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Impact of the individual characteristics of French trotters on their racing performance

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Abstract: The aim of this study was to investigate the influence of selected biometric characteristics on French trotters' racing performance. Moreover, the work attempts a prediction of racing performance indexes based on the horse's individual characteristics, as well as the evaluation of the usefulness of an alternative method of a horse's intravital measurements that limits the stress of the animal. A population of 64 horses of French trotter breed appearing in the Polish Stud Book of Trotters, which had participated in races in 2015, were subject to the investigation. The research material was represented by the indexes of racing performance combined with photo-biometric measurements of those horses. It was proved that the angulation patterns of trotters' limbs have an influence on the value of racing performance indexes. The highest statistical significance was found for the pelvic limb. A significant discrepancy in the values of the racing performance indexes was found in the tested population. Furthermore, the usefulness of the alternative photo-biometric methods was proved. In conclusion, based on the results and using the presented method, a trotter horse can be visually examined in terms of its predisposition to win races.

Key words: Biometrics, race performance, horse, French trotter

1. Introduction

Trotting races have recently gained greater popularity in Great Britain, Italy, and Spain. Across the world, different breeds of trotter horses are used, including American, French, Orlowski, Russian, Finnish, Icelandic Toelter, Gudbrandsdal valley (Dole Trotter), Couroce-Malblanc, and Hinchcliff. This sport has gained new fans, spectators, and jockeys year after year, mainly due to the spectacularity and the dynamism of the horses' movement [1].

The recent literature on trotters' conformation is mainly based on the trotters entered in the German and Danish Stud Books [2,3]. The results obtained are only appropriate for the groups of horses that were tested and should not be extrapolated to other populations that are significantly different in their use. Furthermore, there is not much information about the influence of biometric characteristics on racing performance. In addition, there is a lack of information concerning a trotter's predisposition to win a race with respect to its body posture and conformation, and such information cannot be deduced when taking into account different breeds of racehorses (e.g., thoroughbred conformation).Therefore, the aim of this study was to attempt to combine the characteristics of individual horses with their predispositions for trotting races. This work includes an entire population of French trotters participating in the races in a given season.

2. Materials and methods

The investigation consisted of the statistical elaboration of the influence of a horse's body postures on its racing performance. The statistical trial included 64 horses of French Trotter breed competing in Poland. The races took place on a grass track. All of the races were done with a flying start. Furthermore, all of the races held in Poland in 2015 were included in the investigation. The racing distance varied from 1800 m to 2600 m. The racing performance is represented here by a specifically defined indicator.

2.1. Calculation of horse racing performance indicators

The racing performance was evaluated by means of two indicators, which in general describe how many times a horse has won a competition of various ranks. Therefore, the main indicator, in this case, is the money that has been won by the horse. More important and prestigious races command higher prices. The first indicator, win over start (WoS), is the ratio of the money earned in the considered

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period to the number of starts, as shown in Eq. (1). The second indicator is the individual success rate (ISR), which is the amount of money won by a horse during the considered period concerning the average money won by all horses competing during the season, shown in Eq. (2). The last indicator shows the condition of the horse compared with the rest of the trial population.

$$\mathrm{WoS} = \frac{\mathrm{W}}{\mathrm{S}} \quad (1)$$

where W is the prize money [PLN] won during the considered period and S is the number of starts.

$$\mathrm{ISR} = \frac{\mathrm{W}}{\bar{\mathrm{x}}} \quad (2)$$

$$\bar{\mathrm{x}} = \frac{\mathrm{W_{all}}}{\mathrm{n}} \quad (2a)$$

where W is the prize money [PLN] won during the considered period, $\bar{x}$ is the average prize money [PLN] earned by all horses participating in the competition during the considered period, n is the number of horses born in a given year entered into the Polish Trotter Book, and W_{all} is the total amount of prize money won during the considered period.

2.2. Angulation patterns of the horses

The angulation patterns of horses were determined with the aid of a photo-biometric method, which in essence consists of image processing and analysis. Here, it was performed in the MATLAB environment using the Image Processing Toolbox. For reliability of the process, all photos were taken with the same resolution of 3456 × 2304 pixels. The camera was positioned at a distance of 3 m from the horse in a perpendicular plane and was set at a height of 1.7 m. The horses were measured in the middle of the racing season when they had the highest performance level and body musculature. Every horse included in the investigation was measured as shown in Figure 1. The details of the conformation are explained in the Table.

The results of any race depend upon a vast number of unpredictable variables. For this reason, with a significance level of $\alpha = 0.1$, statistical data analysis was done according to the ISO 3534-3 standard ("Part 3 –Design and analysis of the experiment").

3. Results

Measurements of the angles of the forelimbs and hindlimbs made using the photo-biometric method showed that the population of French trotters did not deviate from the standard values described in the literature [4–7]. The results of the horses' body posture measurements are shown in Figure 2.

The analysis of ANOVA of main effects of horse conformation on racing performance revealed that forelimbs and hindlimbs independently influence different indicators. The hindlimbs only significantly affected ISR, having no statistical impact on the win on start (WoS) ratio. Conversely, the forelimbs only statistically affected WoS, having no impact on ISR. In fact, different angles of the forelimbs only have a statistical impact on this indicator.

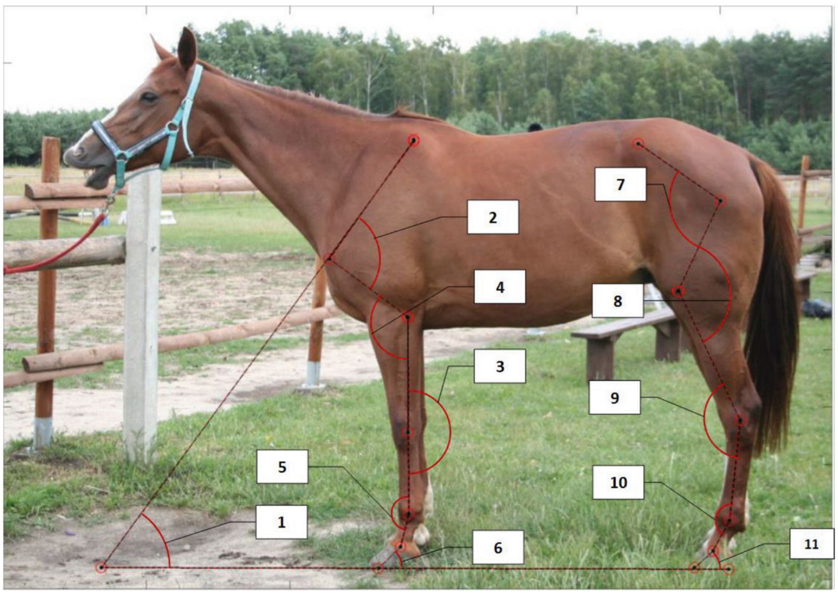

Figure 1. Horse conformation: (1) Shoulder vs. ground angle; (2) Shoulder angle; (3) Caprus joint; (4) Elbow angle; (5) Fetlock joint angle; (6) Pastern vs. ground angle; (7) Hip angle; (8) Stifle angle; (9) Hock angle; (10) Hind fetlock joint angle; (11) Hind limb pastern vs. ground angle.

Table. Details of horse conformation.

1	Shoulder vs. ground angle	The angle between lines designated by the tuber of the scapula's spine to the ground
2	Shoulder angle	The angle between lines designated by the tuber of the scapula's spine - the greater tubercle of the humerus - radius bone head
3	Caprus angle	The angle between lines designated by the radius bone head through the center of the carpus to the fetlock joint
4	Elbow angle	The angle between lines designated by the grater tubercle of the humerus through the radius bone head to the lateral styloid process of the radius
5	Fetlock joint angle	The angle between lines designated by the center of the carpus though the fetlock joint to the pastern joint
6	Pastern vs. ground angle	The angle between lines designated by the pastern joint through the coffin joint to ground level
7	Hip angle	The angle between lines designated by the point of hip through the hip joint to the stifle joint
8	Stifle angle	The angle between lines designated by the hip joint through the stifle joint to the lateral malleolus of the tibia
9	Hock angle	The angle between lines designated by the stifle joint through the center of the hock to the lateral collateral ligament of the hind fetlock joint
10	Hind fetlock joint angle	The angle between lines designated by the base of the 4th metatarsal bone through the fetlock joint to the pastern joint
11	Hindlimb pastern vs. ground angle	The angle between lines designated by the pastern joint through the coffin joint to ground level

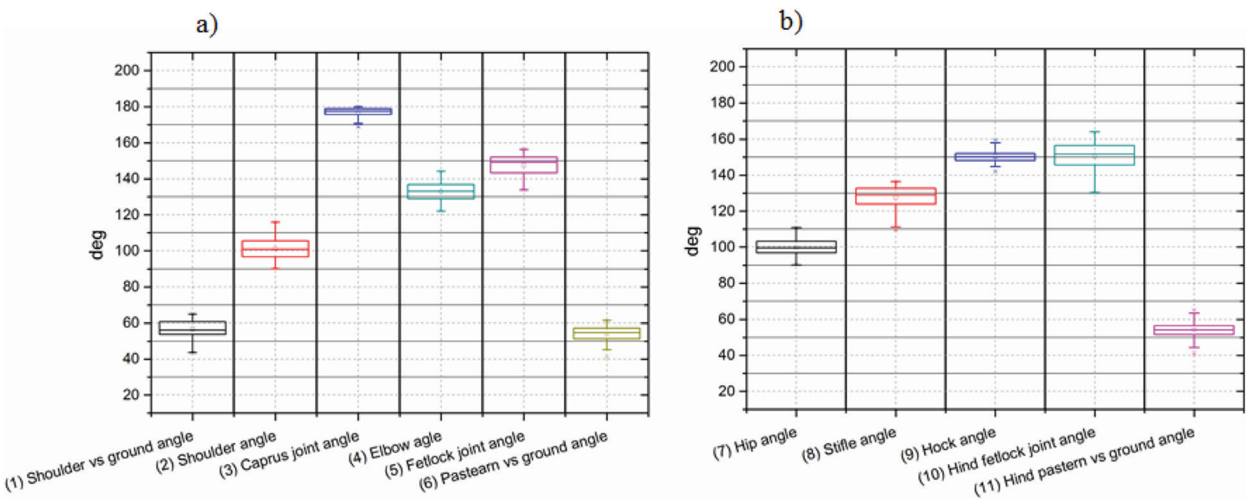

Figure 2. Results of observed angles: a) front legs; b) hind legs.

Furthermore, in this case, a strong, quadratic influence is present. The results of WoS and ISR are represented in the form of a box and whiskers chart in Figure 3.

Pareto charts depicting statistically valid angles are shown in Figure 4. As can be seen, the WoS indicator is only dependent on the set of individual angles. The influence is strong, and in the case of the elbow angle it is even quadratic. All of the values indicated on the right side of the Pareto chart bars (Figure 4) express the effect of the variable on the result. It is a quotient of an effect/standard

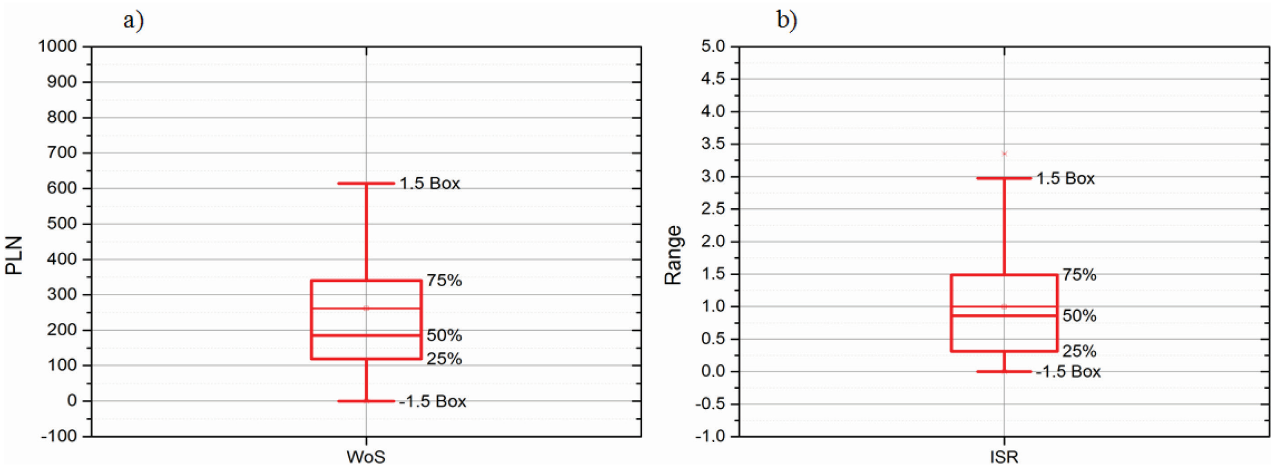

Figure 3. Observed results for the entire trotter trial: a) WoS; b) ISR.

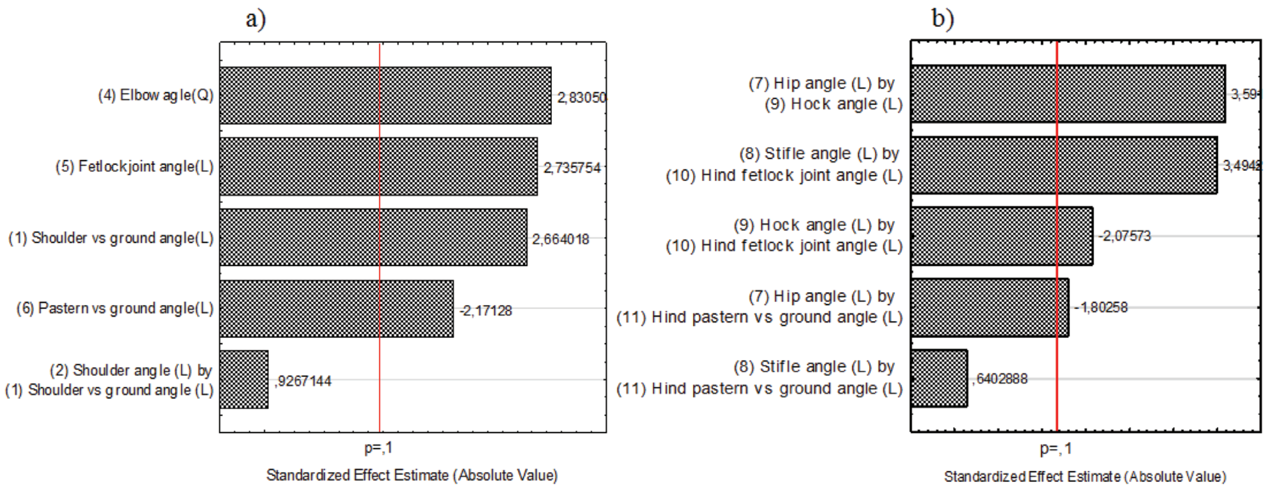

Figure 4. Pareto charts of the statistically significant angles: a) angles affecting WoS; b) angles affecting ISR; (L) – linear relationship, (Q) – quadratic relationship.

error; hence, the higher the value, the more significant the impact of the variable on the results. This suggests that all of the angles similarly affect the WoS factor. The value of the coefficient, in this case, is greater than 2.

The influence of all the angles considered together on the racing performance indicator was evaluated by determining the desirability function, as well as the response profile. Figure 5 contains grid points for each factor ranging from the observed minimum to the observed maximum, which, in consequence, depicts the tendency of the variable rather than the value itself. The optimum is obtained by means of finding the values of the angles, which provides the highest value of the indicator. The optimal value of the desirability function is 0.52, which corresponds to the value of WoS of 982.7 PLN. The angles that provide such a value are in bold and indicated by the red line in Figure 5.

The same procedure was also applied to the hindlimbs. The desirability function for the ISR indicator, which is statistically valid for the hindlimb conformation, is shown in Figure 6. Here again, the chart contains the five grid points between the observed value of the angles written in bold in Figure 6 under the red line.

In order to depict the relation of two interacting angles, a fitted response surface is presented in Figure 7. The blue circles in the figure represent the observed value of angles, and the surface colors represent the value of the ISR indicator. For example, the highest importance was found for the hip angle interacting with the hock angle (Figure 4).

4. Discussion

The literature is limited in terms of the impact of body posture on the predisposition of a horse to win a race, especially when trotters are considered. The research

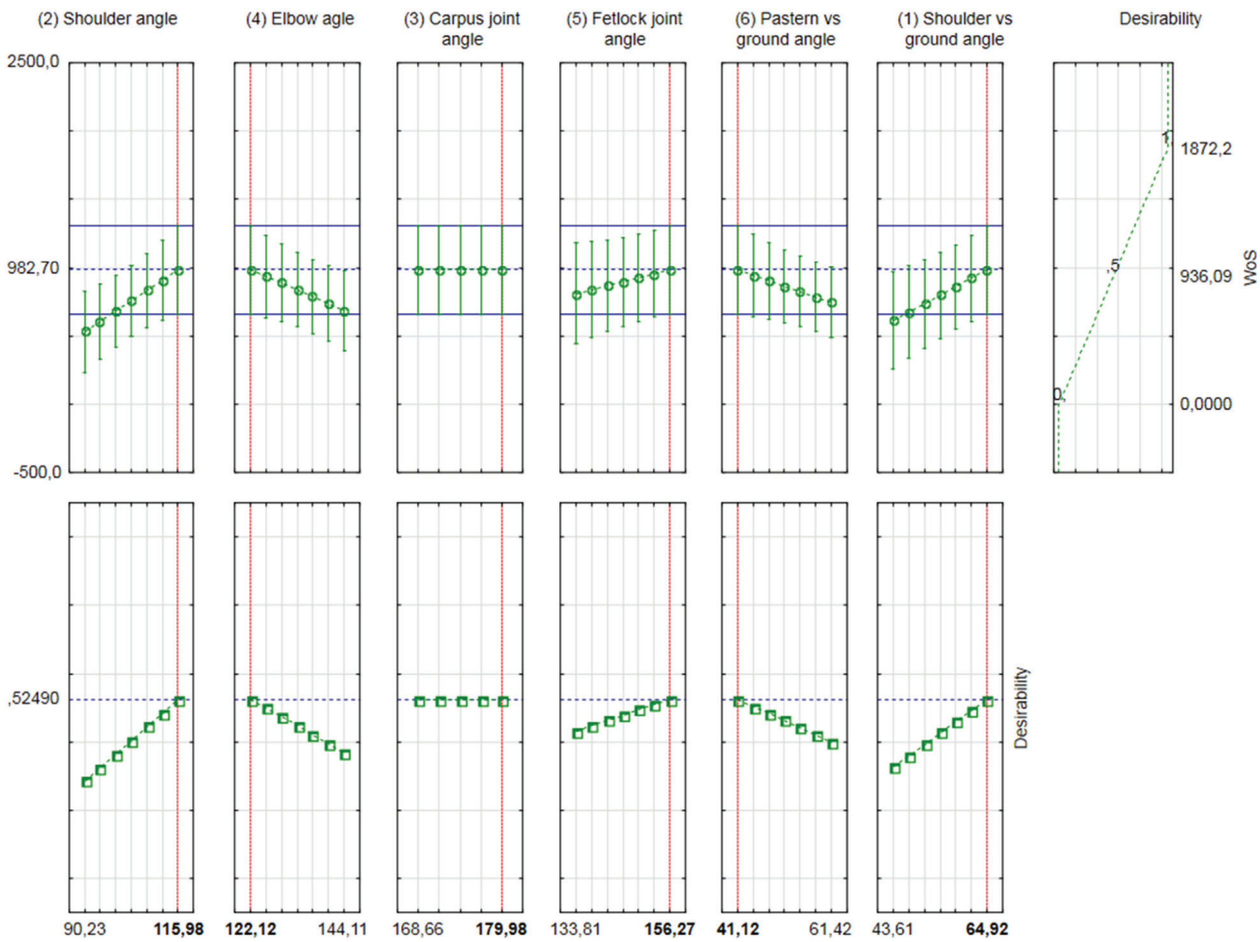

Figure 5. The desirability function of WoS.

described here indicates that such a tendency exists and is statistically valid; therefore, including this knowledge during trotter race horse selection and training seems to be justified.

The conformation of trotters correlated with the indicators described in this work was considered in a previous work [8]. In this case, based on the observed runs of 30 young trotters (approximately 16 months old), variables such as length and frequency of step were determined in relation to the conformation of the horse. Furthermore, based on biometric measurements and the racing performance indicators, the statistically significant parameters of body posture were evaluated. It was found that of all 23 biometric dimensions, only 14 have a significant relation to the racing performance indicators. There was not, however, any specification of the optimal value of dimensions of body posture.

Identifying patterns of individual breeds of horses and linking them with racing performance can help predict the effectiveness of training and sports performance. Therefore, in the literature, there are many studies related to equine conformation, including Polish horses [9–11], Hucul horses [12], Pura Raza Espanol horses [13–15], and sports use [3,16,17]. The available studies are based on the analysis of body indexes, such as body length index, the peak of the croup, eurysomy (percentage of thoracic vertebrae to the angular length of the body), or measurements (e.g., head length, chest circumference).

Measurements of the angles of the forelimb and hindlimb joints made with the aid of the photo-biometric method and computer program showed that the population of French trotters does not differ from the norms of the angles of the joints described in the literature [4–7]. Furthermore, based on the data, it can be stated that the trotters, by their conformation, are predisposed to racing. This is due to the angle of the shoulder in the range of 90° to 105°, which causes a greater range of step; the diagonal positioning of the blade relative to the ground, with a prominent, fast, and long step; the sloping rump and open stifle angle cause rebound from the ground as well as the fetlock joint that has a high impact on the strength of the limb reflection from the ground and the converting

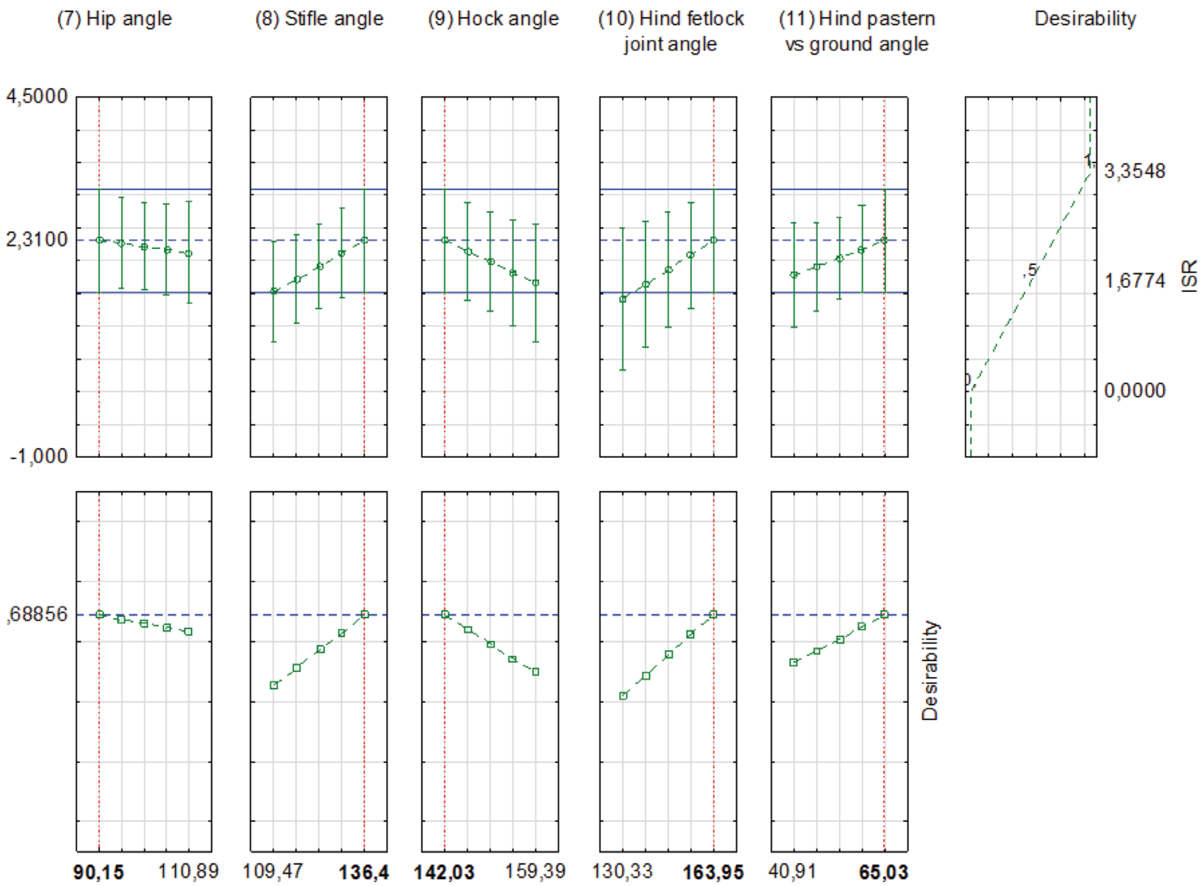

Figure 6. The desirability function of ISR.

of muscle contraction into motion [18]. In the publication presented by Kaproń et al. [19], it was found that the proportions in the body posture of purebred Arabian and full blood English horses had a significant effect on their race performance.

Forelimbs (statistically influencing only WoS) correspond to the maneuverability of a horse during a race and the length of its step. There is not much energy generated by the forelimbs. It appeared in this case that only individual angles are statistically important. There was no interaction between them. Furthermore, the elbow angle is represented by a quadratic function, which means that a small alteration would significantly change the result. Therefore, the angle of the elbow can be considered as the most important index in the forelimb in terms of the WoS indicator. It was found that all of these angles have a similar value of the effect/standard error coefficient (Figure 4), which means that these input factors are almost equally important.

The hindlimb angles (Figure 4) only have a statistical impact on the ISR racing performance indicator. Furthermore, each angle in the interaction is linear. This means that only the correlation of two angles can have an effect on the predisposition of the horse to win. Such a tendency was anticipated. Hindlimbs are the main source of power during a race [20]. The appropriate conformation of hind legs provides, among others, the power to bounce off the ground, the length of the step, and amortization [21].

The highest importance was found for the hip angle interacting with the hock angle. It appears that the highest value of the ISR indicator is present with the lowest value of the angle. The opposite tendency is present for the interaction of the stifle angle and pastern angle. In this case, the indicator increases with respect to the increase of both of these angles. It is because obtuse angles provoke the loss of the springiness of hindlimbs. A larger stifle angle and pastern angle provide a greater range of limb motion with a longer step, and the pastern angle generates larger shock dissipating properties. These enable the ISR factor (and hence the predisposition of a horse to win), with respect to the random value of interacting angles, to be predicted.

Based on the current investigation, it can be stated that a photo-biometric method can be used as a predictor of a horse's racing performance and therefore of the predisposition of the horse to win a competition. This, in

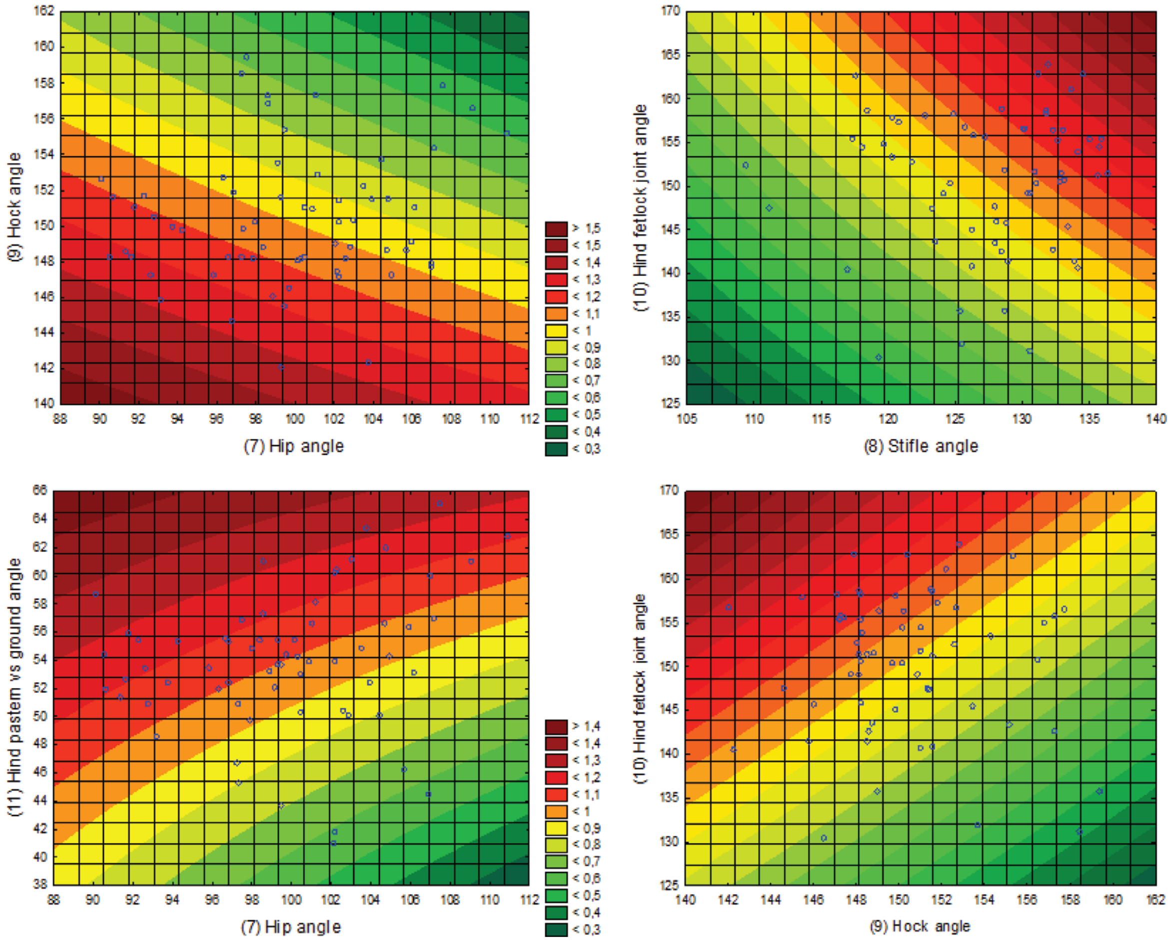

Figure 7. Fitted surfaces of interactive angles influencing the ISR.

turn, is directly proportional to the value of a horse. It was found that the angles of a horse's limbs potentially increase the horse's predisposition to win. However, it should be remembered that the condition of the outcome of both indicators also depends on variable values, such as the experience of the jockey or the condition of the horse during the season. The only way to counter the unpredictable disturbing variables is to consider a large enough trial that could statistically represent the population. The photo-biometric measurements were performed on every trotter horse that actively participated in races, both in Poland and in several cases abroad. Moreover, the analysis of the test power allows the trial to be considered as a representation of the population.

In conclusion, the primary outcome of the investigations described here is the determination of the optimal body posture of French trotters. Knowing this, the visual inspection can help to predict the predisposition of a horse to win. The optimal body angulation was found and shown in Figures 5 and 6. Furthermore, a general tendency was evaluated for each angle.

In general, based on the conducted research, it can be concluded that a French trotter will have the highest potential to successfully win a race with the following angulations of the forelimb:

1. Shoulder angle – the increasing angle increases the potential of a horse. The optimal value of this angle is 116°.
2. Elbow angle – the most sensitive angle amongst the others. A small change can be significant in the overall results. The decreasing angle increases the potential of a horse. The optimal value of this angle is 122°.
3. Knee angle – the range of this angle should be close to 180°.
4. Fetlock joint angle – the increasing angle increases the potential of a horse. The optimal value of this angle is 156°.
5. Pastern vs. ground angle – increasing angle increases the potential of a horse. The optimal value of this angle is 65°.

Hindlimb:

1. Hip angle – decreasing angle increases the potential of a horse. The optimal value of this angle is 90°.

2. Stifle angle – increasing angle increases the potential of a horse. The optimal value of this angle is 136°.

3. Hock angle – decreasing angle increases the potential of a horse. The optimal value of this angle is 142°.

4. Hind fetlock joint angle – increasing angle increases the potential of a horse. The optimal value of this angle is 90°.

5. Hind pastern vs. ground angle – decreasing angle increases the potential of a horse. The optimal value of this angle is 65°.

Furthermore, in the case of the hindlimb, an interaction between angles was found. Hence, during the visual evaluation of a trotter, a set of angles should be considered rather than individual angles. The potential of an examined trotter, in this case, can be evaluated by considering the following:

1. Hock angle with hip angle.
2. Hind fetlock joint angle with stifle angle.
3. Hind pastern vs. ground angle with hip angle.
4. Hind fetlock joint angle with hock angle.

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