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INVESTIGATION INTO THE OCCURRENCE OF WIND SURGERIES IN UK NATIONAL HUNT HORSES OVER 3 SEASONS (2018, 2019, 2020)

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Abstract

Upper respiratory dynamic obstructions are a known causative of ventilation dysfunction and poor performance. The aetiology of dynamic obstructions is not fully elucidated and as such there is a wide variety of surgical procedures available, each with beneficial and negative connotations. Wind surgery does not offer certain results- reoccurrence and the secondary obstructions are common. Equally, it does not augment athletic capabilities but rather restores ventilation rates to a physiologically normal range.

The study employed inferential statistics in order to investigate the occurrence of wind surgeries in a population of national hunt horses in the UK over a 3 year period. As well as post-operative performance evaluation, descriptive statistics were obtained, describing the distribution of dynamic obstructions in the population in addition to age and gender distribution. Data was attained from the Racing Post website which provided race form and details of the animal.

The findings of this thesis ascertained that performance was improved post-operatively in a cohort of National Hunt horses. A significant difference was determined between pre and post surgery RPR. Similarly the number of horses pulled up early during racing was decreased versus that of pre-surgery suggesting that endurance capacity was reinstated . In older horses wind surgery was found to be negatively correlated with performance with the majority of horses >9 years showing deterioration of race form post surgery. Descriptively, a gender imbalance was seen with predominantly geldings receiving surgery with 6-7 year olds the most common age for wind surgery.

Conclusively, wind surgeries increase performance post-operatively in national hunt racehorses. This study provides valuable information on the distribution of wind surgeries and dynamic obstructions within a population. The success of wind surgery depends on an accurate assessment and clinical diagnosis. Further research is necessitated into the pathoaetiology of upper respiratory dynamic obstructions to increase the efficiency and success rates of surgery.

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Finally, I would like to dedicate this thesis to my late father, Pat who started me on the path towards veterinary medicine.

List of Abbreviations

1.	BHA	British Horseracing association
2.	CAD	Cricoarytenoid Dorsalis
3.	CAL	Cricoarytenoid Lateralis
4.	DDSP	Dorsal displacement of soft palate
5.	EIPH	Exercise induced pulmonary haemorrhage
6.	LPVC	Laryngoplasty with ventriculocordectomy
7.	PI	Palatal instability
8.	RAO	Recurrent Airway Obstruction
9.	RLN	Recurrent laryngeal neuropathy
10.	RPR	Racing Post Rating
11.	URT	Upper respiratory tract
12.	US	Ultrasound

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1 Introduction

Wind operations are frequently used in national hunt horses who struggle to finish a race, seeming to “go off the bridle” in the finishing stages in hopes of improving performance as well as individuals making a noise during exercise or showing a pathological cause on endoscopy. These surgeries are frequently perceived by the racing community as enhancing racing performance, however there is limited to no statistical evidence to support this assumption.

As of 19 January 2018, the British Horseracing Authority (BHA) must be informed of national hunt horses in the UK which have undergone a wind surgery since their last run. This information is declared to the public via racecards and records by the abbreviation “WS” signifying that the horses has had a new wind surgery since its last performance. Procedures that must be declared include Tie backs (prosthetic laryngoplasty), Hobdays (ventriculectomy/cordectomy), Epiglottic entrapment surgeries, Tie forwards (dorsal displacement soft palate surgery) and Soft palate cautery surgeries.

The declaration of wind surgeries in UK racing offers an novel opportunity to quantify the number of national hunt horses receiving such surgeries and statistical evidence on its impact on performance. Information on this topic would be valuable as wind surgeries present both an economical and welfare challenge. Financially, this is represented by both the number of days lost in training and prize money as well as the depreciated cost of the individual in the sales ring. Information pertaining to performance has the potential to improve welfare standards as it is widely believed amongst trainers without statistical verification, that wind surgeries consistently improves performance meaning that there is potentially a large number of horses receiving these surgeries unnecessarily.

1.1 Aims

- To investigate the occurrence of wind operations in UK National Hunt horses over a 3 year period (2018-2020).
- To quantify the incidence of wind surgeries in National Hunt horses in a large cohort
- To examine the impact of these surgeries on racecourse performance.

- To estimate the average number of wind surgeries per individual over a 3 year period
- To compare the lifetime performance of racehorses who have received a wind surgery with those who have not in a population.
- To investigate if there is a gender predisposition to individuals receiving surgical treatment of dynamic obstruction.

1.2 Hypothesis

I hypothesise that wind operations will improve track performance post-operatively.

2 Literature Review

2.1 Introduction

This literature review aims to give context and background information pertaining to the aims and objectives of the thesis. As such it will focus on the pathoaetiology of dynamic upper respiratory obstructions including common predisposing factors as well as individual diseases recognised in the scope of the BHA regulations on wind surgery. Subsequentially it will then focus on the diagnosis of these disorders, treatment and impact on performance.

2.2 Predisposing factors to Dynamic Upper Respiratory Tract Obstruction

2.2.1 Anatomy

Due to the anatomical relationship between the larynx and caudal soft palate, horses are obligate nasal breathers (Janicek & Ketzner, 2008). It is thought that this originated as an evolutionary adaption, allowing dual grazing and olfaction in order to perceive nearby predators (Holcombe & Ducharme, 2008). The juxtaposition of the caudal soft palate to the larynx does not facilitate interaction between the oropharynx and nasopharynx, excluding oral breathing as a viable source of airflow and in the modulation of air resistance (Cheetham, 2019). In contrast to species that can utilise oral breathing during exercise, obligate nasal breathers cannot disperse the elevated pressure generated by exercise via the oral route, making them susceptible to dynamic airway collapse as the work of breathing increases (Van Erick- Westergren et al., 2013). Consequently, any change to airflow resistance is counteracted by a change in tension of the musculature of the upper respiratory tract (Joo et al., 2015; Janicek & Ketzner, 2008).

The simultaneous actions of upper respiratory tract musculature and capacitance vessels, permits prompt adaptation of the upper airway to rapid changes in airflow pressure(Cheetham, 2019). However, the upper respiratory tract is prone to collapse particularly in the nasopharynx region which is devoid of bone or cartage support (Van Erick- Westergren et al., 2013). Both the laryngeal and nasopharyngeal regions rely on active muscle work and thereby, harmonised sensory and motor function to support respiratory activity (Joo et al., 2015; Van Erick- Westergren et al., 2013).

2.2.2 Upper Airway Mechanics

Breathing generates two separate air flow pressures. As air is inhaled during inspiration, a negative pressure develops throughout the respiratory tract as the diaphragm contracts. Inversely, expiration creates a positive pressure as air is exhaled. As exercise intensifies, so does the requirements for air causing an escalation in airflow rate and pressure (Janicek & Ketzner, 2008). Consequently, the URT is exposed to variance in air flow and pressure in the course of inspiration and expiration during exercise. (Rakesh et al., 2008).

The maximal oxygen uptake (VO2max) during intense exercise in thoroughbreds has been estimated at 160ml/kg/min (Cheetham, 2019). In order to achieve VO2max, tidal volume and respiratory frequency are amplified aided by diaphragmatic contractions allowing an escalation in minute ventilation while produced increased negative pressure within the URT (Cheetham, 2019).

A minor change in airway diameter significantly influences airway resistance; a 20% reduction in airway diameter can cause a two-fold increase in airway resistance. (Janicek & Ketzner, 2008). Exercise intensifies the volume of air required, producing greater negative pressure in the URT (Joo et al., 2015). Pertinently, the majority of total airway resistance is caused by the extrathoracic URT (Rakesh et al., 2008). 66% of total respiratory airflow resistance during rest is encountered in the upper respiratory tract rising to 80% during inspiration and 50% during expiration as the animal exercises (Janicek & Ketzner, 2008).

A change in airflow resistance is correlated to structural changes in the URT in adjusting to additional airflow (Cheetham, 2019). The highest impedance to airflow can be seen at the nasal passages and larynx respectively (Rakesh et al., 2008). Negative pressure from inspiration causes unsupported tissue to be pulled into the airway, constricting the upper airway. Conversely, expiratory positive pressure will dilate upper airways. (Janicek & Ketzner, 2008). Concomitantly to the rise in airway resistance, respiratory work increases to match demand (Van Erick- Westergren et al., 2013).

A study conducted Rakesh et al (2008) localized anatomical variances in the biomechanics of respiration in the upper airways, thereby pinpointing areas at risk of dynamic collapse during exercise. Peak turbulence, negative pressure and airflow velocity during inspiration were linked to the larynx, rostral nasopharynx and soft palate respectively. Similarly, peak turbulence, positive pressure and airflow velocity was demonstrated in the rostral and mid nasopharynx, caudal soft palate and nasopharynx individually.

Obstructive conditions further exacerbate airflow resistance causing decreased airflow or an increase in upper airway pressure. Consequent hypoventilation instigates an increase in blood lactate concentrations as well as intensifying arterial hypoxaemia and hypercapnia (Van Erick- Westergren et al., 2013). Compromisation of respiratory function can have systemic effects. In a study by Marr et al., (2021) racehorses with URT obstructions were found to be higher risk of cardiac rhythm disturbances. It is ill understood what mechanisms lies behind this.

2.2.3 Discipline

The incidence and seriousness of dynamic respiratory tract obstructions can be connected with the type of exercise performed. Racing requires a higher oxygen demand with increased respiratory work therefore using a larger proportion of total respiratory capacity versus horses competing in dressage. Additionally, as speed increases so does the negative inspiratory pressure meaning that URT resistance can be related to stride frequency (Van Erick- Westergren et al., 2013). While stride frequency is unconnected to respiratory frequency in walk and trot, at canter and gallop they are harmonised in a 1:1 ratio allowing some mechanical assistance (Cheetham, 2019).

2.2.4 Head and Neck Position

During exercise, the horse expands the angle of the pharynx by stretching the head and neck forward to facilitate breathing. Flexion of the head and neck doubles upper airway impedance by altering the radius of the pharynx as well as intensifying respiratory effort, thereby amplifying the threat of dynamic URT collapse (Janicek & Ketzner, 2008). In this manner, flexion of the poll can induce the protrusion of soft tissue of the URT, initiating an obstruction (Van Erick- Westergren et al., 2013). Head and neck carriage in the aetiology of dynamic obstruction is more relevant in showjumpers and dressage horses where horses are actively ridden “on the bit”. In racing, horses run with their head and necks elongated forward which has less bearing on the risk of a dynamic URT obstruction developing.

2.2.5 Miscellaneous factors

Additional factors have been implicated in the background of dynamic URT obstructions, including inflammation, immaturity of the nasopharynx and lower respiratory obstructions. Bronchoconstriction and inflammation in the lower airways can precipitate URT disorders by increasing negative pressure in the URT. In a study by Davidson et al., (2011) EIPH was found in the concurrent to URT disorders in a large cohort. Similarly, Joo et al., (2020) detected Equine asthma in the majority of a sport horses sample group confirmed with DDSP during resting endoscope.

2.3 Dynamic Upper Airway Disorders

2.3.1 Recurrent Laryngeal Neuropathy

2.3.1.1 Pathoaetiology

Recurrent laryngeal neuropathy (RLN) is a progressive, bilateral mononeuropathy causing dysfunction of the arytenoid cartilage. While laryngeal paralysis can be often seen bilaterally, it is more often seen unilaterally on the left side effecting the left recurrent laryngeal nerve (Ducharme & Rossignol, 2019; Anderson, 2007).

Unilateral paralysis of the larynx can be instigated by trauma to the left and right recurrent laryngeal nerves including accidental perivascular injection, injury to the neck, guttural pouch mycosis, strangles and toxins as well as impinging neoplasms in this region. Conversely, the majority of cases are of unknown aetiology- deemed idiopathic laryngeal hemiplegia originally and subsequently re- named recurrent laryngeal neuropathy (Ducharme & Rossignol, 2019; Anderson, 2007). Hypotheses to the exact background of RLN include failings in the neuronal soma leading to atypical energy metabolism, anomalies in embryonic development and mechanical compression of the recurrent laryngeal nerves.

The occurrence of RLN differs between breeds. In thoroughbreds it has been estimated to affect between 2.6-8% of the population (Brown et al., 2005). This is consistent with the findings of Barett and Arkins (2020) who reported that 5.3% of national hunt 3 and 4 year olds offered at auction in Ireland were diagnosed with RLN after endoscopic examination. Asynchronous laryngeal movements are a common finding in thoroughbreds, found in an estimated 50-78% of individuals (Anderson, 2007).

The genetic basis of RLN has been much debated with anecdotal evidence of the heritance of RLN to offspring from its parents. RLN has been linked to a locus for body height on ECA3 LCORL/ NCAPG in thoroughbreds (Boyko et al., 2014). Furthermore, analysis of Warmblood horses has associated a quantitative gene locus with haplotype protection on a myosin gene (Dupuis et al., 2011). Similarly, in a study of flat racing Kikuta et al., (2006) found that the appearance of laryngeal hemiplegia was correlated to sex and height, with males and heavier horses predisposed to RLN. The role of genetics in the aetiology of RLN remains vague with a multifactorial background more likely to influence its occurrence.

The pathology of RLN is thoroughly documented with the principle lesion being the gradual demyelination of distal nerve fibers of the left recurrent laryngeal nerve and subsequent atrophy of the intrinsic laryngeal musculature (Anderson, 2007). While atrophy of the adductor muscles is of greater severity, atrophy of the dorsal cricoarytenoid muscle (DCAM) which acts as the sole abductor of both the arytenoid cartilage and vocal cords is the primary cause of clinical disease (Anderson, 2007).

Consequently a recurring cycle of denervation and reinnervation ensues with failure in abduction of the left side of the larynx when repair mechanisms are unable to counteract the level of muscle dystrophy and axonal injury (Anderson, 2007). The failure in abduction of the arytenoid cartilage decreases the radius of the rima glottidis as negative pressure increases during exercise, causing an obstruction to inspiratory airflow. An abnormal inspiratory noise develops due to the turbulent air vibrating the impinged vocal cord and ventricle as it travels (Ducharme & Rossignol 2019). This sound is dubbed roaring or whistling due to the its high pitch, exacerbated as exercise intensifies (Anderson, 2017; Parente, 2018).

2.3.1.2 Diagnosis

2.3.1.2.1 Clinical findings

The presence of an abnormal inspiratory whistle or roar with simultaneous exercise intolerance is indicative of RLN. Clinical signs in thoroughbreds include sudden deterioration in form and early fatigue in the final furloughs of racing (Davidson et al., 2019).

On palpation, the atrophy of the CAD may be evident as an asymmetrical percutaneous protrusion of the processus muscularis of the arytenoid cartilage. Mild asymmetry of the CAD can be normal in horses, however any obvious asymmetry can be considered pathological (Davidson et al., 2011). Additionally, fremitus may be evident on palpation of the larynx post exercise with an increase in stridor on auscultation of the region (Ducharme & Rossignol, 2019; Anderson, 2017).

The “Slap test” is used as an accessory test to examine laryngeal function at rest. Arytenoid movement is stimulated by slapping the individual caudal to the saddle region, provoking the adduction of the contralateral arytenoid when spinal reflexes remain intact (Davidson & Martin, 2003).

2.3.1.2.2 Endoscopic assessment

Resting Endoscopy

Resting endoscopy can be conclusive of RLN if asynchrony of an arytenoid is evident with a simultaneous finding of inspiratory noise and atrophy on the CAD on palpation (Parente, 2018). On endoscopy, RLN may present as resting asymmetry of the rima glottis, total or partial failure in abduction of the arytenoids or an exposed laryngeal ventricle and flaccid vocal cord (Anderson, 2017).

Arytenoid functionality is evaluated during quiet breathing in terms of symmetry and movement, directly after swallowing and during nasal occlusion (Davidson et al.,2019). Provoking swallowing causes transitory maximal abduction of the arytenoid cartilage. Similarly, protracted occlusion of the nares can initiate a similar response (Ducharme & Rossignol 2019).

Swallowing is stimulated by introducing water via the biopsy channel of the endoscope with full abduction and adduction of the cartilage visible in sound horses (Davidson et al., 2019). Transient or absent abduction is seen in the case of RLN (Anderson, 2017). It is considered a more accurate accessor of laryngeal function than nasal occlusion (Davidson & Martin, 2011).

Nasal occlusion compels the horse to breathe more deeply via temporary asphyxiation, supposedly mimicking upper respiratory pressure encountered during maximal exercise without airflow (Anderson, 2017; Davidson & Martin, 2003). Thereafter it causes innate adduction and adduction of the arytenoid cartilage which are reduced in individuals with RLN (Davidson & Martin, 2003). Although it provokes a more elongated phase of abduction than swallowing, it is more disadvantageous as it requires a tolerant horse and has been demonstrated to be a poor indicator of function during exercise (Davidson et al., 2019; Davidson & Martin, 2003).

During standing endoscopy, clinically normal horses can show asynchronous movement of the arytenoids without any bearing making it an inaccurate aid in diagnosing RLN (Ducharme & Rossignol, 2019). If diagnosis remains uncertain after resting endoscope, dynamic endoscopy and or ultrasound of larynx should be performed (Parente, 2018).

Dynamic Endoscopy

Exercise endoscopy is necessitated where residual arytenoid activity is evident on resting endoscope (Van Erck Westergren et al., 2013). Similarly it is warranted in individuals making abnormal inspiratory noise without evident abnormalities on resting endoscope (Davidson & Martin, 2003).

Treadmill endoscopy allows for the diagnosis of complex upper airway obstructions. During treadmill endoscopy, racehorses are exercised to maximal exertional effort until maximal target heart rate is reached (> 200beats/ min) Thereafter, exercising laryngeal function is classified into grade A-C with Grade A. denoting full abduction during inspiration and Grade C indicating simultaneous collapse of arytenoid cartilage and vocal cord during exercise. (Davidson et al., 2019)

Overground endoscopy is now the gold standard in diagnosing URT obstructions, allowing a definitive diagnosis under standardised conditions applicable to the individual. These include stimulated training and racing conditions such as surface, rider, and equipment (Davidson & Martin, 2003). Additionally, videoendoscopy facilitates viewing the image in real time and in slow motion post exam (Davidson et al., 2019).

2.3.1.3 Ultrasound

Ultrasonography is considered a useful adjunct in the diagnosis of RLN. Aside from being used on the standing horse, it can elucidate information on the location and degree of damage and allow for a greater assessment of laryngeal intrinsic musculature. In particular, US examination of the cricoarytenoid lateralis (CAL) and cricoarytenoid dorsalis (CAD) muscles is a highly specific and sensitive adjunctive tool in diagnosing RLN especially when resting and dynamic endoscope findings are not corresponsive (Davidson et al., 2019). Ultrasound of larynx is more accurate in diagnosing of RLN and foretelling dynamic collapse of arytenoids than resting endoscope by itself. (Parente, 2018). Garett et al., (2011) found that US assessment had an sensitivity of 90% and a specificity of 98% in foretelling arytenoid dysfunction in contrast to resting endoscope (80% and 81% respectively).

2.3.1.4 Treatment

RLN is more often than not treated surgically via prosthetic laryngoplasty, ventriculectomy (sacculectomy), ventriculocordectomy or reinnervation of the CAD

2.3.1.4.1 Prosthetic Laryngoplasty

The first choice surgery for clinicians in the treatment of RLN remains prosthetic laryngopalasty (Compostella et al., 2012). Prosthetic laryngoplasty (tie back) aspires to reinstate a permanent degree of arytenoid abduction by inserting a non-absorbable suture prothesis between the dorsocaudal margin of the cricoid cartilage and muscular process of the arytenoid cartilage (Ducharme & Rossignol, 2019; Adreani & Parente, 2007). It can be performed standing which allows for a better gauge of abduction as well as bypassing complications associated with anaesthesia. (Ducharme & Rossignol 2019) Abduction loss is the principle complication of PL, mainly occurring between 6 days to 6 weeks post - surgery (McCarrel & Woodie, 2015).

Reinstating arytenoid abduction aims to augment ventilation whilst subsiding the risk of aspiration post operatively (McCarrel & Woodie, 2015). As such LP has been demonstrated to decrease peak respiratory pressure while restoring ventilation, pH and arterial blood gas constituents to pre-operative levels (Adreani & Parente, 2007).

Laryngoplasty by itself does not eradicate abnormal expiratory noises and is often performed in conjunction with a left sided ventriculocordectomy or ventriculectomy in hopes of doing so. However abnormal respiratory sounds may still persist despite intervention (Compostella et al., 2012).

2.3.1.4.2 Ventriculectomy

Ventriculectomy is the amputation of the mucosa of the laryngeal ventricle, caudal to the vocal cord, usually by transendoscopic laser. It is most often used in combination with prosthetic laryngoplasty, to reduce abnormal respiratory sounds. By itself it has no effect on arytenoid abduction (Ducharme & Rossignol, 2019).

2.3.1.4.3 Ventriculocordectomy

Ventriculocordectomy utilises the principles of the ventriculectomy procedure as well as removing part of the vocal cord. Due to the reduced risk of vocal cord collapse post operatively, it has replaced VC as the principle conjunctive surgery (Ducharme & Rossignol, 2019).

2.3.1.4.4 Laryngeal innervation

Rossignol et al., (2018) innovated an altered cervical nerve transplantation procedure for reinnervation of the CAD in the management of RLN. Preliminary study showed that it was successful in 11/12 cases and improved performance in 9/14 horses assessed 12 months post-surgery. Laryngeal innervation is recommended in younger horses with moderate arytenoid dysfunction (Ducharme & Rossignol, 2019).

2.3.2 Dorsal Displacement of the Soft Palate

2.3.2.1 Pathoaetiology

Palatal instability is the volatility of the caudal soft palate and its consequential bulging into the nasopharynx. DDSP is a common sequel of PI whereby the caudal margin of the soft palate dislocates over the epiglottis causing further obstruction of the URT (Chesen & Whitfield-Cargile, 2015). DDSP is most commonly seen in racehorses, 2-4 year old but may be seen in older horses (Holcombe & Ducharme, 2007). It has been identified as the most frequent diagnosed cause of nasopharyngeal collapse (Reardon et al., 2008).

Intermittent DDSP is more common than the persistent form which result from permanent impairment of efferent nerves to the pharyngeal musculature. (Janicek & Ketzner, 2008)

The pathoaetiology of DDSP is uncertain; neuromuscular and anatomical abnormalities as well as URT inflammation and infection have been proposed as factors in the background of DDSP. A known cause such as persistent epiglottic frenulum and entrapment or subepiglottic cysts, is only identified in a minority of cases (Chesen & Whitfield-Cargile, 2015).

Predisposing factors of DDSP include an elongated soft palate, subepiglottic masses, epiglottic hypoplasia and caudal retraction of the tongue and larynx (Reardon et al., 2008). The aetiology of DDSP is often classified into those relating to the intrinsic musculature (palatinus and palatopharyngeus muscles) or extrinsic musculature (thyrohyoid muscle). Sources of intrinsic pathology include neuromuscular weakness and structural abnormalities of the pharynx such as subepiglottic cysts, epiglottis, epiglottic chondritis and granulomas. RAO may be seen in the background of DDSP in sports horses with an increase in negative pressure in the LRT causing a consequential increase in negative pressure in the URT (Joo et al., 2015). Furthermore, damage to the pharyngeal branch of the vagal nerve after guttural pouch infection may cause DDSP (Reardon et al., 2008).

2.3.2.1.1 Intrinsic causes

In younger thoroughbreds, intrinsic causes may be in the background of DDSP specifically immaturity of the nasopharynx. These cases usually resolve themselves with time (Joo et al., 2015).

Similar to RLN, neuromuscular abnormalities have be suggested as a cause of DDSP. DDSP has been instigated experimentally by blocking both the pharyngeal division of the vagal nerve and hypoglossal nerve as well as resection of the thyrohyoideus muscle. Additional studies have shown that neuromuscular dysfunction can be attributed to URT inflammation with a greater prevalence of DDSP reported in horses post URT infection (Chesen & Whitfield- Cargile, 2015). Infection of the guttural pouch is of significance as several nerves pass through it that innervate the nasopharyngeal region. Impinging of these nerves due to inflammation may potentiate dysfunction of the intrinsic palatal muscles (Holcombe & Ducharme, 2007). Histological lesions associated with chronic denervation has been confirmed within the palatinus muscle highlighting the role of neuromuscular dysfunction in the aetiology of DDSP (Van Erck Westergren et al., 2013).

2.3.2.1.2 Extrinsic Causes

DDSP frequently affects thoroughbreds in which it is predominantly extrinsic (Joo et al., 2015). Extrinsic causes affecting laryngohyoid location have been suggested as a potential cause of DDSP; in particular the arrangement of the sternohyoideus, sternothyroideus, omohyoideus and thyrohyoid muscles in causing laryngopalatal repositioning. Bilateral resection of these muscles forms the basis of the tie forward surgery (Van Erck Westergren et al., 2013).

Movement of the tongue caudally causes simultaneous dislocation of the larynx while placing pressure on the soft palate dorsally thereby displacing the soft palate dorsal to the epiglottis (Chesen & Whitfield- Cargile 2015). Data implies that the cranial positioning of the larynx relative to the hyoid bone is beneficial to soft palate patency (Holcombe & Ducharme, 2007). It has been proposed that increasingly rostral positioning of the basihyoid bone predisposes individuals to DDSP. Equally, the degree of DDSP is correlated with caudal positioning of the larynx. This is concurrent with findings that excessive poll flexion causes DDSP as the larynx is relocated caudally while URT negative pressure increases. (Chesen & Whitfield- Cargile, 2015).

2.3.2.2 Diagnosis

2.3.2.2.1 Clinical Findings

DDSP is characterised by the development of a respiratory “gurgle” or “snore”, however this may be absent or substituted by coughing (Joo et al., 2015; Holcombe & Ducharme). The expiratory gurgling sound may be alternatively styled “choking down” or “swallowing the tongue” (Janicek & Ketzner 2008).

Clinical findings include exercise intolerance in particular sudden fatigue towards the end of the race (Allen & Franklin, 2015). Poor performance is linked to changes in URT pressure, reduced airflow and exacerbation of URT expiratory resistance. While minute ventilation and tidal volume decrease, breathing frequency does not, implying that a decrease in oxygen consumption and subsequent hypoxaemia and hypercarbia cause exercise intolerance (Van Erck Westergren et al., 2013; Reardon et al., 2008).

During displacement, air flows under the soft palate. The soft palate digresses dorsally during expiration into the nasopharyngeal lumen. False "mouth breathing" may be evident as airflow is redirected below the soft palate into the oropharynx (Holcombe & Ducharme, 2007). The gurgling noise associated with DDSP is caused by vibration of the free margin of the soft palate (Allen & Franklin, 2007). It is less likely to develop in sports horses as expiratory air velocity is lower than racehorses and therefore there is reduced reverberation of the free margin of the soft palate (Joo et al., 2015).

Diagnosis of DDSP is complicated by the fact that abnormal respiratory sounds may be absent in up to 30% of horses with DDSP with only 58-85% making an abnormal respiratory sound during exercise (Davidson & Martin, 2003; Allen & Franklin, 2007). Gurgling as a clinical sign has a specificity of 0.77 and sensitivity of 0.5 for DDSP making it an unreliable predictor of nasopharyngeal dysfunction (Allen & Franklin, 2007).

2.3.2.2.2 Endoscopic Assessment

During resting endoscopy, DDSP may be stimulated by nasal occlusion or swallowing similar to RLN (Holcombe & Ducharme, 2007). Indications of DDSP during resting endoscopy include soft palate ulceration, small or limp epiglottis and temporary displacement of the soft palate (Allen & Franklin, 2007).

Studies have indicated that only 8-51% of suspected cases displace the soft palate during resting endoscope. While specificity of resting endoscopy is high (0.89-0.96), sensitivity is low (0.02-0.64) (Allen & Franklin, 2007). Reardon et al., (2008) reported a misdiagnosis rate of 35% when resting endoscopy was used as the sole diagnostic tool in assessing DDSP. Additionally while higher grades of undeviating DDSP may be evident at rest during endoscopy, lower grades of transient DDSP can be missed (Janicek & Ketzner, 2008). It can therefore be implied that resting endoscopy is a poor predictor of DDSP during exercise and cannot be definitively diagnosed on the basis of resting endoscopy due to the dynamic nature of the disorder (Allen and Franklin, 2007).

In the majority of cases, exercise endoscopy is warranted as displacements more evident at maximal exertion. Parente et al., (2002), assessed the incidence of DDSP during treadmill endoscopy. Of those in which DDSP was diagnosed, 38% of horses had no prior account of gurgling and 80% were clinically normal on resting endoscope. Consequently, the use of treadmill and overground videoendoscopy remains the diagnostic tool of choice for clinicians. It is important to note however that, misdiagnosis may still occur with exercising endoscopy. Treadmill endoscopy does not factor in surface differences as well as the weight of the rider and raceday environment (Reardon et al., 2008). Similarly, it has been alluded that DDSP is often underreported when using overground endoscopy versus treadmill diagnosis due to exercise tests being less arduous due to the design of training facilities versus actual racecourses (Allen & Franklin, 2015).

2.3.2.2.3 Ultrasound

US has been used as an ancillary tool in diagnosing DDSP. Chalmers et al., (2009) discovered an sonographic connection between the resting depth of the basihyoid and risk of DDSP developing. Ventral positioning of the basihyoid was determined as a precursor for DDSP developing. The study implied that variation in depth is associated with hypertrophy or atrophy of muscles as well as head position altering muscular stance via flexion or extension. Measurement at the caudal aspect of lingual process of the basihyoid demonstrated the biggest connection with DDSP. Subsequently, each centimetre of additional depth correlates to a reduction in the chance of DDSP developing by 17-fold (Chesen & Whitfield-Cargile, 2015).

2.3.2.3 Treatment

2.3.2.3.1 Conservative treatment

Conservative management of DDSP include the use of tongue ties and nosebands. Proposedly, they prevent caudal dislocation of the tongue and keep the mouth closed. However, they are suggested to incline the individual to DDSP by disturbing the oropharyngeal seal (Allen & Franklin, 2015). Retraction and depression of the tongue is correlated with increased airflow as well as pharyngeal functionality and strength. Alterations in respiration such as hypercapnia, hypoxia or occlusion prompt electrical activity of the protractor and retractor muscles, thereafter dilating and reinforcing the nasopharynx. This could subsequently explain the ineffectiveness of tongue ties in preventing DDSP (Holcombe & Ducharme, 2007). It has been established that tongue ties do not make a visible difference in managing DDSP with computed tomography ascertaining no change pharyngeal diameter with or without a tongue tie (Janicek & Ketzner 2008).

2.3.2.3.2 Surgical treatment

Treatment of DDSP must be aetiologically adapted (Joo et al., 2015). The amount of surgical options available for the correction of DDSP highlights the lack of knowledge on the aetiology of DDSP as well as the dynamic nature of the obstruction. (Allen & Franklin, 2015).

The basis of soft palate therapies lies in the stiffening of the palate by provoking fibrosis which in turn increases the intrinsic strength of the caudal soft palate and thereby, its resistance to respiratory forces (Allen & Franklin, 2015). Intrinsic treatments increase rigidness of the soft palate or epiglottis; such interventions include staphylectomy, epiglottic augmentation and palatoplasty. In contrast, extrinsic surgery inhibit caudal retraction of the larynx. These consist of myectomy of the sternohyoideus and sternothyroideus muscles (Janicek and Ketzner, 2008).

Palatoplasty has been described, using both laser and thermal cautery on the oral surface of the soft palate under general anaesthesia. Similarly, the use of palatal sclerotherapy has had some success in treating DDSP. Cehak et al., (2006) pioneered a transendoscopic injection of Poly-L-Lactic Acid into the soft palate for treatment of DDSP with good preliminary results. Staphylectomy utilises excision or laser to decrease the length of the soft palate and so amplifying the intrapharyngeum opening. In this manner it decreases the extent of obstruction rather than preventing its occurrence.

Due to the hypothesis that the epiglottis is involved in the aetiology of DDSP, Epiglottic Augmentation has been used to in the management of DDSP by enhancing the size, thickness and stiffness of the epiglottis. Similarly, subepiglottic mucosal resection has been suggested as a means to counteract flaccidity of the epiglottis (Allen & Franklin, 2015). The role of the epiglottis has been debated in the aetiology of DDSP. The consensus suggests that epiglottic abnormalities are a consequent of DDSP rather than a precursor as originally thought. For this reason, epiglottic augmentation is no longer advisable in managing DDSP (Chesen &Whitfield-Cargile, 2015).

2.3.2.3.2.1 Laryngoplasty

Tie forward surgery is the preferred treatment where extrinsic causes are cited (Joo et al., 2015). Laryngeal tie forward procedures change the stance of the larynx by moving it forward. A suture is positioned between the thyroid cartilage and basihyoid bone. The suture mimics the resected thyrohyoideus muscle by shifting the basihyoid dorso-caudally and the larynx dorso-rostrally (Allen & Franklin, 2015).

2.3.3 Epiglottis Entrapment

2.3.3.1 Pathoaetiology

Epiglottic entrapment is caused by the aryepiglottic membrane enclosing the rostral epiglottis, with the permanent transposition of the sub-epiglottic tissue over the epiglottis (Epstein & Parente, 2007; Curtiss et al., 2020). It is known to appear both incessantly and sporadically, usually becoming permanent over time (Epstein & Parente, 2007). Sub-epiglottic cysts have been proposed as a predisposing factor for entrapment via alterations in the sub-epiglottic tissue. Similarly, a hypoplastic epiglottis may be a precursor of entrapment with 31-36% of entrapments estimated to have epiglottis hypoplasia in its background (Curtiss et al., 2020; Ducharme & Rossignol, 2019).

Epiglottic entrapment is frequently seen in dynamic obstruction, occurring simultaneously with DDSP (Epstein & Parente, 2007). It is a rare finding in thoroughbreds, affecting 0.74-2.1% of racehorses (Curtiss et al., 2020). While epiglottic entrapment is more frequently seen in younger horses, it also may affect older racehorses (Parente, 2018).

2.3.3.2 Diagnosis

2.3.3.2.1 Clinical findings

The degree of entrapment as well as any parallel URT obstruction influences the clinical outcome of the disease. Typically, individuals affected make abnormal respiratory sound and show exercise intolerance however also may be asymptomatic. Abnormal respiratory noise is the main clinical sign of epiglottic entrapment, only a minority show poor performance (McCarrel & Woodie, 2015).

Increased airflow turbulence results from bulging of the aryepiglottic membrane during expiration causing respiratory noise as the radius of the epiglottis is reduced. This decrease causes an increase in inspiratory pressure, pre-empting exercise fatigue. (Epstein & Parente, 2007). Uncomplicated entrapments are unlikely to cause atypical respiratory sounds or decreased performance. However, secondary entrapment may be linked to DDSP which is a known cause of abnormal noises and exercise intolerance (Parente, 2018).

2.3.3.2.2 Endoscopic Assessment

Endoscopy is the preferred method of diagnosis. The enveloping membrane distorts the visibility of the scalloped border of the epiglottis as well as its dorsal vascular pattern. This must be differentiated from primary DDSP which while similar, completely obliterates view of the epiglottis (Epstein & Parente, 2007).

On endoscope, the entrapment may be alleviated during swallowing in intermittent cases however the majority of entrapments are persistent (Ducharme & Rossignol, 2019). Additionally a common finding in epiglottic entrapment is the ulceration of the sub-epiglottis and caudal soft palate (Curtis et al., 2019). Videoendoscopy may be warranted when entrapment is suspected but not visible (Epstein & Parente, 2007).

2.3.3.3 Treatment

The majority of individuals diagnosed with persistent epiglottic entrapment are treated surgically. Epiglottic entrapment is resolved most frequently by the axial division of the ensnared tissue, using laser or hooked blades via video-endoscopy (Curtiss et al., 2020; Epstein & Parente, 2007). Axial division is usually favoured as it permits for retraction of the membrane without tissue removal (Ducharme & Rossignol. 2019).

Alternatively, resection via a laryngotomy is performed. Liberation of the entrapment by laryngotomy is not recommended due to the high failure rate and increased risk of post-operative complications. DDSP is the main post-operative complication of epiglottic entrapment, happening in 10% horses following axial division (McCarrel & Woodie., 2015).

2.4 Impact of Wind surgeries on post-operative performance

2.4.1 RLN

The influence of surgical treatment of RLN on post-operative performance has been correlated with several factors including grade of hemiplegia pre-surgery, degree of surgical abduction of the arytenoids and performing discipline.

Disciplines performed at lower exertion levels such as dressage result in higher success levels post-surgery (Compostella et al., 2012). Laryngoplasty only reinstates physiological performance ; even in clinically normal horses ventilation thresholds are encountered during maximal racing speeds (Ducharme & Rossignol, 2019). Studies that have assessed owners and trainers opinions about performance post-surgery have mainly concluded that the majority of horses improved (48-69%) (Adreani & Parente, 2007). However a study by Radcliffe et al., (2006) found that while LPVC and MPA improved arterial blood gas values and ventilation, they did not normalise airway mechanics or arterial blood gas values post-surgery

The grade of RLN has been shown to correlate with return to racing post-laryngoplasty and ventriculocordectomy (LPVC). Broyles et al., (2020) found that horses with grade 3 RLN had a greater chance of returning to racing and a shorter interval between surgery and return to racing than grade 4 RLN. Grade 4 RLN has been associated with poor performance with 80-84% of these individuals unable to sustain arytenoid abduction during exercise. In contrast, Barakzai et al., (2009) found no correlation between pre-operative grade of RLN on performance after LP with no significance disparity in performance in horses with Grade 1-3 abduction.

Rakesh et al., (2008) concluded that ideal arytenoid abduction should be that in which attains 88% of the laryngeal lumens radius. Similarly, it has been implied that the degree of post surgical arytenoid abduction may be of greater importance in jumps horses (Barakzai et al., 2009). These assumptions however has come under much scrutiny with many authors suggesting that a lesser degree of abduction may be sufficient. Interestingly, the grade of laryngeal abduction post-operatively has not been associated with decrease in prize money, return to racing or career starts (McCarrel & Woodie 2015).

In a study by Barakzai et al., (2009), postoperative race performance was not linked to the extent of surgical abduction in national hunt horses post- LP. Higher degrees of surgical arytenoid abduction during LP was correlated with post-operative failure. The authors proposed that moderate surgical abduction (Grade 3 abduction) is sufficient to maximise ventilation and reduce post-operative complications with the benefit of greater arytenoid abduction negated by the possibility of dysphagia post operatively.

2.4.2 DDSP

Thermal cauterisation has been reported to have some success in treating DDSP however, improvement in race form is varied (28%-59%) with only 48% of individuals ceasing gurling post-operatively (Allen & Franklin, 2015; Reardon et al., 2008). In one study, Casslers & McNally (2019) found that soft palate thermocautery did not significantly influence performance post-operation. The after results of laser cautery is more controversial. Reports suggest that while fibrosis is induced, secondary damage to the palatal muscles can occur. Interestingly, doctored horses were shown to have a more lax soft palate than those in the control group bringing the effectiveness of the procedure into question. Similarly, success rates for staphylectomy have been mixed suggested in the region of 59% with DDSP reoccurrence common (Allen & Franklin, 2015).

The injection of sclerosing agents into the submucosa of the soft palate has a better impact on performance than cautery and myomectomy methods aforementioned. It has been reported to increase race-form (70%) as well as decrease the occurrence of gurgling (60%) in a cohort examined (Allen & Franklin, 2015).

Success rates of laryngeal tie forwards post operatively have been estimated at 68-90% (Joo et al., 2015). In studies regarding the effectiveness of Laryngeal tie forward, no statistical difference in URT air pressure was observed with horses post operatively versus the control group (Janicek & Ketzner 2008). A study by Woodie et al., (2005) found that 87% of horses had an increase in performance and earnings post tie-forward. This is consistent with the findings of Cheetham et al., (2008) in which Laryngeal tie forward increased the chance of racing post-operatively as well as reinstated race winnings to pre-surgery levels.

2.4.3 Epiglottic entrapment

Prognosis post-surgery is variable. Russel & Wainscott (2007) reported similar race performance in terms of number of starts and handicap rating pre and post operatively. Recurrence may occur, estimated as 5-15% after axial division using a curved bistoury, 10% after laser axial division, 40% after electrosurgical axial division and 36% after resection via laryngotomy. Outcome may be further complicated by co-existing upper respiratory disorders. Individuals with parallel disorders such as DDSP, RLN, subepiglottic cysts or arytenoid chondropathy have been found to have a less race starts (Epstein & Parente, 2007).

Prognosis following laryngotomy is least favourable with only 27% returning to racing post-operatively. Comparatively, axial deviation of the epiglottis has had more favourable results in return to racing. However, it is understood that surgery does not enhance performance with studies finding no significant change in performance after surgery (Beard and Waxman, 2007).

Interestingly, Brown et al., ascertained that horses with epiglottic entrapment were 8.3 times more likely to win or place in the race before surgery and had higher lifetime earnings. The authors suggested that poor performance may not be entirely due to epiglottic entrapment with surgical intervention in the case of epiglottic entrapment not necessitated in some individuals.

3 Materials and Methods

3.1 Population selection

National hunt horses running under rules in the UK in 2017-2020 were selected for evaluation. They were conscripted retrospectively into the study using race form that indicated that a wind operation had occurred. Due to the large size of the population, a sample population was thereafter chosen at random from the total study population for assessment using the sample size equation: (Z value)^2 X standard deviation (1-standard deviation)/(margin of error)^2 = n. Confidence interval was set as 95%, corresponding to a Z-Value of 1.96. Likewise standard deviation and margin of error were fixed as 0.05 and 5%, respectively. This gave a sample size of 385 in which continuous variables and performance were assessed representative of the larger population.

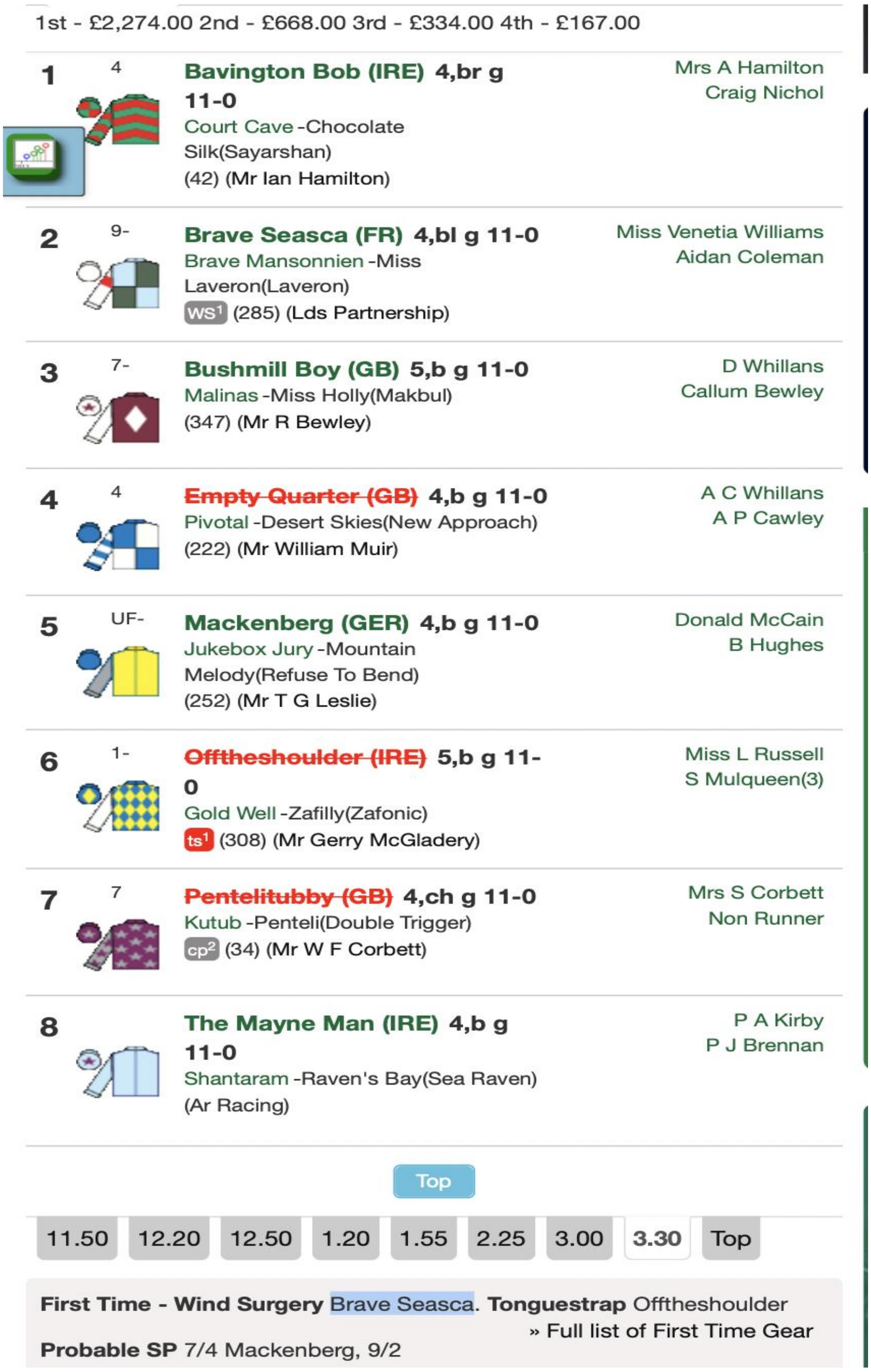
The control population was selected from the annual BHA Data Pack (http://media.britishhorseracing.com/bha/Racing_Statistics/Racing_Data_Packs_Full_Year/Full_Year_2020.pdf). This provided statistics on continuous variables in the entire population which was later used as a comparison.

3.2 Data Collection

Race entries were assessed over a 3 year period for 2018, 2019 and 2020 using the Irish Racing database. (https://www.irishracing.com). Horses having their first run post-surgery are indicated by "WS1" on race cards, illustrated below (Picture 1). Race results were collected from the Racing Post lifetime form database (https://www.racingpost.com).

Median and mean were determined for continuous variables (age, total earnings, handicap rating and number of surgeries) as well as maximum and minimum values. Frequency distributions was additionally described for sex, age and pre-operative and post-operative failure to complete races.

Picture 1: Race Card with “WS1” indicated



1st - £2,274.00 2nd - £668.00 3rd - £334.00 4th - £167.00

1	4	**Bavington Bob (IRE)** 4,br g 11-0 Court Cave -Chocolate Silk(Sayarshan) (42) (Mr Ian Hamilton)	Mrs A Hamilton Craig Nichol
2	9-	**Brave Seasca (FR)** 4,bl g 11-0 Brave Mansonnien -Miss Laveron(Laveron) WS1 (285) (Lds Partnership)	Miss Venetia Williams Aidan Coleman
3	7-	**Bushmill Boy (GB)** 5,b g 11-0 Malinas -Miss Holly(Makbul) (347) (Mr R Bewley)	D Whillans Callum Bewley
4	4	~~**Empty Quarter (GB)**~~ 4,b g 11-0 Pivotal -Desert Skies(New Approach) (222) (Mr William Muir)	A C Whillans A P Cawley
5	UF-	**Mackenberg (GER)** 4,b g 11-0 Jukebox Jury -Mountain Melody(Refuse To Bend) (252) (Mr T G Leslie)	Donald McCain B Hughes
6	1-	~~**Offtheshoulder (IRE)**~~ 5,b g 11-0 Gold Well -Zafilly(Zafonic) ts1 (308) (Mr Gerry McGladery)	Miss L Russell S Mulqueen(3)
7	7	~~**Pentelitubby (GB)**~~ 4,ch g 11-0 Kutub -Penteli(Double Trigger) cp2 (34) (Mr W F Corbett)	Mrs S Corbett Non Runner
8		**The Mayne Man (IRE)** 4,b g 11-0 Shantaram -Raven's Bay(Sea Raven) (Ar Racing)	P A Kirby P J Brennan

Top

11.50 12.20 12.50 1.20 1.55 2.25 3.00 3.30 Top

First Time - Wind Surgery Brave Seasca. **Tonguestrap** Offtheshoulder

» Full list of First Time Gear

Probable SP 7/4 Mackenberg, 9/2

3.3 Performance evaluation

3.3.1 Handicap rating

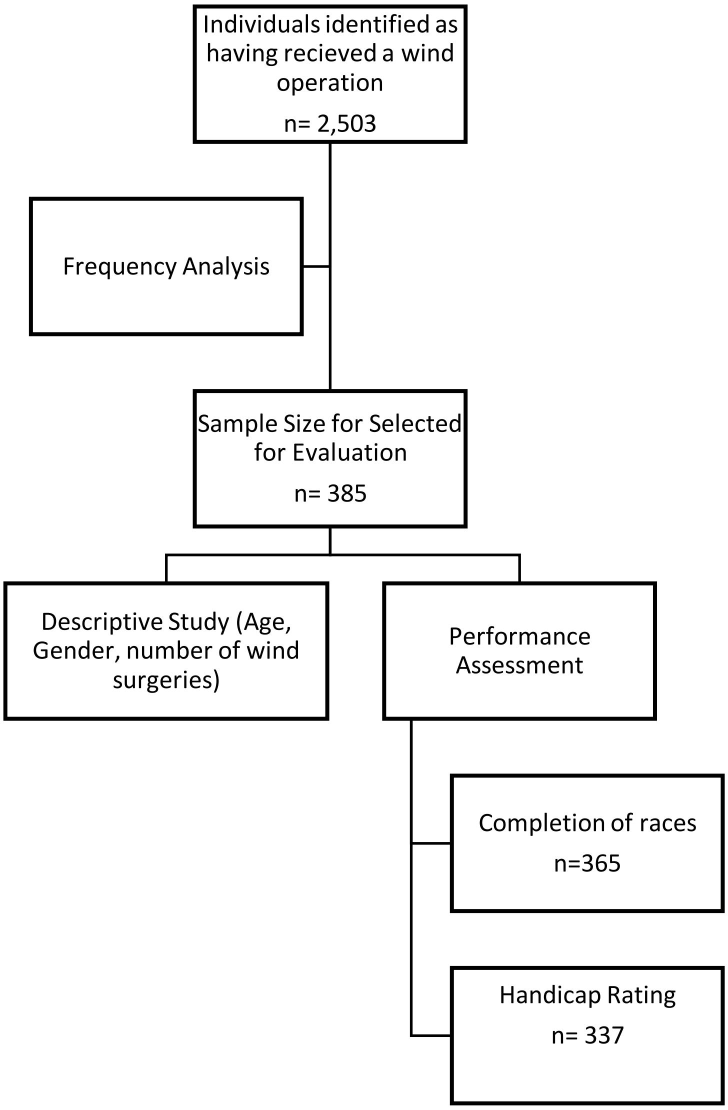
Improvement in performance post-surgery was defined in this study as an increase in its Racing Post Rating (RPR). RPR are allocated post-race and correspond to the horses capacity to perform relative to the weight carried. Each increment in value correlates to 1lb whereby 1lb is the equivalent to a 1 length difference in races over 2 miles. Change in performance was calculated by subtracting the handicap rating before surgery from the handicap rating after surgery. If the individual had been pulled up on its initial run before or after surgery, the last viable rating was used. In the event that a handicap rating was unavailable before surgery (horses that had not run under rules 3 times before surgery), the individual was excluded from performance analysis. Similarly if a horse had run only in point to points before a wind surgery was performed they were omitted. A student T-test was then performed to evaluate if a significate correlation between wind surgery and an increase in performance existed by comparing the handicap rating before and after surgery.

3.3.2 Completion of Races

Details regarding completion of races was obtained from the Racing Post website.

4 Results

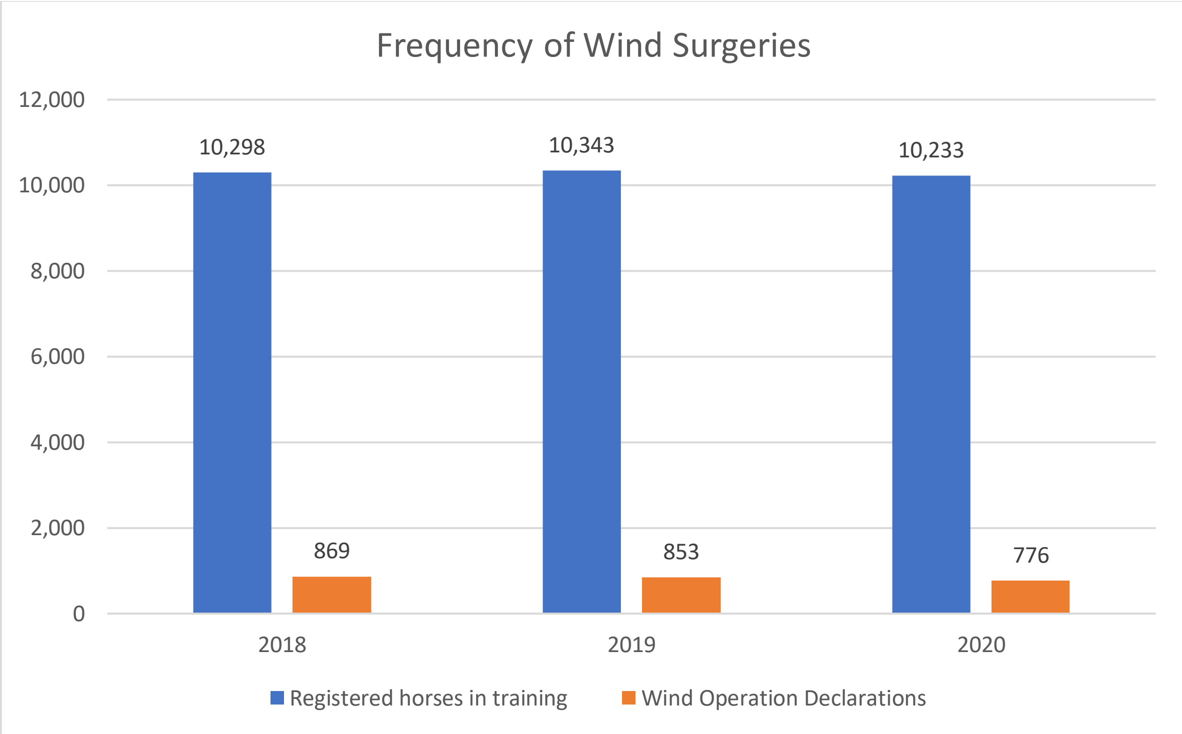
Figure 1: Flow chart illustrating the selection process of horses in various parts of the study. The number of horses in each cohort for assessment is also detailed.



4.1 Frequency Analysis

The occurrence of wind surgeries (Table 1) was similar over the 3 year period with 8.44% (869/10,298), 8.25% (853/10,343) and 7.58% (776/ 10,233) of individuals undergoing wind operations in 2018, 2019 and 2020 respectively.

Table 1: Frequency of Wind Surgeries



4.2 Descriptive Statistics

385 horses were selected for descriptive analysis. Age at surgery ranged from 3-13 years old with a mean of 6.5 years and a median of 6 years. The distribution of ages undergoing surgery is detailed in the graph below (Table 2) An asymmetrical gender balance was ascertained. Of the 385 horses, 315 (81.82%) were geldings and 70 (18.18%) were mares. The mean number of surgical procedures per individual over the 3 year period was 1.14 with a median of 1 and a maximum of 4. 12.47% of individuals received more than one wind surgery in this timeframe with 11.43% having two, 0.78% having three and 0.26% having four surgeries. (Table 3)

Table 2: Age distribution of wind surgeries

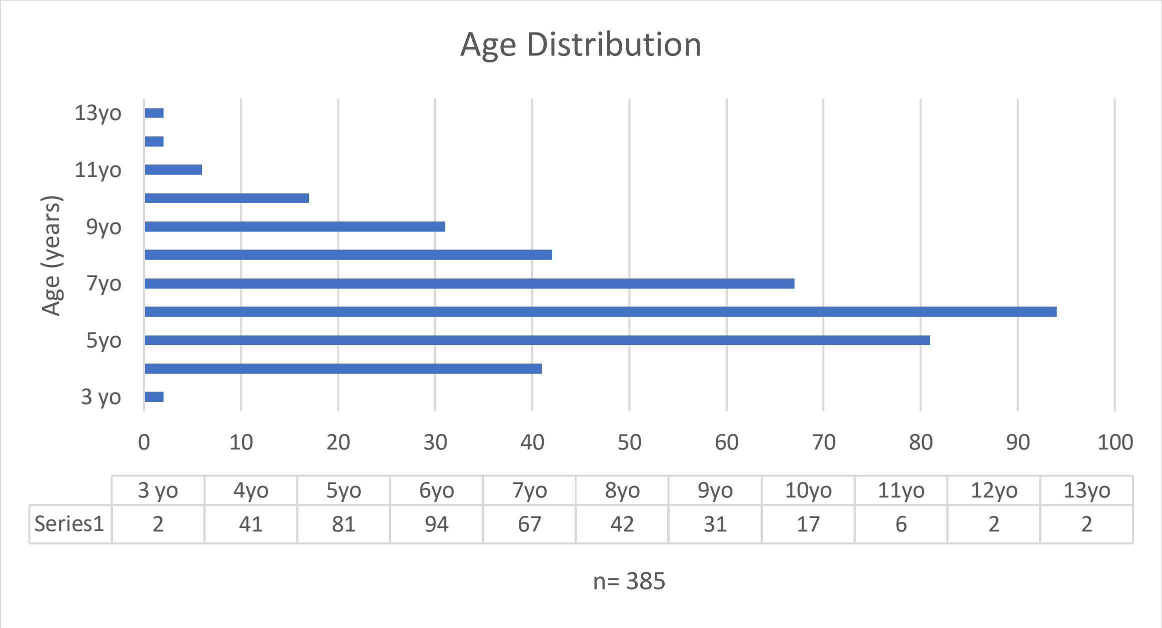
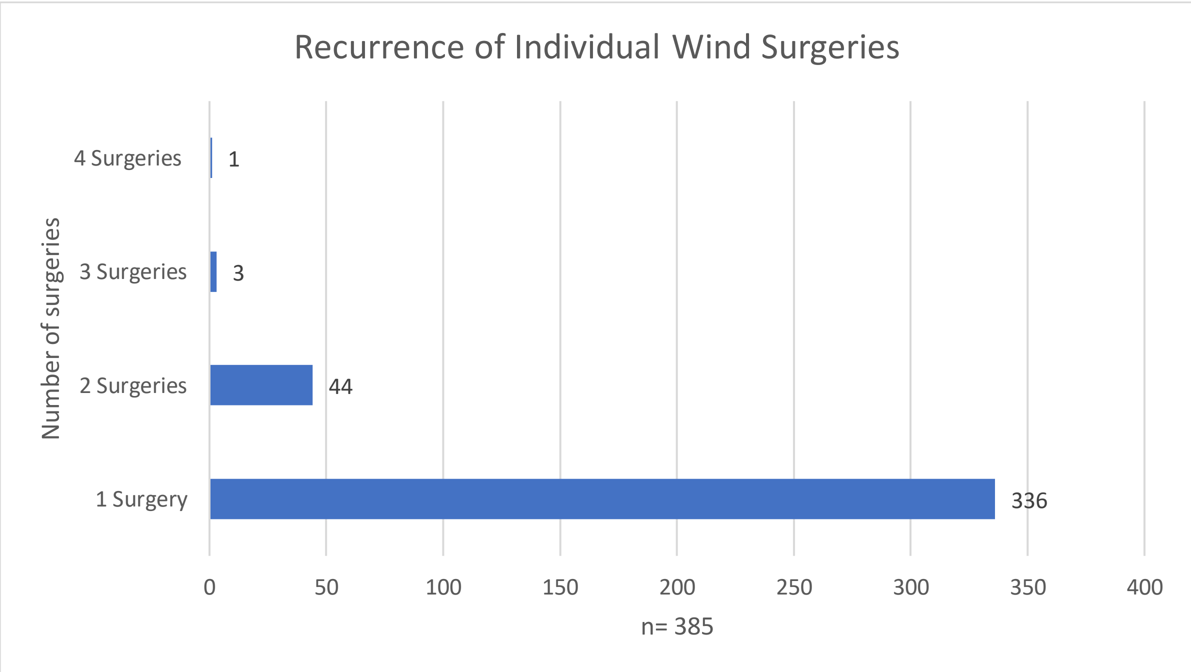


Table 3: Recurrence of wind surgeries



4.3 Performance

4.3.1 RPR

From records available, 337 were eligible for performance analysis. Of the 48 horses (48/385) which failed to meet criteria for performance evaluation, 19 never ran in a race post operatively, 16 only ran in point to points before having wind surgery and 13 had never ran in a point to point or under rules before surgery.

RPR showed improved form post-operatively with the difference between the before and after mean and median of 3.59lbs and 4lbs respectively. Pre surgical performance was in the range of 6-172 with a mean value of 96.37 and a median value of 98. In comparison, post-surgical ratings were in the range of 11-171 with a mean value of 99.98 and a median value of 102. The greatest change in RPR post-operatively were an increase of 73lbs and a decrease of -86lbs.

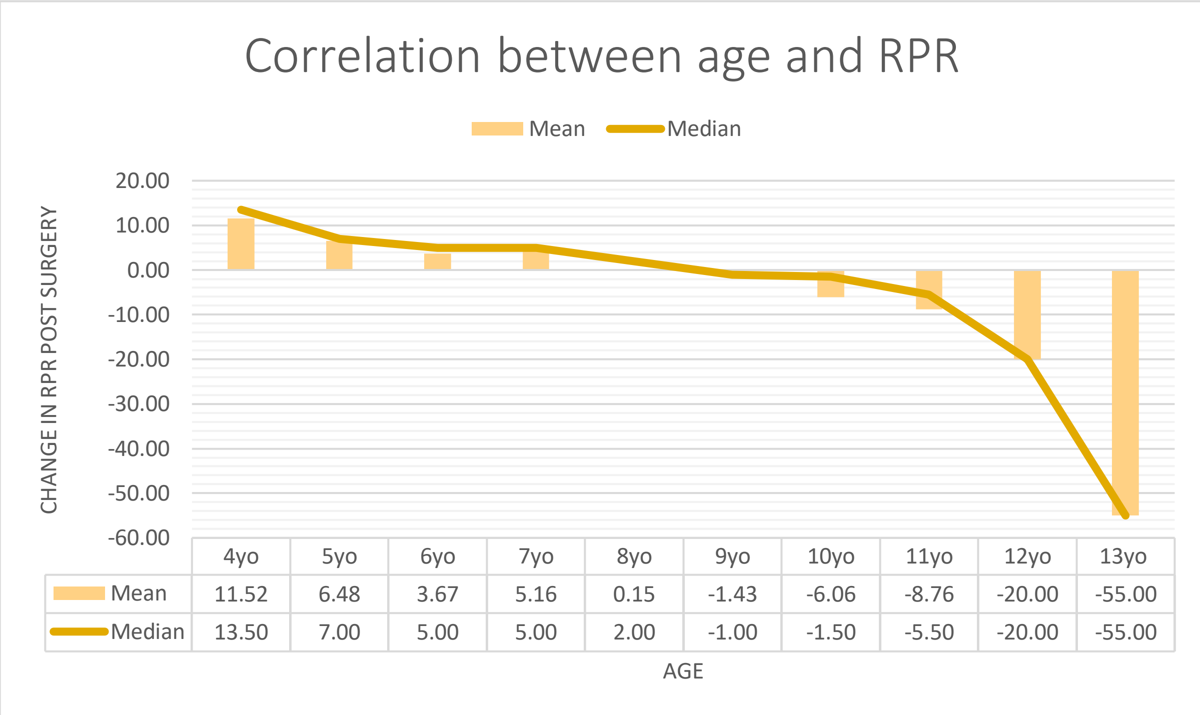
A paired T-Test (Table 4) was performed to compare mean RPR pre and post-surgery. The resulting P value (P= 0.0025) T-Value (2.83) indicated a strong statistical significance between mean values and thereby rejected the null hypothesis that no difference in RPR would be seen.

Table 4: t-Test: Paired Two Sample for Means

	RPR After	*RPR Before*
Mean	99.97626113	96.37388724
Variance	868.2732443	947.7347923
Observations	337	337
Pearson Correlation	0.699711243	
Hypothesized Mean Difference	0	
Df	336	
t Stat	2.828728387	
P(T<=t) one-tail	0.002476971	
t Critical one-tail	1.64940126	
P(T<=t) two-tail	0.004953942	
t Critical two-tail	1.967049384	

Improvement in RPR post-surgery was found to negatively correspond with increasing age (Table 5). The biggest increase was in 4 year olds with a mean increase of 11.52 and median increase of 13.50. In this cohort, improvement of form is evident until the age of 8, after which RPR decreased post-surgery with the largest deterioration seen in 13 year olds (mean and median= -55).

Table 5: Correlation between age and RPR



	4yo	5yo	6yo	7yo	8yo	9yo	10yo	11yo	12yo	13yo
Mean	11.52	6.48	3.67	5.16	0.15	-1.43	-6.06	-8.76	-20.00	-55.00
Median	13.50	7.00	5.00	5.00	2.00	-1.00	-1.50	-5.50	-20.00	-55.00

4.3.2 Completion of races

Records pertaining to the completion of races pre and post-surgery were available for 365 individuals. Of these, 20.27% (74/ 365) were pulled up on their last run pre surgery with 16.44% (60/ 365) unable to finish on their preliminary run post-surgery.

5 Discussion

5.1 Prevalence of URT Disorders

Few studies have investigated the prevalence of URT disorders in national hunt horses. Most research has focused on its distribution amongst flat racing population. In this study, occurrence was estimated at 8.44%, 8.25% and 7.5% for three consecutive years. Prevalence of URT disorders in a project by Brown et al., (2005) was lower than expected (6.3%) which was hypothesised to be due to the cohort studied of top tier flat horses; therefore horses may have been eliminated from this pool by prior selection. Of more relevance, an investigation into National Hunt store horses offered at auction in Ireland by Barrett & Arkins (2020) found that disorders of the URT were present in 10.9% of horses with 10.5% making irregular respiratory sounds. Endoscope examination revealed 50.3% of these had RLN or 5.3% of the entire group. Only horses making an abnormal respiratory noise on the lunge were scoped therefore prevalence of URT disorders may have be underrepresented.

5.2 Descriptive Statistics

5.2.1 Age

The mean age of surgery in national hunt horses is consistent with the findings of Barakzai et al (2009). The broad range in age (3-13 years old) with a mean of 6.5 years demonstrates the progressive nature of dynamic upper airway obstructions.

5.2.2 Gender

The results of this study revealed a gender imbalance consisting of 81.82% geldings and 18.18% mares. Gender imbalance may reflect the negative attitude towards mares in national hunt racing. Fewer mare are offered at public auctions as 3 year stores as well as realising lower prices at such sales. Similarly, a decreased number of mares run on the track due to an assumption that they are athletically more inadequate and difficult to train than their male counterparts. In the last 10 years initiatives such as listed mares races and bonus schemes have been introduced to encourage participation of mares in jumps racing. Additionally, owners of mares who are considered valuable breeding stock may opt to retire the mare to stud if a dynamic respiratory obstruction is diagnosed. This can rationalised by the publication of a wind surgery on the mares race form history which may deter prospective buyers from her offspring due to the common assumption in the bloodstock industry that wind problems are hereditary.

5.2.3 Reoccurrence rate

Over 10% of horses in the representative sample received more than one wind surgery over the 3 years. Reoccurrence may be attributed to surgical failure or the development of concurrent secondary dynamic obstructions. t is widely acknowledged that surgical treatment of URT obstructions may cause secondary URT disorders. Complex dynamic collapse was identified in 30% of horses with URT obstructions in a study by Lane et al., (2006). Likewise, an additional study indicated that complex dynamic collapse was evident in 87% of horses post- laryngostomy with palatal dysfunction (83%) most common as well as axial deviation of aryepiglottic fold (60%) and vocal cord collapse (43%) (Compostella et al., 2012).

5.3 Performance

Wind surgery was positively correlated to performance with a paired T-Test demonstrating a strong significance. The left sided negative distribution of mean and median RPR reflects that the majority of horses showed above average improvement in RPR. However it also highlights that in horses where form dropped post-operatively, a large decrease in RPR was noted. This could be attributed to the natural ability of the individual. Wind operations only restore upper airway respiratory function; they do not augment the innate athleticism in the animal. Performance potential is a dynamic concept with genetics, training, nutrition and environment influencing athleticism as well the health status of the individual.

The variance in performance post-operatively may reflect the different severity of the clinical effects on individual as well as the procedures performed. Brown et al., (2005) found that neither epiglottic entrapment or grade 2 laryngeal asymmetry were associated with reduced performance. In the same study it was concluded that surgical treatment of grade 2 RLN may be not necessary when horses are performing to best of their capabilities.. Individuals with grade 2 laryngeal asymmetry had better performance pre-surgery but not over entire lifetime than control group. Grade 2 still allows full abduction of arytenoids during exercise however may still significantly impact gas exchange.

Other studies have used prize earnings as a marker for performance. In one such study , Barakzai et al., 2009. found that 47.6% earned more prize money post-tie back in a small cohort of national hunt horses. However, this author considers RPR a superior evaluator of performance. RPR reflects an individual's performance relative to other horses running in the field while prize money does not reflect this.

A correlation between age at surgery and post-surgical performance was evident with post-operative RPR significantly decreased in horses 9 years old and over. This is coherent with other studies which described diminished earnings in older horses post-surgery. Lane et al., (2006) ascertained that DDSP and laryngeal collapse was associated with age. The authors postulated that younger horses were at greater risk of DDSP while older horses were prone to vocal cord collapse. Equally, it can be assumed that athletic performance physiologically diminishes with increasing age as maximal heart rate and VO2 max decreases, reducing cardiac output.

A second indicator of performance was included in this study. Early fatigue during exercise is considered an indicator of a dynamic upper airway obstruction. In this study, 20.27% of the sample group were pulled up on their primary run pre-surgery with 16.44% pulled up on their initial race post-surgery. While this may appear like an insignificant improvement, race form improved for the majority of horses. Dynamic factors such as ground condition, fitness and distance are other reasons for early fatigue in jumps racing and may be at play in these cases.

6 Conclusion

This study demonstrates that wind surgery improves racing performance with the prevalence of URT disorders varying between age and gender. In contrast to other studies, this thesis is a comprehensive analysis of the effect of the surgical correction of dynamic upper airway obstructions on performance as a whole, without specifying individual surgical procedures. The publication of wind surgeries on race cards offers a novel opportunity to study the occurrence and characteristics of dynamic respiratory obstruction in a large population. Future studies are needed to elucidate the precise causatives of dynamic upper respiratory disorders in order to improve surgical remedies and reduce potential wastage and economic loss.

7 Bibliography

ADREANI, C. AND PARENTE, E.J., (2007) ‘Surgical Treatment of Laryngeal Hemiplegia and Hemiparesis’,Mcgorum, B.C., Equine respiratory medicine and surgery. Edinburgh ; New York: Saunders Elsevier, pp497-508

ALLEN, K. AND FRANKLIN, S.H., (2015) ‘Dorsal Displacement of the Soft Palate’, Sprayberry, K.A. and Robinson, N.E. Robinson’s current therapy in equine medicine. (Seventh Edition) St. Louis, Missouri Elsevier/Saunders, pp 235-239

ANDERSON, B.H., (2007) ‘Recurrent Laryngeal Neuropathy: Clinical Aspects and Endoscopic Diagnosis’, Mcgorum, B.C. (2007). Equine respiratory medicine and surgery. Edinburgh ; New York: Saunders Elsevier, pp483-495

BARAKZAI, S.Z., BODEN, L.A. AND DIXON, P.M. (2009). Race Performance After Laryngoplasty and Ventriculocordectomy in National Hunt Racehorses. Veterinary Surgery, 38(8), pp.941–945.

BARRETT, E. AND ARKINS, S. (2019). Abnormalities detected at pre-purchase examination of National Hunt racehorses presented at sale. Equine Veterinary Journal, 52(2), pp.281–289.

BEARD, W.L. AND WAXMAN, S. (2007). Evidence-Based Equine Upper Respiratory Surgery. Veterinary Clinics of North America: Equine Practice, 23(2), pp.229–242.

BROWN, J.A., HINCHCLIFF, K.W., JACKSON, M.A., DREDGE, A.F., O’CALLAGHAN, P.A., McCAFFREY, J.P., SLOCOMBE, R.F. and CLARKE, A.F. (2010). Prevalence of pharyngeal and laryngeal abnormalities in Thoroughbreds racing in Australia, and their association with performance. Equine Veterinary Journal, 37(5), pp.397–401.

BROYLES, A.H., EMBERTSON, R.M., BRETT WOODIE, J. AND MACHADO, V. (2021). The impact of grade of laryngeal function immediately prior to laryngoplasty and ipsilateral ventriculocordectomy on postoperative performance: 623 Thoroughbred racehorses (1998-2013). Equine Veterinary Journal.

BOYKO, A., BROOKS, S., BEHAN-BRAMAN, A., CASTELHANO, M., COREY, E., OLIVEIRA, K., SWINBURNE, J., TODHUNTER, R., ZHANG, Z., AINSWORTH, D. AND ROBINSON, N. (2014). Genomic analysis establishes correlation between growth and laryngeal neuropathy in Thoroughbreds. BMC Genomics, 15(1).

CASSIERS, C AND MCNALLY T (2019). Description and racing performance of soft palate thermocautery (SPT) in 47 Thoroughbred racehorses performed under standing sedation. Equine Veterinary Journal, 51(S53), pp.14–14.

CEHAK, A., DEEGEN, E., DROMMER, W., LÜTKEFELS, E. AND OHNESORGE, B. (2006). Transendoscopic injection of poly-L-lactic acid into the soft palate in horses: A new therapy for dorsal displacement of the soft palate? Journal of Equine Veterinary Science, 26(2), pp.59–66.

CHALMERS, H.J., YEAGER, A.E. and DUCHARME, N. (2009).Ultrasonographic assessment of laryngohyoid position as a predictor of dorsal displacement of the soft palate in horses. Veterinary Radiology & Ultrasound, 50(1), pp.91–96.

CHEETHAM, J., (2019) ‘Overview of Upper Airway Function’ , Auer, J.A., Stick, J.A., Kümmerle, J.M. and Timo Prange, Equine surgery (Fifth Edition) . St. Louis, Missouri: Elsevier, pp 678-682

CHEETHAM, J., PIGOTT, J.H., THORSON, L.M., MOHAMMED, H.O. AND DUCHARME, N.G. (2008). Racing performance following the laryngeal tie-forward procedure: A case-controlled study. Equine Veterinary Journal, 40(5), pp.501–507.

CHEETHAM, J., RADCLIFFE, C.R., DUCHARME, N.G., SANDERS, I., MU, L. and HERMANSON, J.W. (2008). Neuroanatomy of the equine dorsal cricoarytenoid muscle: Surgical implications. Equine Veterinary Journal, 40(1), pp.70–75.

CHESEN, A.B. AND WHITFIELD-CARGILE, C. (2015). Update on Diseases and Treatment of the Pharynx. Veterinary Clinics of North America: Equine Practice, 31(1), pp.1–11.

COMPOSTELLA, F., TREMAINE, W.H. AND FRANKLIN, S.H. (2012). Retrospective study investigating causes of abnormal respiratory noise in horses following prosthetic laryngoplasty. Equine Veterinary Journal, 44, pp.27–30.

CURTISS, A.L., ACETO, H. AND EMBERTSON, R.M. (2019). Race performance following epiglottic entrapment surgery in Thoroughbred yearlings. Equine Veterinary Journal, 52(1), pp.52–58.

DAVIDSON, E.J. AND MARTIN, B.B. (2003). Diagnosis of upper respiratory tract diseases in the performance horse. Veterinary Clinics of North America: Equine Practice, 19(1), pp.51–62.

DAVIDSON, E.J., FRANKLIN, S.H., AND CHALMERS, H.J., (2019) ‘Diagnostic Techniques in Equine Upper Respiratory Tract Disease’, Auer, J.A., Stick, J.A., Kümmerle, J.M. and Timo Prange, Equine surgery (Fifth Edition) . St. Louis, Missouri: Elsevier, pp 683-698

DAVIDSON, E.J., HARRIS, M., MARTIN, B.B., NOLEN-WALSTON, R., BOSTON, R.C. AND REEF, V. (2011). Exercising Blood Gas Analysis, Dynamic Upper Respiratory Tract Obstruction, and Postexercising Bronchoalveolar Lavage Cytology—A Comparative Study in Poor Performing Horses. Journal of Equine Veterinary Science, 31(8), pp.475–480.

DUCHARME, N.G. AND ROSSIGNOL, F., (2019) ‘Larynx’, Auer, J.A., Stick, J.A., Kümmerle, J.M. and Timo Prange, Equine surgery (Fifth Edition). St. Louis, Missouri: Elsevier, pp 734-769

BOYKO, A., BROOKS, S., BEHAN-BRAMAN, A., CASTELHANO, M., COREY, E., OLIVEIRA, K., SWINBURNE, J., TODHUNTER, R., ZHANG, Z., AINSWORTH, D.

AND ROBINSON, N., (2014) Genomic analysis establishes correlation between growth and laryngeal neuropathy in Thoroughbreds. *BMC Genomics*, 15(1).

EPSTEIN KL AND PARENTE EJ. (2007). 'Epiglottic Fold Entrapment" Equine respiratory medicine and surgery. Edinburgh ; New York: Saunders Elsevier. Pages 459-465

FITZHARRIS, L.E., FRANKLIN, S.H. AND ALLEN, K.J. (2014). The prevalence of abnormal breathing patterns during exercise and associations with dynamic upper respiratory tract obstructions. Equine Veterinary Journal, 47(5), pp.553–556.

FRANKLIN, S.H., NAYLOR, J.R.J. and LANE, J.G. (2010). The effect of a tongue-tie in horses with dorsal displacement of the soft palate. Equine Veterinary Journal, 34(S34), pp.430–433.

GERBER, V. (2020). Genetics of Equine Respiratory Disease. Veterinary Clinics of North America: Equine Practice, 36(2), pp.243–253.

HAHN, C. AND MAYHEW, J., (2007). 'Idiopathic Recurrent Laryngeal Neuropathy: Etiopathogenesis', Mcgorum, B.C. (2007). Equine respiratory medicine and surgery. Edinburgh ; New York: Saunders Elsevier, pp 473-477

HOLCOMBE, S.J. AND DUCHARME, N.G., (2007). 'Disorders of the Nasopharynx and Soft Palate', Mcgorum, B.C. Equine respiratory medicine and surgery. Edinburgh ; New York: Saunders Elsevier, pp 437-457

JANICEK, J. C. AND K. M. KETZNER, (2008) Airflow mechanics, upper respiratory diagnostics and performance-limiting pharyngeal disorders. Compendium Equine, 3, 366–380.

JOÓ, K., POVÁZSAI, Á., NYERGES-BOHÁK, Z., SZENCI, O. AND KUTASI, O. (2021). Asthmatic Disease as an Underlying Cause of Dorsal Displacement of the Soft Palate in Horses. Journal of Equine Veterinary Science, 96, p.103308.

JOO, K., SZENCI, O., BOHAK, Z., POVAZSAI, A. AND KUTASI, O. (2015). Evaluation of Overground Endoscopy Findings in Sport and Pleasure Horses. Journal of Equine Veterinary Science, 35(9), pp.756–762.

KIKUTA, A., HOBO, S., TAKIZAWA, Y. and KAWASAKI, Y. (2006). Effect of Laryngeal Hemiplegia of Thoroughbred Racehorses on Racing Performance and the Usefulness of Laryngoplasty Performed on Horses with Laryngeal Hemiplegia. Journal of Equine Science, 17(2), pp.33–37.

LANE, J.G., BLADON, B., LITTLE, D.R.M., NAYLOR, J.R.J. and FRANKLIN, S.H. (2010). Dynamic obstructions of the equine upper respiratory tract. Part 1: Observations during high-speed treadmill endoscopy of 600 Thoroughbred racehorses. Equine Veterinary Journal, [online] 38(5), pp.393–399. Available at: https://onlinelibrary.wiley.com/doi/10.2746/042516406778400583 [Accessed 28 Dec. 2019].

MARR, C.M., FRANKLIN, S., GARROD, G., WYLIE, C., SMITH, L., DUKES-MCEWAN, J., BRIGHT, J. AND ALLEN, K. (2020). Exercise-associated rhythm disturbances in poorly performing Thoroughbreds: risk factors and association with racing performance. Equine Veterinary Journal.

MCCARREL, T.M. AND WOODIE, J.B. (2015). Update on Laryngeal Disorders and Treatment. Veterinary Clinics of North America: Equine Practice, 31(1), pp.13–26.

MCGIVNEY, C.L., SWEENEY, J., GOUGH, K.F., HILL, E.W. AND KATZ, L.M. (2018). Serial evaluation of resting and exercising overground endoscopic examination results in young Thoroughbreds with no treatment intervention. Equine Veterinary Journal, 51(2), pp.192–197.

OELLERS, S., BARTON, A.K. AND OHNESORGE, B. (2020). Progression of dynamic obstructions of the upper respiratory tract in 135 Thoroughbreds during exercise as cause of poor performance. Pferdeheilkunde Equine Medicine, 36(3), pp.227–237227–237.

ORTVED, K.F., CHEETHAM, J., MITCHELL, L.M. and DUCHARME, N.G. (2009). Successful treatment of persistent dorsal displacement of the soft palate and evaluation of laryngohyoid position in 15 racehorses. Equine Veterinary Journal, 42(1), pp.23–29.
PARENTE, E.J. (2018). Upper Airway Conditions Affecting the Equine Athlete. Veterinary Clinics of North America: Equine Practice, 34(2), pp.427–441.

PARENTE, E., MARTIN, B., TULLENERS, E. AND ROSS, M., (2002). Dorsal Displacement of the Soft Palate in 92 Horses During High-Speed Treadmill Examination (1993–1998). *Veterinary Surgery*, 31(6), pp.507-512.

RADCLIFFE, C.H., WOODIE, J.B., HACKETT, R.P., AINSWORTH, D.M., ERB, H.N., MITCHELL, L.M., SODERHOLM, L.V. and DUCHARME, N.G. (2006). A Comparison of Laryngoplasty and Modified Partial Arytenoidectomy as Treatments for Laryngeal Hemiplegia in Exercising Horses. Veterinary Surgery, 35(7), pp.643–652.

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 Veterinary Journal, 40(7), pp.629–635.

RAKESH, V., DUCHARME, N.G., DATTA, A.K., CHEETHAM, J. and PEASE, A.P. (2008). Development of equine upper airway fluid mechanics model for Thoroughbred racehorses. Equine Veterinary Journal, 40(3), pp.272–279.

REARDON, R.J.M., FRASER, B.S.L., HELLER, J., LISCHER, C., PARKIN, T. AND BLADON, B.M. (2008). The use of race winnings, ratings and a performance index to assess the effect of thermocautery of the soft palate for treatment of horses with suspected intermittent dorsal displacement. A case-control study in 110 racing Thoroughbreds. Equine Veterinary Journal, 40(5), pp.508–513.

ROSSIGNOL, F., BRANDENBERGER, O., PERKINS, J.D., MARIE, J.-P. ., MESPOULHÈS-RIVIÈRE, C. AND DUCHARME, N.G. (2018). Modified first or second cervical nerve transplantation technique for the treatment of recurrent laryngeal neuropathy in horses. Equine Veterinary Journal, 50(4), pp.457–464.

TAN, R.H.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. The Veterinary Journal, 170(2), pp.243–248.

VAN ERCK-WESTERGREN, E., FRANKLIN, S.H. AND BAYLY, W.M. (2013). Respiratory diseases and their effects on respiratory function and exercise capacity. Equine Veterinary Journal, 45(3), pp.376–387.

WOODIE, J.B., DUCHARME, N.G., KANTER, P., HACKETT, R.P. and ERB, H.N. (2010). Surgical advancement of the larynx (laryngeal tie-forward) as a treatment for dorsal displacement of the soft palate in horses: a prospective study 2001-2004. Equine Veterinary Journal, 37(5), pp.418–423.

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