

Studies in the Relationship between some Morphological Characters and Jumping Parameters in Sport Horses (Part II - OXER FENCE)

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Abstract

The multilinear regression model introduced the variables control and estimated the contribution of every independent variable in the explication of the dependent variable variance, in a standard situation, when all independent had constant values. The taken into study independent variables were 19 morphological characters. The dependent value was represented by the entire length of the jump over an oxer fence and the bar-limbs distance in the same obstacle. The obtained value, for the multiple determination coefficients, nearby 1.00, in most of the cases in the high performance levels (B and C) showed the efficiency of the model and a good selection for the included factors. The obtained result focusing on the ensemble reports, in fact a result which can lead us to think that this kind of modeling can be applied freely to the horse height.

Keywords: morphological characters, oxer obstacle, sport horses.

1. Introduction

Starting from the form-function principle, the present paper, proposed to analyse the relation between the morphological characters' of the equine jumpers and the jumping over obstacles parameters, respectively the entire length of the jump and the bar-limbs distance in an oxer spread fence.

However, a morphological trait that would be able to stand as a mark in choosing a sport horse should be found. Although the established mark cannot ensure future competition results (which involve numerous elements, a fact acknowledged by more and more authors [1, 2, 3, 4 and 5]. But, it can function as a starting point in a competition horse career. It is well-known that a horse will not be able to become at least an average competition horse unless it has the biometric and biomechanical required trials, even if it is trained and led by a really valuable

trainer and rider. In most cases when horses will not cooperate during the training, this refuse is considered due to their temperament, but it can also be a pain that prevents them to perform an exercise, or even a problem concerning their body structure or balance and equilibrium.

2. Materials and methods

In order to describe the morphological traits 15 body measurements and the body weight were carried out on 158 sport horses. These measurements (all in cm) were: height at withers (a), height at back (b), height at croup (c), thorax depth (d), hearth girth height (e), body length (f), head length (g), ancoliure (h) and neck (i) length, croup length (j), hearth girth (k), cannon girth (l), chest width (m), croup width at hips (n) and croup width at ischium (o). Body mass (p) was calculated using specific formulas (kg). For a better description of these equines there were made another 3 measurements on bone angles (all express in degrees): the inclination of scapula (q), the hock joint angle (r) and the pelvis inclination (s).

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For the jumping parameters description, we obtained for one of the most used spread obstacles, an oxer fence. All studied jumps were been executed during show jumping competitions and recorded with a video camera and a photo one. In this sense, the following height dimensions were the standard values for the jumps (values established by FEI, for every competition level). In order for the B, C, D, E and F levels, the bars were situated at 130, 120, 110, 100 and 80 centimeters height, respectively at 150, 140, 130, 120 and 100 centimeters width of the obstacle. The arena earth was covered classically with grass or with sand.

It was measured four parameters for every jump: the taking-off distance, the landing distance, and the distance between bar and limbs for the front limbs and for the hind limbs. The taking-off distance, was measured between the last contact of the hind legs with the earth and the base of the obstacle. The distances between bar and limbs, were calculated by an average; measured for the front legs the distance in the moment in the ascendant phase, when the legs were above the first bar and for the hind limbs the nearest point between one of these and the second bar in the last moment before the front limbs take the contact with earth. The landing distance, it was represented by the measurement from the base of the obstacle and the first contact of the front limbs with the earth after the jump. For the mathematical modeling which follows were taken into count the entire length of the jump and the average limbs-bar distance over the oxer fence.

The connections between the dependent variable (the length of the horse jump and the bar-limbs distance) and the body measurements of the horse have been established and analysed by the use of mathematic research in order to explain and foresee the variation of the dependent variable. The multiple regression analysis has been used and the statistical significance of the parameters has been analysed during the research. The multilinear regression model introduces the horse control variables and it estimates the contribution of each variable to the explanation of the

dependent variable variations while all the other variables have constant values. There is a need to mention that the regression does not prove the causal chain between the variables, but it helps the study of their nature and their interference.

The 15 body measurements, the body weight and 3 bone angles as independent variables have been taken into account. The dependent variables have been represented by the total length of the jump over the vertical spread obstacle, and the bar-limbs distance in the same fence, at the same jumps.

The following multilinear regression model has been used in order to introduce the importance of the above mentioned features (point 1 in table 1). After processing the data on the 5 competition licences, K had different values according not only to the height and the type of the obstacle, but also to the different values of Y , which varied according to the total length of the jump and to bar-limbs distance. The 19 morphological traits taken into work, were represented with letters from a to s .

The regression equation parameters (the partial constant rate and partial coefficients) have been estimated according to the smallest squares using the Data Fit 8.2.79 Oakdale Engineering programme. A procedure of determining these parameters has been made so that it should minimize the total error and maximize the correlation between the observed values of the dependent variable and those calculated by using the regression model in the same time. The statistic significance of the regression model has been tested by checking the 0 hypothesis, according to which there is no connection between the dependent variable and any other independent variable. On the one hand, this testing had into account the global significance evaluation of the regression model, on the other hand it focused on the evaluation of the partial regression coefficients (namely, evaluating the importance of each independent variable). In both cases, the F test has been adapted accordingly. The initial equation and the definition model are number 2 and 3 in table 1.

Table 1. Mathematical equations used in the computing data's process

Nr.	Equations
1	$y = a_0 + b_1 x_1 + c_2 x_2 + d_3 x_3 + \dots + s_{19} x_{19}$
2	$a*x1+b*x2+c*x3+d*x4+e*x5+f*x6+g*x7+h*x8+i*x9+j*x10+k*x11+l*x12+m*x13+n*x14+o*x15+p*x16+q*x17+r*x18+s*x19$
3	$Y=a*x1+b*x2+c*x3+d*x4+e*x5+f*x6+g*x7+h*x8+i*x9+j*x10+k*x11+l*x12+m*x13+n*x14+o*x15+p*x16+q*x17+r*x18+s*x19$

3. Results and discussion

After having processed the data of the observed sample tests, the values of the regression equation coefficients have been registered for the studied horse jumps over the oxer fence in the entire length of the jump and the bar-limbs distance. Thus, $x_1, x_2, x_3, \dots, x_{19}$, being the coefficients corresponding to the a, b, c, \dots, s variables interpreted as points of the regression line $y = f(x_j)$ while all the values of x_j (for $j < i$) are constant. It has been proved that the a variable is unnecessary, taking into account that the a, \dots, s variables are included in the model (as an alternative hypothesis, a is necessary in the model to predict the y values). In this case, a (Student) partial t test has been used, calculated according to the variation explained by x_i , excluding the explanation based on the other variables. The obtained *prob* (t) probabilities included in the table, show that for the $p < 5\%$ coefficients, the hypothesis rejects the analysis leading us to the conclusion that the variables corresponding to those coefficients cannot be removed from the model. On the other hand, the variables corresponding to the $p > 5\%$ coefficients can be removed from the model. R^2 , the multiple determination coefficient, which explains the influence of the y dependent variable upon the studied parameters (a, b, \dots, s), has also been calculated for each particular licence and obstacle (the length of the jump and the corresponding to the bar-limbs distance).

After calculating R^2 , the multiple determination coefficient which explains the influence of the y dependent variable upon the studied parameters (a, b, \dots, s), (the term parameter is statistically used, it actually refers to the morphological traits; *mathematical model based on regression equation*, namely the total length of the jump and the bar-limbs distance were considered parameters

in this context), the following situations has been obtained:

B level – 130 cm height / 150 cm width oxer

Length of the jump

$R^2 = 0.99927$, meaning that the explained variant is of 99.92%, and only 0.08% stand for other factors that have not been included in the equation. Thus, for the length of the jump over the oxer obstacle, the mathematical model based on regression equation emphasized only one major character. The morphological character is represented by figure 1 and it is represented by the body mass. But, it must be underline here, that the calculated body mass was calculated on the values registered for the height at withers, the thorax perimeter or the hearth girth and the body length.

Bar-limbs distance

$R^2 = 0.87053$, meaning that the explained variant proportion is of 87.05%, and 12.95% depend on other characters. Thinking that it was a reason to balance the penury of characters for the length of the jump, all 18 traits have been obtained again (figure 2) corresponding to $p > 5\%$. With values upper than 9.0% were the ancoliure length (9.8), the body length (9.7), the height at croup (9.6) and at back (9.3), the neck (9.1) and the head length (9.1); values upper or equal than 8.0% were determined at the height at withers (8.8), the pelvis inclination angle (8.6), the hearth girth (8.5) and the hearth girth height (8.4), the croup width at hips (8.3) and the chest width (8.1), the cannon girth (8.1) and the thorax depth (8.0); there were two characters with values upper than 7.0%, respectively the body mass (7.9) and the hock joint angle (7.8); and again two, upper than 6.0%, the croup length (6.9) and the croup width at ischium (6.6).

For the two analyzed parameters, the total length of the jump and the bar – limbs distance, there was only one regression variable value in common, the body mass.

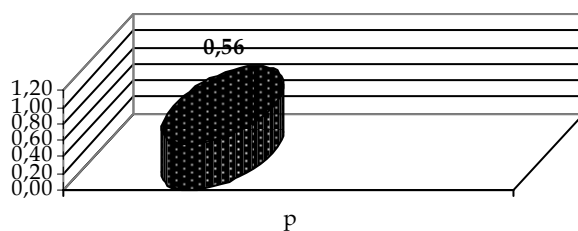


Figure 1. Main influence characters for the B level in the length of the jump at the oxer obstacle

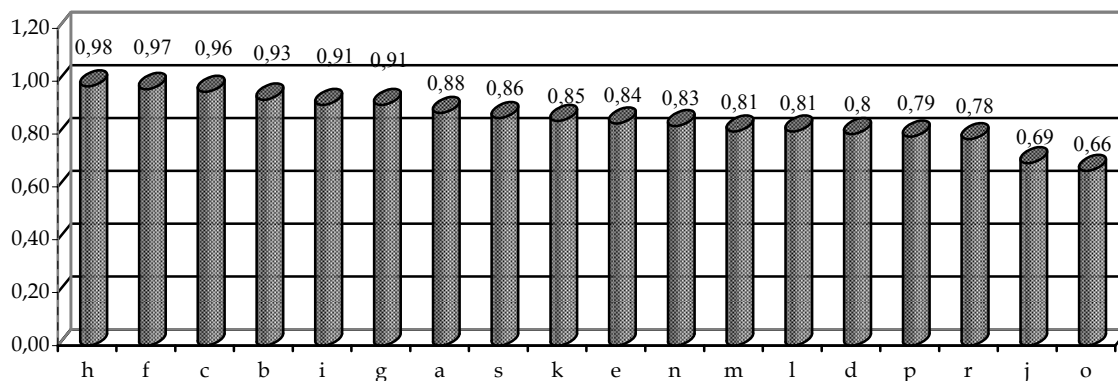


Figure 2. Main influence traits for the B level in the bar-limbs distance at the jump over the oxer fence

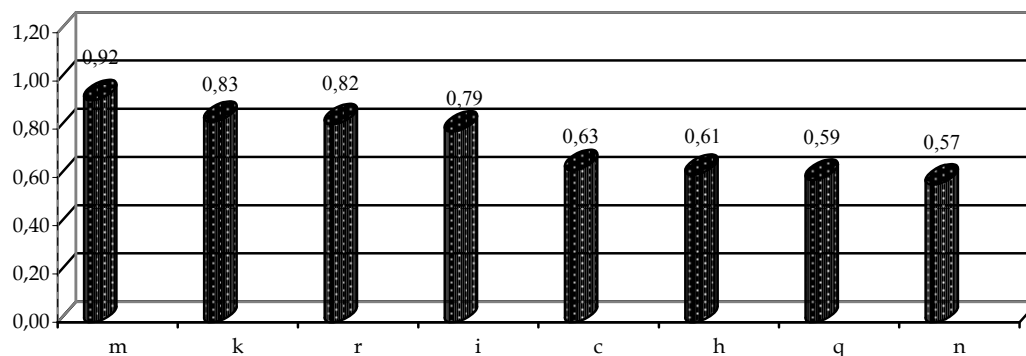


Figure 3. Main influence characters for the C level in the length of the jump at the oxer obstacle

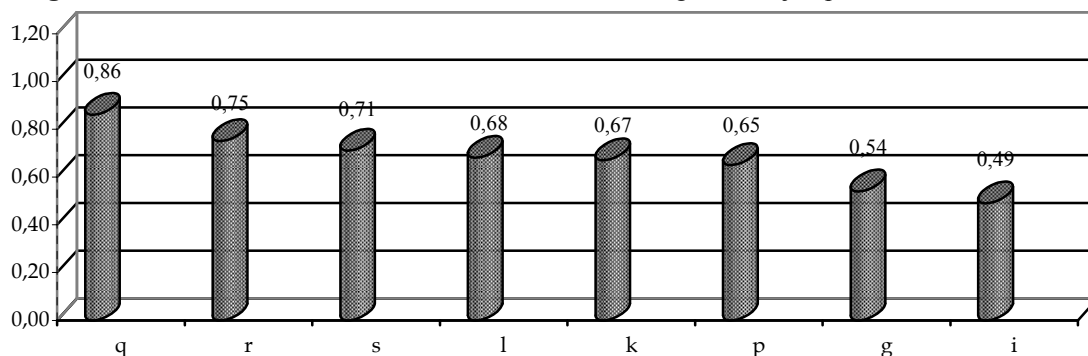


Figure 4. Main influence traits for the C level in the bar-limbs distance at the jump over the oxer fence

C level – 120 cm height / 150 cm width oxer
Length of the jump
 $R^2 = 0.60018$, that means a proportion of 60.01% explicated variance, lower than in the B case, and

an implicit value of 39.99 percentage points for the not included trials. A large number of characters registered again values upper than 5% (figure 3): chest width, 9.2%; hearth girth, 8.3%,

hock joint angle, 8.2%; neck length, 7.9%; height at croup, 6.3%; ancoliure length, 6.1%; inclination of scapula, 5.9%; croup width at hips, 5.7%.

Bar-limbs distance

Almost 1, was the value for $R^2 = 0.99999$ (99.99%). Indeed, the unexplained part was the lower part ever unexplained, 0.01%. Again, a series of 8 numbers of traits (figure 4): the

inclination of scapula angle, 8.6% was the higher value and at the other side was the neck length, 4.9%. Between these were the hock joint, 7.5%; the pelvis inclination, 7.1%; cannon girth, 6.8%; hearth girth 6.7%; the body mass 6.5% and head length, 5.4%. Traits in common, for the two parameters of the jump were the hearth girth, hock joint, neck length and the inclination of scapula.

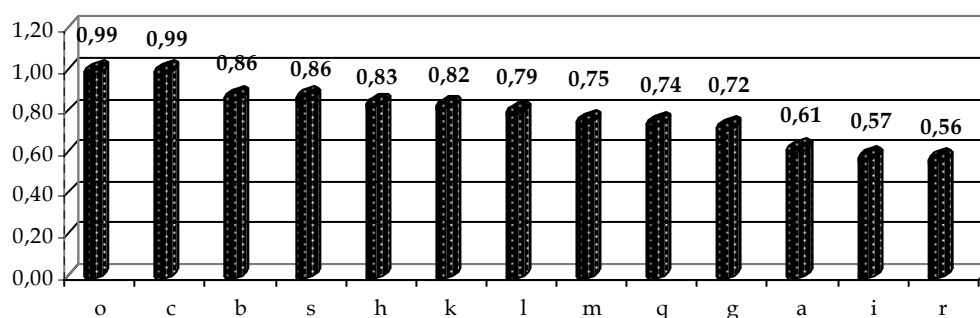


Figure 5. Main influence characters for the D level in the length of the jump at the oxer obstacle

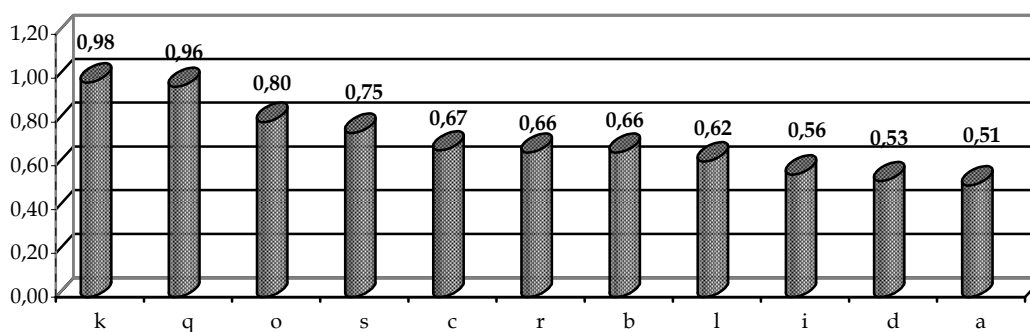


Figure 6. Main influence traits for the D level in the bar-limbs distance at the jump over the oxer fence

D level – 110 cm height / 130 cm width oxer

Length of the jump

A low score points percentage was obtained here with $R^2 = 0.50680$ (50.68%), that it means a half was explainable and a half was not explained by other non-computed data's (49.62%) for this case. Height probability results came out for two morphological characters both describing the croup (figure 5) and having the same result 9.9%: width at ischium and the height of it. The height at back and the pelvis inclination registered 8.6%, the ancoliure length 8.3%, the hearth girth 8.2% and the cannon girth 7.9%, the chest width 7.5%, inclination of scapula obtained 7.4%, the head length 7.2% and the lowest values were for the height at withers (6.1%), neck length (5.7%) and hock joint angle (5.6%).

Bar-limbs distance

In the case of the mathematical modelling regression equation for the bar-limbs distance, the

result was lower, respectively $R^2 = 0.47062$ (47.06%), not a very important or significant difference, but it turns the balance in the favour of the un-known elements with 52.94% on the other side. Like figure 6 shows, the obtained values were: hearth girth, 9.8%; inclination of scapula, 9.6%; croup width at ischium, 8.0%; pelvis inclination, 7.5%; height at croup, 6.7%; hock joint, 6.6%; height at the back, 6.6%, cannon girth (6.2%), neck length (5.6%), thorax depth (5.3%) and the height at withers, 5.1%.

For the length of the jump were obtained 13 characters with values upper than 5% and for the bar – limbs distance 11 characters; out of these, 10 were in common for the both parameters.

E level – 100 cm height / 130 cm width oxer

Length of the jump

$R^2 = 0.73927$, respectively 73.92% was the proportion of the explicated variance at this level;

correspondently, 26.08% was in the favour of other elements that were not take part in this analyze. Out of the 19 tested morphological traits, 9 obtained to stay in the first half of the results (figure 7): body length, 9.9%; thorax depth, 9.7%; inclination of scapula, 9.6%; height at withers, 9.2%; hearth girth height, 9.2%, hock joint (8.7%), height at croup (8.6%), ancoliure length (7.6%) and croup width at ischium, 5.8%.

Bar-limbs distance

The second time, we registered here a score under 50 percent, with $R^2 = 0.45999$, respectively

45.99% versus 54.01% uncounted trials. Even the result in ensemble has a low participation; there were a lot of characters (10) included (figure 8), as follows: croup width at hips, 9.5%; chest width 9.4%; pelvis inclination, 9.2%; inclination of scapula, 8.4%; croup length, 8.1%; croup width at ischium, 7.8%; head length, 7.2%; body mass, 6.9%; hock joint, 5.9%; cannon girth. Three traits were in common: the inclination of scapula, the hock joint and the croup width at ischium.

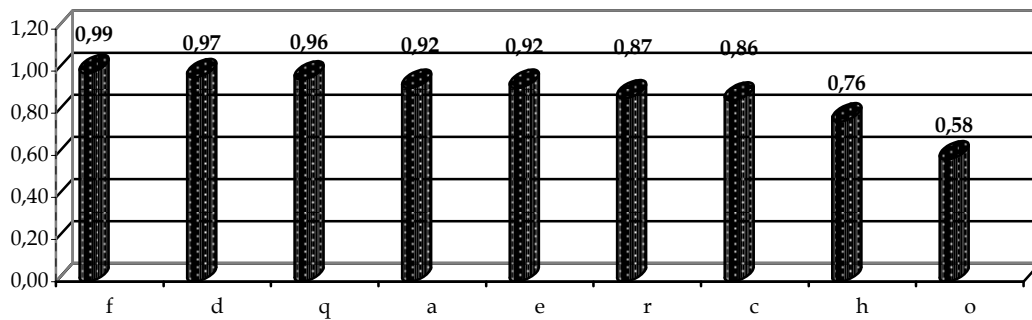


Figure 7. Main influence characters for the E level in the length of the jump at the oxer obstacle

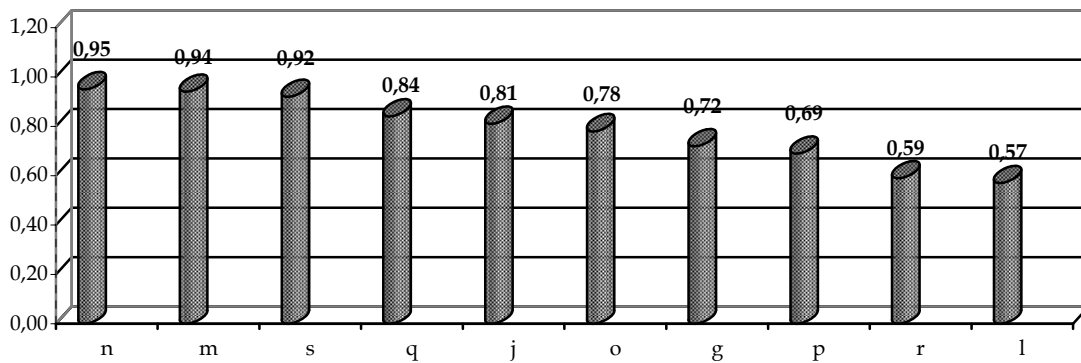


Figure 8. Main influence traits for the E level in the bar-limbs distance at the jump over the oxer fence

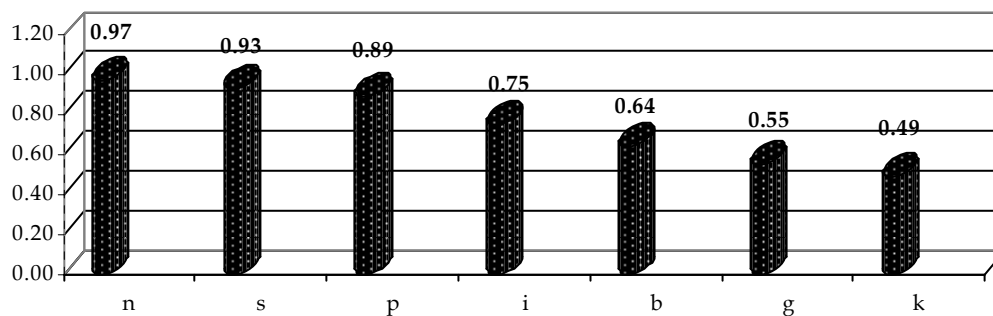


Figure 9. Main influence characters for the F level in the length of the jump at the oxer obstacle

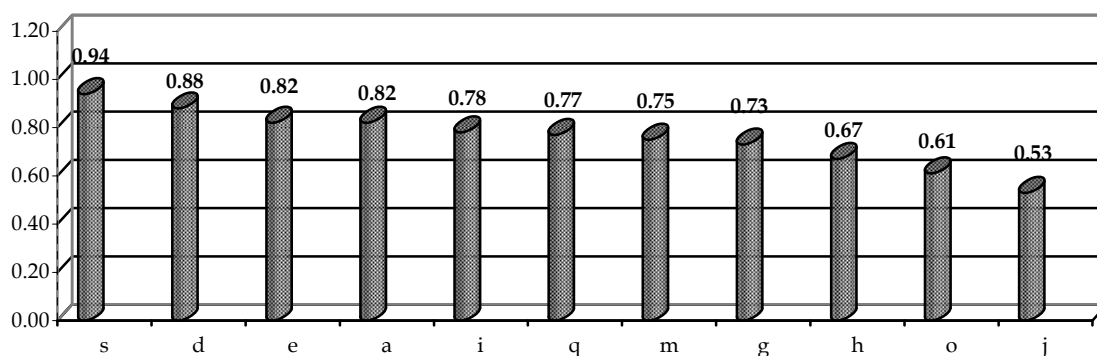


Figure 10. Main influence traits for the F level in the bar-limbs distance at the jump over the oxer fence

F level – 80 cm height / 100 cm width oxer

Length of the jump

The last studied F competition level, relieve a parameter $R^2 = 0.67359$ (67.36%) and implicit a not analyzed 32.64% trials proportion. Seven characters resulted here with percentage values from 9.7 to 4.9 (figure 9). There were: croup width at hips, 9.7%; pelvis inclination, 9.3%; body mass, 8.9%; neck length, 7.5%; height at back, 6.4%; head length, 5.5%; hearth girth 4.9%.

Bar-limbs distance

For the second measured parameter at this height, $R^2 = 0.40471$, that means an under unit report for the explicated variance (40.47%) in one hand and for the non explicated variance (59.53%) in the other hand. Figure 10 show the main influence morphological characters at this point: pelvis inclination, 9.4%; thorax depth 8.8%; heart girth height, 8.2%; height at withers, 8.2%; neck length, 7.8%; inclination of scapula, 7.7%; chest width, 7.5%; head length, 7.3%; ancoliure length, 6.7%; croup width at ischium, 6.1%; croup length, 5.3%. The neck length and the head length were both present in the obtained results from the mathematical modelling.

4. Conclusions

The power of explication, of the multilinear regression model is indicated by R^2 which shows the percent of the dependent variable variance was explicated by the variance of the independent variables.

The taken into study parameters, respectively the entire length of the jump and the bar-limbs distance in jumping over a spread obstacle, an oxer, was explicated extremely looked from 99.99% to 40.47% based on the taken into study biometrical characteristics of the sport horses. The

length of the jump, count results from 99.92% (B level) to 50.68% for the D competition level; others in order were E with 73.92%, F with 67.35% and C with 60.01%. For the second distance, the highest result was 99.99% for the C level; the lowest was for F, 40.47%. On the second place was for the B level, 87.05% and than 47.06% for D level and 45.99% for the level E.

The morphological characters, included in the above results, counted from 1 to 18 elements.

The horse selection, for sport generally and for obstacles particularly, is a theme for the owner, or the future owner, trainers and riders. To obtain a new generation with correct biometrical characters, is an important target which can start based on studies like this.

The obtained value, for the multiple determination coefficients, nearby 1.00, in most of the cases and especially for the high B and C levels, showed the efficiency of the model and a good selection for the included factors. The lower values for this determination coefficient, obtained sporadically, for the middle categories (D and E) and the lowest one F, showed in fact, that there are some sport horses which did not accede in the equestrian sports based on a correct conformation and good biometrical aspects, but probably on a greater capacity of détente and a lot of suitable work.

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