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SHORT REPORT

Analysis of angles of taking off, landing, and work of limbs in horses jumping above the spread obstacle of different structure

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Visual structure of obstacle course is one of factors that create difficulty of parcourse in horse show jumping. The aim of this study was to investigate the effect of different obstacle (doublebarre) height and structure on selected jumping parametres of horses. Observations of routine training were carried out in the training centre for young stallions. Fifty-six jumps of 18 stallions were filmed and measured on two different heights (95 cm and 105 cm) and two different front views of the spread obstacle (difference between highest poles – 5 cm and 15-20 cm). The effects of obstacle structure on angle of taking off, angle of landing, two angles describing position of limbs above obstacle and distances of limbs lifting above the obstacle were evaluated by analysis of variance. The differences in taking off and landing angles as well as position of limbs above the obstacle appeared to be more markedly affected by height ($P<0.001$) than by front view ($P<0.05$) of the spread obstacle. The parametres that were affected by front view of the obstacle were angles describing position of front limbs above the obstacle, however, not regulary.

KEY WORDS: doublebarre / horse jumping / jumping parametres / obstacle structure / parcourse / spread obstacle

Visual structure of obstacle is widely known as one of the main factors that create difficulty of parcourse in horse show jumping [Koziarowski and Jankowski 2004, Gego 2006]. Visual aspects of obstacle course concern line, form, light, colour, space, frame and symmetry [Gego 2006]. The open-work structure of obstacle is described as important element of horse's recognition of the obstacle difficulty [Niecko 2004]. Obstacles with open-work front view are thought to be especially difficult for young horses [Paalmann 1979]. The present work aimed at studying the effect of different front views of spread obstacle on jumping parametres in horses.

Material and methods

The observations were carried on 18 halfbred stallions trained under the same conditions of 100 days performance test in Poland. Horses were filmed during their regular work in the mid-training period. Stallions jumped over the combination line of three obstacles in a jumping corridor assigned for free jumping according to Polish Horse Breeders Association rules [PZHK 2005abc]:

– **the guarding pole on the ground**;
– **the first cross-poles obstacle with the height 60 cm**;
– **the second cross-poles obstacle with the height 60 cm**;
– **the spread obstacle (doublebarre), height 95 cm and 105 cm with the same width of 75 cm for both heights (Fig. 1 – A, B, C and D).**

The distance between the first (ground) pole and the first cross-poles obstacle was 2.5 m while distances between next obstacles were 6,4 m and 6,8 m, respectively.

Data file consisted of 56 jumps. According to obstacle structure the data were divided into different classes according to obstacle heights (95 cm and 105 cm) and its different front view expressed as the differences between heights of the highest poles of the first and second stand (open-work structure of the obstacle – 5 cm and 15-25 cm). All horses jumped first over lower heights and smaller differences between poles of the obstacle. Warming-up consisted from 20 minutes work on longing in walk and trot.

Films were digitalized and frames with the adequate legs position were selected for measurements.

Following angles were measured on selected frame:

1. **Angle of trunk at taking off** (an angle between line parallel to the ground and line formed by the highest point of wither and the highest point of croup on the selected frame at taking off, when the last full hoof contact of leading limb was observed[1]).
2. **Angle of trunk at landing** (an angle between line parallel to the ground and line formed by the highest point of wither and the highest point of croup on the selected landing frame, when the first full hoof contact of the trailing limb was observed).

[1]Terminology according to Hole *et al* [2002].

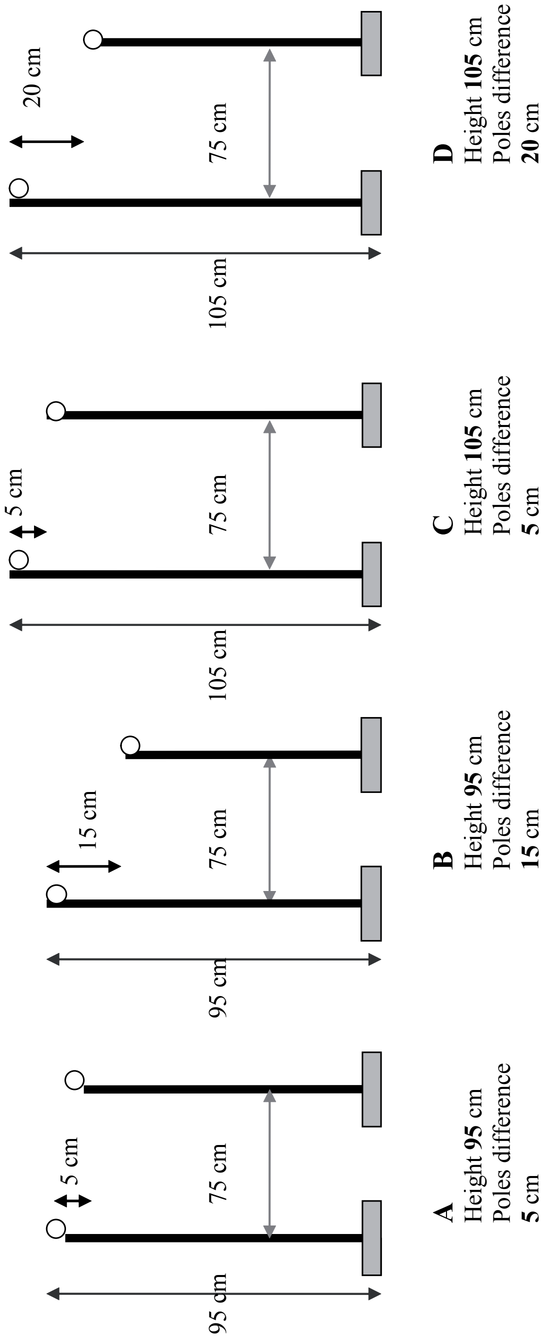

Fig. 1. Different obstacle structures – two heights of the obstacle (95 cm and 105 cm) with two different front views of the obstacle (5 cm and 15-20 cm)

3. **Angle of work of the knee joint** (an inside angle between forearm and cannon-bone at the frame where the hoof of limb was above the middle of the pole).
4. **Angle of position of front limb** (an outside angle of position of cannon-bone in relation to the line parallel to the ground).
5. **Angle of work of hock joint** (an inside angle between second thigh and cannon-bone at the frame where the hoof of limb was above the middle of the pole).
6. **Angle of position of hind limb** (an outside angle of position of cannon-bone in relation to the line parallel to the ground).

Additionally, linear parametres of limbs liftings above the obstacles were considered. Height of limb lifting was defined as distance between the lowest point of limb above the highest pole of obstacle and the highest point of that pole. Described data were obtained for left and right limb separately.

All measurements were performed with MULTISCAN manual programme for video image analysis. The influence of obstacle structure was investigated by analysis of variance using Mixed procedure of SAS programme. The statistical model included two fixed effects: height of the obstacle and difference between poles of the obstacle and the random effect of the horse.

Results and discussion

The effect of obstacle height on jumping parametres is presented in Table 1. This factor affected all parametres of work of front limbs as well as the angles of the trunk at taking off and landing. Heights of lifting were lower on higher obstacles about 4 cm in both front limbs. The lower values of angles of the work of limbs suggested that horses bent their limbs more above higher obstacles. The angles of the trunk at taking off and at landing were higher by higher obstacles. Majority of differences for the effect of the obstacle height were identified as signifcant at $P<0.01$.

Less remarkable was the respective effect of front view of the obstacle, as presented in Table 2. The effect was significant for some parametres of the work of front limbs, however, not for all of them. Significant differences for this effect were identified at $P<0.05$. Horses tended to keep their limbs more bent by the smaller difference between poles. Reported results do not seem to be in accordance with the common opinion. Handbooks dealing with training of young jumping horses include information that the obstacle visual structure is of special importance. Larger differences are not recommended during training of young horses because of their expected difficulty to recognize the real size of the obstacle [Paalmann 1979, Némethy 1997, Pollmann-Schweckhorst 2002]. However, small differences found in this study between pole visualisations might be caused by getting used of horses to such obstacles during training. Different results could be achieved in studies performed on less trained horses.

Table 1. The effect of obstacle height on selected jump parametres measured

Parametre		Obstacle height	
		95 cm (n=31)	105 cm (n=25)
Angle of the trunk at taking off (°)	LSM	24.7[A]	26.7[A]
	SE	0.7	0.7
Height of lifting of FL (cm)	LSM	11.0[A]	7.6[A]
	SE	1.1	1.2
Angle of the work of the knee joint FL (°)	LSM	74.9[A]	60.9[A]
	SE	3.1	3.3
Angle of the position of the cannon-bone FL (°)	LSM	69.1[A]	54.7[A]
	SE	4.0	4.3
Height of lifting of FR (cm)	LSM	12.0[A]	8.5[A]
	SE	1.0	1.1
Angle of the work of the knee joint FR (°)	LSM	67.6[a]	58.7[a]
	SE	2.5	2.8
Angle of the position of the cannon-bone FR (°)	LSM	61.0[A]	48.8[A]
	SE	3.4	3.7
Height of lifting of HL (cm)	LSM	14.8	12.9
	SE	1.8	1.9
Angle of the work of the hock joint HL (°)	LSM	75.0	73.6
	SE	3.8	4.0
Angle of the position of the cannon-bone HL (°)	LSM	80.8	78.9
	SE	3.5	3.7
Height of lifting of HR (cm)	LSM	14.6	12.3
	SE	1.6	1.7
Angle of the work of the hock joint HR (°)	LSM	73.4	70.3
	SE	3.5	3.7
Angle of the position of the cannon-bone HR (°)	LSM	82.2	82.4
	SE	3.1	3.3
Angle of the trunk at landing (°)	LSM	21.2[A]	24.8[A]
	SE	0.9	0.9

[aA]Within rows means bearing the same superscripts differ significantly at: small letters –$P \leq 0.05$; capitals – $P \leq 0.01$.

Differences between spread obstacles of different structure were reported in investigations based on penalty points [Stachurska 2002] as well as on the basis of biomechanical studies [Clayton and Barlow 1989] in which the differences between types of obstacle as well as between heights and widths of them were found. The height of obstacle is widely known as a basic effect influencing jumping parametres [Jeleń 1976, Clayton and Barlow 1989, Lewczuk *et al*. 2004ab]. Some differences in difficulty of visual perception were reported between obstacle colours [Stachurska 2002]. The effect of the obstacle structure on jumping parametres in horses should further be investigated. Even the visual perception of the horse is not a new topic [Hall 2007] its the practical aspect were less studied. Different reports exist on the discrimination of colours, degree of luminescence and shades of colour [Murphy and

Table 2. The effect of spread obstacle structure on selected jump parametres measured

Parametre		Height difference of the highest poles between the first and second stand of the spread obstacle 15-20 cm (n=26)	5 cm (n=30)
Angle of the trunk at taking off (°)	LSM	25.9	25.6
	SE	0.7	0.7
Height of lifting of FL (cm)	LSM	9.4	9.3
	SE	1.1	1.2
Angle of the work of the knee joint FL (°)	LSM	71.5 [a]	64.4 [a]
	SE	3.1	3.2
Angle of the position of the cannon-bone FL (°)	LSM	67.3 [a]	56.4 [a]
	SE	4.0	4.2
Height of lifting of FR (cm)	LSM	10.0	10.5
	SE	1.1	1.1
Angle of the work of the knee joint FR (°)	LSM	65.8	60.5
	SE	2.5	2.8
Angle of the position of the cannon-bone FR (°)	LSM	59.8 [a]	50.3 [a]
	SE	3.4	3.7
Height of lifting of HL (cm)	LSM	12.9	14.7
	SE	1.8	1.9
Angle of the work of the hock joint HL (°)	LSM	74.7	73.7
	SE	3.9	4.0
Angle of the position of the cannon-bone HL (°)	LSM	79.7	79.9
	SE	3.6	3.6
Height of lifting of HR (cm)	LSM	12.3	14.6
	SE	1.6	1.8
Angle of the work of the hock joint HR (°)	LSM	72.7	71.0
	SE	3.5	3.6
Angle of the position of the cannon-bone HR (°)	LSM	81.8	82.8
	SE	3.2	3.2
Angle of the trunk at landing (°)	LSM	22.7	23.3
	SE	0.9	0.9

[aA]Within rows means bearing the same superscripts differ significantly at: small letters –P≤0.05; capitals – P≤0.01.

Arkins 2007] what can also be based on different testing procedures used. However, it was reported that overall horse vision is less able to give information about visual detail than the human one, even if the field of the vision is wider [Saslow 2002]. That thesis could explain the obtained results.

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Analiza wybranych kątów odbicia, lądowania i pracy nóg koni skaczących przez przeszkodę *doublebarre* o różnym stopniu wizualizacji drągów

S t r e s z c z e n i e

Struktura przeszkód jest jednym z elementów, które decydują o trudności pokonywania parkuru przez konie. Celem pracy było zbadanie wpływu wyglądu przeszkody widzianego przez konia na wybrane parametry skoku. Prowadzono obserwacje rutynowego treningu młodych ogierów trenowanych podczas testu 100-dniowego w zakładzie treningowym. Skoki 18 ogierów (łącznie 56 skoków) filmowano i mierzono na dwóch różnych wysokościach (95 cm i 105 cm) oraz dwóch różnych ustawieniach frontu przeszkody typu *doublebarre* (5 cm i 15-20cm). Parametry skoków (kąt odbicia, kąt lądowania, dwa kąty opisujące ustawienie nóg nad przeszkodą oraz wysokość przenoszenia nóg nad przeszkodą) charakteryzowano za pomocą analizy wariancji. Różnice między kątem odbicia a lądowania, jak również pozycji nóg nad przeszkodą były zależne w większym stopniu od wysokości przeszkody ($P<0.001$) niż od ustawienia jej frontu ($P<0.05$). Jedynymi parametrami, które okazały się zależne od ustawienia frontu przeszkody były pozycje nóg przednich nad przeszkodą, które jednak okazały się niejednakowe dla nogi lewej i prawej.