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Tongue ties do not widen the upper airways in racehorses

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Abstract

Background: There is contradictory evidence on the potential benefits of tongue ties on upper airway function and their efficacy in inhibiting intermittent dorsal displacement of the soft palate (DDSP) in racehorses.

Objectives: To test the hypothesis that tongue ties increase the pharyngeal diameter and decrease the occurrence of dynamic airway obstruction in racehorses.

Study design: Prospective, crossover blinded clinical study.

Methods: Data of 22 Thoroughbred and 8 Standardbred racehorses examined using overground endoscopy under full-intensity exercise on training racetracks with and without fixation of the tongue by use of tongue ties were analysed. Equivalent exercise intensity was ensured by measuring heart rate (bpm), speed (GPS) and venous lactate. Pharyngeal diameter was expressed as pharyngeal-epiglottis (PE) ratios and laryngeal abduction accordingly as laryngeal-median-ratios. Data were analysed using multivariable repeated-measurements ANOVA.

Results: The PE ratio increased significantly from 1.11 ± 0.19 to 1.28 ± 0.30 in all horses between rest and full-intensity exercise ($p < 0.01$). Multi-variable analysis revealed that this effect decreased significantly by the application of tongue ties (1.15 ± 0.27, $p < 0.01$). Tongue ties did not influence maximum laryngeal width ($p = 0.09$) and area ($p = 0.2$) significantly. DDSP was found in 4 of 30 examinations with tongue tie and in 1 of 30 examinations without tongue tie.

Main limitations: The study population was not randomly chosen and was heterogeneous. Few horses had a respiratory noise and the prevalence of upper respiratory tract disorders was too low for statistical comparison of the rate of DDSP with and without tongue ties.

Conclusions: A positive effect of tongue ties on pharyngeal or laryngeal diameters was not found in this study. Therefore, the results of this study do not support the use of tongue ties to enhance upper airway function.

KEYWORDS
DDSP, endoscopy, exercise, horse, tongue tie

1 | INTRODUCTION

A range of equipment may influence the upper airways in horses and therefore inhibit the occurrence of dynamic airway obstruction, including different bits which influence the position of the tongue, side reins reducing the pharyngeal diameter[1] and the Cornell Collar which inhibits retraction of the larynx and therefore the occurrence of dorsal displacement of the soft palate (DDSP).[2,3] Tongue ties are expected to decrease the occurrence of DDSP, as they inhibit retraction of the larynx connected to the tongue via the thyrohyoid bone. They may also increase the pharyngeal diameter, as the fixated tongue base cannot press against the soft palate from the oral cavity. An increase in pharyngeal diameter would reduce the negative inspiratory pressure and; therefore possibly also prevent other forms of dynamic airway obstruction such as laryngeal or pharyngeal collapse.

Tongue tie application had no influence on the diameters of oro- and nasopharynx visualised by computer tomography during general anaesthesia in horses,[4] but increases in racing performance were found when applied in Thoroughbreds in the United Kingdom.[5,6] Potentially, conditions in general anaesthesia might not be representative of the racing situation with strenuous exercise leading to increased overall muscle tone and excitement of the horse. On the other hand, no differences in inspiratory and expiratory pressures were found with the use of tongue ties during high-speed-treadmill exercise.[7,8] It is possible that the effect of tongue ties is not based on increases of pharyngeal diameter, but better control of the horse, which cannot place its tongue over the bit with the tongue fixated to the mandible.

The conflicting evidence on the efficacy of tongue ties at preventing DDSP, combined with public concerns of potential welfare implications, led to the registration and documentation of tongue tie use in international Thoroughbred and Standardbred racing by the International Federation of Horseracing Authorities in 2001 and the banning of tongue ties by the Fédération Equestre Internationale (FEI) in performance horses in 2004. The use of tongue ties in Thoroughbred racing in Germany was banned in June 2018.[9] However, tongue ties are still allowed in Standardbred racing in Germany and many other countries permit tongue ties for Standardbred and Thoroughbred racehorses despite ongoing discussion on animal welfare issues.

In this study, a population of racing Thoroughbreds and Standardbreds was evaluated using overground endoscopy during race training with and without the application of tongue ties. We hypothesised that tongue ties would increase pharyngeal diameter and that the occurrence and severity of DDSP and recurrent laryngeal neuropathy (RLN), would be reduced when tongue ties were applied.

2 | MATERIALS AND METHODS

2.1 | Horses

Overall, 38 horses were included, 30 Thoroughbreds and 8 Standardbreds (8 geldings, 11 stallions, 19 mares). Their mean age was 3.7 years (2–8 years) and their mean weight 439 kg (390–538 kg). All were in race training and had raced previously. All had a history of poor exercise tolerance; three also had a history of abnormal respiratory noise. According to their trainers, 20 horses were familiar with tongue ties and had worn these several times during training and/or racing, 18 had never worn tongue ties previously.

2.2 | Study design

Participants were acquired from a casuistic questionnaire study focusing on tongue tie use in Germany,[10] where trainers and owners had the opportunity to apply for participation in the current study. As many horses as possible were included during the study period, where a second dynamic respiratory endoscope was provided by the manufacturer for a month, so that horses could be examined in pairs to simulate the racing situation. In a crossover study design, overground endoscopy was performed during full-intensity exercise, where horses were examined on their training racetrack with and without fixation of the tongue. In Standardbreds, the order of pairs racing with/without tongue tie was randomised on two consecutive days. In Thoroughbreds, randomisation of racing with/without tongue tie was not possible. Overground endoscopy with fixation of the tongue was performed first, as loosening of the tongue tie was possible after first racing at full speed, while application of the tongue tie was only possible at rest in the stable. In Thoroughbreds, both sessions took place on the same day and horses performed two high-speed intervals separated by one round of the racetrack trotting. Digital measurements of larynx and pharynx were conducted in anonymised and randomised images (A.T.). Videos were also anonymised and evaluated for dynamic airway obstruction by two blinded observers (D.K. and A.B.).

2.3 | Equipment and type of race training

Apart from the overground endoscope (Dynamic respiratory scope, Optomed), all horses were equipped with their usual training tack, including bits and other equipment like check reins or martingales. An elastic bandage (Meproflex™) was used as a tongue tie and was applied by the trainer/driver. Standardbreds were driven and Thoroughbreds ridden by their usual trainers and jockeys during overground endoscopy. Distance, type of racetrack and speed varied between horses due to differences in Thoroughbred and Standardbred racing, age and training condition. Sufficient exercise intensity was ensured by measuring venous lactate immediately after the exercise session(s) and for inclusion lactate concentrations had to exceed 4 mmol/L confirming horses reached an anaerobic metabolic level.[11]

2.4 | Image analysis

For the evaluation of overground endoscopy, freeze frames were prepared using a video-editing program (EDIUS 5.5, Grass Valley, San Francisco, USA). Five freeze frames each analysed at the beginning of

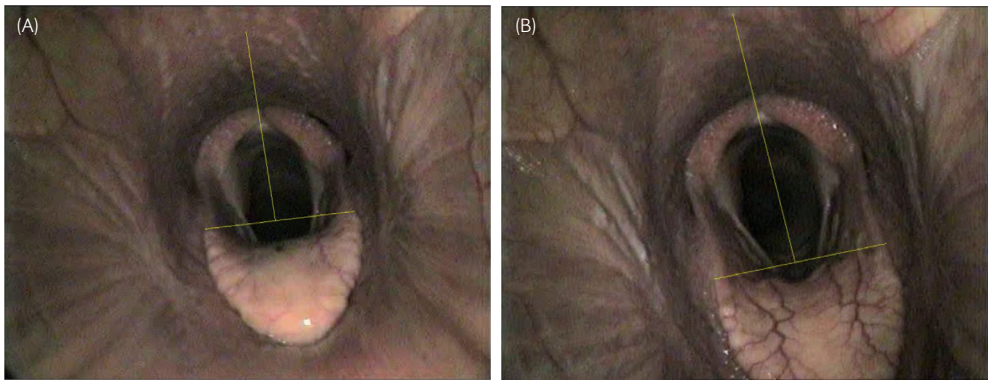

FIGURE 1 Pharyngeal measurements in the same horse with (A) and without (B) a tongue tie applied

expiration phase at rest after, during maximum exercise with and without tongue tie applied. The pharyngeal diameter can be measured during exercise endoscopy using a ratio of epiglottic width and a perpendicular line to a fixed point at the dorsal nasopharyngeal wall as described by Go et al.[1] This ratio compensates for the differing distance between endoscopy camera and soft tissue structures, which changes with differing head and neck positions. Therefore, we used this technique to evaluate the effect of tongue tie on pharyngeal diameter. As shown in Figure 1A,B, a defined width of the epiglottis and a point on the dorsal pharyngeal wall was determined. Easily recognisable vascular patterns or follicles were used as fixed points on all freeze frames of each horse. Using a graphics software program (ImageJ 1.45e™, rsweb.nih.gov/ij/), the width of the epiglottis as well as the distance of the perpendicular line from the fixed point on the dorsal pharyngeal wall to the reference length on the epiglottis was measured. The ratio of these two distances (PE ratio) allows objectifying measurements of the pharyngeal diameter, as a magnification factor by different head positions is deleted.[1]

Laryngeal measurements were performed including opening area of the larynx, maximum width of laryngeal opening area, width at 2/3 of opening area height and relative aperture angle (Figure 2).[12] We modified this procedure by using the ratio of these measurements and the height of the laryngeal opening area to objectify the measurements by exclusion of the magnification factor as described for pharyngeal measurements.

The occurrence of DDSP and other forms of dynamic airway obstruction, for example RLN, axial deviation of the aryepiglottic fold or vocal cord collapse, were also documented in all videos by the observer blinded to whether a tongue tie was applied or not.

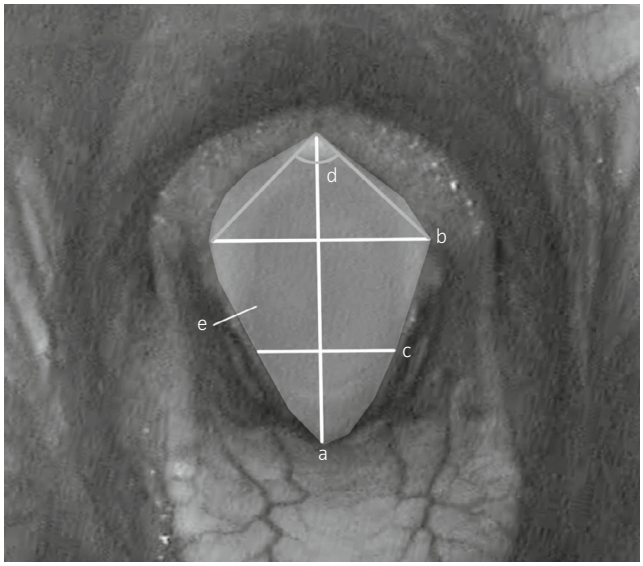

FIGURE 2 Laryngeal measurements from a horse with a tongue tie in place showing (a) maximum height of the opening area, (b) maximum width of the opening area, (c) width at 2/3 height, (d) relative opening angle and (e) total opening area

2.5 | Data analysis

Statistical analysis was performed using SPSS Statistics 25.0® (SPSS Inc.). Normality of continuous variables was inspected visually and using Shapiro–Wilk test. Since all variables showed normal distribution results were expressed as means ± standard deviation (SD). To compare the effect of tongue tie, the values before simulated racing were subtracted from the respective values during simulated racing with and without tongue tie. These differences from the baseline values were used for statistical analyses. Differences in pharynx and larynx parameters and in venous lactate concentrations between training sessions with and without tongue tie were examined with *t*-tests for dependent samples. The influence of former habituation on tongue tie use was investigated using ANOVA for repeated measurements. For each of the factors 'PE ratio', 'width at 2/3 of height', 'relative aperture angle', 'maximum width' and 'area', one separate model was developed. The repeated variable was the time point, which consisted of the time points 'before race', 'with tongue tie' and 'without tongue tie'. We investigated whether there were significant differences in the respective dependent variable between the time points and 'with tongue tie' and 'without tongue tie' compared with 'before race'. The level of significance was set at $p \leq 0.05$.

3 | RESULTS

Due to poor image quality, 8 Thoroughbreds were excluded. Therefore, data and images of overall 30 horses (22 Thoroughbreds and 8 Standardbreds) were included for further analysis.

TABLE 1 Mean pharyngeal-epiglottic (PE) ratios ± standard deviation at rest, during maximum exercise without and with tongue tie applied in all horses, Thoroughbreds and Standardbreds

	At rest	Maximum exercise with tongue tie	Maximum exercise without tongue tie
All horses ($n = 30$)	1.11 ± 0.19	1.15 ± 0.27	1.28 ± 0.30*
Thoroughbred ($n = 22$)	1.13 ± 0.16	1.22 ± 0.31	1.34 ± 0.40*
Standardbred ($n = 8$)	1.10 ± 0.21	1.12 ± 0.26	1.25 ± 0.26*

*Significant differences compared with measurements at rest ($p < 0.05$).

3.1 | Exercise intensity

Median venous lactate immediately after exercise was 11.16 ± 5.46 mmol/L in Standardbreds and 8.41 ± 3.12 mmol/L in Thoroughbreds.

3.2 | Pharyngeal diameter

A significant increase in PE ratio between rest and full-intensity exercise was found in all horses ($p < 0.01$, ANOVA with repeated measurements), but further analysis showed that this difference was only statistically significant without the use of tongue ties (inner subject contrast, $p < 0.01$). The mean PE ratio at rest was 1.11 ± 0.19, during exercise with a tongue tie applied 1.15 ± 0.27 and without a tongue tie applied 1.28 ± 0.30 respectively (Table 1). When looking at each horse, 5 of 8 Standardbreds and 16 of 22 Thoroughbreds had an increased PE ratio under exercise compared with the ratio at rest and application of the tongue tie led to a decrease in mean PE ratio in 4 of 5 of these Standardbreds and 15 of 16 of these Thoroughbreds compared with maximal diameter without a tongue tie. Examples of PE ratio measurements are shown in Figure 1A,B.

3.3 | Laryngeal parameters

Tongue tie application increased width at 2/3 of height ($p = 0.001$, ANOVA with repeated measurements), and relative aperture angle ($p = 0.008$), while maximum width ($p = 0.09$) and area ($p = 0.2$) did not differ significantly (Table 2). Under the maximum exercise, the values were higher with tongue tie than at rest with differences in width at 2/3 of height ($p < 0.001$) and angle ($p = 0.002$) being statistically significant. Values under maximum exercise without tongue tie were close to those of the resting examination.

Differences between horses that had previously exercised with tongue tie and those that had were not detected in any of the ANOVA tests.

3.4 | Dynamic airway obstruction

DDSP was found in 4 of 30 examinations with tongue tie and 1 of 30 examinations without tongue tie. Due to these unexpected low numbers, statistical analysis was not performed. In seven horses, endoscopy at rest revealed RLN grade IIa and in three horses RLN grade IIb according to the Havemeyer grading system.[13,14] The evaluation of the laryngeal function of these horses during peak exercise showed full abduction in nine horses, grade A according to Rakestraw et al.[15] and insufficient abduction in one horse (grade B). The mean PE ratio of horses with DDSP was larger than that of horses without dynamic airway obstruction and RLN at rest, during peak exercise with and without tongue tie (Table 3). Additionally, two horses had endoscopic evidence of exercise-induced pulmonary haemorrhage.

TABLE 2 Mean laryngeal-median ratios ± standard deviation at rest, during maximum exercise with and without tongue tie applied ($n = 30$)

Parameter	At rest	Maximum exercise with tongue tie	Maximum exercise without tongue tie
Opening area	0.28 ± 0.09	0.31 ± 0.12	0.28 ± 0.05
Maximum width	0.86 ± 0.09	0.95 ± 0.30	0.85 ± 0.09
Width at 2/3 of height	0.58 ± 0.09	0.64 ± 0.10*	0.59 ± 0.08
Relative aperture angle	0.32 ± 0.07	0.35 ± 0.07	0.33 ± 0.06

*Significant differences ($p < 0.05$).

TABLE 3 Mean pharyngeal-epiglottic (PE) ratios ± standard deviation at rest, during maximum exercise without and with tongue tie applied in horses with no dynamic airway obstruction, recurrent laryngeal neuropathy (RLN) and dorsal displacement of the soft palate (DDSP), $n = 30$

	At rest	Maximum exercise with tongue tie	Maximum exercise without tongue tie
No dynamic airway obstruction ($n = 19$)	1.01 ± 0.21	1.12 ± 0.28	1.26 ± 0.32
RLN ($n = 8$)	1.1 ± 0.21	1.18 ± 0.30	1.27 ± 0.31
DDSP ($n = 4$)	1.28 ± 0.08	1.35 ± 0.07	1.52 ± 0.10

4 | DISCUSSION

There is contradictory evidence on the potential efficacy of tongue ties on upper airway function and for treatment of intermittent DDSP in racehorses.[5,6,16] In this study, a positive effect on pharyngeal diameters or laryngeal maximum width was not found.

A tongue tie consists of a leather, nylon or rubber strap applied around the tongue and the lower jaw. It has been used as a training device for over 100 years with the goal of facilitating control of the horse and as a conservative treatment for DDSP.[5,17] Fixation of the tongue is believed to inhibit retraction of the tongue and therefore caudal displacement of the larynx, as both are connected via the thyrohyoid bone.[18] Retraction of the larynx may induce DDSP at rest and

during exercise.[19] Swallowing is also hindered by the application of a tongue tie, which may additionally prohibit the occurrence of DDSP.[4] Tongue ties are approved for use in racing in many countries. The prevalence of tongue tie use is about 5% in racehorses in Great Britain, increasing up to 89% of horses with a diagnosis of DDSP,[6,20] so they are used commonly and often in combination with other equipment.[16] Lately, a study including data of over 60 000 horses from the Racing Information Service Australia (RISA) found a prevalence of 21% of tongue tie use in the racing population in Australia.[2]

Retraction of the tongue may lead to a reduction of the pharyngeal diameter when the root of the tongue presses against the soft palate from the oral cavity in a horse fighting the bit. In consequence, fixation of the tongue may prevent this by keeping the pharynx open or even increasing its diameter. A reduction of the nasopharyngeal diameter leads to even more negative inspiratory negative pressure, restriction of airflow and increased upper airway resistance.[21,22] If tongue ties have an influence on the pharyngeal diameter, their use may therefore prevent the occurrence or reduce the severity of dynamic airway obstruction. The most common forms include RLN and DDSP, for which further decreases in inspiratory negative pressure are a logical risk factor concerning occurrence and severity.[1]

This is the first study to look at pharyngeal diameters and laryngeal opening under the use of tongue ties during intense exercise. Calculation of PE ratios of pharyngeal diameter showed that the pharyngeal diameter increased under full-intensity exercise in the majority of Standardbreds and Thoroughbreds, which can be explained by muscular tension of the pharynx surrounding muscles (i.e., Mm. palatopharyngeus, salpingopharyngeus, stylopharyngeus) despite more negative inspiratory pressure during exercise. The tongue tie, nevertheless, did quite the opposite of what we had expected. Instead of widening the pharynx, it led to a reduction of pharyngeal diameter in up to 93% of horses. Although other authors described that pressing down the tongue is essential for stability and widening of the nasopharynx,[8] our results do not support this theory. This is in unison with another study, where the nasopharyngeal diameter was not influenced by tongue tie application during general anaesthesia.[4]

An increase in pharyngeal diameter would likely decrease the occurrence of laryngeal dysfunction including dynamic collapse during intense exercise.[21,22] Unfortunately, only one horse suffered from RLN at a stage visible during maximum exercise and no horse showed any other dynamic airway obstruction. Therefore, it was not possible to evaluate a possible effect of the tongue tie and increases in pharyngeal diameter, or as actually seen, decreases in pharyngeal diameter, on laryngeal function. Another study also found no effect of decreasing pharyngeal diameter on laryngeal function in warmblood horses under exercise and head flexion.[23] In our study, the percentage of horses used to the application of tongue ties during training was comparable to horses naïve to the tongue tie. No differences in pharyngeal diameter were found after application of the tongue ties in horses which had previously worn tongue ties and those that had not. In resting horses, increased frequencies of headshaking and gasping were found in horses with previous experience of tongue tie use than naïve horses.[24]

Nevertheless, DDSP occurred about 4-times more often with a tongue tie applied than without a tongue tie, in this small study population, with no horse displaying DDSP with and without a tongue tie. DDSP is the most common dynamic obstruction in Thoroughbreds with a prevalence of 10%–20%.[25–28] This prevalence is comparable to our study population (4 of 38 horses). A higher prevalence might have been observed with more strenuous exercise. Mean lactate concentrations post exercise were well above 4 mmol/L in Standardbreds and Thoroughbreds, nevertheless, they are much higher after real racing. In the overall racehorse population, a lower prevalence of 1%–6.5% has been described for DDSP.[29] Interestingly, horses with DDSP had larger pharyngeal diameters during exercise than horses without DDSP, although no formal statistical comparison was made.

Tongue ties have been used in racehorses for over 100 years.[17] Although an increase in racing performance was found after tongue tie use in horses diagnosed with DDSP, the inclusion criteria of these studies may have led to a bias in results.[5,6,20] In one study, horses had to be started 3–5 times before the diagnoses of DDSP and 3–5 times afterwards.[6] It seems reasonable that only horses with improved performance by tongue tie application remained in race training. Several studies on the high-speed-treadmill and using overground endoscopy demonstrated DDSP under tongue tie application in the majority of cases[30] and showed much less improvement of DDSP by the application of a tongue tie in comparison to other conservative approaches like the Cornell Collar.[31] Our results are in unison with these studies, therefore a positive effect of the tongue tie on the occurrence of DDSP remains at least speculative.

The study has several limitations, we studied horses presenting with poor exercise tolerance of unclear origin. We hoped to include many horses showing DDSP and other respiratory tract disorders. Unfortunately, this was not the case and the number of horses affected by DDSP was too low for statistical analysis. DDSP may have occurred more often in a real racing situation due to higher exercise intensity and stress level. We tried to study conditions as realistic as possible by exercising horses in pairs. The order of exercise sessions with/without tongue tie in Thoroughbreds was not randomised and we do not know if this influenced results. Therefore, we could not answer the question, of whether tongue tie application increases or decreases the occurrence of DDSP and also could not determine whether DDSP horses differ in pharyngeal diameter.

In conclusion, our results do not support the use of tongue ties to improve upper airway function. Pharyngeal diameters during strenuous exercise were reduced by tongue tie application. These results might provide objective evidence for future decisions of equine sports organisations concerning the regulations on tongue ties.

AUTHOR CONTRIBUTIONS

Ann Kristin Barton analysed the data and prepared the manuscript. Anne Troppenz, Dana Klaus and Inga Lindenberg examined the horses. Roswitha Merle and Anne Troppenz performed the statistical

analysis of the data. All authors contributed to the preparation of the manuscript and approved the final version.

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CONFLICT OF INTEREST STATEMENT

No competing interests have been declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Research ethics committee oversight not currently required by this journal: procedures were performed as part of clinical investigations.

INFORMED CONSENT

Informed client (owners/trainers) consent for inclusion in the study was obtained.

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