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Short Communication

Echocardiography and electrocardiography as means to evaluate potential performance in horses

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Prediction of potential performance is one of the goals of exercise physiology investigations. When Selecting a horse for competition, one of the main objectives is to choose the one that predictably will reveal a competitive aptitude above the average. The horses used in this study underwent a two-dimensional echocardiography study and a conventional 3 leads electrocardiogram. The results show that heart score is not an appropriate index to evaluate the heart size in the horse. On the other hand, there are currently more suitable and accurate procedures such as echocardiography that allow performing a clear anatomical evaluation and accurate measurement in order to calculate LVMM and to predict performance.

Key words: echocardiography, electrocardiography, left ventricular myocardial mass, heart score, performance, horse

When selecting a horse for competition, one of the main objectives is to choose the one that predictably will reveal a competitive aptitude above the average. In the past several approaches have been performed to succeed in this kind of selection, since the future yield of the horse is ignored when the selection is carried out. In 1963 Steel [1] established a relationship between some electrocardiographic values and heart weight in horses. This was confirmed to be statistically significant. More recently, the same author gained evidence of statistically significant correlation between the same electrocardiographic values and the total amount of prices won in races [2]. The mean value of QRS interval, measured in msec using the standard three bipolar leads recording, outlined the strongest correlation with the heart weight. Relying upon these data, he established the “Heart Score” concept (HS) suggesting that this index would allow inferring the heart size. Since a large heart size is a useful characteristic for excellent competition achievements, the HS is reckoned to be a valuable indicator of potential performance. The publication and diffusion of this concept raised an up to date controversy, among those considering this index and its related results adequate for predicting the best performers [3,4,5] and those stating that the average duration of QRS interval HS is not a valid indicator of potential performance [6,7,8,9], whereas its feasibility makes this technique very appealing. In horses, earlier studies emphasized a tight correlation between body weight (BW), body surface area (BSA) and left ventricular myocardial mass (LVMM) measured by means of a guided M-Mode echocardiography [10]. If HS is related to the heart weight and LVMM correlates strongly with BW, it is reasonable to think that, being heart weight similar to myocardial mass, HS should correlate in a statistically significant way with LVMM and BW. Other investigations have also demonstrated a genetically determined breed relationship between body weight and heart weight [11]. The QRS interval (intraventricular conduction time) represents the time required for the electric wave to spread and depolarize the ventricular mass. Hence, as the ventricular muscular mass increases, a longer time will be necessary for the ventricular depolarization to take place. This has been clearly demonstrated [12]. On the basis of the abovementioned arguments and to assess whether the HS is a suitable index of potential performance, the objective of our study was to investigate the occurrence of a statistically significant correlation between HS and LVMM and between HS and body weight in horses.

Forty-eight thoroughbreds and half-bred thoroughbred race horses, aged between 17 and 25 months, males and females, were used. They were cardiologically healthy, as

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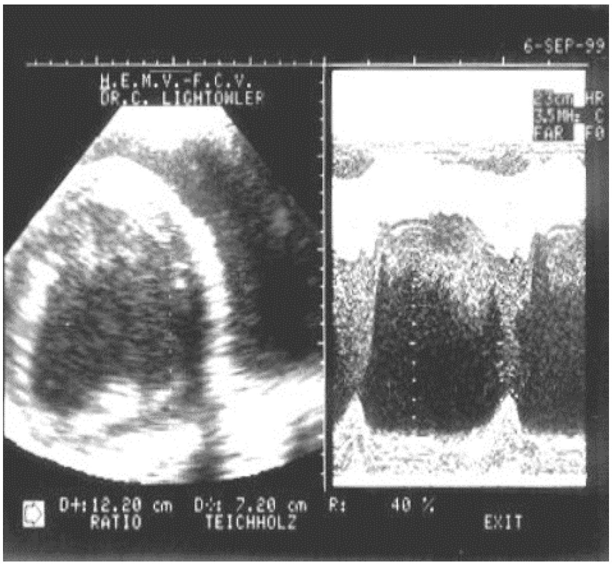

Fig. 1. Right parasternal window. Image captured in order to infer the measurements to calculate LVMM. Left: 2D view in short axis, at the chordae tendineae level. Right: guided M-Mode view.

confirmed by a clinical evaluation, a routine echocardiography and an electrocardiography examination.

All horses underwent a two-dimensional echocardiographic study and a conventional 3 leads electrocardiogram (bipolar standard). The echocardiographic study was carried out by means of a Kontron equipment (model Sigma Iris 440), specifically equipped with a 3,5 MHz dual mechanical-sector transducer, and an Esaote Biomedica equipment (model Caris) featuring a phase-array multifrequency transducer. In order to calculate LVMM, measurements were carried out by means of M-Mode guided images captured from the right parasternal window, in short axis, at the *chordae tendinae* level (Fig. 1).The Left Ventricular Diastolic Diameter (LVDD), the Diastolic Thickness of the Interventricular Septum (DTIS) and the Diastolic Thickness of the Left Ventricular Wall (DTLVW) were also recorded. For the determination of the Left Ventricular Myocardial Mass (LVMM) the following formula was applied: $1,5\,(DTIS + DTLVW + LVDD)^3 - (LVDD)^3$. For all measurements obtained values correspond to the mean values of six recordings made in by different echotomograms. Measurements diverging more than 12% were discarded. For the electrocardiographic recording, the principles recommended by Steel and col[3] were followed. A Cardio Técnica, dual RG-201 electrocardiograph model, was used. The sensitivity was set at 1 cm = 1 mV and paper speed at 25 mm/sec. "HS" was obtained by calculating the mean value of the QRS interval recorded by means of the three standard bipolar leads (LI, LII and LIII). QRS interval value for each lead, taken into account for the final calculation, was the average of 10 recordings, each of them carried out in a different ventricular complex (Fig. 2).

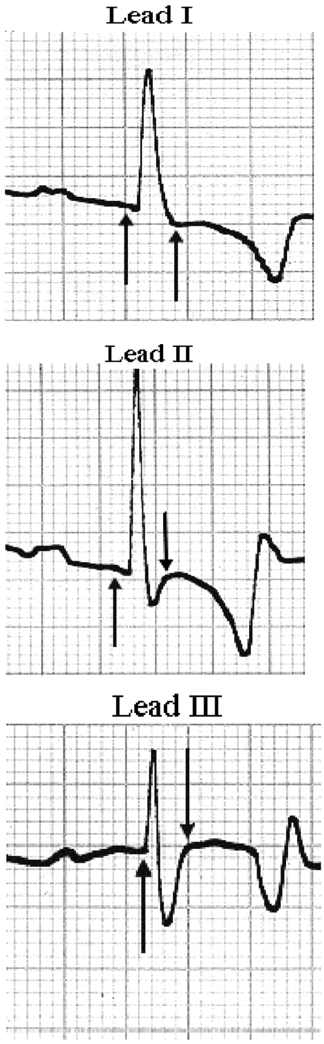

Fig. 2. Electrocardiogram traces from leads I, II and III. The arrows show the beginning and end points of the QRS complexes.

All horses were weighted on a special scale with a proven error of ± 2 kilograms with the used value corresponding to the average of three serial weights. The statistical study featured the analysis of the linear correlation between body weight and the heart score and between left ventricular myocardial mass and the heart score.

1-For the body weight vs. the heart score variable: coefficient of Pearson = 0,1315 (P-value 0,5497). The result indicates no statistically significant correlation. Also, the variables do not show linear regression and the graphic representation of the obtained values does not show a tendency toward a non linear regression either (Fig. 3).

2-For the left ventricular myocardial mass vs. the heart score variable: coefficient of Pearson = 0,0705 (P-valued 0,7482). The result indicates no statistically significant correlation. The variables do not show either a linear regression or a tendency toward non-linear regression (Fig. 4).

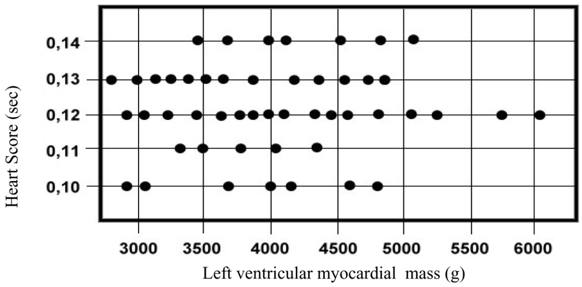

Fig. 3. Graphic representation of the obtained values (Heart Score *vs* LVMM).

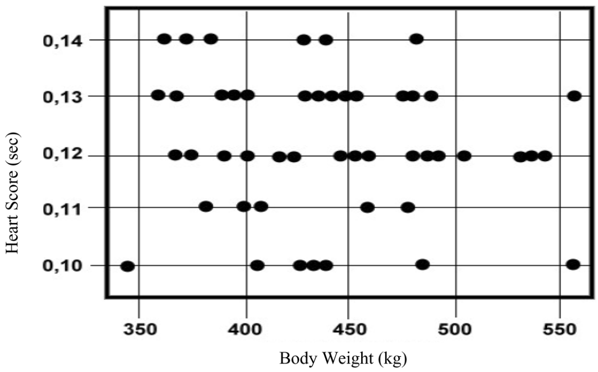

Fig. 4. Graphic representation of the obtained values (Heart Score *vs* Body Weight).

In order to understand these results, a few concepts should be summarized:

1) It is acknowledged that there is a relationship between heart sizes and body weight (BW). This varies according to the race and it is genetically determined [9].

2) This relationship can be clinically evaluated by an echocardiographic measurement of the left ventricular myocardial mass (LVMM). The latter correlates strongly with body weight [10].

3) The LVMM is a proportional part of heart size and therefore of the heart weight.

4) The value of the QRS interval depends on the amount of muscular tissue run through by the electric wave.

Bearing in mind what previously reported, what follows arise as a logical consequence:

1-LVMM represents a percentage of the heart weight. Given that QRS interval value depends upon the amount of muscular tissue undergoing depolarization, hence both variables should correlate each other in a statistically significant way.

2-According to Steel studies, QRS interval value correlates strongly with the heart weight. LVMM, which is a proportion of the heart weight, correlates strongly with the body weight. Consequently the QRS interval should correlate with the body weight. Regarding the obtained results, it is clear that HS shows a relationship neither with the body weight nor with LVMM, as determined by echocardiography. Hence its value does not correlate with the heart size and it cannot be regarded as a suitable index for predicting potential performance. The lack of correlation between BW and HS and between LVMM and HS observed in this study can be explained by the following arguments.

First, the results and the statement resulting from Steel [1] paper are erroneous.

The questionable topics of the paper are:

a) the size of the sample (n = 34);

b) sex, race, body weight and other important factors were not taken into account in his study;

c) the effects of training on the heart were not considered. They wanted to determine the heart size modifications due to genetic background but not due to entrainment while it is known that exercise modifies the size and weight of the heart.

d) the influence, on heart weight and electrocardiogram, of potential specific pathologies affecting the chosen sample, was not adequately investigated. Furthermore an intrinsic error in carrying out the measurements can be found. This is important in view of the narrow magnitude of the QRS interval values. These values are very small with a tight range of variation. Thus when measurements are carried out, errors may become significant. In the horse, the extreme values of the QRS interval range between 0,08 and 0,17 seconds. The average value of the QRS interval is 0,125 seconds while LVMM mean value is 3.200 g. Hence 100 g of left ventricle cardiac muscle are depolarized within 0,00391 seconds.

Steel established that a paper speed of 25 mm/sec was adequate for the measurement of the QRS interval [3]. With the paper speed set at as above, each mm corresponds to 0,04 seconds. Carrying out the measurements with appropriate magnification and minimizing the variations of the line thickness, it is unlikely to accomplish accurate measurements. Also these recordings are inadequate to infer heart weight. As a logical consequence, if 100 g of cardiac muscle are depolarized within 0,00391 seconds and this time is recorded in 0.098 mm of paper, it is easy to observe as a small measurement error (or a paper dragging mechanics flaw) can increase or diminish the heart weight in a significant way. Tolerating a 10% error for the measurement of the QRS interval, a value of 0,108 mm would be obtained. This corresponds to 110,20 g of cardiac muscle instead of the previously mentioned 100 g, thus artificially reducing the heart weight in a 326,4 g value. The third explanation is related to the peculiarity of ventricular depolarization in the horse. The concept of “wave front”, valid for the rest of the mammals, it does not apply to hoofed species. In the horse, the beginning and the end of the QRS interval does not necessarily correspond to the beginning and the end of the ventricular depolarization. Due to the particular distribution of the Purkinje net in the ventricular cardiac muscle of the horse, a certain amount of the electric potential output during the ventricular depolarization is lost thus not showing manifest electric superficial phenomena. There is a chance that, at least in the final part of the PQ interval and/or in the initial part of the ST interval, the ventricular depolarization could start and continue with currents that conceal each other, without manifestations in the surface recording. In this context, the concept that the duration of the ventricular depolarization develops entirely within the QRS interval could prove not to be valid for the horse. In this way an unknown amount of electricity (and therefore of muscle weight) could be lost and not represented in the inscription time of the QRS interval. In this way, a horse with a 0,10 sec Heart Score can have a bigger heart than another featuring a 0,12 sec value, since electricity gets covered to a larger extent and a bigger proportion of muscle is hidden. It has been demonstrated that the QRS interval value rises with the increasing mass of heart muscle as a result of hypertrophy (physiologic or pathologic) [12,14,15]. However, it should be kept in mind that it only shows that cardiac mass has increased but it does not quantify such growth. Opposite deductions can be drawn when LVMM is calculated through echocardiography. If measurements are carried out appropriately, the results are exacts and reliable. For this reason echocardiography is a valuable instrument for the assessment of potential performance. It is important to underline that in order to validate LVMM as a tool for predicting potential performance, this index should only be evaluated in fully-grown and untrained horses. On this basis, the obtained value corresponds to the genetically determined heart size that is the only value suitable for selecting horses for future performance. The obtained results show that HS is not an appropriate index to evaluate the heart size in the horse and that it should not be considered as a tool for assessing potential performance. On the other hand, there are currently more suitable and accurate instruments such as echocardiography that allow performing of a clear anatomical evaluation and accurate measurements in order to calculate LVMM [10].

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