Pferdeheilkunde – Equine Medicine 40 (2024) 5 (September/October) 482–488
DOI 10.21836/PEM20240507

Impact of bit types on equine upper airways – implications for performance and welfare

Julia Schacht[1], Anna May[2] and Heidrun Gehlen[3]

[1] Equine Clinic, Internal Medicine, Freie Universität Berlin, Berlin, Germany
[2] Equine Clinic, Ludwig Maximilians University Munich, Oberschleissheim and Germany
[3] Equine Clinic, Internal Medicine, Freie Universität Berlin, Berlin, Germany

Summary: This study was conducted to clarify the behavioral dynamics of the equine larynx during exertion and rest under the influence of different bits, and to ascertain potential variations in the overall surface area of the larynx among bits within individual horses. Various researchers highlight the impact of bits on equine breathing and upper airway disorders. While some attribute respiratory discomfort solely to bit use, others suggest negative effects in combination with rein tension. Riding without a bit has been associated with improved animal welfare and reduced hyperreactive behaviors. The extreme sensitivity of the mouth to mechanical stimulation makes the bit a potential source of discomfort, leading to resistance, lesions, and injury. Poll flexion induced by rein tension and bit use can obstruct the airway, causing hypoxia and decreased performance. This investigation focused on three bits commonly used in international grand prix showjumping events in Europe during 2022: the loose ring bit, the three-ring bit, and the Pelham snaffle. Employing overground endoscopy, this research observed nine Warmblood horses engaging in walking, trotting, and cantering with different bits. An overground endoscope facilitated the examination of laryngeal behavior during motion. Statistical analyses revealed that the chosen bits did not significantly influence laryngeal behavior during different gaits. Similarly, there was no substantial variation in laryngeal surface area among bits within individual horses. However, a significant main effect of state (rest, trot, canter) highlighted the considerable influence of the horse's physiological state on laryngeal behavior.

Keywords: horses, bits, breathing, upper respiratory tract, overground endoscopy, larynx, influence of bits, animal welfare, rider-horse interaction

---

Citation: Schacht J, May A, Gehlen H (2024) Impact of bit types on equine upper airways – implications for performance and welfare. Pferdehlk Equine Med 40, 482–488; DOI 10.21836/PEM20240507

Korrespondenz: Julia Schacht, Klinik für Pferde, Oertzenweg 19B, 14163 Berlin; j.schachtnl@gmail.com

Submitted: February 20, 2024 | **Accepted:** May 27, 2024

Introduction

In recent years, equine sport has gained a lot of public attention. The accomplishments achieved by horses up to Olympic level showcase their exceptional physiological capabilities. Thoroughbred and Standardbred racehorses exhibit a remarkable increase in oxygen consumption during peak exertion, surpassing values at rest by about 40 times [1]. This elevation in oxygen demand requires substantial nasopharyngeal airflow, approximately 1800–2000 L/min in Thoroughbreds, a staggering 25–27-fold increase compared to resting values [2,3]. However, when horses train intensely, they are bound to their nasal breathing pattern because they cannot switch to mouth breathing [4]. In response, the equine respiratory system employs various adaptive mechanisms to enhance airflow, such as external nasal dilation, laryngeal abduction, and partial bronchodilation. Despite these intrinsic adaptations, friction and turbulence can appear, which can affect these mechanisms. In ridden horses, the breathing system becomes even more complex, because rider and equipment interact with the airflow dynamics [5]. In the context of airflow resistance, head-neck position or head carriage play a crucial role, influencing the jowl angle, defined as the angle of intersection between the leading edge of the neck and the line of the lower jaw [6]. Studies have shown that a jowl angle approaching 33°, where the nasal bone is nearly vertical to the ground, results in a decreased cross-sectional area of the nasopharynx [7]. Horses typically maintain a jowl angle of about 90° at rest, but during galloping, they may extend their head and neck to jowl angles of 120–130°, straightening and widening the nasopharynx and reducing nasopharyngeal airflow resistance disproportionately [6]. This extension also affects the extrathoracic trachea, making it less compliant and less susceptible to dynamic narrowing during inspiration [8,9].

During exercise, various dynamic disorders, including transient palatal instability (PI) and dorsal displacement of the soft palate (DDSP), can narrow the nasopharynx and hinder airflow in horses [10,11]. Certain theories underscore the importance of maintaining an airtight seal between the larynx and the ostium intrapharyngium in the soft palate during exercise. This prevents the dissipation of negative oropharyngeal pressure, subsequently averting the bulging or ballooning of the soft palate that could partially obstruct the nasopharynx and larynx [10–12]. Predisposing factors for dynamic pharyngeal collapse during high-speed treadmill exercise include low jowl angles from rein use or aversive bit sensations causing mouth opening, disrupting the airtight lip seal necessary for negative oropharyngeal pressure [13]. This may destabilize the soft palate, increase airflow resistance, and lead to exercise-induced respiratory issues [14]. In contrast, a closed mouth maintains the airtight lip-seal and larynx engagement, preventing soft palate displacement, minimizing airflow resistance, and providing respiratory benefits during exercise.

In conclusion, understanding how different bits affect equine respiratory function is crucial for the well-being and performance of horses during various activities. Recognizing gaps in current knowledge, our research involves using overground endoscopy to observe horses walking, trotting, and cantering with different bits. In this study, we focused on determining whether the equine larynx behaves differently during exertion/rest with different bits (RQ1). We also explored potential differences between bits, aiming to find out whether the overall surface area of the larynx varies among bits within individual horses (RQ2). Additionally, our investigation delved into variations in throat behavior during different phases – rest, trot, and canter (RQ3). This approach allowed us to thoroughly examine the dynamic interactions between bits, respiratory function, and states of activity in horses, providing valuable insights into equine welfare and performance.

Materials and methods

Horses

Overall, 9 Warmbloods were included in the study (5 geldings, 1 mare, 3 stallions). Their ages ranged from three to twelve years, with a mean age of 5.5 years. All horses were actively undergoing training, with the three-year-old horses having recently completed their breaking-in process within the current year. The remaining horses followed individually tailored training plans that catered specifically to their required level of proficiency in show jumping. All horses were examined at their home facilities. A thorough clinical examination was conducted on all horses to assess the general health status of the horse. Particular attention was given to respiratory and cardiovascular parameters. All horses deemed fit for the procedure were considered. Also, only horses demonstrating cooperative behavior, allowing for the introduction of the endoscope without the need for force, were included in the study.

Schedule of procedure

Three relevant bits were selected for investigation and corresponding endoscopic video records were obtained. The bits were chosen based on their frequent use in seven international grand prix showjumping events (FEI events) in Europe during 2022. The chosen bits included the loose ring bit (Figure 1), the three-ring bit (Figure 2), and the Pelham snaffle (Figure 3), each featuring distinct mouthpieces. The Pelham had a straight mouthpiece with a medium tongue port, the three-ring bit was a 21 mm thick single-jointed bit, and the loose ring bit was a double-jointed 14 mm bit. Additionally, a control group was established where horses were longed without any bit. The initial step involved using the three pre-selected bits in the control group and when observable changes in the laryngeal opening were noted, alternative bits with different side and mouthpieces were considered. This selection of bits was performed to provide an initial impression, with the possibility of modification based on observed outcomes in the laryngeal region. The decision to opt for different bits would only be implemented in response to identified changes during the assessment. This resulted in a dataset, holding N = 108 observations (9 horses × 3 gaits × 4 bits).

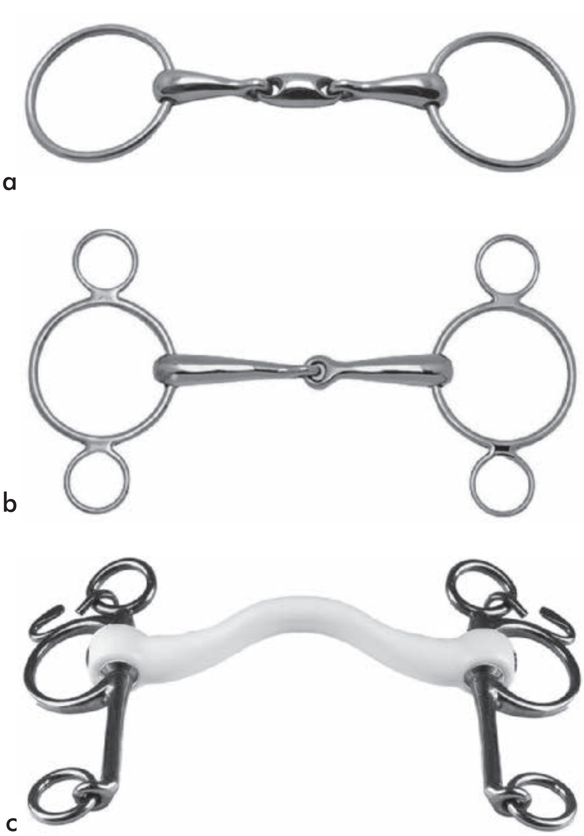
A skilled horseman guided the horses during longing, allowing them to maintain a natural head and neck position with loose reins, so that they maintained a jowl angle of at least 90°.

Our study involved three different stages of investigation. First, the horses were observed at rest. Next, they were evaluated during a light trot. Lastly, they were evaluated while cantering for 5 minutes.

This comprehensive study protocol spanned over four consecutive days, ensuring a consistent and systematic approach to data collection and analysis.

Data collection

The 'Dr Fritz overground endoscope' was employed for conducting overground endoscopy. This system enables the examination of the larynx and pharynx of horses while they are in motion. In addition to the endoscope itself (Figure 4), the system includes an adjustable bridle, and two laptops. One



a

b

c

Fig. 1–3 Bits used. Examples of the loose ring bit (a), the three ring bit (b), and the pelham bit (c). | *Verwendete Gebisse. Beispiele für das losen Ringgebiss (a), das Dreiringgebiss (b) und das Pelhamgebiss (c).*

Fig. 4 Photo of a horse with overground endoscopic equipment. The endoscope is equipped with a light source and an insufflation pump. The examiner can remotely control the insufflation pump through their laptop. The entire endoscopy process can be monitored in real-time on the laptop, both when the horse is at rest and during exercise. The system also allows for adjusting the position of the endoscope as needed during the examination. | *Foto eines Pferdes mit oberirdischer endoskopischer Ausrüstung. Das Endoskop ist mit einer Lichtquelle und einer Insufflationspumpe ausgestattet. Der Untersucher kann die Insufflationspumpe über seinen Laptop fernsteuern. Der gesamte Endoskopieprozess kann in Echtzeit auf dem Laptop überwacht werden, sowohl wenn das Pferd ruht als auch während der Bewegung. Das System ermöglicht es auch, die Position des Endoskops während der Untersuchung nach Bedarf anzupassen.*

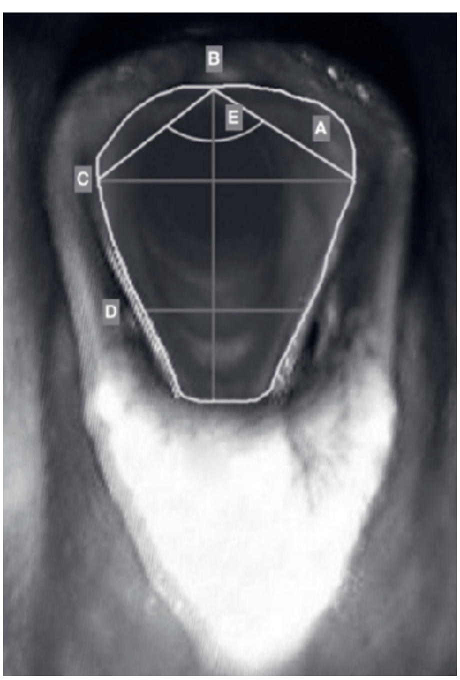


Fig. 5 Laryngeal area with measured parameters. A) Opening area, B) Height, C) Max. width, D) Width at 2/3 of the height, E) Relative aperture angle. (*Zebisch* et al.) [9] | *Kehlkopfbereich mit gemessenen Parametern. A) Öffnungsfläche, B) Höhe, C) Max. Breite, D) Breite bei 2/3 der Höhe, E) Relativer Öffnungswinkel. (Zebisch et al.)* [9]

laptop is responsible for controlling the endoscope's proximal part and receiving the video feed, while the other laptop is positioned on the horse to transmit data directly to the controlling laptop.

The endoscope is equipped with a light source and an insufflation pump. The examiner can remotely control the insufflation pump through their laptop. The entire endoscopy process can be monitored in real-time on the laptop, both when the horse is at rest and during exercise. The system also allows for adjusting the position of the endoscope as needed during the examination.

To facilitate comparison of different bits, video sequences were obtained endoscopically for 9 horses while they were at rest, in trot and while they cantered for five minutes.

Video analysis was undertaken through a meticulous frame-by-frame inspection and the measurement method of *Zebisch* et al. [9] was used.

For each of the 9 horses and across the three examination stages, three respiratory cycles were measured, and an average was calculated. Any potential distortions stemming from perspective issues in the images of these respiratory cycles were effectively reduced using image editing software, namely Adobe Photoshop (Adobe Systems GmbH, Munich, Germany). The variable under investigation pertains to the number of pixels within a defined area, as illustrated in the accompanying image. These pixels represent quantifiable aspects of equine physiological characteristics.

Several parameters of the larynx were measured, as depicted in Figure 6:

1. The area of the larynx opening (A).
2. The vertical dimension of the laryngeal opening area (B).
3. The maximum horizontal width of the laryngeal opening area (C).
4. The width at 2/3 of the vertical dimension of the laryngeal opening area (D).
5. The relative aperture angle, represented by a line connecting the endpoints of the maximum width and the vertical dimension of the larynx or the laryngeal opening area (E).

Data analysis

The data was collated in an Excel spreadsheet and analyzed using statistical software (IBM SPSS Statistics, Version 28.0). The experimental design employed a within-subject repeated measures ANOVA to scrutinize the effects of three gaits and four bits. This investigation embraced a full factorial design, enabling the exploration of the interaction between gait and bit.

To ascertain the significance of individual bits, contrast tests were deployed, involving comparisons between the control condition (absence of any bit) and experimental conditions featuring bits 1 through 3.

In delving into the association between gaits and the surface area of the larynx opening, an analysis was conducted using a post-hoc test, systematically adjusted with the Bonferroni correction. This analytical approach aimed to pinpoint specific pairs of gaits contributing to variations in laryngeal characteristics.

The assumption of Sphericity was rigorously examined through Mauchly's test. In instances where a significant result was obtained, Sphericity was deemed untenable, and the lower-bound estimation was duly reported.

For evaluating effect size, the partial eta squared emerged as the chosen metric. This quantitative indicator provided a pragmatic assessment of the magnitude of observed effects within the confines of the statistical analyses.

Results

Addressing Research Question 1, which focused on the distinct behavior of the equine throat under exertion and rest with the influence of different bits, our analysis revealed a negative response. The statistical examination indicated an insignificant interaction between the state (exertion or rest) and the type of bit used. The three bits chosen did not interact differently with the different breathing patterns in rest, trot, or canter. The $F(6, 16)$ value of 0.294 with a p-value of .937 and a partial eta squared of .035 provided robust evidence against any discernible influence of the bits on the behavior of the larynx during different gaits.

Turning to Research Question 2, which explored potential differences between bits and whether the overall surface area of the larynx varies among bits within individual horses, our findings had a negative outcome. The absence of a significant main effect of bit, as indicated by the $F(1, 8)$ value of 0.39 with a p-value of .55 and a partial eta squared of .047, pointed towards a lack of substantial variation in laryngeal behavior across the diverse bits. Contrast tests further supported these results, affirming the non-significant differences between the control condition (no bit) and each of the tested bits (bit 1, bit 2, and bit 3).

In response to Research Question 3, which aimed to explore differences between the gaits (rest, trot, and canter), our analysis revealed a positive outcome (Figure 6). A significant main effect of state was identified, with an $F(1, 8)$ value of 5.43 and a p-value of .048, accompanied by a substantial partial eta squared of .404. This emphasized the considerable influence of the different states on laryngeal behavior, with the model accounting for 40.4 % of the variance. The variations observed underscored the impact of the horse's physiological state, whether at rest, trotting, or cantering, on the behavior of the equine larynx.

Discussion

Our investigation aimed to clarify the behavioral dynamics of the equine larynx during exertion and rest under the influence of different bits, as well as to ascertain potential variations in the overall surface area of the larynx among bits within individual horses. The chosen bits, namely the loose ring bit, the three-ring bit, and the Pelham snaffle, were selected based on their prevalent use in international grand prix showjumping events (FEI events) in Europe during 2022.

Many studies have emphasized on the impact of bits on breathing and on dynamic upper airway disorders in horses. *Mellor* and *Beausoleil* [15] stated that bit use leads to an "unpleasant respiratory effort" in affected horses. Whereas in this study the bit solely was made responsible for the impact on breathing [15], other studies found that negative effects occurred only in combination with rein tension. *Luke* et al. [16] found improved animal welfare scores and fewer hyperreactive behaviors in horses that were ridden without a bit. The bit is a potential source of considerable discomfort for horses, as the mouth is extremely sensitive to mechanical stimulation [17]. Horses often fight against bits [18,19], and lesions in the mouth area are also common [20–22]. Studies have shown that even simple bits that may be used gently, such as the snaffle bit [19,23], can cause significant injury and pain when they are used without expertise or with the intention to force the horse [24,25]. Previous examinations found that poll flexion induced by rein tension and bit use obstructs the nasopharyngeal airway [5,26] and the resulting hypoxia may lead to decreased performance. Furthermore, dynamic upper airway obstructions such as dorsal displacements of the soft palate (DDSP) are due to retraction of the tongue as aversive movement caused by the bit [26,27]. On the other hand, *Cornelisse* et al. [28] found that depression of the tongue by some bits may stabilize the pharynx, allowing the horses for better respiratory function. Furthermore, studies failed to find increased negative inspiratory pressures with wearing a bit [29]. Another possible explanation for occurring

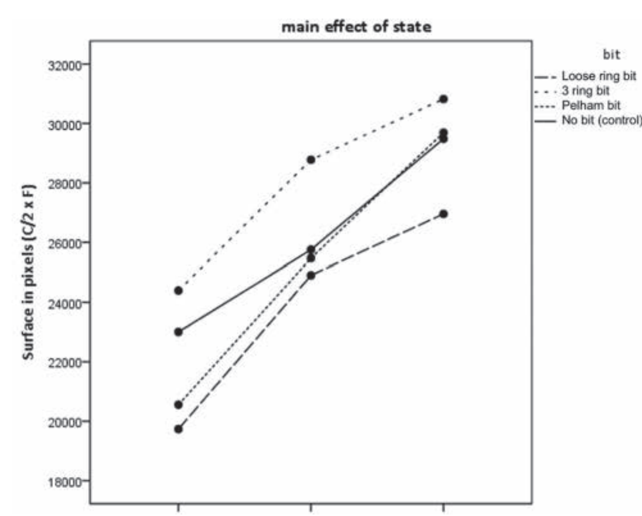


Fig. 6 Post hoc tests between the states found significant results for the difference between rest and trot (mean difference = 4304.8, SE = 949.0, p = .006). The difference between resting and canter was significant at p < .10 level (with 90% reliability), mean difference = 7316.0, SE = 2596.8, p = .068. No significant difference was found between trot and canter, mean difference = 3011.3, SE = 2701.3, p = .89. | *Post-hoc-Tests zwischen den Zuständen ergaben signifikante Ergebnisse für den Unterschied zwischen Ruhe und Trab (mittlere Differenz = 4304,8, SE = 949,0, p = ,006). Der Unterschied zwischen Ruhe und Galopp war signifikant auf dem Niveau p < ,10 (mit 90% Zuverlässigkeit), mittlerer Unterschied = 7316,0, SE = 2596.8, p = ,068. Es wurde kein signifikanter Unterschied zwischen Trab und Galopp festgestellt, mittlerer Unterschied = 3011,3, SE = 2701,3, p = ,89.*

DDSPs is the breaking of the airtight lip seal by the bit or the adverse reactions to it. The current study supports the thesis that not the bit itself is the factor to counteract this mechanism, but the riders' impact on the bit. *Manfredi* et al.[30] also found that horses spent less time quiet and more time mouthing the bit and retracting and bulging the tongue over the bit when rein tension was applied.

Our comprehensive examination provides valuable insights into the equine larynx's response to exertion and rest with different bits, highlighting the negligible impact of bit type on laryngeal behavior during longing. Moreover, the study underscores the significant influence of physiological states on the overall surface area of the larynx, shedding light on the intricate interplay between horse state and laryngeal dynamics during various equestrian activities. Horses display remarkable capacities to dynamically enhance airflow to achieve optimal respiratory performance.

Limitations of this study were the absence of riders, so the impact of the different bits was only examined without rein tension and riders' influence. As the horses in this study were longed with an open jaw angle and care was taken that they did not take a low and round position, obstruction of the nasopharynx did not occur.

Summarizing previous studies and the current examination, the bit itself is not the main issue in breathing-related upper airway obstruction for ridden horses. Rather, factors such as riders' hands, riders' weight, and the head-neck-position in ridden horses play a significant role[31,32].

These findings of our study support the fact that bit-related breathlessness rather is a problem of the decreased jaw angle and aversive behavior because of a riders' hard hands.

Conclusion

The findings in this study should not lead us to conclude that bits exert no impact on horses' performance or their emotional and physiological well-being. Instead, it suggests that the focus should shift away from examining breathing patterns and bits as the primary factors influencing these aspects.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Ethical animal research

The study received approval from the "Landesamt für Arbeitsschutz, Verbraucherschutz und Gesundheit" (State Office for Occupational Safety, Consumer Protection, and Health; reference number 2243/6–2024-4).

Source of funding

No source of funding was required for this study.

References

1. Hinchcliff K, Kaneps A, Geor R (2013) Basic and clinical sciences of the equine athlete. Equine Sports Med Surg E-Book, ISBN 978-0-7020-8370-9
2. Butler PJ, Woakes AJ, Smale K, Roberts CA, Hillidge CJ, Snow DH (1993) Respiratory and cardiovascular adjustments during exercise of increasing intensity and during recovery in thoroughbred racehorses. J Exp Biol 179, 159–180, DOI 10.1242/jeb.179.1.159
3. Art T, Anderson L, Woakes AJ, Roberts C, Butler PJ, Snow DH, Lekeux P (1990) Mechanics of breathing during strenuous exercise in Thoroughbred horses. Respir Physiol 82, 279–294, DOI 10.1016/0034-5687(90)90098-j
4. Tilley P, Simões J, Sales Luis JP (2023) Effects of a 15° Variation in Poll Flexion during Riding on the Respiratory Systems and Behaviour of High-Level Dressage and Show-Jumping Horses. Animals 13(10), 1714, DOI 10.3390/ani13101714
5. Mellor DJ, Beausoleil NJ (2017) Equine Welfare during Exercise: An Evaluation of Breathing, Breathlessness and Bridles. Animals 7, 41, DOI 10.3390/ani7060041
6. Petsche V, Derksen F, Berney C, Robinson N (1995) Effect of head position on upper airway function in exercising horses. Vet J 27, 18-22, DOI 10.1016/S1090-0233(95)80009-3
7. Go L Mei, Barton AK, Ohnesorge B (2014) Objective classification of different head and neck positions and their influence on the radiographic pharyngeal diameter in sport horses. BMC Vet Res 23, 118, DOI 10.1186/1746-6148-10-118
8. Fitzharris LE, Franklin SH, Allen KJ (2015) The prevalence of abnormal breathing patterns during exercise and associations with dynamic upper respiratory tract obstructions. Equine Vet J 47, 553–556, DOI 10.1111/evj.12325
9. Zebisch A, May A, Reese S, Gehlen H (2014) Effects of different head-neck positions on the larynges of ridden horses. J Anim Physiol Anim Nutr (Berl) 98, 894–900, DOI 10.1111/jpn.12154
10. Parente EJ, Martin BB, Tulleners EP, Ross MW (2002) Dorsal displacement of the soft palate in 92 horses during high-speed treadmill examination (1993-1998). Vet Surg 31, 507–512, DOI 10.1053/jvet.2002.36009
11. Franklin SH, Naylor JRJ, Lane JG (2006) Videoendoscopic evaluation of the upper respiratory tract in 93 sport horses during exercise testing on a high-speed treadmill. Equine Vet J 38, 540–545, DOI 10.1053/jvet.2002.36009
12. Lane JG, Bladon B, Little DRM, Naylor JRJ, Franklin SH (2006) Dynamic obstructions of the equine upper respiratory tract. Part 1: observations during high-speed treadmill endoscopy of 600 Thoroughbred racehorses. Equine Vet J, 393–399, DOI 10.2746/042516406778400583
13. Ahern TJ (1999) Pharyngeal dysfunction during exercise. J Equine Vet Sci 19, 226–231, DOI 10.1016/S0737-0806(99)80309-8
14. Mellor DJ, Beausoleil NJ (2017) Equine Welfare during Exercise: An Evaluation of Breathing, Breathlessness and Bridles. Animals 7, 41, DOI 10.3390/ani7060041
15. Beausoleil NJ, Mellor DJ (2015) Introducing breathlessness as a significant animal welfare issue. New Zeel Vet J 63, 44–51, DOI 10.1080/00480169.2014.940410
16. Luke KL, McAdie T, Warren-Smith AK, Smith BP (2023) Bit use and its relevance for rider safety, rider satisfaction and horse welfare in equestrian sport. Appl Anim Behav Sci 259, 105855, DOI 10.1016/j.applanim.2023.105855
17. Mills DS, McDonnell SM (2005) The domestic horse: the origins, developments, and management of its behaviour. Cambridge University Press, ISBN 0-521-89113-2
18. Cook WR, Kibler M (2019) Behavioural assessment of pain in 66 horses, with and without a bit. Equine Vet Educ 31, 162–171, DOI 10.1111/eve.12916
19. Quick JS, Warren-Smith AK (2009) Preliminary investigations of horses' (Equus caballus) responses to different bridles during foundation training. J Vet Behav 4, 169–176, DOI 10.1016/j.jveb.2008.12.001

20. Tell A, Egenvall A, Lundström T, Wattle O (2008) The prevalence of oral ulceration in Swedish horses when ridden with bit and bridle and when unridden. Vet J 178, 405–410, DOI 10.1016/j.tvjl.2008.09.020
21. Tuomola K, Mäki-Kihniä N, Valros A, Mykkänen A, Kujala-Wirth M (2021) Bit-Related Lesions in Event Horses After a Cross-Country Test. Front Vet Sci 31, 8, 651160, DOI 10.3389?fvets.2021.651160
22. Uldahl M, Bundgaard L, Dahl J, Clayton HM (2022) Assessment of Skin and Mucosa at the Equine Oral Commissures to Assess Pathology from Bit Wear: The Oral Commissure Assessment Protocol (OCA) for Analysis and Categorisation of Oral Commissures. Animals 12, 643, DOI 10.3390/ani12050643
23. Cook WR, Mills DS (2009) Preliminary study of jointed snaffle vs. crossunder bitless bridles: quantified comparison of behaviour in four horses. Equine Vet J 41, 827–830, DOI 10.2746/042516409x472150
24. Mcgreevy P, Mclean A, Buckley P, Mcconaghy F, Mclean C (2011) How riding may affect welfare: What the equine veterinarian needs to know. Equine Vet Educ 23, 531–539, DOI 10.1111/j.2042-3292.2010.00217
25. Mata F, Johnson C, Bishop C (2015) A cross-sectional epidemiological study of prevalence and severity of bit-induced oral trauma in polo ponies and race horses. J Appl Anim Welf Sci 18, 259–268, DOI 10.1080/10888705.2015.1004407
26. Cook WR (2000) Störungen der Atemwegsfunktion und andere durch das Gebiss verursachte Probleme des Pferdes - Ein Ansatz zur Problemlösung. Pferdeheilkunde 16, 333–351, DOI 10.21836/PEM20000401
27. Cook WR (2000) A solution to respiratory and other problems caused by the bit. Pferdeheilkunde 16, 333–351, DOI 10.21836/PEM20000401
28. Cornelisse CJ, Rosenstein DS, Derksen FJ, Holcombe SJ (2001) Computed tomographic study of the effect of a tongue-tie on hyoid apparatus position and nasopharyngeal dimensions in anesthetized horses. Am J Vet Res 62, 1865–1869, DOI 10.2460/ajvr.2001.62.1865
29. Manfredi J, Clayton H, Derksen F (2005) Effects of different bits and bridles on frequency of induced swallowing in cantering horses. Equine Comp Exerc Physiol 2, 241–244, DOI 10.1079/ECP200569
30. Manfredi JM, Rosenstein D, Lanovaz JL, Nauwelaerts S, Clayton HM (2009) Fluoroscopic study of oral behaviours in response to the presence of a bit and the effects of rein tension. J Vet Behav 4, 146–155, DOI 10.1017/S1755254010000036
31. Warren-Smith AK, Curtis RA, Greetham L, McGreevy PD (2007) Rein contact between horse and handler during specific equitation movements. Appl Anim Behav Sci 108, 157–169, DOI 10.1016/j.applanim.2006.11.017
32. Christensen JW, Zharkikh TL, Antoine A, Malmkvist J (2011) Rein tension acceptance in young horses in a voluntary test situation. Equine Vet J 43, 223–228, DOI 10.1111/j.2042-3306.2010.00151.x