

## Epistaxis related to exercise-induced pulmonary haemorrhage in South African Thoroughbreds

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### ABSTRACT

This study investigated if environmental factors had an effect on the incidence of epistaxis related to exercise-induced pulmonary haemorrhage (EIPH) among racehorses in southern Africa. Data covering the period 1986–2001 and involving 778 532 race runs were analysed. This included the following information: date of race, age, sex, name of breeder, trainer, distance, jockey, state of going, weight carried, racing centre and altitude. Veterinarians employed by the Jockey Club suspended officially entered horses that presented with epistaxis (frank bleeding from the nostrils) after racing. On-course endoscopy is not performed as a standard practice at any southern African racetrack. Epistaxis was identified in 1287 horses (0.165 %). More horses presented with EIPH-related epistaxis (a) at sea level, (b) from May to October, (c) when older (>3 years), (d) after 1995, (e) on Fridays and Sundays, and (f) more in geldings than in mares or entire males. No association could be established between epistaxis and breeder, trainer, distance run, jockey, state of going and weight carried. It is concluded that the frequency of EIPH-related epistaxis is associated with altitude, winter and spring, sex and age. It is suggested that racing at lower altitudes may increase the probability of exercise-induced pulmonary haemorrhage.

**Keywords:** bleeding, blood vessel breaking, EIPH, epistaxis, pulmonary haemorrhage, racehorse, Thoroughbred.

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### INTRODUCTION

Epistaxis is defined as bleeding from the nostril(s) and this condition has been known for at least 300 years. It was for a long time thought to be of a nasal origin and due to unusually weak vessel walls within the nose<sup>21</sup>. In 1974, the lung was identified as the primary site of haemorrhage<sup>6</sup>, and in 1981, after examining racehorses with a flexible fiberoptic endoscope, this was confirmed by Pascoe *et al.*<sup>16</sup> They coined the term 'exercise-induced pulmonary haemorrhage' (EIPH), linking the readily identifiable features, exercise and lung haemorrhage, to an apparently common clinical condition. This term more precisely describes the problem than earlier ones such as 'blood vessel breaking', 'bleeder' or 'epistaxis'. Pascoe *et al.*<sup>16</sup> also reported that although some horses manifested epistaxis after exercise,

far more had endoscopic evidence of pulmonary haemorrhage without epistaxis. Whereas epistaxis has a relatively low incidence of 0.8–13.5 %<sup>13,19</sup>, EIPH has an incidence of 26.5–74.5 %<sup>16</sup> in Thoroughbreds. Most horses afflicted with EIPH therefore do not bleed from the nostrils. Problems that still have to be addressed are, for example, why some horses are affected to a greater extent or bleed more severely than others, and the relationship between the amount of blood seen and the actual volume of haemorrhage<sup>12</sup>. Based on its severity, at least 5 levels of pulmonary haemorrhage are recognised<sup>9</sup>. This ranges from the simple rupturing of the capillary endothelium, allowing red blood cells to escape into the interstitial tissue (level 1), to level 3 where the amount of blood flowing into the alveoli is sufficient to ascend into the trachea and to be visualised. At level 4, blood is visible at the nostril (epistaxis), and at level 5 death occurs during or after a race from severe pulmonary failure. Following Takahashi *et al.*<sup>25</sup>, we refer to the level 4 condition as 'EIPH-related epistaxis' in this paper.

A number of hypotheses have been put

forward regarding the pathophysiology of EIPH-related epistaxis, for instance that upper airway obstruction or lower airway disease are necessary to induce abnormalities in ventilation and increases in alveolar pressure that would eventually lead to the tearing of lung tissue. West and Mathieu-Costello<sup>26</sup> suggested that bleeding from the lungs is caused by stress failure and rupture of the capillary bed of the pulmonary circulation, a finding substantiated by Birks *et al.*<sup>1</sup>, who showed that Thoroughbred horses develop extremely high pulmonary vascular pressures during racing. The last authors found that a pressure of between 75 and 100 mmHg was required to cause stress failure of the pulmonary capillaries in horses. Subsequently, Schroter *et al.*<sup>22</sup> suggested that the lung is subjected to high levels of locomotor-derived impulsive forces during high-speed exercise. They suggested that during locomotion, the force following ground-strike of the front legs is transmitted through the forelimbs to the scapulae, which in turn produces an impulsive force on the rib cage. As a result, pressure waves are transmitted through the lungs, causing a complex pattern of wave interactions within the lung that ultimately leads to haemorrhage.

According to the Jockey Club's *Racing Calendar of Southern Africa* (Vols 95–98), about 110 southern African horses are stricken annually with EIPH-related epistaxis. Worldwide, EIPH is of great concern because of financial losses resulting from decreased performance, suspension of horses from racing, lost training days, and the cost of pre-race medication. An appreciable number of horses have died as a result of EIPH during racing<sup>7,8</sup>. There appears to be a consistent pattern of incidence of EIPH throughout the world despite diverse environmental factors such as climate, training and management practices, racing surfaces and types of competition. During the early 1980s, *post mortem* examinations and epidemiological studies failed to demonstrate clear relationships between a variety of environmental factors and EIPH<sup>5</sup>, but subsequently these findings were shown to be

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invalid, as discussed below.

The present study was undertaken to determine if environmental factors have had any effect on EIPH-related epistaxis in southern Africa.

## MATERIALS AND METHODS

Racing in South Africa and Zimbabwe falls under the control of the Jockey Club of Southern Africa, therefore veterinarians employed by the Jockey Club examine all horses before and after racing. Any horse with epistaxis is reported as a 'bleeder' and suspended from racing. Horses with an initial bout of epistaxis are automatically suspended from racing for a period of 3 months. A repeat bleeder receives a 6-month suspension and any further incident of bleeding results in permanent suspension. Owing to time and cost constraints, on-course endoscopy is not a standard practice on any South African racetrack. The use of furosemide is not allowed in South African Thoroughbred racing. Jockey Club-reported cases are recorded for all the racing centres in South Africa and Zimbabwe. For each case, the Jockey Club of Southern Africa's database includes the following data: identification number of horse, its name, age, sex, breeding status, stud where born and raised, trainer, distance raced, date and race when epistaxis occurred, racing centre, date of last run before epistaxis was reported, state of going, jockey, weight carried, altitude, and date of return to racing. Racing in southern Africa is conducted at sea level (Durban, Cape Town and Port Elizabeth), ~1000 m a.s.l. (Pietermaritzburg) and ≥2000 m (Johannesburg, Bloemfontein, Kimberley and Zimbabwe).

The data covering the period 1986–2001 and involving 51 465 individual horses that ran a total of 778 532 race runs, were analysed. Classification trees methodology was used to determine the influence of various predictor variables on epistaxis as demonstrated in Thoroughbreds<sup>2</sup>. This splits the data into various subgroups based on predictors. If the predictors have an influence on the occurrence of epistaxis, then certain subgroups will have proportionately more epistaxis than other subgroups. The subgroups were determined by rules based on the predictors.  $\chi^2$  tests (Statistica 6) for contingency tables were used to determine the significance of differences between subgroups.

The association of EIPH-related epistaxis with a number of variables was tested statistically using classification trees (Cart version 5). Owing to the very low incidence of epistaxis (0.17%, or 1287 occurrences from 778 532 race starts), samples with more manageable propor-

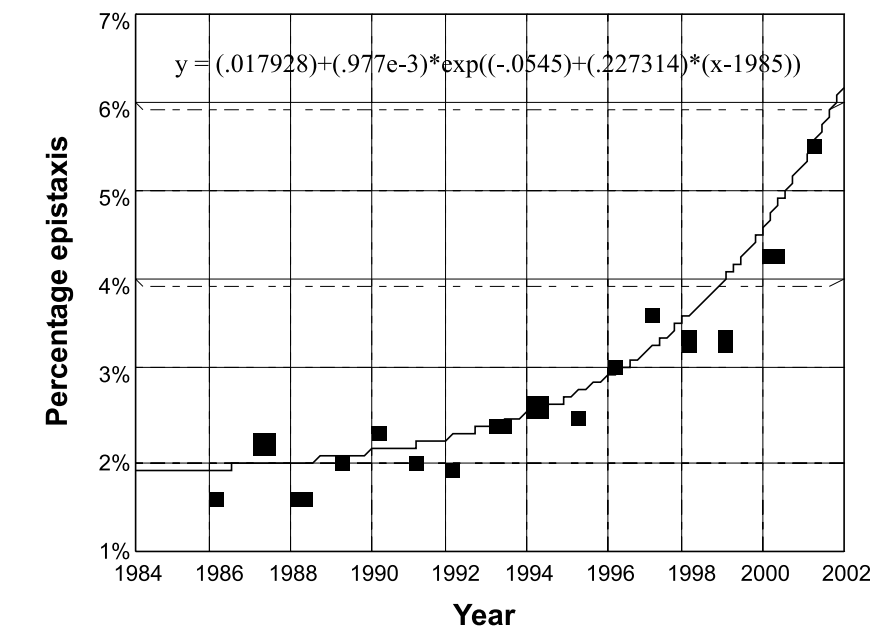


Fig. 1: Percentage EIPH-related epistaxis in a randomly selected sample according to year.

tions of epistaxis were drawn from the original data. These samples were:

- All the horses with epistaxis were included (1118 horses). This excluded data for starts following the 1st episode of epistaxis.
- From the remaining horses, 1118 were selected randomly, and referred to as the 50 % sample. This sample was duplicated using a further 1118 randomly selected horses. In the same manner, a sample containing the 1118 bleeders and 4472 randomly selected horses (20 % sample) was acquired and duplicated. Finally a single 9.1 % sample was drawn using all the bleeders and 12 298 randomly selected horses. The 5 samples had identical or very similar values, and only the 50 % sample is therefore used to illustrate the results of the study.
- All the race starts for each selected horse were included. For the 50 % sample, this for example gave a total of 43 863 races with a proportion of 0.026 episodes of epistaxis.

- In thirty-eight cases, epistaxis was observed after training; these were excluded from analyses in some instances when relevant data were not available.

## RESULTS

Positive relationships were established between EIPH-related epistaxis and race year, altitude, age, sex, the day of racing and month. An exponential increase in the incidence of EIPH-related epistaxis was evident for the period 1986–2001 (Fig. 1).

A significantly higher incidence of EIPH-related epistaxis occurred in southern Africa after 1995 ( $P < 0.001$ ) (Fig. 2.) The histogram in Fig. 3 shows that a significantly larger percentage of EIPH-related epistaxis occurred in horses racing at sea level compared with horses racing at a higher altitude ( $P < 0.001$ ).

The randomly selected sample established an association between EIPH-related epistaxis and age (Fig. 4).

Only 1.1 % of 2-year-olds were stricken

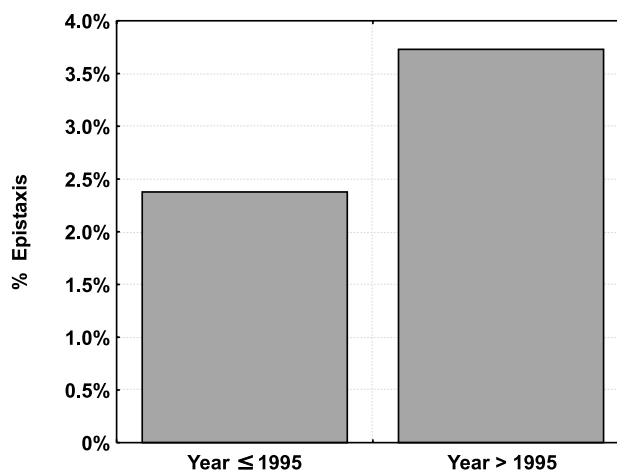


Fig. 2: Percentage EIPH-related epistaxis before and including 1995 and after 1995.

with EIPH-related epistaxis during their 1st year of racing. The 3-year-olds showed a significant increase in the incidence of EIPH-related epistaxis to 2.7 % ( $P < 0.001$ ). The ages 4 years and older showed a further significant increase compared to both the 2-year-old ( $P < 0.001$ ) and the 3-year-old groups ( $P = 0.0186$ ).

The incidence of EIPH-related epistaxis was also found to be significantly greater in geldings than in females and entire males ( $P < 0.001$ ). As illustrated in Fig. 5, geldings showed 2.5 % epistaxis compared to 3.3 % in males and females combined.

Racehorses in southern Africa experience EIPH-related epistaxis significantly more often on Sundays and Fridays than on any other day (Fig. 6).

A significantly higher ( $P < 0.001$ ) incidence of epistaxis was observed in winter and spring (months 5–10; May–October) than in summer and autumn (months 11–12, 1–4; November–April) (Fig. 7).

No association was found between state of going, trainer and location of racetrack, and this is in agreement with an earlier study<sup>15</sup>. The present study could also not establish a relationship between distance raced and EIPH. This is also in agreement with other studies<sup>15,23</sup>. However, in a number of other studies, a positive association was found between EIPH-related epistaxis and distance raced or breezed<sup>19,20</sup>.

## DISCUSSION

In the present study, EIPH-related epistaxis was observed in 0.16 % of all race starts, which is appreciably lower than 0.84 % reported in an earlier study<sup>13</sup> but close to 0.15 % recorded in a comparable study in Japan<sup>25</sup>. In the Japanese study the authors suggested that the low incidence could have been the result of the lower mean age of horses racing there than in other countries. Sixty-four percent of horses in Japan were  $\leq 3$  years old, which is equal to or higher than the percentage in other countries. In the present study, which confirmed that the frequency of epistaxis increased with age, it was found that approximately 40.4 % of horses in racing were 2–3 years of age while 40.3 % were 4 or 5 years old.

A total of 1118 (2.1 %) racehorses suffered from EIPH-related epistaxis during or after racing, with 150 (13.4 %) showing a repeated bout of epistaxis and a further 12 horses (1.0 %) experiencing a 3rd bout and permanent suspension from racing.

### Altitude

Only 1 reference to the relationship between altitude and pulmonary haemorrhage could be found in the literature.

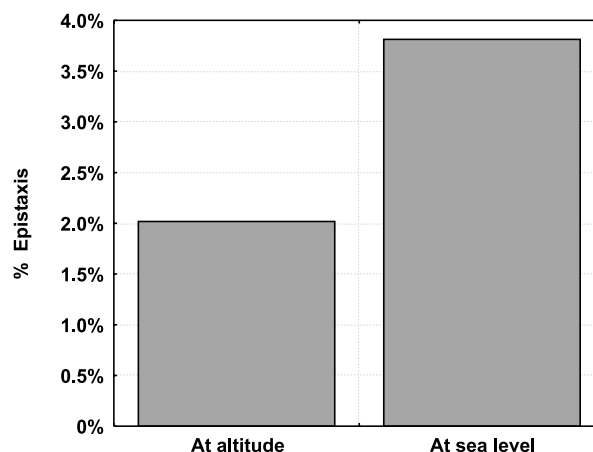


Fig. 3: Percentage EIPH-related epistaxis at different altitudes.

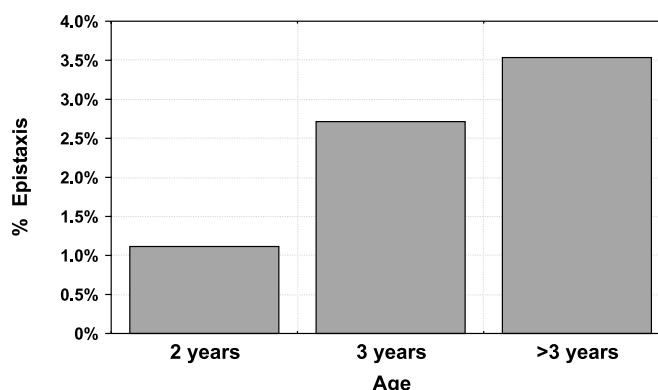


Fig. 4: Percentage EIPH-related epistaxis per age group.

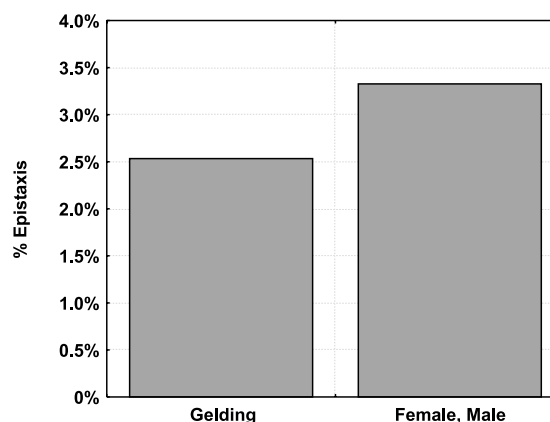


Fig. 5: Percentage EIPH-related epistaxis according to sex.

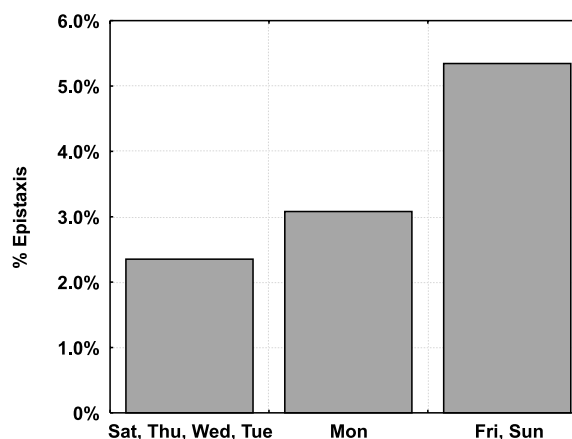


Fig. 6: Percentage EIPH-related epistaxis on Sundays and Fridays compared to other days.

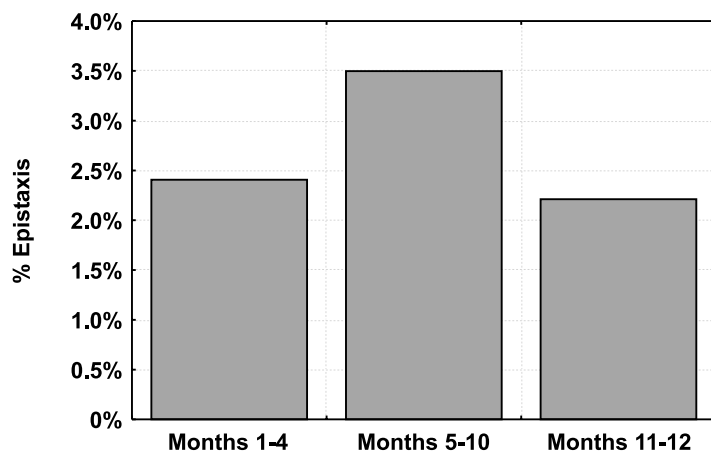


Fig. 7: Percentage EIPH-related epistaxis according to grouped months.

Raphel and Soma<sup>19</sup> cited a paper by Pfaff<sup>18</sup>, who found that epistaxis was more likely to occur at sea level than at an altitude of approximately 2000 m. It was based on racing records that were, however, not analysed statistically<sup>19</sup>. This is in agreement with our observations. The paucity of research on the relationship between altitude and EIPH-related epistaxis may be ascribed to the fact that most European and Eastern countries race at sea level or only slightly above.

There have been reports that geographical and environmental factors influence the frequency of EIPH-related epistaxis<sup>25</sup>. In the present study, significantly more racehorses manifested epistaxis at sea level than horses racing at high altitude. In the United States, where much racing takes place at higher altitudes, a popular belief exists that epistaxis occurs with greater frequency in the mid-Atlantic states (mostly at sea level)<sup>19</sup>. However, the use of furosemide, a supposed suppressor of pulmonary haemorrhage, is allowed in a number of states and its use may hamper research on epistaxis in the USA.

An increase in both the resting packed cell volume and red cell numbers occurs at higher altitudes, accompanied by an increase in total blood volume, apparently due to the expansion of the red cell volume<sup>27</sup>. Further research on the pulmonary mechanism in horses with EIPH at different altitudes, is clearly indicated.

### Age

A positive association between age and EIPH was reported during the 1970s and 1980s<sup>3,4,6,13,15,19,24</sup>, the severity increasing with age<sup>3,20</sup>. A link between age and epistaxis was suggested by Pfaff<sup>17</sup>, and a subsequent study by the same author showed that the tendency to bleed increases up to the age of 5 years, but he noted that that 4- and 5-year-olds probably do more racing than horses of other ages<sup>18</sup>. The low incidence of epistaxis

among 2-year-olds can be attributed to the fact that they are introduced to racing only towards the end of the 2nd year. The higher incidence of haemorrhage in older horses could also indicate that there are cumulative effects of pulmonary damage<sup>24</sup>. By contrast, no association between age and EIPH were found in 2 other studies<sup>16,23</sup>.

### Day of racing

Saturdays and Wednesdays were the traditional racing days in southern Africa. In 1986, 14 % of all meetings took place on Wednesdays. Saturdays have always occupied the 'elite' position on the racing calendar and 2 to 3, even 4, meetings were held on this day whereas no racing took place on Sundays. At present, however, racing takes place every day of the week. Since the mid-1990s, most racing on Fridays and Sundays took place at Port Elizabeth (at sea level), with an additional meeting every Sunday either in Cape Town, Durban or Johannesburg.

Compared with horses racing at the major southern African centres, the average performance of horses participating at Port Elizabeth is slightly below average. The benchmark handicap merit rating system used by the Jockey Club rates the average Port Elizabeth horse 4 pounds (2 kg) lower than the average horse in the major centres. Horses unable to earn their keep in the main centres find their way to Port Elizabeth, and horses that 'bleed' at work in other centres might also be quietly sent there<sup>18</sup>. The notion that horses 'bleed' more on Fridays and Sundays because most racing on these days takes place at Port Elizabeth, is challenged by the fact that the same class of horse participates at Bloemfontein (same merit rating as Port Elizabeth) and Kimberley (1 kg lower than Port Elizabeth), race tracks with comparable racing frequencies but a smaller incidence of epistaxis. If this is so, then altitude (racing at sea level)

as an environmental factor, indeed has an effect as demonstrated above. This warrants further investigation.

### Sex

The incidence of epistaxis in male and female racehorses over a 2½-year period at a New York racetrack was approximately equal<sup>11</sup>. In another study the incidence of epistaxis was found to be significantly greater in geldings than in females and entire males<sup>18</sup>, a finding also of the present study. However, no relationship between sex and EIPH could be established in a number of other studies<sup>6,14,16,19,23</sup>. A significantly lower EIPH prevalence in entire male racehorses, compared with mares and geldings, has also been reported<sup>10</sup>. Research in Japan failed to reveal any relationship between sex and epistaxis; however, this factor was significant in a multiple logistic regression analysis, when adjusted for the other factors<sup>25</sup>.

### Month/season of racing

Investigations at New York racetracks have shown that most horses bleed during autumn and spring<sup>11,13</sup>, while the worst months for bleeding were the colder months (April to July; winter)<sup>18</sup>, a finding in agreement with our study in which most horses were found to bleed during the cooler to cold months (May–October). A highly significant negative relationship between air temperature and EIPH has been reported in the literature, *i.e.* more horses were EIPH positive as temperature decreased<sup>14</sup> [temperatures were designated as warm (>10 °C), tempered (0 °C to ≤ 10 °C) or cold (<0 °C)]. Since there is no physiological reason for this, one can only speculate as to the nature of the relationship between air temperature and EIPH. A possible explanation could be that a factor such as cold air would render the capillary walls more fragile, thereby increasing their tendency to rupture during exercise.

### Year of racing

We were unable to explain the significant increase in epistaxis since 1995.

### Furosemide

The use of furosemide is allowed in a number of states in the USA, purportedly to decrease the incidence of EIPH. This medication could mask the symptoms of EIPH and result in bleeders not being identified. The indiscriminate use of such horses for stud purposes when its epistaxis status is not known, could have a possible negative influence on the breed as a whole. This will be investigated in a further study.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. Birks E K, Mathieu-Costello O, Fu Z X, Tyler W S, West J B 1997 Very high pressures are required to cause stress failure of pulmonary capillaries in Thoroughbred racehorses. *Journal of Applied Physiology* 82: 1584–1592
2. Breiman L, Friedman J H, Olshen R A, Stone C J 1993 *Classification and Regression Trees*. Chapman & Hall, London
3. Bourke J M 1973 Cited in Cook W R 1974 Epistaxis in the racehorse. *Equine Veterinary Journal* 6: 45–582
4. Bourke J M 1978 *Proceedings of Victorian Division, Australian Veterinary Association*: 23–24
5. Clarke A F 1985 Review of exercise-induced pulmonary haemorrhage and its possible relationship with mechanical stress. *Equine Veterinary Journal* 17: 166–172
6. Cook W R 1974 Epistaxis in the racehorse. *Equine Veterinary Journal* 6: 45–58
7. Gelberg H B, Zachary J F, Everitt J I, Jensen R C, Smetzer D L 1985 Sudden death in training and racing Thoroughbred horses. *Journal of the American Veterinary Medical Association* 187: 1354–1356
8. Gunson D E, Sweeney C R, Soma L R 1988 Sudden death attributable to exercise-induced pulmonary hemorrhage in racehorses: nine cases (1981–1983) *Journal of the American Veterinary Medical Association* 193(1): 102–106
9. Harkins J D, Mundy G D, Stanley S D, Harrison L, Poonacha K B, Williams N A, Tobin T 1997 Exercise-induced pulmonary hemorrhage: a review of the etiology and pathogenesis. *Equine Practice* 19(1): 22–28
10. Hillidge C J, Whitlock T W 1986 Sex variation in the prevalence of exercise-induced pulmonary haemorrhage in racing Quarter horses. *Research in Veterinary Science* 40(3): 406–407
11. Johnson J H, Garner H E, Hutchesson D P, Merriam J G 1973. Epistaxis. *Proceedings of the Annual Convention of the American Association of Equine Practitioners* 19: 115–121
12. Jones W E 1998 EIPH. *Quarter Racing Journal* October: 1–2
13. Kim B S, Hwang Y K, Kwon C J, Lim Y J 1998 Survey on incidence of exercise induced pulmonary haemorrhage (EIPH) of Thoroughbred racehorses at Seoul Racecourses. *Korean Journal of Veterinary Clinical Medicine* 15: 417–426
14. Lapointe J M, Vrans A, McCarvill E 1994 A survey of exercise-induced pulmonary haemorrhage in Quebec Standardbred racehorses. *Equine Veterinary Journal* 26(6): 482–485
15. Mason D K, Collins E A, Watkins K L 1983 Exercise-induced pulmonary hemorrhage in horses. In Snow D H, Persson S G B, Rose R J (Eds) *Equine exercise physiology*. Granta Editions, Cambridge: 57–63
16. Pascoe J R, Ferraro G L, Cannon J H, Arthur R M, Wheat J D 1981 Exercise-induced pulmonary haemorrhage in racing thoroughbreds: a preliminary study. *American Journal of Veterinary Research* 42(5): 703–707
17. Pfaff G 1950 Epistaxis in racehorses. *Journal of the South African Veterinary Association* 21: 74–78
18. Pfaff G 1976 The incidence of epistaxis in racehorses in South Africa. *Journal of the South African Veterinary Association* 47: 215–218
19. Raphael C E, Soma L R 1982 Exercise-induced pulmonary hemorrhage in thoroughbreds after racing and breezing. *American Journal of Veterinary Research* 43: 1123–1127
20. Roberts C, Hillidge C, Marlin D 1993 Exercise-induced pulmonary haemorrhage in racing thoroughbreds in Great Britain. *Proceedings, International EIPH Conference* Guelph, 1–2 September 1993: 11
21. Robertson J B 1913 Biological searchlight on racehorse breeding: VI – the heredity of blood vessel breaking in the Thoroughbred. *The Bloodstock Breeders Review* 2: 265–281
22. Schroter R C, Marlin D J, Denny E 1998 Exercise-induced pulmonary haemorrhage (EIPH) in horses results from locomotory impact induced trauma – a novel, unifying concept. *Equine Veterinary Journal* 30: 186–192
23. Speirs V C, van Veenendaal J C, Harrison I W, Smyth G B, Anderson G A, Wilson D V, Gilbo B 1982 Pulmonary haemorrhage in standardbred horses after racing. *Australian Veterinary Journal* 59: 38–40
24. Sweeney C R, Soma L R 1983 Exercise-induced pulmonary hemorrhage in horses after different competitive exercises. In Snow D H, Persson S G B, Rose R J (Eds) *Equine exercise physiology*. Granta Editions, Cambridge: 51–56
25. Takahashi T, Hiraga A, Ohmura H, Kai M, James H 2001 Frequency of and risk factors for epistaxis associated with exercise-induced pulmonary hemorrhage in horses: 251 609 race starts (1992–1997). *Journal of the American Veterinary Medical Association* 218, 1462–1464
26. West J B, Mathieu-Costello O 1994 Stress failure of pulmonary capillaries as a mechanism for exercise induced pulmonary haemorrhage in the horse. *Equine Veterinary Journal* 26: 441–447
27. Wickler S J, Anderson T P 2000 Hematological changes and athletic performance in horses in response to high altitude (3800 m) *American Journal of Physiology Regulatory Integrative Comparative Physiology* 279: R1176–R1181