

Comparative Hematological Study of Two Breeds of Foals (Andalusian and Arab) Subjected to Exercise of Progressive Intensity

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ABSTRACT. Exercise-induced hematological alterations were studied in 20 four-year old foals, 11 Andalusian and 9 Arabian. They were subjected to a test exercise program consisting of 4 levels of gradually increasing intensity (15, 20, 25 and 30 km/hr) with a duration of 5 min each. Blood samples were taken during resting, after each exercise level and at 10 and 30 min of recovery from exercise. The following hematic parameters were analyzed: red blood count, hematocrit value, hemoglobin, volumetric indexes (MCV, MCH and MHCH) and total plasma proteins. The alterations as a result of the physical effort were studied as well as any possible differences between the two breeds. The Arabian foals showed higher total plasma protein concentrations when resting, after each exercise level and at 10 mins of recovery time. The other variables studied remained with similar values in the two breeds without any significant changes.—**KEY WORDS:** exercise, foal, hematology.

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Hematological research in horses, while resting and during exercise has been used in an attempt to improve training programs and obtain a better performance and optimum fitness from the animal.

The problems posed by these analyses are based on several factors, both endogenous and exogenous, which may modify hematic constituents. Amongst the exogenous factors, training should be mentioned because of the relevant part that it plays. Thus, on comparing the resting and exercising hemograms the most significant differences are obtained in non-trained horses [1, 12]. Moreover, Carlson [4] described different hematic responses according to the type of training received by the animal (endurance or speed). Among the endogenous factors, age, sex and breed can be cited as being the most important ones.

Various research works have been carried out on the hematological responses to exercise in different breeds, mostly in Arabian and Thoroughbred horses but there are few investigations on the Andalusian horse.

The main aims of this paper are to clarify hematic changes in Arabian and Andalusian foals during and after increasing exercise intensity and to establish possible differences between both breeds in association with their physical performance.

MATERIALS AND METHODS

The hematological response of two breeds of horses subjected to an exercise program was evaluated. This program consisting of 4 levels of progressive intensity exercise (15, 20, 25 and 30 km/hr), each level lasting 5 min, extracting the samples within the first minute after each exercise. This was followed by 2 control periods during the rest interval at 10 and 30 min.

We used four-year-old male foals of the Andalusian (n=11) and Arabian (n=9) breed belonging to the

Military Stud Training Center, Jerez de la Frontera, (Spain). The exercise program was carried out on an oval-shaped track that was specially built on a flat surface at the training center. It was 1,000 m long and 6 m wide.

RBC (Red Blood Cell), PCV (Packed Cell Volume), HB (Hemoglobin), TPP (Total Plasma Protein) and the volumetric indexes (MCV, MCH and MCHC) were analyzed after each level of exercise and at 10 and 30 min of recovery. The RBC was made with an Ibercell (HF-24) particle count. The PCV was carried out following the microhematocrit technique, HB was measured by spectrophotometry and the TPP was determined by an inversion refractometer.

Data were processed by one-way analysis of variance. Differences between breeds were identified by a *t*-test, and were considered significant at $p \leq 0.05$.

RESULTS

The Arabian foals showed lower RBC values than the Andalusian at all the exercise levels (Fig. 1). However, these variations were only significant after 30 min of recovery from exercise.

The maximum RBC value corresponded to a speed of 30 km/hr in both breeds, although a rise above the resting levels was more apparent in the Arabian foals. Thirty minutes after carrying out the exercise test, both the Arabian and the Andalusian foals showed red corpuscle concentrations similar to the starting values.

The hemoglobin concentrations at rest and at 10 min or recovery time were similar in both breeds (Fig. 1). However, during the first three speeds (15, 20 and 25 km/hr), the hemoglobin concentration was higher in the Andalusian foals, contrary to what occurred at the maximum speed (30 km/hr) level of exercise where the Arab foals showed higher values. After the 30 min recovery period, the hemoglobin reached very similar

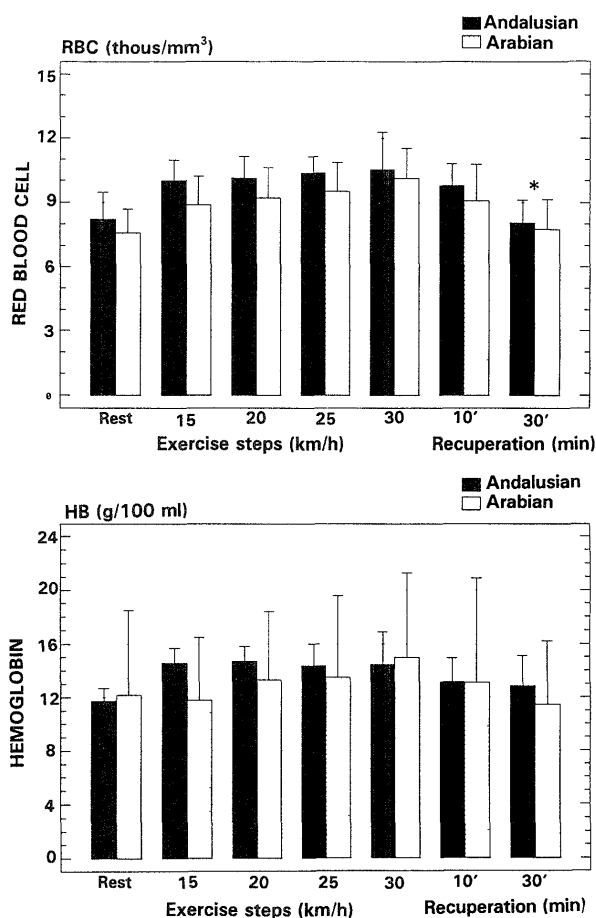


Fig. 1. Mean red blood cells (RBC) values and mean hemoglobin (HB) values in two breeds of horses (Andalusian and Arabian) at rest and during and after exercise. Significant difference between breeds: * $p \leq 0.05$.

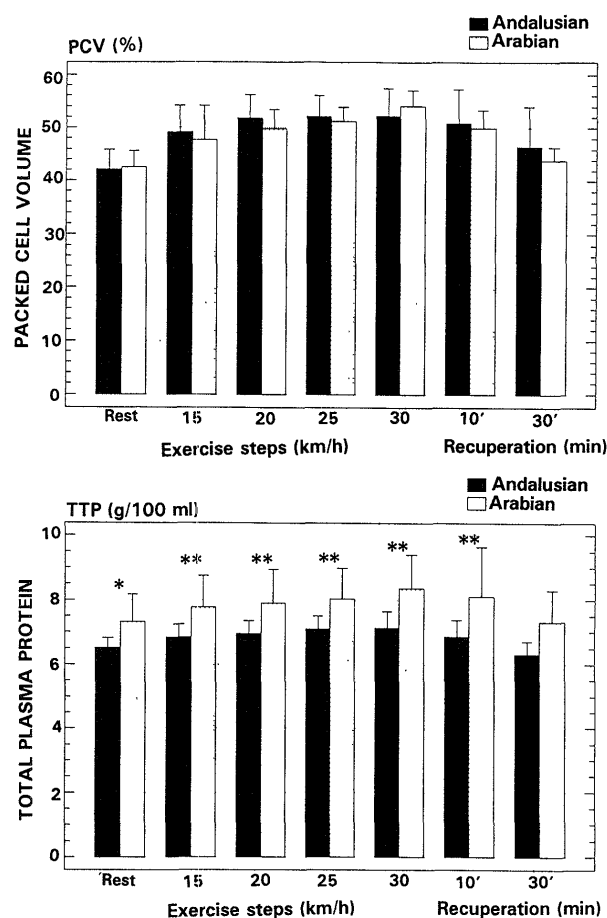


Fig. 2. Mean packed cell volume (PCV) and mean total plasma protein (PPT) values in two breeds of horses (Andalusian and Arabian) at rest and during and after exercise. Significant differences between breeds: * $p \leq 0.05$; ** $p \leq 0.01$.

values to those of the resting time in both breeds.

With respect to the hematocrit value (Fig. 2), both breeds showed similar values during resting (42.6% for Arabian foals and 42% for Andalusian foals). The PCV of the Arabian and Andalusian foals progressively increased in the four stages of the exercise program to which they were subjected. Ten minutes after completing the exercise, a fall in the hematocrit value was already observed in both breeds. However, in neither of them did it diminish sufficiently to reach similar values to that of the resting period. As was seen for the hemoglobin concentration, no significant difference was found between either breed in the PCV response to exercise.

The Arabian foals displayed significantly higher total plasma protein concentrations in all the stages of the test (Fig. 2), except at 30 min of recovery time. The highest values for both breeds were reached at the moment of maximum activity (speed of 30 km/hr).

The Arabian foals gave higher resting figures for the mean corpuscular volume (MCV) (57.5 fl compared to 52.1 fl). In this breed, the MCV decreased during exercise, with a minimum value at its most intense stage,

rising during recovery, after 30 min of which values slightly above those of resting were obtained. The modifications of the MCV in the Andalusian foals fluctuated. Thus, after the first stage of exercise, a value below that of pre-exercise was obtained, but it slightly increased in the next stage (Fig. 3). From that moment it maintained very similar rates during the whole test up to recovery time. At 30 min after recovery, the MCV had risen above the resting values.

The mean corpuscular hemoglobin (MCH) evolution was different in both breeds, according to the increase in speed. The Arabian foals showed a diminution in their base values after the first level of exercise. As from the second stage of exercise, no changes were observed for this index. At 30 min recovery, no rise above the resting values was observed, in contrast to what was found for Andalusian foals, whose values after this same period of time were higher than those described for the exercise period. This breed also showed an increase after the first five minutes of exercise (speed of 15 km/hr) (Fig. 4).

In Andalusian foals, the highest value for mean

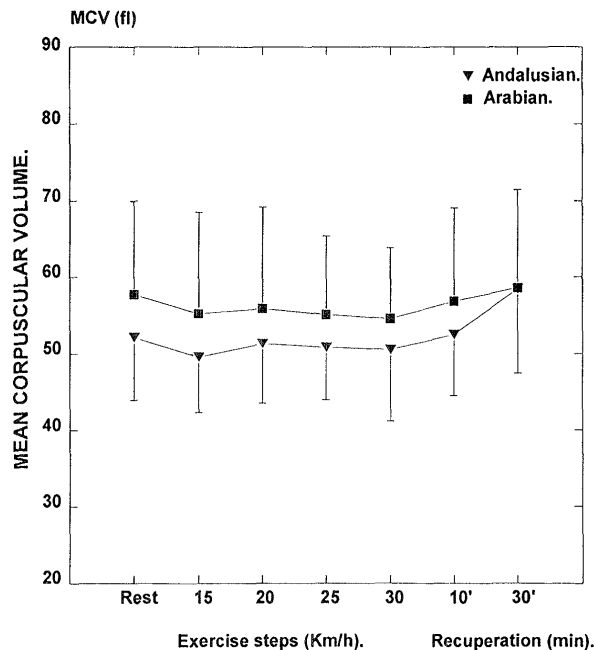


Fig. 3. Mean corpuscular volume (MCV) values in two breeds of horses (Andalusian and Arabian) at rest and during and after exercise.

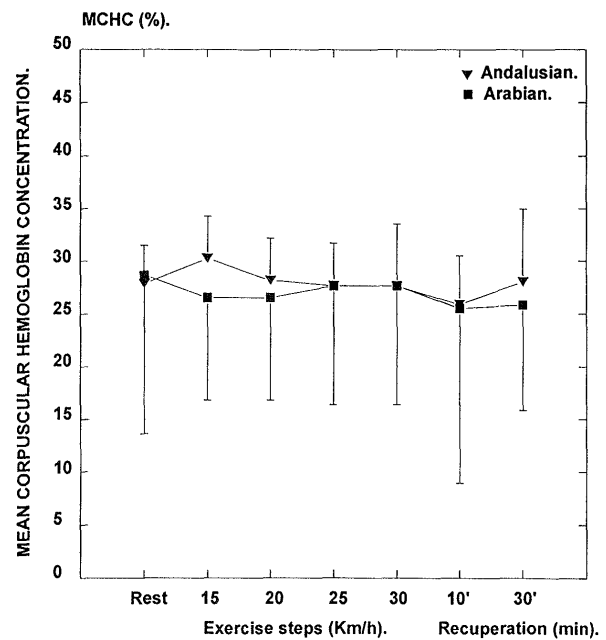


Fig. 5. Mean corpuscular hemoglobin concentration (MCHC) values in two breeds of horses (Andalusian and Arabian) at rest and during and after exercise.

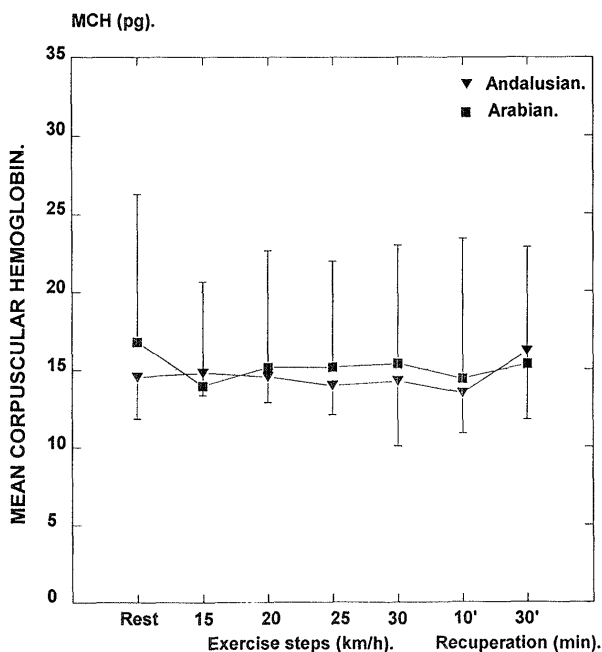


Fig. 4. Mean corpuscular hemoglobin (MCH) values in two breeds of horses (Andalusian and Arabian) at rest and during and after exercise.

corpuscular hemoglobin concentration (MCHC) was obtained after the first exercise level, decreasing from this moment on and reaching a value above that of the resting period at 30 min of recovery time (Fig. 5). However, in the Arab foals, the highest value was obtained in rest, after falling in the first speed trial, underwent a progres-

sive increase, but was reduced in the recovery time.

In contrast with the Andalusian breed, the Arabs showed, 30 min after completing the test, lower values of MCHC than those of the resting period.

No significant differences existed between either breed in the three hematic indices studied (MCV, MCH and MCHC) either in the different exercise stages or during recovery.

DISCUSSION

Some prior studies had been made on the hematological and biochemical alterations caused by exercise in relation to tolerance, state of physical fitness and aptitude for sport in adult horses of different breeds among which the Andalusian breed was included [5, 20]. In this research, this breed has been considered anew and compared with the Arab breed, using young animals, to evaluate their response to an exercise test.

Persson *et al.* [17] and Snow *et al.* [22] showed that an equine spleen is a fundamental deposit of red cells which are expelled into the blood stream by the joint action of two groups of hormones: catecholamines and glucocorticoids, namely adrenalin and cortisol. Although action on the spleen red cells deposit is carried out by adrenalin, which is released from its site of production as a result of stress at the beginning of the exercise, cortisol maintains the reactivity of the spleen blood vessels against the circulating catecholamines [9]. In spite of that the duration and intensity of the exercise which are the fundamental factors influencing the magnitude of the release of cortisol [6, 14, 18, 23, 24] should be the same for both breeds, an

increase in erythrocytes above the base levels at the moment of the maximum intensity of the exercise (Speed = 30 km/hr) was slightly higher in the Arab foals. This fact, which has also been observed in males of the two breeds being studied [20], might indicate that the Arab breed, at the same exercise intensity, releases more cortisol or more adrenalin than the Andalusian breed. This may reflect a possible sympathetic predominance in the Arab horse although other more profound studies are necessary to corroborate this hypothesis.

However, a second consideration should be made: since the Arab foals, in the same stage of the exercise, showed significantly higher plasma protein concentrations than the Andalusians (Fig. 2) a higher hemoconcentration in the Arabs may result in higher RBC values in the latter breed.

After the exercise, the spleen again recovered the red cells expelled previously at a volume estimated at about 10 liters [10]. Both breeds had a similar capacity for recovery and returned to their base values after 30 min resting.

In the same way as the results of a recent study of stallions [20] show, the hemoglobin concentration at rest was similar in both breeds. Other authors have found the highest hemoglobin concentration in the most intense stage of exercise. In Andalusian foals however, stress, muscular metabolism and a greater number of erythrocytes have combined to produce the highest hemoglobin concentration in the third stage of exercise. Owing to variations between individuals statistical analysis has not revealed any significant difference between the two breeds. As other possible explanation for this discrepancy, the shift from trotting to galloping could be considered. This change possibly occurred at a speed of 15 km/hr and would therefore be hematologically observed at a speed of 20–25 km/hr at which the intensity of exercise increased, being even higher than that carried out at 30 km/hr at which the horse would have adapted to a constant load of gallop.

The Andalusian and Arab foals showed a similar speed of regression of this blood parameter to their pre-exercise levels. As occurred with the number of red blood cells after the 30 min recovery period, the hemoglobin reached very similar values to those of the resting time in both breeds.

Adefeya *et al.* [1], Graig *et al.* [11], Grant *et al.* [12] and Popescu *et al.* [19] found very obvious alterations in the hemogram during resting and after exercise with significant increases in the hematocrit value, red blood cell count and hemoglobin concentration. In the present study, the hematocrit value of the Arabian and Andalusian foals progressively increased in the four stages of the exercise program to which they were subjected. The emission of new red cells from the spleen was the possible cause [2]. The stage when the exercise was at its most intense was corresponded to the stage when the hematocrit value was the highest, according the report to Snow [22] who demonstrated a direct relationship between sympathetic activity and speed. In fact, the highest hematocrit value observed at the stage of the highest

intensity of exercise ($v = 30$ km/hr) as well as showing the highest plasma protein concentrations.

Oropesa de Cáceres [16] and Rubio *et al.* [20] reported a slow recovery of PCV values after exercise in Andalusian horses. Although this tendency was also observed in the foals in the present study, the difference was very small between both breeds with no statistical relevance.

Both the Arab and the Andalusian foals experienced significant rise in plasma proteins with the exercise. Although there are diverse theories which attempt to explain the increase in plasma protein with exercise, the one most accepted is based on a loss of plasma volume caused by sweating [4, 7, 13] and respiration [7].

By virtue of this reasoning, it might be deduced that sweating was more intense in the Arab foals than in the Andalusians throughout the whole exercise test and for the first ten minutes of recovery and that has meant that the Arab foals showed higher plasma proteins. However, this same difference was even observed during resting although it became much more significant in the different exercise levels.

In stallions [20], the Andalusian breed showed higher plasma protein concentrations than the Arab breed, at speeds of 20, 25 and 30 km/hr and at after ten minutes' of recuperation time. However, in this study, the Arabian foals showed higher plasma protein concentrations than the Andalusian foals at all of stages of the exercise test. The evolution of the MCV with exercise is not clear. Thus, in Andalusian foals, Escribano [8] observed a significant increase of this index in correlation with an increase in the hematocrit value during the exercise. However, McClay *et al.* [15] described a decrease in the MCV with physical effort. This discrepancy is also noticeable in this study with diverse fluctuations in the MCV values during the test although no significant differences were found between the two breeds.

As occurred with some of the hematic parameters studied, and in spite of the differences between the two breeds, the MCH value was not statistically significant due to the influence of the specific characteristics of each animal since the environmental conditions were the same for both breeds when the study was carried out. However, the MCH response in the Arab foals at the first speed of the test ($v = 15$ km/hr) experienced a sharp fall, something that was not observed in the work on males [20]. This appearance of this reduction has been related by this authors [20] to an increase in the number of red hypovolemic cells, as it coincides with a lower value for the MCV.

Low hemoglobin figures signify small values of mean corpuscular hemoglobin concentration (MCHC), so that the Andalusian foals during resting showed a slightly lower rate of MCHC than the Arabian foals, further supported by a smaller hematocrit value (Fig. 5).

The behaviour of this hematic index during exercise has not been well defined, since a rise in its resting values or an increase parallel of the speed were described [3, 15, 16, 21]. Such inconsistent findings would be proved by study

in which both rises and falls were recognized throughout the exercise test.

Although, the response to an exercise test in these two breeds of horses in basically similar, there were some differences in hematic indexes, i.e. the greater hemoconcentration in the Arab foal during resting, at all the stages of the test and at 10 min of recovery time accompanied by the higher concentration of plasma proteins and a higher PCV. These results would be expected to contribute in consideration the aptitude for sport between Arabs and Andalusians. Castejón *et al.* [5] speculated that the Andalusian horse has a lesser athletic capacity than the Arabian.

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