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ORIGINAL ARTICLE

Effects of different head–neck positions on the larynges of ridden horses

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Summary

Hyperflexion, that is the strong deflection of the horse's head, poll and neck, is a prevalent training technique in equitation. Hyperflexion has come under criticism in recent years for being suspected of affecting the horses' well-being contrary to animal welfare. The goal of the present study is a comparison between the impacts of different poll-neck positions on findings in the upper respiratory tract of ridden horses. For this purpose, video recordings of the larynges of 14 horses were taken using an overground endoscope. The videos were recorded at rest and during three different riding phases: firstly, in a stretching posture, secondly, in a working position and, thirdly, in hyperflexion. A comparison between the analyses of the working position and hyperflexion phases revealed a significant reduction in the laryngeal opening area ($p = 0.001$) with a value of $8.2 \pm 5.0\%$. Furthermore, other parameters of the larynx evaluated also showed a significant diminishment. These changes did not correlate with the age of the horses or their level of education, and they were independent of the individual anatomical conditions of the poll-neck region. In summary, it can be stated that hyperflexion causes a considerable compression of the larynx.

Keywords hyperflexion, video endoscopy, stress, animal welfare, training

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Introduction

To achieve goals in equitation, horsemen have always tried to form and present their horses according to their perceptions by optimising the training methods for a maximum of success. For many years, one of those training methods has been criticised: hyperflexion of the horses' head, poll and neck. An International Equestrian Federation (FEI) workshop took place in 2006 to work out whether this method conflicts with principles of animal welfare or not. They concluded that this training method, so far known as 'rollkur', should better be called hyperflexion. Hyperflexion was defined as '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'. However, the FEI was of the opinion that when the hyperflexion provided was being performed by an experienced rider, it would have no harmful effects on the horse (International Equestrian Federation, 2006). At another workshop in February 2010, the FEI decided that a head–neck position achieved by an aggressive application of force is not acceptable. Hyperflexion, in which extreme deflection of the head and neck is accomplished by force, must therefore also be classified as unacceptable (International Equestrian Federation, 2010).

In the meantime, several scientific studies dealing with this topic are available. One of those studies examined the heart rate and the heart rate variability and came to the conclusion that hyperflexion does not lead to an increased stress reaction (Van Breda, 2006). In another study, blood lactate concentration was measured among other physiological stress parameters. It was found out that the blood lactate concentration of a horse ridden in hyperflexion was higher than that of a horse ridden with loose reins (Sloet van Oldruitenborgh-Oosterbaan et al., 2006). In 2012, lunged horses were compared where no differences relating to heart rate and heart rate variability could be observed, but an irregular pattern relating to the body surface temperature was found when the horses were lunged in hyperflexion

(Becker-Birck et al., 2013). These horses were lunged in hyperflexion, on the one hand, and fixed with side reins in a position allowing a forward extension of the poll, on the other hand (Becker-Birck et al., 2013).

In the present study, a video endoscope was used to provide video records of the horses' larynx region which were evaluated after the horses had been ridden in different head–neck positions (Table 1). Our hypothesis was that hyperflexion causes a compression of a horse's larynx.

Materials and methods

Horses

In this study, 14 horses were taken into account: one of these was an Andalusian, while the others were Warmbloods. They were between 4 and 21 (9 ± 5) years of age. Four were jumping horses, nine were dressage horses and one was used for both. Among these were seven geldings, three mares and four stallions. All horses were used to classical training methods and not to hyperflexion.

Schedule of procedures

Four relevant head–neck positions were chosen for investigation, and corresponding endoscopic video records were obtained. The first investigation stage was an at-rest position, in which the horses had a relaxed natural head–neck position with loose reins. A stretching posture was the second stage, a working position was the third and hyperflexion was the fourth. Regarding the working position, the horses were ridden with contact through the reins, each with their nose line slightly before the vertical with the poll being the highest point of the horse. Head and neck were bent down as much as possible for hyperflexion. Despite the best efforts, the horses sometimes briefly left the desired position and got a little more flexion in the neck while in the working position or the degree of flexion showed a mild change while hyperflexion was being investigated. The horses were walked out for 10 min before they were ridden in the different head–neck positions for investigation. The study was conducted on two consecutive days. The riding programme for the investigation included ten to 15 min of trot and canter while the endoscopic videos were recorded.

Measurement of anatomical structures of the horse

Sizes of the relevant anatomical regions mentioned below were determined in all 14 horses by measuring with a tape marked in centimetres. This was performed at rest, in a working position and in hyperflexion. In each case, the circumference of the neck, length of the mandible in the area of the centre of the masseter muscle and thickness of the masticatory muscles ventral to the mandible (Fig. 1) were measured. This was to show differences in the compression of the soft tissue structures of the relevant region to obtain information on the processes taking place inside.

Overground endoscopy

Overground endoscopy was performed with the 'Videomed Active Airway Endoscope' (Videomed GmbH, Munich, Germany). This device is a system allowing the examination of the larynx and pharynx of horses

Fig. 1 Measurement of thickness of the masticatory muscles.

Table 1 Changes in larynx parameters measured through the various head–neck positions (HNPs)

	Working HNP		Hyperflexion	
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation
Opening area%	100.0	3.7	92.0	5.4
Height%	96.0	6.0	95.0	5.7
Width at 2/3 of height%	107.0	10.6	100.0	7.4
Max. width%	98.0	5.6	92.0	7.7
Opening angle%	102.0	3.7	93.0	4.0

during exercise. Besides the endoscope itself, an adjustable noseband, a saddle pad for fastening further constituents and two laptops are part of the system (Fig. 2). One laptop controls the proximal part of the endoscope and receives the video sequence, the other laptop remains on the horse and passes the data directly on to the controlling laptop. A light source and an insufflation pump, which can be remote-controlled directly by the examiner over his laptop, are further properties of the equipment. Endoscopy can be monitored live on the laptop at rest and during exercise using this system. Furthermore, the position of the endoscope can be adjusted as necessary during the investigation. Video sequences of 14 horses at rest and for each position were obtained endoscopically to be able to compare the different head–neck positions.

Analysis of the videos

Videos were viewed frame by frame (VIRTUALDUB v1.9.10 Software, GNU General Public License, Free Software Foundation, Cambridge, MA, USA) to obtain an image at the end of inspiration, and the corresponding images were selected (IRFANVIEW4.27, Korth, Tino, Rostock, Germany). Three breath cycles were measured, and an average was built for each of the 14 horses and each of the four examination stages. Perspective distortions in the images of these breath cycles were eliminated using image editing software (Adobe Photoshop CS5.0, Adobe Systems GmbH, Munich, Germany). The following parameters of the larynx were measured (Fig. 3):

i the opening area of the larynx (A),
ii the height of the laryngeal opening area (B),

Fig. 2 Image of a horse with video endoscopic equipment.

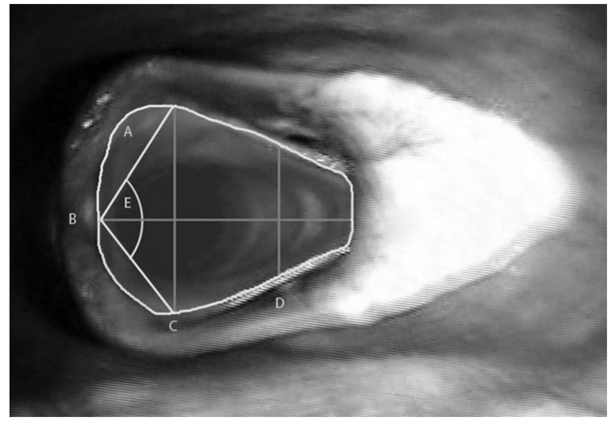

Fig. 3 Laryngeal area with measured parameters. A) Opening area, B) Height, C) Max. width, D) Width at 2/3 of the height, E) Relative aperture angle.

iii the maximum width of the laryngeal opening area (C),
iv the width at 2/3 of the height of the laryngeal opening area (D) and
v the relative aperture angle (line connecting the endpoints of the max. width and the height of the larynx or of the laryngeal opening area; E).

Ten breath cycles of two horses in the at-rest position with loose reins were analysed in the preliminary test. Then, a variety of parameters were measured, and the ones mentioned above were selected. These parameters were chosen because of their results in a preliminary test related to their coefficient of variation.

In the present study, only a size comparison using percentages was performed because it was not technically possible to use a measurement tool for centimetres or square centimetres together with the endoscope during the riding programme.

Statistical analysis

Commercially available software (SPSS 17.0; SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. The data were tested for normality by the Kolmogorov–Smirnov test adapted by Lilliefors (1967). No significant differences to a normal distribution were found. All values are presented as arithmetic mean and standard deviation.

Differences between the head–neck positions were tested by the t-test for paired samples. An influence on laryngeal values between age or level of training of the horse or the individual anatomy of the head was calculated with the correlation coefficient by Pearson. A p-value <0.05 was considered significant.

Results

Acceptance

The video endoscope used in the present study offers the advantage of creating images while working with the horses, in addition to obtaining images in an at-rest position. The horses were not subjected to any medication, and the endoscope had to be fitted without sedation for the riding programme. This was difficult regarding some anxious and nervous horses. Initially, 18 horses were available for the study, but four horses would not accept the endoscope. The remaining 14 horses tolerated insertion and the use of the video endoscope. There were no defensive movements during the riding programme.

Measurement of the anatomical structures of the horse

At-rest position

At rest, the horses' circumference of the neck was 90 ± 3.7 cm. The thickness of the masticatory muscles ventral to the mandible was 5.6 ± 0.4 cm, and the length of the mandible in the area of the centre of the masseter muscle was 13.4 ± 1.0 cm.

Working position

In the working position, circumference of the neck amounted to 91.9 ± 3.6 cm, and thickness of the masticatory muscle amounted to 6.1 ± 0.5 cm.

Hyperflexion

In hyperflexion, circumference of the neck increased to 95.5 ± 3.8 cm, and thickness of the masticatory muscle to 7.1 ± 0.6 cm.

The neck size and the thickness of the masticatory muscles tended to have a larger extent in hyperflexion than in the normal head and neck posture.

Overground endoscopy

The values which resulted from the measurement at rest were equated to 100% and then compared to the results of the different head–neck positions. A specification of absolute values was not possible because the use of a measurement tool synchronised with the video endoscope was not practicable for the present study.

Working position

Here, the larynx opening area had a size of 100 ± 3.7%. The height of the laryngeal opening area had a length of 96 ± 6.0%, the width at 2/3 of the height of the laryngeal opening area was 107 ± 10.6%, the maximum width of the laryngeal opening area was 98 ± 5.6% and the relative aperture angle was 102 ± 3.7%.

Stretching posture

In this posture, the larynx opening area represented 102 ± 3.1%, height 97 ± 4.7%, larynx width at 2/3 of the height was 109 ± 10.1%, maximum width of the laryngeal opening area was 100 ± 3.9% and the relative aperture angle was 102 ± 3.8%.

Hyperflexion

Compared to the resting position, the larynx opening area had a size of 93 ± 5.5% during hyperflexion. The height of the laryngeal opening area was 95 ± 5.7%, the width at 2/3 of the height of the laryngeal opening area was 100 ± 7.4%, the maximum width was 92 ± 7.7% and the relative aperture angle was 93 ± 4.0%.

The opening area of the larynx in hyperflexion was reduced significantly compared to the working head position by 8.2 ± 5.0% ($p = 0.001$; Fig. 4). Similarly, there was a significant difference at the maximum width of the laryngeal opening area ($p = 0.001$), the larynx width at 2/3 of the height ($p = 0.017$) and the relative opening angle ($p = 0.001$; Fig. 5). The height of the larynx showed no significant variations between the different investigation stages.

Changes in the values measured showed no correlation to the age or level of training of the horse and the head measurements (width of mandible, thickness of the jaw muscles, neck circumference).

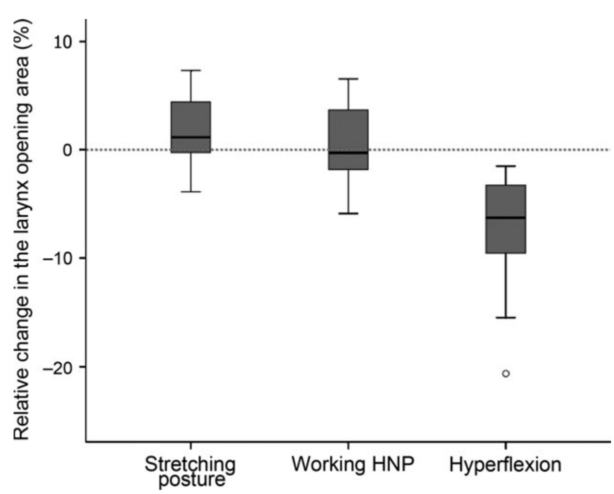

Fig. 4 Changing of the opening area of the larynx. (HNP, head–neck position; the zero line corresponds to the rest position).

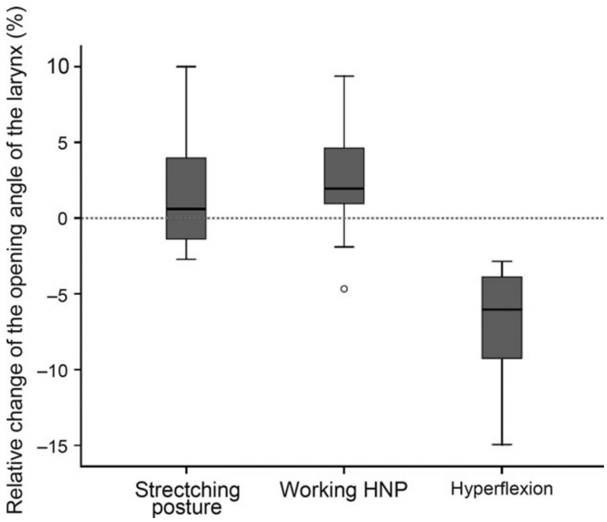

Fig. 5 Changing of the opening angle of the larynx. (HNP, head–neck position; the zero line corresponds to the rest position).

Discussion

Overground endoscopy is a fairly new technology which has not been used in this context so far. A study with 15 horses was carried out in 2008 and came to the conclusion that video endoscopy can be performed properly in practice. There are advantages compared to treadmill endoscopy, such as the possibility to examine horses under natural training conditions and the fact that no habituation or training is necessary for using the technique (Franklin et al., 2008). In a study with 68 horses, it has been established that the safety and reliability of the method with respect to the imaging of the upper respiratory tract under natural training conditions are ensured (Desmaizieres et al., 2009). A further investigation from the same year supports these results (Pollock et al., 2009). Thus, video endoscopy is a scientifically proven method providing high-quality images of the upper respiratory tract for different purposes.

In the present study, it was proven that the hyperflexion posture while riding causes a compression of the larynx. This could affect the well-being of horses. The air supply and, as a result, the oxygen supply could possibly be reduced in comparison with other head–neck positions, and for this reason, hyperflexion could be a stressor for horses.

Our results indicate that the height of the larynx, irrespective of the head–neck position, hardly changes, and the reduction in the opening area while in hyperflexion must be caused by the lack of lateral extension. The measurements show that there is an increase in circumference in the neck and thickness of the masticatory muscles. Thus, the soft tissues seem to be subjected to a higher compression, which leads to a latero-lateral compression of the larynx. A lower air exchange, higher flow resistance and hypoxia could be the result.

Cehak et al. (2010) also found that there is a significant correlation between the head–neck position and the pharyngeal diameter. According to their results, the pharynx narrows by flexing the head, and the diameter increases by extending the head, resulting in a limitation of airflow when in a flexed head–neck position. This could cause turbulences with subsequent dynamic collapse.

Not only head flexion, but also rider interactions lead to instability in the pharyngeal and laryngeal area. This instability can promote the occurrence of complex upper airway obstructions (Van Erck, 2011). Instability in the pharyngeal and laryngeal areas can be associated with lower airway inflammation and pharyngeal lymphoid hyperplasia, which are not linked to other upper airway obstructions (Van Erck, 2011).

It was also found in previous studies that hyperflexion of head and neck in comparison with other head–neck positions leads to the greatest influence on the intrathoracic pressure during exercise, and the arterial oxygen saturation decreases in this position (Sleutjens et al., 2012).

According to the present study, earlier studies were also not able to show clearly whether hyperflexion causes physiological or psychological stress for horses and affects their well-being or not.

Van Breda (2006) conducted a study to measure stress resulting from hyperflexion by analysing heart rate variability, a recognised stress parameter in the horse (Rietmann et al., 2004) . Well-trained dressage horses which were ridden in hyperflexion were compared with recreational horses which were ridden in a natural head–neck position. No differences between the two groups could be found which would allow the conclusion that hyperflexion means increased stress for horses. However, the mere riding programme could have already been exhausting by itself for the untrained recreational horses, and thereby, it could be a physiological stress factor. For an objective comparison, both groups of horses would have been required to undergo the programme in both head–neck positions.

It has been concluded in another study that heart rate, blood lactate concentration and blood pH value increased during hyperflexion, but other blood parameters did not change (Sloet van Oldruitenborgh-Oosterbaan et al., 2006). According to that, an increased workload but no stress could be demonstrated. Furthermore, it has been reported that the course of movement and the reaction to the rider's impact improved during hyperflexion (Sloet van Oldruitenborgh-Oosterbaan et al., 2006). In this study, the horses were ridden with draw reins, although it is already evident that the use of draw reins leads to incorrect collection and a loss of impulsion (Oedberg and Bouissou, 1999). Therefore, in the present study, the horses were ridden without artificial aids.

It has been stated that lunging is the method of choice for obtaining stress tests in the horse. Compared to riding, it is easier to objectify, as the impact of the rider is missing, and both techniques are superior to the treadmill, where the horses generally show more stress-associated behaviour (Van Denderen, 2011). This was also picked up in another study where the horses were lunged with various head and neck positions, and the following stress parameters were measured: salivary cortisol, heart rate, heart rate variability and body surface temperature (Becker-Birck et al., 2013). In hyperflexion, no increased stress was measured, but body surface temperature showed an inhomogeneous pattern (Becker-Birck et al., 2013). The present study was conducted under natural training conditions with only small changes in the head–neck position during the investigation, similar to normal riding and training. The conditions for investigation are, of course, difficult to objectify while riding, and the results need to be confirmed by further studies. Particularly horses with a very supple poll may occasionally remove their nose behind the vertical even in working position if the reins and the driving aids are not entirely balanced, nevertheless, there are differences to hyperflexion. Compared to a low neck position in hyperflexion, the neck remains in the normal posture while working position and furthermore the nose position are not enforced by very strong aids.

However, the advantage of natural training conditions is that negative effects of a constricted larynx will possibly occur earlier while riding than while lunging or on the treadmill, and the influence of the rider may create differences that should not be left unattended.

Therefore, it can be concluded that studies which have been conducted so far have led to heterogeneous results. Some show results indicating that hyperflexion does not lead to increased stress, and others identify indications of a limitation of well-being by possibly reducing oxygen supply. The possible reduced oxygen supply could be a problem especially if hyperflexion is combined with a strong motion development.

In the present study, hyperflexion resulted in a significant compression of the larynx, regardless of the individual anatomical conditions of the head–neck region. This could be another indication of hyperflexion affecting the well-being of the horse. Further studies are necessary to assess the long-term effects conclusively. Furthermore, it would be interesting to compare the reduction in the laryngeal opening area during hyperflexion to the reduction in the laryngeal opening area caused by upper airway diseases, such as hemiplegia laryngis, to show the clinical relevance for the horses. In addition, further studies are needed to prove whether the oxygen supply is actually correlated with the extent of the larynx narrowing.

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