EQUINE VETERINARY JOURNAL

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Equine vet. J. (2011) **43** (Suppl. 40) 18-24
doi: 10.1111/j.2042-3306.2011.00492.x

Dynamic respiratory videoendoscopy in ridden sport horses: Effect of head flexion, riding and airway inflammation in 129 cases

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Keywords: horse; ridden exercise; overground endoscopy; head flexion; upper respiratory obstruction; inflammation

Summary

Reasons for performing study: **Dynamic upper airway obstruction (UAO) is a cause of respiratory noise and sometimes poor performance in sport horses. Riding, head flexion and airway inflammation may impact upper respiratory tract stability during exercise.**

Objectives: **To evaluate upper airway mechanical behaviour in ridden sport horses using overground endoscopy and the effect of head flexion, rider intervention and underlying airway inflammation on the pharynx and larynx.**

Methods: **Resting and exercising videoendoscopic recordings during ridden exercise were obtained in 129 sport horses referred mainly for respiratory noise, poor performance or routine evaluation. The rider modified poll flexion and way of riding during the test and associated changes in UAO were recorded. Presence of upper and lower airway inflammation was also assessed.**

Results: **Dynamic UAO was diagnosed in 91% (64/70) of the horses referred for respiratory noise and in 71% (29/41) of horses referred for poor performance. Pharyngeal instability was the most frequently diagnosed problem. However, differences were observed between dressage horses and showjumpers. Rider interaction and head flexion exacerbated upper airway instability and promoted the occurrence of complex UAO. Both lower airway inflammation and pharyngeal lymphoid hyperplasia were associated with pharyngeal instability, but not with any other UAO.**

Conclusions: **Rider intervention during ridden exercise (i.e. the various movements a horse might be asked to perform) influences upper airway morphology and function and, in cases of upper airway dynamic obstruction, can contribute to increasing laryngeal and/or pharyngeal instability in sport horses.**

Potential relevance: **As these are changes that would not usually be seen with treadmill videoendoscopy, ridden videoendoscopy should be the preferred method for evaluation of the upper airway in sport horses.**

Introduction

Dynamic upper airway obstruction (UAO) is a common cause of respiratory noise during exercise and may lead to poor performance in equine athletes (Tan *et al*. 2005). The noise generated by an obstruction in the airway, whether functionally disabling or not, is often of concern to the horse's rider, can count against it in competition and can decrease the commercial value of the horse.

Upper airway obstruction may be caused by multiple conditions, most of which remain undetectable or misdiagnosed upon resting examination (Parente and Martin 1995; Ferrucci *et al*. 2004; Tan *et al*. 2005; Lane *et al*. 2006b). The advent of overground endoscopes has allowed the evaluation of upper airway mechanical behaviour in normal exercising conditions. The technique has already been used to evaluate racehorses, but reports regarding its use in sport horses (also known as show horses) are scarce (Franklin *et al*. 2008; Desmaizieres *et al*. 2009; Pollock *et al*. 2009). A recent retrospective study evaluated the prevalence of UAO in nonracing performance horses (Davidson *et al*. 2011); however, endoscopic examination was performed on a high-speed treadmill. It has been suggested that because treadmill exercise does not entirely replicate field exercise conditions, this may lead to some conditions being underdiagnosed (Van Erck *et al*. 2009; Allen *et al*. 2011). In sport horses, ridden examination could be of particular importance, as equitation-related manoeuvres or movements could be a factor in the development of dynamic airway instability. Indeed, in a study comparing treadmill to track endoscopy in saddle horses, some conditions could not be elicited on a treadmill due to the absence of rider intervention (Van Erck *et al*. 2009).

Although the effect of head flexion has been recognised as a factor contributing to an increase in upper respiratory tract resistance (Petsche *et al*. 1995), the combined effects of rider equitation and head flexion on upper airway morphology have not been well documented. The aim of this study was to investigate upper airway mechanical behaviour in ridden sport horses and to assess the effect of head flexion and equitation on them. Because a number of horses also had observable signs of airway

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[Paper received for publication 15.03.11; Accepted 04.08.11]

inflammation, the relationship between this and UAO was also investigated.

Materials and methods

Horses

Between January 2010 and February 2011, 129 sport horses referred for ridden upper airway videoendoscopy were recorded in the field. The population was composed of 53 stallions, 34 geldings and 42 mares. Age was 6.6 ± 4.2 years (mean ± s.d.), ranging in age from 2 to 20 years. Fifty-nine horses were dressage horses, 63 were showjumpers, 5 were driving horses and 2 were 3-day eventers. The majority of the horses participated regularly in competitions. Reasons for referral included poor performance (n = 41), respiratory noise (n = 70), cough (n = 5), epistaxis (n = 2) and headshaking (n = 1). Table 1 summarises age and reasons for referral according to the practiced discipline. Upper airway overground videoendoscopy was included in a routine seasonal clinical evaluation of 10 normally performing showjumping horses and these served as a reference. Nine horses had had previous laryngoplasty but were still making noise during exercise.

Equipment

A dynamic respiratory scope (DNS) (DR-V2)[1] was used to record videoendoscopic sequences before and during exercise. The processor containing the battery unit, telemetry transmitting device, water pump and recording unit were placed on a custom-made saddle pad. Once the saddle pad was placed on the horse's back, the DRS semi-rigid scope was passed through one of the nares and fastened to the bridle. The tip of the endoscope was generally positioned just rostral to the guttural pouch openings. To better clarify some clinical observations, the horse was sometimes stopped in order to reposition the tip of the endoscope and exercise immediately resumed thereafter. It could be advanced to obtain a better view of the larynx or slightly withdrawn to provide a more global view of the nasopharynx and of the rostral part of the soft palate. Videoendoscopic recordings were started before the onset of exercise and terminated during the recovery phase.

Resting endoscopy was performed with a portable battery powered endoscope (PE-scope)[1] either prior to exercise and/or post exercise.

TABLE 1: Discipline, age and referral motives of 129 cases of sport horses examined for ridden upper airway endoscopy

n	Discipline	Age mean	Age Range	Referral reasons	n
59	Dressage	5.4	2–20	Poor performance	16
				Respiratory noise	41
				Other	2
63	Showjumping	7.5	2–15	Poor performance	20
				Respiratory noise	26
				Routine seasonal examination	10
				Other	7
5	Driving	8.2	4–14	Poor performance	2
				Respiratory noise	3
				Other	0
2	Eventing	8.0	8	Poor performance	2

Exercise test

The horses were ridden by their usual rider in an outdoor or indoor arena and examined at the walk, trot and canter at both leads during at least 15 min of exercise and at least until they developed fatigue or the clinical signs for which they were referred. They were initially left with their heads free and then gathered to increase head and neck flexion (Fig 1). The rider was asked to perform a usual work session during which typical equitation exercises were integrated: changes in lead, circles, gait transitions. According to their level of training, some horses performed more sophisticated exercises or went over jumps. The differences induced by changes in head position were noted, as well as alterations in airway appearance associated with rider interventions such as firm tightening of the reins, applying spurs to the thorax, abrupt transitions between gaits, working in tight circles, sudden change in direction, excessive gathering of the horse, inducing increased vertical movements and execution of dressage figures (pirouette, piaffé and change of lead at the canter). Twelve horses were also examined while jumping over obstacles. Side reins were used in 5 horses whose riders indicated that the noise only occurred when these were fastened. Horses were initially exercised without the side reins and these were subsequently placed and fastened later in the exercise session.

Clinical data

The presence of noise and the time any diagnosed problem occurred were noted, as well as their relation to particular events or changes in equitation. A time cue displayed on the telemetric screen allowed recording of the timing of events during the test. As it corresponded to an identical time cue on the recorded videos, timing could be similarly monitored during *post hoc* review. The occurrence of the following diagnostic features were evaluated for each horse:

- Pharyngeal lymphoid hyperplasia (PLH scored I–IV) (Raker and Boles 1978)
- Laryngeal score at rest (I–IV) (Anon 2003)
- Degree of arytenoid cartilage collapse (ACC) during exercise (scores B or C) (Anon 2003)
- Pharyngeal instability (PI), including rostral billowing of the soft palate, caudal palatal instability (without displacement) and/or lateral, dorsal or circumferential nasopharyngeal collapse
- Dorsal displacement of the soft palate (DDSP)
- Vocal cord collapse (VCC)
- Axial deviation of the aryepiglottic folds (ADAEF)

Resting endoscopy was performed either prior to exercise or after work. The scope was passed through a nostril: the ipsilateral nasal passage, ethmoid region, pharynx, larynx, trachea and bronchial carina were examined. Laryngeal and pharyngeal function was assessed by inducing swallowing and hyperventilation (by transient nasal occlusion). Bilateral guttural pouch endoscopy was performed when indicated, for instance if the horse had a PLH score ≥3, if it presented unilateral nasal discharge, cough or swelling of the retropharyngeal region or had mucus or mucopurulent discharge seen at the pouch openings.

Tracheal score was determined from post effort endoscopic observations only. The presence of mucus in the trachea, with a score ≥2, was regarded as a sign of lower airway inflammation

Fig 1: Ridden sport horse equipped with an overground videoendoscope, with either the head and neck in an open position (left) or with increased head flexion (right).

TABLE 2: Effects of head flexion and other forms of rider intervention on dynamic upper airway obstruction

	Head flexion			Rider intervention		
Diagnosis	OR	95% CI	P (2-tailed)	OR	95% CI	P (2-tailed)
PI	10.68*	3.97–28.75	<0.0001	6.56*	2.90–14.87	<0.0001
DDSP	1.98	0.69–5.68	0.239	2.41	0.91–6.45	0.082
ACC	8.37	2.39–29.31	0.0002	3.62*	1.50–8.70	0.0034
VCC	10.28*	2.94–36.02	<0.0001	9.11*	3.27–25.38	<0.0001
ADAEF	8.56*	1.10–66.48	0.027	3.63*	1.01–13.07	0.047
Multiple UAO	13.31*	4.65–38.04	<0.0001	10.83*	4.49–26.15	<0.0001

* = Significant associations; PI = pharyngeal instability, DDSP = dorsal displacement of the soft palate, ACC = arytenoid cartilage collapse, VCC = vocal cord collapse, ADAEF = axial deviation of the aryepiglottic fold, UAO = upper airway obstruction, OR = Odds ratio 95% CI = 95% confidence interval.

(LAI) and recorded as present or absent (Gerber *et al*. 2004). When indicated or possible, a cytological analysis of a bronchoalveolar lavage (BAL) sample obtained post exercise was performed. A diagnosis of inflammatory airway disease (IAD) was established if inflammatory cell counts were increased, namely neutrophils >10% and/or mast cells >2% and/or eosinophils >2% (Couëtil *et al*. 2001).

Data analysis

The prevalence of respiratory abnormalities were determined and the positive predictive values of specific riding manoeuvres and UAO in the different types of horses were calculated. A Spearman's rank correlation test was used to assess the relationship between age and PLH score. As the clinical and exercise data was recorded in a dichotomous way (present or absent), Fisher's exact test and logistic regression were used to assess potential associations between the UAO, inflammation and riding. Results were expressed as odds ratios (OR). A P value <0.05 was considered to be statistically significant.

Results

All horses accepted the procedure well and the exercise tests were performed without incident. Ninety percent and 81% of the horses had an exacerbation of UAO with head flexion and rider intervention, respectively. The UAO were more readily observable when the horse was exercised more intensely, for instance during canter or collection of the horse with increased upward body movements. Head flexion and riding had a more significant influence on the development of UAO in dressage horses than in showjumpers (positive predictive value [PPV] for head flexion = 86 vs. 65%; PPV for other riding manoeuvres = 83 vs. 57%). The effects of head flexion and other rider interventions on UAO are summarised in Table 2. There was a significant association between rider intervention and exercising with increased head flexion for the detection of all dynamic upper airway obstructive conditions except DDSP (Table 2). However, the incidence of DDSP was significantly higher in dressage horses than in showjumpers (Fig 2). Dressage horses also had a significantly higher incidence of both forms of laryngeal collapse (ACC and VCC).

Exercising endoscopy provided a definitive diagnosis of UAO in 106 of 129 cases. Dynamic UAO was diagnosed in 91% (64/70) of horses referred for respiratory noise, in 71% (29/41) of horses referred for poor performance, in 5/10 horses presented for routine seasonal evaluation and in all 8 horses presented for other reasons. The remaining 23/129 cases did not have an upper airway abnormality based on the dynamic examination; 5 of these horses had been referred for a routine seasonal evaluation. Of the others, 12 had been referred for poor performance and 6 for respiratory noise and were diagnosed with other conditions. In the latter group, the respiratory noise was identified as excessive vibration of the nostrils in 4 cases and in 2 horses dyspnoeic breathing due to LAI.

The prevalence of the different forms of UAO is summarised in Figure 3. Thirty-two horses had a single UAO condition and 74 horses had a combination of 2 or more forms of UAO (multiple dynamic obstructions). In 80 cases, resting endoscopy did not reveal any functional or morphological abnormalities and exercise videoendoscopy was necessary to establish a diagnosis. Data comparing laryngeal functional observations during rest and exercise are presented in Table 3. Only resting laryngeal scores of >3 could predict laryngeal dysfunction (*grades B* or *C* or VCC) during exercise. In 15 horses with normal laryngeal function at rest, 2 had left arytenoid collapse and 13 had VCC during exercise. These abnormalities were identified as the source of the noise. All the horses had an acceptable degree of left arytenoid abduction at rest but were diagnosed with multiple UAO during exercise. These included any combination of ACC, VCC, PI or DDSP, but no combination occurred more frequently than any other.

In all cases of DDSP, PI was also observed and it often appeared to be a preceding condition for DDSP. However, there were cases of PI without DDSP.

In the 10 normally performing horses, 2 had palatal instability that worsened with changes in equitation or head flexion. These horses had a *grade 3* PLH whereas the 8 others had *grade 1* (n = 7) or *2* (n = 1) PLH. Data comparing resting PLH scores to nasopharyngeal or laryngeal dysfunction is summarised in Table 4. A higher percentage of horses with a PLH score of 2 or more had palatal instability.

Age and PLH were negatively correlated (r = -0.43, P<0.0001). Conditions indicative of inflammation of the airways was frequently observed, with PLH present in 67% (87/129) and LAI in 66% (86/129) of the cases. A BAL was undertaken in 66 cases and a diagnosis of IAD was confirmed by BAL fluid cytology in 56/66 horses. There was a significant association between palatal instability and inflammation, with similar odds ratios for PLH (OR = 2.53, 95% CI = 1.19–5.38, P = 0.022) and LAI (OR = 2.35, 95% CI = 1.12–4.98, P = 0.036). No other associations could be found between inflammation and the other UAO conditions.

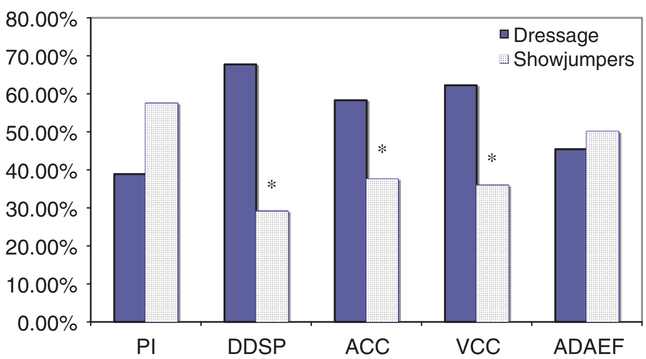

*Fig 2: Comparison of the prevalence of various UAO in dressage horses and showjumpers. *indicates a significant difference in prevalence of the disorder between disciplines. PI = pharyngeal instability; DDSP = dorsal displacement of the soft palate; ACC = arytenoid cartilage collapse; VCC = vocal cord collapse; ADAEF = axial deviation of the aryepiglottic fold.*

Discussion

This study investigated upper airway functional behaviour in ridden sport horses and, for the first time, demonstrated that rider intervention had a significant effect on the stability and morphology of the upper airways. Rider intervention in forms such as the use of spurs, change of gait or short turns appeared to disrupt the rhythm of ventilation and may have aggravated any functional instability of the airways. The degree of poll flexion was not standardised but was adjusted according to the rider's usual way

TABLE 3: Relationship between laryngeal functional scores at rest (according to Hackett *et al.* 1991) and during exercise (according to the Havemeyer scoring system) and number of horses with bilateral vocal cord collapse (VCC) and axial deviation of the aryepiglottic folds (ADAEF)

Resting laryngeal score	n	Arytenoid cartilage collapse during exercise	n	VCC	ADAEF
1	81	A	74	6	10
		B	4	4	0
		C	3	3	0
2	5	A	2	0	0
		B	2	2	1
		C	1	1	0
3	21	A	0	0	0
		B	13	12	1
		C	8	8	3
4	13	A	1	1	0
		B	2	2	0
		C	10	9	3
Previous laryngoplasty	9	A	3	0	2
		B	3	3	0
		C	3	2	2
Total	129		129	53	22

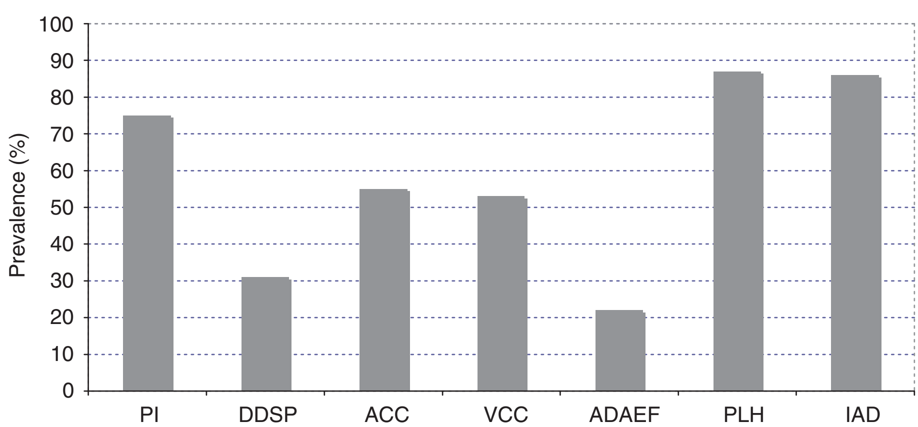

Fig 3: Prevalence of the different dynamic upper airway obstructive and inflammatory conditions diagnosed in 129 cases of sport horses. PI = pharyngeal instability; DDSP = dorsal displacement of the soft palate; ACC = arytenoic cartilage collapse; VCC = vocal cord collapse; ADAEF = axial deviation of the aryepiglottic fold; PLH = phangeal lymphoid hyperplasia; IAD = inflammatory airway disease.

TABLE 4: Relationship between pharyngeal lymphoid hyperplasia (PLH) score and pharyngeal instability (PI), dorsal displacement of the soft palate (DDSP) and any form of laryngeal dysfunction (vocal chord collapse, arytenoid cartilage collapse, axial deviation of the aryepiglottic fold) during exercise

PLH score	n	PI	DDSP	Laryngeal dysfunction
1	42	18 (42.9%)	8 (19.0%)	17 (40.5%)
2	45	31 (68.9%)	14 (31.1%)	21 (46.7%)
3	30	17 (56.7%)	5 (16.7%)	20 (66.7%)
4	12	9 (75.0%)	4 (33.3%)	8 (66.7%)

of riding. Additional tack, such as side-reins, was seldom used. The purpose of this type of equipment is usually to further increase poll flexion.

Dynamic obstructive conditions usually occurred when the intensity of exercise increased, i.e. at the canter, with increased collection and vertical movements or when the horse started to tire. Similarly, when audible, the intensity of noise generated by the obstructive conditions increased with increasing gait, fatigue, head flexion or other forms of rider intervention. Jumping over obstacles was useful to generate fatigue or to elicit specific symptoms described by the rider (e.g. respiratory noise, grunting) but was not necessarily a trigger factor *per se* in the induction of UAO. As exercise intensity increases, transpulmonary inspiratory pressures become more negative (Slocombe *et al*. 1992; Bayly *et al*. 1994; Ducharme *et al*. 1994). Consequently, more strenuous exercises and fatigue of the upper airway musculature may promote instability, i.e. simple or multiple forms of UAO, also in sport horses.

In comparison with the recent study by Davidson *et al*. (2011) that examined nonracing performance horses on the treadmill, the prevalence of UAO was greater in our population (82 vs. 72%). Multiple obstructions (56%) were diagnosed more frequently than in any other studies using treadmill exercise (19% Davidson *et al*. 2011; 21% Franklin *et al*. 2006). The proportion of horses referred for poor performance in which a diagnosis of UAO was made was also considerably higher in this study (70 vs. 21%) than was reported by Davidson *et al*. (2011). The population of horses seemed to be similar in age and breed-types in both studies; however, there could have been differences in level of work or competition as most of the horses participating in the current study competed at national or international levels. This might involve more strenuous training work, permanent indoor housing and frequent transportation, factors known to promote lower airway disease by an increased exposure to inflammation and/or infection (Couëtil *et al*. 2007).

Flexion of the head was either associated with induction of UAO or exacerbation of the obstruction in this study and that of Davidson *et al*. (2011), suggesting that this alone was not responsible for the greater proportion of UAOs seen with overground endoscopy. Although differences in the 2 respective case populations may account in part for these variations in results, the absence of the effect of a rider when a horse is investigated on a treadmill might also help explain the greater frequency of UAO seen in this study. This highlights the importance of examining horses under normal exercising conditions with overground endoscopy (if available).

Pharyngeal wall instability was the most common cause of UAO diagnosed under saddle in this group of 129 sport horses. However, there were significant differences according to the type of equestrian sport discipline in which the horses usually competed. Dorsal displacement of the soft palate and laryngeal collapse were more frequent in dressage horses than in showjumpers. The occurrence of more dramatic obstructive conditions in dressage horses suggests that excessive poll flexion and a more compact gathering of the horse could more markedly influence upper airway mechanics. This could be caused by exercise that is more physically strenuous, although that is unlikely with dressage. It is more likely due to an increase in upper airway resistance due to poll flexion, an increase in inspiratory and expiratory pressures and subsequently an associated increase in the amplitude of airflow through the narrowed airway (Petsche *et al*. 1995). Enforced poll flexion is an important predisposing factor in the development of dynamic airway instability in horses (Davidson *et al*. 2002; Franklin *et al*. 2006).

Higher negative inspiratory pressures promote instability of the rostral part of the soft palate and increase its susceptibility to displacement (Rakesh *et al*. 2008). By increasing negative pressures in the airways, poll flexion promotes palatal instability (Strand *et al*. 2009) and such mechanisms may explain the higher prevalence of DDSP observed in dressage horses. In racehorses, both pharyngeal wall instability and multiple UAO are a recognised cause of poor performance and have been shown as the most deleterious to respiratory functional parameters during strenuous exercise (Durando *et al*. 2002). In the current group of sport horses, UAO, even in its complex forms, was not systematically associated to a complaint of poor performance and generation of noise was of an equal concern, as it is considered to depreciate horses' commercial value. The higher the airflow, the greater the likelihood that upper airway noise will be associated with breathing during exercise.

An accurate assessment of whether DDSP is a problem in a horse is difficult to determine from a resting examination because the condition typically occurs during strenuous exercise (Lane *et al*. 2006). Even during maximal exertion, choosing an appropriate workout is essential to establish a diagnosis of DDSP with overground endoscopy (Franklin *et al*. 2008). This also applies to the dynamic videoendoscopic examination of sport horses for which riding under the saddle of their usual rider and performing a workout similar to the one eliciting the recognised symptoms is of paramount importance to obtain an accurate diagnosis.

In the present study, only 2 horses had recurrent and prolonged DDSP at rest on the day the examination was undertaken. The referring veterinarians had seen intermittent DDSP at rest but had referred the cases for overground examination for the confirmation of their diagnosis, as one horse made a respiratory noise that did not seem to correspond to DDSP and the other was not making any noise, which in the practitioner's opinion was incompatible with DDSP as being the cause of poor performance. The other 29 cases occurred only during exercise. The condition typically appeared after several minutes of cantering, increased head flexion, or increased demands from the rider. It sometimes generated a cough or resentment from the horse and the desire to extend the neck and head. However it was seldom associated with respiratory noise.

According to Lane *et al*. (2006b), in 15% of the cases, DDSP was not associated with a history of noise during intense exertion in Thoroughbreds. In the present study, insufficient amplitude of airflow at slow speeds (i.e. the trot and canter) could be an explanation for the absence of audible noise in a number of the cases in which PI and DDSP were observed.

The incidence of laryngeal instability was high and also significantly associated with head flexion, riding and the type of equine sport. It was less frequently associated with poor performance than with respiratory noise during exercise. Because ACC and VCC generate a similar type of inspiratory noise, but may have a different impact on performance, discrimination between both conditions is important from a therapeutic and management perspective (Brown *et al*. 2003, 2004). The VCC causes a lesser degree of UAO in comparison to ACC and can be treated by minimally invasive laser surgery, whereas a laryngoplasty procedure requires general anaesthesia and a longer recovery period.

Underlying airway inflammation has been suggested as a possible aetiology or predisposing factor to UAO. Because about 2/3 of horses also had observable signs of airway inflammation, we investigated the relationship between this and UAO. Pharyngeal instability, either in the form of palatal instability or nasopharyngeal collapse, was significantly affected by the presence of upper (pharyngeal) or lower airway inflammation, but no other link between airway inflammation and UAO was demonstrated. The pathophysiology of nasopharyngeal collapse is not fully understood but has been associated with neuromuscular dysfunction of the upper airways (Holcombe *et al*. 1999). Inflammatory conditions such as PLH could result in nasopharyngeal instability and possibly DDSP (Blythe *et al*. 1983; Holcombe *et al*. 2001; Sullivan and Parente 2003). In racehorses, only severe forms of PLH or those associated with other respiratory disorders have been shown to generate upper airway dysfunction (Bayly *et al*. 1984; Williams *et al*. 1990; Bayly and Slocombe 1997). A greater percentage of horses affected by PLH developed palatal instability during exercise. Lower airway inflammation may also impact upper airway stability, by increasing respiratory impedance and work of breathing (Couëtil *et al*. 2001; Richard *et al*. 2009). A significant correlation has been shown between the presence of tracheal mucus and poor performance is racehorses (Holcombe *et al*. 2006). In show horses, although IAD does not seem to affect performance (Gerber *et al*. 2003), it has been associated with decreased willingness to perform (Widmer *et al*. 2009). This is in accordance with our findings, where LAI, including IAD, is shown to be detrimental to upper airway stability and may accelerate the onset of fatigue. The type of riding may also enhance the contribution of LAI to UAO.

In conclusion, this study brings to light the importance of rider interaction in inducing instability of the upper airways during exercise as well as promoting the occurrence of multiple obstructions. This has implications for the establishment of an accurate diagnosis in cases of poor performance or exercising respiratory noise. Overground endoscopy in ridden sport horses may also be helpful to predict prognosis in cases of prepurchase examinations.

Authors' declaration of interests

No conflicts of interest have been declared.

Source of funding

No external source of funding (the exams were paid for by the owners as a veterinary consultation).

Acknowledgements

The author wishes to thank Professor Warwick M. Bayly for his encouraging support and valued help with the manuscript.

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References

Anon (2003) Havemeyer Consensus Workshop Havemeyer Foundation Monograph Series No.11 (Equine Recurrent Laryngeal Neuropathy). p 96.

Allen, K.J., Hillyer, M.H., Terron-Canedo, N. and Franklin, S.H. (2011) Equitation and exercise factors affecting dynamic upper respiratory tract function: a review illustrated by case reports. *Equine vet. Educ.* **23**, 361-368.

Bayly, W.M. and Slocombe, R.F. (1997) Evaluation of air-flow mechanics in a model of obstructive upper airway disease under conditions simulating exercise. *Res. vet. Sci.* **62**, 205-211.

Bayly, W.M., Grant, B.D. and Breeze, R.G. (1984) Arterial blood gas tension and acid base balance during exercise in horses with pharyngeal lymphoid hyperplasia. *Equine vet. J.* **16**, 435-438.

Bayly, W.M., Slocombe, R.F., Weidner, J.P., Schott, H.C. and Hodgson, D.R. (1994) Influence of air movement, facemask design and exercise on upper airway, transpulmonary, and transdiaphragmatic pressures in Thoroughbred horses. *Cornell Vet.* **84**, 77-90.

Blythe, L.L., Cardinet, G.H. 3rd, Meagher, D.M., Brown, M.P. and Wheat, J.D. (1983) Palatal myositis in horses with dorsal displacement of the soft palate. *J. Am. vet. med. Ass.* **183**, 781-785.

Brown, J.A., Derksen, F.J., Stick, J.A., Hartmann, W.M. and Robinson, N.E. (2003) Ventriculocordectomy reduces respiratory noise in horses with laryngeal hemiplegia. *Equine vet. J.* **35**, 570-574.

Brown, J.A., Derksen, F.J., Stick, J.A., Hartmann, W.M. and Robinson, N.E. (2004) Effect of laryngoplasty on respiratory noise reduction in horses with laryngeal hemiplegia. *Equine vet. J.* **36**, 420-425.

Couëtil, L.L., Rosenthal, F.S., DeNicola, D.B. and Chilcoat, C.D. (2001) Clinical signs, evaluation of bronchoalveolar lavage fluid, and assessment of pulmonary function in horses with inflammatory respiratory disease. *Am. J. vet. Res.* **62**, 538-546.

Couëtil, L., Hoffman, A., Hodgson, J., Buechner-Maxwell, V., Viel, L., Wood, J. and Lavoie, J. (2007) Inflammatory airway disease of horses. *J. vet. intern. Med.* **21**, 356-361.

Courouсé-Malblanc, A., Pronost, S., Fortier, G., Corde, R. and Rossignoi, F. (2002) Physiological measurements and upper and lower respiratory tract evaluation in French Standardbred Trotters during a standardized exercise test on the treadmill. *Equine vet. J., Suppl.* **34**, 402-407.

Davidson, E.J., Martin, B.B., Boston, R.C. and Parente, E.J. (2011) Exercising upper respiratory videoendoscopic evaluation of 100 nonracing performance horses with abnormal respiratory noise and/or poor performance. *Equine vet. J.* **43**, 3-8.

Davidson, E.J., Martin, B.B., Parente, E.J. and Birks, E.K. (2002) Dynamic evaluation of sport horses with poor performance: 80 cases (1992–2000). In: *Proceedings of Conference on Equine Sports Medicine and Science*. pp 133-136.

Desmaizieres, L.M., Serraud, N., Plainfossé, B., Michel, A. and Tamzali, Y. (2009) Dynamic endoscopy without treadmill in 68 performance Standadbred, Thoroughbred and saddle horses under natural training conditions. *Equine vet. J.* **41**, 347-352.

Ducharme, N.G., Hackett, R.P., Ainsworth, D.A., Erb, H.N. and Shannon, K.J. (1994) Repeatability and normal values for measurement of pharyngeal and tracheal pressures in exercising horses. *Am. J. vet. Res.* **55**, 369-374.

Durando, M.M., Martin, B.B., Hammer, E.J., Langsam, S.P. and Birks, E.K. (2002) Dynamic upper airway changes and arterial blood gas parameters during treadmill exercise. *Equine vet. J., Suppl.* **34**, 408-412.

Ferrucci, F., Zucca, E., Croci, C., Di Fabio, V. and Ferro, E. (2004) Rest and treadmill endoscopic findings in 87 race horses presented for poor performance. In: *The Elite Race and Endurance Horse*, Conference on Equine Sports Medicine and Science, Ed: Arno Lindner, CESMAS. pp 133-136.

Franklin, S.H., Naylor, J.R.J. and Lane, J.G. (2006) Videoendoscopic evaluation of the upper respiratory tract in 93 sport horses during exercise testing on a high speed treadmill. *Equine vet. J., Suppl.* **36**, 540-545.

Franklin, S.H., Burn, J.F. and Allen, K.J. (2008) Clinical trials using a telemetric endoscope for use during over-ground exercise: a preliminary study. *Equine vet. J.* **40**, 712-715.

Gerber, V., Robinson, N.E., Luethi, S., Marti, E., Wampfler, B. and Straub, R. (2003) Airway inflammation and mucus in two age groups of asymptomatic well-performing sport horses. *Equine vet. J.* **35**, 491-495.

Gerber, V., Straub, R., Mart, I.E., Hauptman, J., Herholz, C., King, M., Imhof, A., Tahon, L. and Robinson, N.E. (2004) Endoscopic scoring of mucus quantity and quality: observer and horse variance and relationship to inflammation, mucus viscoelasticity and volume. *Equine vet. J.* **36**, 576-582.

Hackett, R.P., Ducharme, N.G., Fubini, S.L. and Erb, H.N. (1991) The reliability of endoscopic examination in assessment of arytenoid cartilage movement in horses. Part I: subjective and objective laryngeal evaluation. *Vet. Surg.* **20**, 174-179.

Holcombe, S.J., Derksen, F.J., Sick, J.A. and Robinson, N.E. (1999) Pathophysiology of dorsal displacement of the soft palate in horses. *Equine vet. J.* **31**, 45-48.

Holcombe, S.J., Derksen, F.J., Berney, C., Becker, A.C. and Horner, N.T. (2001) Effect of topical anesthesia of the laryngeal mucosa on upper airway mechanics in exercising horses. *Am. J. vet. Res.* **62**, 1706-1710.

Holcombe, S.J., Robinson, N.E., Derksen, F.J., Bertold, B., Genovese, R., Miller, R., de Feiter Rupp, H., Carr, E.A., Eberhart, S.W., Boruta, D. and Kaneene, J. (2006) Effect of tracheal mucus and tracheal cytology on racing performance in Thoroughbred racehorses. *Equine vet. J.* **38**, 300-304.

Lane, J.G. (2004) 5-point grading system of laryngeal function in horses during quiet breathing. In: *Proceedings of Havermeyer Foundation's Workshop on Equine Recurrent Laryngeal Neuropathy*, Eds: P.M. Dixon, N.E. Robinson and J. Wade, R and W Publications, Newmarket. pp 24-25.

Lane, J.G., Bladon, B., Little, D.R.M., Naylor, J.R.J. and Franklin, S.H. (2006a) Dynamic obstructions of the equine upper respiratory tract. Part 1: observations during high speed treadmill endoscopy of 600 Thoroughbred racehorses. *Equine vet. J.* **38**, 393-399.

Lane, J.G., Bladon, B., Little, D.R.M., Naylor, J.R.J. and Franklin, S.H. (2006b) Dynamic obstructions of the equine upper respiratory tract. Part 2: comparison of endoscopic findings at rest and during high-speed treadmill exercise of 600 Thoroughbred racehorses. *Equine vet. J.* **38**, 401-408.

Martin, B.B., Reef, V.B., Parente, E.J. and Sage, A.D. (2000) Causes of poor performance of horses during training, racing or showing: 348 cases (1992–1996). *J. Am. vet. med. Ass.* **216**, 554-558.

Parente, E.J. and Martin, B.B. (1995) Correlation between standing endoscopic examination and those made during high-speed exercise in horses – 150 cases. *Proc. Am. Ass. equine Practnrs.* **41**, 170.

Parente, E.J., Martin, B.B., Tulleners, E.P. and Ross, M.W. (2002) Dorsal displacement of the soft palate in 92 horses during high-speed treadmill examination (1993–1998). *Vet. Surg.* **31**, 507-512.

Petsche, V.M., Derksen, F.J., Berney, C.E. and Robinson, N.E. (1995) Effect of head position on upper airway function in exercising horses. *Equine vet. J., Suppl.* **18**, 18-12.

Pollock, P.J., Reardon, R.J.M., Parkin, T.D.H., Johston, M.S., Tate, J. and Love, S. (2009) Dynamic respiratory endoscopy in 67 Thoroughbred racehorses in training under normal ridden exercise conditions. *Equine vet. J.* **41**, 354-360.

Raker, C.W. and Boles, C.L. (1978) Pharyngeal lymphoid hyperplasia in the horse. *J. equine med. Surg.* **2**, 202-207.

Rakesh, V., Ducharme, N.G., Cheetham, J., Datta, A.K. and Pease, A.P. (2008) Implications of different degrees of arytenoid cartilage abduction on equine upper airway characteristics. *Equine vet. J.* **40**, 629-635.

Richard, E.A., Fortier, G.D., Denoix, J.-M., Art, T., Lekeux, P.M. and Van Erck, E. (2009) Influence of subclinical inflammatory airway disease on equine respiratory function evaluated by impulse oscillometry. *Equine vet. J.* **41**, 384-389.

Slocombe, R.F., Covelli, G. and Bayly, W.M. (1992) Respiratory mechanics of horses during stepwise treadmill exercise tests, and the effect of clenbuterol pretreatment on them. *Aust. vet. J.* **69**, 221-225.

Strand, E., Fjordbakk, C.T., Holcombe, S.J., Risberg, A. and Chalmers, H.J. (2009) Effect of poll flexion and dynamic laryngeal collapse on tracheal pressure in Norwegian Coldblooded Trotter racehorses. *Equine vet. J.* **41**, 59-64.

Sullivan, E.K. and Parente, E.J. (2003) Disorders of the pharynx. *Vet. Clin. N. Am.: Equine Pract.* **19**, 159-167.

Tan, R.H., Dowling, B.A. and Dart, A.J. (2005) High-speed treadmill videoendoscopic examination of the upper-respiratory tract in the horse: the results of 291 clinical cases. *Aust. vet. J.* **170**, 243-248.

Van Erck, E., Frippiat, T., Dupuis, M.-C., Richard, E. and Art, T. (2009) Upper airway dynamic endoscopy: are track and treadmill observations comparable? In: *Proceedings of the 4th World Equine Airways Symposium*. Berne, Switzerland. p 254.

Widmer, A., Doherr, M.G., Tessier, C., Koch, C., Ramseyer, A., Straub, R. and Gerber, V. (2009) Association of increased tracheal mucus accumulation with poor willingness to perform in show-jumpers and dressage horses. *Aust. vet. J.* **182**, 430-435.

Williams, J.W., Meagher, D.M., Pascoe, J.R. and Hornof, W.J. (1990) Upper airway function during maximal exercise in horses with obstructive upper airway lesions effect of surgical treatment. *Vet. Surg.* **19**, 142-147.