Equine Exercise Physiology 3: 17–21, 1991

Heart and Spleen Weights as a Function of Breed and Somatotype

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ABSTRACT. The purpose of this study was to assess differences in heart and spleen mass of different breeds of horse. The entire hearts and spleens were removed and weighed from 8 stock types (S), 8 racing types (R), 8 draft types (D), and 7 Arabian (A) horses of similar body condition. Age in years of horses ranged from 3–20 for S, 3–18 for R, 3–9 for D and 2–19 for A. Horses were killed by captive bolt gun and exsanguination at a horse meat packing plant. Hearts were cut open before weighing to allow full drainage of blood. Spleens were examined for signs of engorgement before weighing and all were found to be free of significant residual red cells. Spleen weights as a percentage of live body weight were 0.44 for R, 0.30 for A, 0.26 for S and 0.19 for D. Heart weights as a percentage of live body weight were 0.86 for R, 0.76 for A, 0.64 for S and 0.62 for D. R had significantly greater ($p < .01$) relative heart size than S or D. R had significantly greater ($p < .01$) relative spleen size than all other types. D had significantly smaller ($p < .01$) relative spleen size than R and A. These results suggest that observed differences in blood volume between breeds of horse may be largely a function of splenic mass.

Key words: Horses; heart; spleen; weight; racing; draft.

INTRODUCTION

Circulatory capacity in the horse has been shown to be positively related to exercise performance.[9] The circulatory capacity of any given horse is at least partially determined by the functional mass of its heart and spleen.

Horses with higher heart scores (mean QRS interval duration from electrocardiogram leads I, II, and III) have been found to have both larger hearts and higher average performance levels.[21] This has been found in racing horses,[20] endurance horses[4,17] and three-day eventing horses.[16] Data indicating the heritability of heart score[19] suggests that breeds of horse adapted for different purposes should differ in heart mass.

The equine spleen has a major impact upon the circulatory function of the exercising horse in terms of red cell volume, total blood volume, and total hemoglobin. Total blood volume has been positively correlated to racing performance in horses and a linear relationship between exercise intensity and splenic emptying has been found.[9] Splenic contraction has been found to increase circulating red blood cells by 50% above resting levels during maximal exercise.[22]

The importance of the splenic red blood cell reserve in the horse was documented in a series of studies utilizing 5 splenectomized saddle horses.[11,12,13,14] Major differences in body and peripheral hematocrit induced by rest, exercise or adrenalin injection were completely abolished by splenectomy. The total red blood cell volume was found to be dependent on the weight of the exsanguinated spleen, but independent of body weight. The mean heart rate at a given submaximal standard exercise was found to be higher after splenectomy, suggesting that the equine spleen acts as a cardiovascular reserve modifying the heart rate response to submaximal exercise by increasing the circulating red cell

volume. Reduced cardiac output during moderate treadmill exercise was also found in splenectomized horses, due mainly to reduced stroke volume which was only partially offset by increased heart rate. This result suggests that the splenic cardiovascular reserve may assist ventricular filling at high heart rates. Reduced systemic and pulmonary arterial pressures were found[1] in exercising splenectomized ponies.

Several researchers have found that blood volume parameters differ between breed of horse. It was reported[5] that blood volume in a group of "hot-blooded" horses including Thoroughbreds, Quarter, Arabian and Saddlebred averaged 53% higher than in Percherons when expressed on a bodyweight basis. This difference fell to 33% when expressed on a fat-free body weight basis. It was found that Thoroughbreds had 68% higher total blood volume than Percherons.[8] Furthermore, Thoroughbreds had 46% higher plasma volume and 2-fold higher red cell volume than Percherons when expressed on a body weight basis.

Major differences were also found in blood volume parameters between breeds of horse.[9] These differences were attributed to differing degrees of training and service in addition to breed characteristics. Total blood volume and total hemoglobin were found to be 19% and 34% higher, respectively, in trained 2 year old trotters compared to untrained controls. It was reported[2] that storage capacity of the equine spleen increases with training.

In the current study, we have determined the mass of the heart and spleen of genetically and morphologically different types of horse in order to detect possible anatomical bases for differences in circulatory capacity.

MATERIALS AND METHODS

Thirty-one horses at a horse-meat packing facility were used to obtain measurements of heart and spleen mass. The horses were selected on the basis of breed type. Horses used were 8 stock types (mostly Quarter horses), 8 racing types (Thoroughbred and Standardbred), 8 draft types (mostly Belgians) and 7 Arabian types.

Height at the withers and live body weight was recorded for all horses immediately before slaughter. Body condition was also assessed and scored[3] from 1 (extremely emaciated) to 9 (extremely obese). Body condition scores of horses used ranged from 3.0 to 7.5. Mean condition scores for the 4 types of horses were 5.25 for stock types, 5.06 for racing types, 5.36 for Arabians and 5.25 for draft types. Due to the similarity of body condition between types, no adjustment was made for fat-free body weight. Thus, all data are expressed as organ weight as a percentage of live body weight.

The racing type horses included 3 geldings and 3 mares of unknown breeding and 2 mares (1 Thoroughbred, 1 Standardbred) whose histories were known, ranging in age from 3 to 18 years. Racing types were selected on the basis of lip tattoos. However, the lack of clarity of some tattoos made it impossible to determine with certainty whether the breed was Thoroughbred or Standardbred. Mean body weight was 440 kg.

Stock type horses used were 2 geldings and 6 mares ranging in age from 3 to 20 years. These horses were also selected on the basis of physical characteristics including muscling through the arm, forearm, stifle, gaskin and hindquarter. Mean body weight was 460 kg.

Draft type horses used were 1 stallion, 2 geldings and 5 mares ranging in age from 3 to 9 years. These horses were relatively small draft horses of predominantly Belgian breeding as evidenced by their typical sorrel (chestnut) coat color and blonde manes and tails. Mean body weight was 543 kg.

The Arabians included 6 mares and 1 gelding ranging in age from 2 to 19 years. Because Arabians were selected only on the basis of physical traits (i.e. dished face, high tail set, level croup, flat muscle pattern), we cannot be certain that all were pure bred. Mean body weight was 365 kg.

Horses were killed by captive bolt gun and

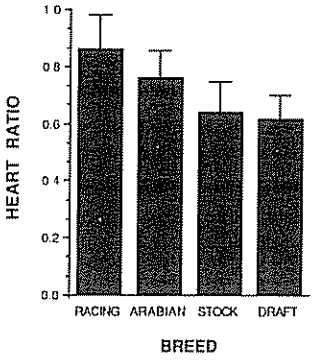

Fig 1 Mean heart weight as a percentage of body weight (heart ratio) and standard deviations in racing, Arabian, stock and draft type horses.

exsanguination. Hearts and spleens were immediately removed and weighed on an electronic, digital display balance. Each heart chamber was cut open before weighing to ensure full drainage of blood. Spleens were examined for signs of engorgement before weighing. The method of slaughter yielded spleens of uniform character, as very little residual red cell mass remained. Only one spleen was rejected due to engorgement.

Organ weight data, expressed as a percentage of live body weight, were analyzed using analysis of variance.[18] Breed types were the independent variables. *t*-tests of values for least square means of organ weights were also done between breeds.[18]

RESULTS

Fig. 1 presents the results of the heart weight measurements on the 4 types of horses. Analysis of variance detected significant ($p<0.01$) differences between types in heart weight. *t*-tests found that racing type horses had significantly greater ($p<0.01$) heart weight than either stock or draft type horses. No significant difference ($p>0.05$) was found between racing types and Arabians. Arabians had significantly ($p<0.05$) greater heart weight than draft type horses, but the advantage in heart size for Arabians over stock type horses was not statistically significant ($p=0.09$). No difference in heart weight ($p>0.05$) was found between stock and draft type horses.

Fig. 2 presents the results of the spleen weight measurements of the 4 types of horses. Analysis of variance detected significant ($p<0.0001$) differences between types in spleen weight. *t*-tests found that racing types had significantly ($p<0.01$) greater spleen weight than all other types. Arabians had significantly greater ($p<0.01$) spleen weight than draft types, but there was no difference ($p>0.05$) in spleen weight between Arabians and stock types. Draft type horses tended to have lower spleen weight than stock type horses, but the difference was not significant ($p=0.08$) with a *t*-test.

DISCUSSION

Heart weights of racing type horses as a percentage of live body weight found in this study were very similar to values reported in a previous study[15] for Thoroughbreds of undetermined training status and body fat. Heart weight values for racing types in this study were lower than those found for trained Thoroughbreds.[6] Although most of the horses of all types used in the current study came from unknown management background, they appeared to possess low levels of fitness. The exception is that two of the racing type horses may have been recent-

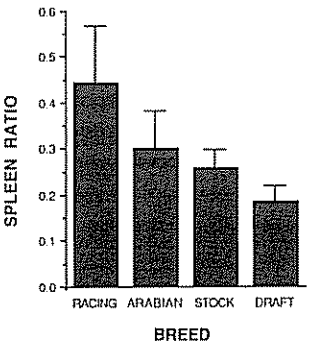

Fig 2 Mean spleen weight as a percentage of body weight (spleen ratio) and standard deviations in racing, Arabian, stock and draft type horses.

ly retired from the racetrack, as they showed signs of being recently shod, and displayed severe lower leg injuries. These two horses also had heart ratios (1.0% body weight) which exceeded the mean of the racing type group (0.86% body weight). However, the mean body condition score of these two horses was 4.0, lower than the mean body condition score of 5.06 for the racing type group.

Two horses in the racing type group were brood mares. These two horses had heart ratios (0.73% body weight) below the mean of their group. The mean body condition score of these two horses was 6.25, higher than the mean body condition score for the racing type group. Although the racing type horses showed apparent variability in heart ratios due to differences in training status, some of this variability was due to differences in the amount of body fat.

Heart weight was not found to be statistically ($p>0.05$) different between racing types and Arabians. The small numerical advantage of the racing group may have been due mainly to conditioning effects. Draft type horses possessed smaller relative heart size than either racing or Arabian horses regardless of possible conditioning effects.

The most obvious difference between groups of horses was in the weight of the spleen. Racing type horses had more than a 2-fold heavier relative spleen weight than draft type. Racing type horses had 47% and 69% greater relative spleen mass than Arabians and stock types, respectively. As with heart weight, the spleen weight of the racing types may have been affected more than the other types by training.[7] However, an examination of the spleens of the two racing type brood mares found their spleen ratio was 0.36% body weight. This value was still higher than the mean of all other types of horses.

The most strikingly different type of horse relative to spleen size was the draft. Spleens from draft types were often smaller on an absolute basis even than the spleens from diminutive Arabians. This finding is consistent with the findings of several authors which have reported that blood volume is lower in cold-blooded horses compared to hot-blooded.[5,8,9] The size of the spleen has been found to have a major effect on total blood volume and red cell volume in the horse.[13] It has been suggested[10] that horses which perform work related to muscular strength or technical skill do not require as great a blood volume as runners or other athletic types whose performance may be limited by the capacity of the cardiovascular system.

Draft horses have also been found to have lower hematocrit values than other breeds.[5,8] One can speculate that a smaller splenic capacity and a lower level of circulating red cells may actually be an advantage to the draft type horse during typical exercise bouts. During prolonged, submaximal draft work, dissipation of body heat may be a more important consideration than aerobic power. A capacious spleen which ejects many red cells into the circulating blood upon work stimulation could increase blood viscosity and blood flow resistance in peripheral capillary beds to the extent that sweating and thus, evaporative cooling might be compromised during prolonged work. This seems plausible upon consideration of the fact that as the mass of a body increases, the surface area as a proportion of the mass decreases. Therefore, the large draft type horse would be expected to require an efficient cooling system to rid itself of heat produced during work. The small splenic capacity may partially be a reflection of this adaptation.

This study has conclusively shown that draft type horses possess substantially smaller spleens than other types. Likewise, racing type horses were found to have significantly larger spleens than other types. These results support previous studies which have found differences in blood volume between breeds and types of horses. They also suggest that differences in blood volume between breeds of horse should be significantly affected by splenic mass.

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Equine Exercise Physiology 3: 22–29, 1991

Electrocardiographic and Echocardiographic Measurements and Their Relationships in Thoroughbred Yearlings to Subsequent Performance

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ABSTRACT. This study was initiated to assess various cardiac parameters in Thoroughbred yearlings and to investigate their relationship to one another, to body weight and height and to subsequent performance. Electrocardiography was used to determine heart score, and echocardiography was used to measure left ventricular parameters and the intraventricular septum in M-mode and 2-D mode, in systole and diastole. A total of 630 yearlings were examined. Two horses had significant arrhythmias. 125 received race ratings at 2 years of age and 127 were rated at 3 years of age. Echocardiographic measures for these yearlings were within the ranges previously reported for adult horses. There were differences between echocardiographic measures recorded on the right and left thorax. Heart score and an echocardiographic estimate of heart weight were more closely related to height than to body weight. There was no significant correlation between either heart score or echocardiographic measurements and subsequent performance, at either 2, or 3 years of age.

Key words: Heart score; echocardiography; Thoroughbred yearlings; performance; horses.

INTRODUCTION

The high correlation (0.89) between mean QRS duration recorded from the standard limb leads (heart score) of the equine electrocardiogram and heart weight provides a means of evaluation of the relationship between heart size and racing performance in adult horses.[12] A correlation of 0.44 was observed between heart score and total stake monies won by horses, and this is supported in similar studies.[8,13,14] However, other reports have produced results which do not demonstrate the same strengths of relationship.[2,7] This may be due to the influence of many confounding variables[10] and the indirect nature of the inference of heart size.

Visualisation and measurements of cardiac structure and function in the horse may be achieved using echocardiography[1,11] and the relationships between echocardiographic and autopsy measures of the equine heart have been described and permit the prediction of cardiac weight.[9]

The initial report of echocardiography in the horse described placement of the ultrasound probe on the right thorax at the level of the third intercostal space[11] and this convention has been followed.[9] However, it has been suggested[15] that a clear echocardiogram can be obtained by placing a probe in the fourth intercostal space on either the left or right side. Stroke index as measured by echo-