

- Straub, R. and Gerber, H. (1975). Effects of prolonged use of corticoids. Proc. 1st Int. Symp. Equine Hematol. Kitchen, H. and Krehbrel, J. D. (eds.). pp. 536–553.
- Zinkl, J. A. and Carlson, G. P. (1983). Evaluation of the hematopoietic system. In: *Current Therapy in Equine Medicine*. Robinson, N. E. (ed.). W. B. Saunders Co. Ltd, London. pp. 293–297.

The Significance of Haematological Data in the Evaluation of Soundness and Fitness in the Horse

S. G. B. PERSSON

Department of Medicine I, College of Veterinary Medicine, Swedish University of Agricultural Sciences, S-750 07 Uppsala, Sweden.

The fact that the total red-cell volume (CV) is a limiting factor for aerobic capacity and performance potential generates a perpetual interest in haematological values in the performance horse. This interest rests on the assumption that these data truly reflect the total red-cell content of the body. This is not valid, however, in the horse, as the function of the equine spleen causes a great variability of the haematological parameters at rest (Persson 1969). In the horse and in several other animal species, the spleen acts as a reservoir of erythrocytes by harbouring a large amount of highly concentrated blood at rest, and this blood store can be mobilized into active circulation when an increased demand for oxygen transport capacity arises. This is brought about by an adrenergically induced contraction of the abundant smooth muscle of the splenic capsule and trabeculae, following e.g. asphyxia, haemorrhage, excitation and exercise (Barcroft 1925; Scheunert and Krzywanek, 1926; Scheunert and Müller, 1926; Persson 1962, 1967). Consequently, exercise as well as excitation causes an increase of the circulating red-cell volume at an essentially unchanged plasma volume, resulting in rising values of the venous haematocrit (VH), haemoglobin concentration (Hb) and red blood cell count (RBC).

Because of the uneven distribution of the erythrocytes in the circulatory system due to the splenic storing, haematological values in the venous blood poorly reflect the size of the total red-cell volume at rest. Furthermore, varying degree of excitation at sampling induces unpredictable changes of these parameters, thus impairing their reproducibility (Persson 1969). This variability is related to the storage capacity of the spleen which, in turn, is dependent on the size of the red cell volume (Persson *et al.*, 1973). A way of eliminating this curtailment of the diagnostic value of haematological data in the horse would obviously be to do the blood sampling after mobilization of the splenic reservoir. This is readily achieved by exercise or intravenous adrenaline injection. The work or adrenaline dose must then be large enough to ensure maximal contraction of the spleen. In this way both reproducibility and diagnostic value of the erythrocyte parameters are greatly improved (Persson 1967, 1969).

Physical training induces adaptations to increased metabolic demands in several respects. One limiting factor for fitness and endurance is the oxygen transport capacity of the blood. This is improved by an increase in the total mass of red cells, and a relationship between state of training and CV is well established both in man (Holmgren *et al.*, 1960) and in the horse (Persson 1962, 1967, 1968). It is also conclusively documented that a

FIGURE 1. Relationship between deviation from predicted normal value for total red-cell volume (ΔCV , litres) expressed as number of standard deviations (SD) and that of post-exercise venous haematocrit (ΔVH , l/l) in 100 trotters with significantly abnormal CV values ($> \pm 2$ SD of the respective predicted normal values). Broken lines denote ± 2 SD with respect to VH.

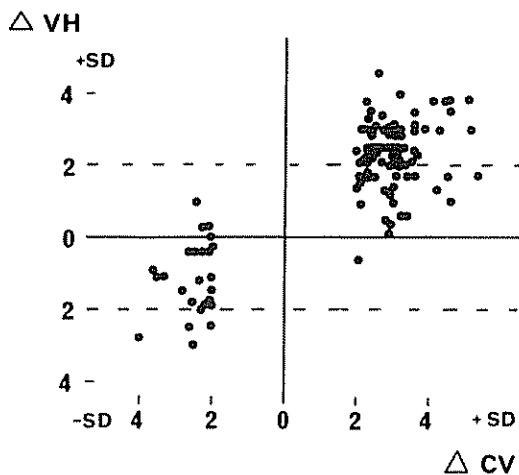
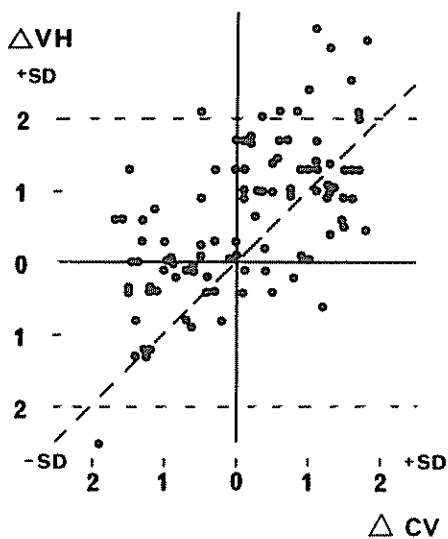


FIGURE 2. Relationship between deviation from predicted normal value for total red-cell volume (ΔCV , litres) expressed as number of standard deviations (SD) and that of post-exercise venous haematocrit (ΔVH) in 100 trotters with CV values within normal limits ($< \pm 2$ SD of the respective predicted normal values). Diagonal dashed line indicates line of identity.



relationship prevails between expressions for the red-cell mass and working capacity and racing performance in horses (Persson 1967, 1968; Persson and Ullberg, 1974). Furthermore, excessive endurance training is known to cause red-cell hypervolaemia and a concomitant impairment of racing performance in some horses (Persson 1967, 1968, 1983; Persson *et al.*, 1980). Thus, poor racing form or exercise intolerance can be associated with both a too small and a too large red-cell volume relative to age, sex and body size.

As post-exercise and post-adrenaline values for VH, Hb and RBC seem to be closely related to CV, they should be indicative of the aerobic potential and make diagnoses of anaemia and red-cell hypervolaemia possible with a satisfactory degree of precision. This is true only to a limited extent, however, as such an assumption disregards the inter-individual variation of the plasma volume. This amounts to approximately $\pm 10\%$ in the resting horse and increases after exercise or adrenaline injection. Thus, only two-thirds of the horses with red-cell hypervolaemia ($CV > + 2$ SD of the respective reference value) also have abnormally high post-exercise VH values, and only one-fifth of the horses with significant red-cell hypovolaemia (anaemia; $CV < - 2$ SD of the respective reference value) also show abnormally low post-exercise VH values (Fig. 1). The incidence of spuriously abnormal post-exercise VH values is low ($\sim 10\%$, Fig. 2), even if exercise tends to overestimate the red-cell mass due to the exercise-induced plasma volume contraction (*cf.* Persson 1967). Consequently, the risk of a false diagnosis of red-cell hypervolaemia is greater than one of anaemia. Furthermore, it might be concluded, that abnormal post-exercise values for VH, Hb and RBC should be regarded as indicative of an abnormal CV, whereas those values being within normal limits (for reference values of CV and VH in Standardbreds see Table 1) does not necessarily mean a normal state in this respect. As a practical means of producing splenic emptying, exercise is preferable to adrenaline injection, as the side effects of adrenaline, although essentially harmless to the horse in the dose used (0.4 mg per 100 kg of body weight in a freshly prepared solution of 0.01% in physiological saline), may be experienced as rather dramatic by the owner.

TABLE 1. Normal values for post-exercise venous haematocrit (VH, l/l) and red-cell volume divided by body weight (CV/Bwt, ml·kg⁻¹) in Standardbreds. *r* = correlation coefficient for the relationship between VH and CV/Bwt, *n* = number of horses. F = filly, C = colt, G = gelding.

	<i>n</i>	VH	CV/Bwt	<i>r</i>
1 year	28	0.37–0.49	33–50	0.85
2 years, untrained	37	0.40–0.52	36–50	0.65
trained	55	0.46–0.57	42–66	0.77
3 years	84	0.48–0.61	48–79	0.75
≥ 4 years, F, G	65	0.50–0.61	53–83	0.70
4 years, C	35	0.53–0.64	60–90	0.70
≥ 5 years, C	46	0.55–0.65	66–95	0.70

References

- Barcroft, J. (1925). Recent knowledge of the spleen. *Lancet* **1**, 319–322.
- Holmgren, A., Mossfeldt, F., Sjöstrand, T. and Ström, G. (1960). Effect of training on work capacity, total haemoglobin, blood volume, heart volume, and pulse rate in recumbent and upright positions. *Acta Physiol. Scand.* **50**, 72–83.
- Persson, S. G. B. (1962). Studier över blodvolym och totalhämoglobin vid olika träningsstillstånd hos häst (Total blood volume and total haemoglobin in relation to physical fitness in the horse.) Proc. 9th Nord. Vet. Congr., Copenhagen.
- Persson, S. G. B. (1967). On blood volume and working capacity in horses. *Acta Vet. Scand. Suppl.* **19**, 1–189.
- Persson, S. G. B. (1968). Blood volume, state of training, and working capacity of race horses. *Equine Vet. J.* **1**, 52–62.
- Persson, S. G. B. (1969). Value of haemoglobin determination in the horse. *Nord. Vet. Med.* **21**, 513–523.
- Persson, S. G. B. (1983). Evaluation of exercise tolerance and fitness in the performance horse. In *Equine Exercise Physiology*. Snow, D. H., Persson, S. G. B. and Rose, R. J. (eds.) Granta Editions, Cambridge. pp. 441–457.
- Persson, S. G. B., Ekman, L., Lydin, G. and Tufvesson, G. (1973). Circulatory effects of splenectomy in the horse. I. Effect on red-cell distribution and variability of haematocrit in the peripheral blood. *Zbl. Vet. Med. A.* **20**, 441–455.
- Persson, S. G. B. and Ullberg, L.-E. (1974). Blood volume in relation to exercise tolerance in trotters. *J. S. Afr. Vet. Ass.* **45**, 293–299.
- Persson, S. G. B., Essén, B. and Lindholm, A. (1980). Oxygen uptake, red-cell volume, and pulse/work relationship in different states of training in trotters. Proc. Meeting Acad. Soc. Large Animal Med., Glasgow. pp. 34–43.
- Scheunert, A. and Krzywanek, F. W. (1926). Über reflektorisch geregelte Schwankungen der Blutkörperchenmenge. *Pflügers Arch. Ges. Physiol.* **212**, 477–485.
- Scheunert, A. and Müller, C. (1926). Einfluss von Bewegung und sportlicher Höchstleistung auf die Blutbeschaffenheit des Pferdes. *Pflügers Arch. Ges. Physiol.* **212**, 468–476.

Effects of Training and Time of Day of Blood Sampling on the Variation of Some Common Haematological Parameters in Normal Thoroughbred Racehorses

B. V. ALLEN and D. G. POWELL

Equine Research Station of the Animal Health Trust,
Balaton Lodge, Snailwell Road, Newmarket, Suffolk CB8 7DW.

Summary

The effect of 20 weeks of training on various haematological parameters was determined in 32 healthy, previously untrained, two-year-old Thoroughbreds. Haemoglobin, erythrocyte count, packed cell volume and total bilirubin increased significantly after training, but serum folate, erythrocyte folate and serum vitamin B₁₂ values were significantly lower. Total and differential leucocyte counts, platelets, plasma viscosity and fibrinogen remained constant. The fall in serum folate levels during training was confirmed in eight other healthy Thoroughbreds bled at regular intervals during a two-year training period.

Blood samples for routine haematological parameters were collected from 15 Thoroughbreds in training, aged 2–4 years, at 08.30 h and 16.00 h on a day of no exercise and again seven days later when strenuous exercise was undertaken at 09.00 h. On the day of no exercise, results obtained at 08.30 h agreed well with those recorded at 16.00 h except for the absolute lymphocyte count which was significantly higher in the afternoon. The results on the day of exercise showed that total leucocyte counts and absolute neutrophil counts were significantly higher at 16.00 h than at 08.30 h, suggesting that a time lapse of about seven hours is insufficient for these parameters to return to resting values.

Introduction

There are relatively few reports establishing the haematological response to training in the Thoroughbred racehorse (Jeffcott 1977). Most investigations have concentrated on comparing erythrocyte and occasionally leucocyte parameters before and after various training programmes. The evidence tends to suggest that erythrocyte counts increase following intensive training, particularly in those racehorses with low values when training commenced (Kitchen *et al.*, 1965; Clarkson 1968; Stewart *et al.*, 1970; Allen 1978; Catling 1978). Rose and Hodgson (1982), however, found erythrocyte counts to be fairly stable in horses subjected to endurance training and concluded that the type and intensity