching techniques'.* *Lengthening of the horse's ligaments and muscles that can be done at the halt (statically) or in motion (dynamically).* *Neck stretches may take different forms, LDR, LDR and LL are just three examples but there are other variations involving both longitudinal and lateral flexion which result in different neck positions.* *It is imperative that stretching should be executed by unforced and non aggressive means.*	*Should only be performed for very short periods. If performed for longer periods the steward will intervene.* *Movements which involve having the horse's head and neck carriage in a sustained or fixed position should only be performed for periods not exceeding approximately 10 minutes without change.* *Change may be constitute a period of relaxation and lengthening or a movement which involves stretching the head and neck of the horse or another stretch.*	*Stewards Manual Annex XIII (21 September 2010) http://fei.org/fei/your-role/stewards-manual*