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CHARACTERISTICS OF LIMB FLEXION ANGLES OF ROADSTER BREEDS IN SHOW RING AND SHOW JUMPING

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ABSTRACT

The image of a horse's movements, its level of endurance, suitability for various types of equestrian sports greatly depend on the quality of its limbs. Horse's movement includes persistent action of limb joints, where the joint is the fulcrum, the force is the muscle movement, and the mass is the part of the horse's body that needs to be set in motion. Movement of a horse is a mechanism including force that lifts the body up and pushes it forward. The influence of forces on the horse's body promotes the movement of the body up and down along an undulating bend. The bend of this movement line gets smaller when a horse walks since the horse almost does not take off the ground. An increase in line bend is presented in trot, gallop, and especially in high jumps, where the horse takes off the ground with all its legs after the hit. Musculature plays a significant role in the upper limbs of the horse, it is also responsible for the body movement and has strong muscles, bones interconnected by angles.

Disciplinary: Equine Studies.

1. INTRODUCTION

Forelimb angles are less but hind limb ones are more opened. The opening of these angles entails lengthening of limbs, therefore, contributing to wide and elastic movements of the horse (Steiner, 2006). Hind limbs of horses include long bones and form acute angles (Dalbiac, 2003). They, therefore, provide bones with a larger spread and greater strengthening of the horse's movement (Golovacheva, 2005).

Strong tendon-ligamentous apparatus plays an important role in the lower part of the horse's limbs as this part consists of bones of smaller volume, length and has few muscles. Thus, the angles in the lower part of the horse's limbs set at an open angle form a greater resistance force (Gorbovskaya, 2009, Hagen, 2004).

The structure of the horse's body includes the strong development of limb muscles and their connection with the trunk (Raynor, 2006). When the horse moves, the extensor muscles work actively

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compared to the flexor muscles (Gorelov, 1955).

Extensor muscles play a significant role in the movement of horses, provide an impulse to the whole body, and support it with tendons and joints while standing (Paalman, 1999).

Flexor muscles perform flexion of limbs free of weight (Kenneth, 2007). The development of muscles and bones of hind limbs precedes the forelimbs since the main load falls on hind limbs during the movement (Klimke, 2015; Myers, 2005).

Extension of the upper gallop show jumping, in particular knee, sacroiliac, shoulder, and elbow joints, plays an important role when the horse moves forward and up. Extension of the lower angles, in particular hock, fetlock joints, occurs simultaneously with the extension of the upper angles of limbs (Wanless, 2017; Pavia, 2007).

Strong muscle tension is necessary for flexion and extension of acute angles formed by the bones, the longer these bones, the longer the horse's stride or jump (Allen, 2003). This structure of limb levers is usual for fast gait horses.

In classical equestrian sports, in particular show jumping and the show ring, the values of flexion angles of fore and hind limbs have great importance (Lonnell, 2017). Efficiency and performance of using horses in sports depend on their opening; the data can be used as preliminary criteria for assessing the quality of horse movement and jumping (Shingalov, 2005; Shreiner, 2001). Thus, present research considering existing issues is relevant.

This research aims to conduct a comparative assessment of limb flexion angles of roadster breeds in the show ring and show jumping. In this regard, the objectives are to determine flexion angles of horse's limbs in trot, gallop, and jump in the flight phase, and to figure out an index of success of horses of various breeds in show jumping and show ring.

2. MATERIALS AND METHODS OR RESEARCH

The research was carried out on the base of the equestrian center of the Perm Krai and the «Repriz» equestrian school on 70 roadster horses of the Trakehner, the Hannoverian breeds, and sports crossbreeds that were 3, 4, and 5 years old.

In show ring and show jumping competitions, the assessment of various kinds of gait such as extended walk, extended trot, gallop, and horse's jump was carried out. The horses took part in show jumping competitions of various levels: up to 100 cm, 110 cm, and 130 cm.

In the flight phase, a fixed position of the horse that meets the requirements of the correct element was chosen. That position was short in time and easily visually fixed.

Motor qualities were assessed when moving at an increased pace, trot, or gallop. The flexion phase of the limbs should be maximum, then the angles between the shoulder blade and shoulder, shoulder and shoulder, shoulder and heel, lower leg and metatarsus were calculated.

Using the method proposed by B. Langlois and J. Froidevaux, points were applied to the joints of horses as orientations, similar to the rotation axes of various sections of the driving rays. As a result, biomechanical characteristics of movement at various gaits were revealed.

The assessment of flexion angles of fore and hind limbs was carried out with a camera set on the distance of 20 meters and a height of 130 meters from the horse.

Digital images of biomechanical values were processed by the Pic Pic Portable computer program. These are the angles between scapula and shoulder, shoulder and forearm, forearm and cannon, gaskin and cannon – in the show ring; the angles between scapula and shoulder, shoulder and

forearm, forearm and cannon, poll and withers, the angle of sacroiliac joint – in show jumping.

The performance capacity of horses was identified according to the results of show jumping and show ring competitions. Index of success that describes a horse's performance in both showjumping and show ring competitions was calculated.

Index of success was defined by the formula:

$$IS = 100 \times (M-1)/(N-1) \quad (1),$$

where

M – place the horse took in competition;

N – the number of participants in percent.

The obtained data were processed biometrically according to the methods of Student's variation statistics using the Microsoft Office Excel program.

Differential significance is determined when $P \geq 0.95$, $P \geq 0.99$, $P \geq 0.999$.

3. RESEARCH RESULTS

In our studies in classic equestrian sports such as show ring and show jumping, different sports horse breeds were used. The Trakehner horses have good health, a calm temperament, light and free movement; perform a wide walk and trot as well as a powerful gallop. The Hannoverian breed has a wide walk, rhythmic trot as well as a springy gallop that significantly affects the results of competitions in the show ring and is appreciated in show jumping. The horses of sports crossbreeds are the following: the Anglo-Trakehner, the Arabian-Trakehner, the Hannover-Latvian. The Anglo-Trakehner crossbreed is distinguished by agility, strength, and endurance. The Arabian-Trakehner crossbreed has endurance and quick temper. Hannover-Latvian horses have dynamic movements and possess innate speed and jumping qualities (Table 1).

Table 1: Distribution of horses according to the breed.

Total number of horses	Breed			Total sum
	The Trakehner	The Hannoverian	Sport crossbreed	
Number	28	21	21	70
%	40.0	30.0	30.0	100

In the research, the horses were represented in a quantitative ratio: the Trakehner breed 40%, the Hannoverian breed 30% and the sports crossbreed 30%.

Bones of horse's limbs are composed of shoulder levers that mean the joints are a rotation point of the lever. The muscles themselves during their contraction contribute to the horse's movement. Moreover, greater development of extensor muscles is more important than flexor muscles.

The values of limb flexion angles in the stand of rest depend on the horse's exterior characteristics. It is worth noting that the flexion angle of forelimbs is more obtuse compared to hind limbs since these bones are shorter. Forelimbs are located almost under the horse's center of gravity and set wider than the hind legs. Therefore, this contributes to less fatigue of forelimbs muscles. The angles of hind limbs are preferably more acute since they perform a repulsion function; they are very firmly connected with the pelvis that fuses with the sacrum. Therefore, this provides bones of hind

limbs with a significant spread, maximum strength as the levers, which move the body forward, especially in fast gait.

The shoulder joint consists of scapula and humerus. This joint has the highest mobility among the joints of forelimbs. The angle of the horse's shoulder joint is 95-105° in the state of rest, the less the angle, the longer its bones. The less the angle of the shoulder joint, the bigger the spread of scapula and humerus, the more straightening and lengthening of the forelimb, the faster the movement, the less sensitive the strikes from the bottom. The shoulder joint of roadster horses has the least angle (according to Prof. W. Durst). The angle of the elbow joint on average is equal to 125-130°.

The hock joint is the most important spring adapter of hind limb for the implementation of its pushing function. The angle of the hock joint increases the springiness of the hind limb; in horses of fast gait, the angle of the hock joint is obtuse, about 150°.

It is noted in the data analyses of Table 2 that 4-5 years old horses of Hannoverian breed have fewer values of angles of the shoulder-scapular joint and hock joint in the extended walk. Due to the closed angles, the Hannoverian horses will have a wide and broad stride while the movement.

Table 2: Angles of limb flexion in an extended walk, (X±Sx).

Criteria	Breed					
	The Trakehner		The Hannoverian		Sports crossbreed	
	Age, years					
	3	4–5	3	4-5	3	4-5
Scapula – shoulder	90*±1,14	89*±1.00	89±0.58	84±0.48	88±1.35	85±0.71
Shoulder – forearm	79*±0.36	78*±1.06	87*±1.26	86*±0.87	79±0.61	83±2.13
Forearm – cannon	103*±1.50	104±0.81	100±1.44	89*±0.31	97*±0.23	100±2.10
Gaskin – cannon	120±2.91	118*±1.75	115*±2.17	108*±0.86	120±4.15	113±1.89

*- P≥0.95; **- P≥0.99; ***- P≥0.999

Analyzing the obtained data, it should be noted that the angles between scapula and shoulder in 4-5 years old horses of Hannoverian breed are more closed in comparison with the Trakehner and horses of sports crossbreeds. The angle between gaskin and cannon is significantly less by 11 ° (P> 0.999) in comparison with a similar angle in 4-5 years old Trakehner horses. Consequently, the closure of these angles entails a wide and broad stride when the horse moves.

Such gaits as extended walk, trot, and gallop are fast gaits. Consequently, the more closed the angles between scapula and shoulder, shoulder and forearm, forearm and cannon, the stronger will be the spread of scapula and humerus according to the research of Langlois B. and Froidevaux J. The load on the horse's joints decreases at this time, the hind limbs also work quite productively (Table 3).

Table 3: Angles of limb flexion in the extended trot, (X±Sx)

Criteria	Breed					
	The Trakehner		The Hannoverian		Sports Crossbreed	
	Age, years					
	3	4 – 5	3	4 – 5	3	4 – 5
Scapula – shoulder	93 *±0.45	92*±0.67	91±1.13	87*±0.45	91*±0.83	89±1.03
Shoulder – forearm	65±0.61	65±0.40	72*±1,21	69±0.90	71±1.30	69±1.23
Forearm – cannon	94±0.88	91±0.59	96±0,53	94±0,96	90±2,09	89±1.44
Gaskin – cannon	126*±0.83	122*±1.36	116*±0.86	114*±0.86	119±2.62	119±2.21

*-P≥0.95; **- P≥0.99; ***- P≥0.999

The data of Table 3 show that the angle between scapula and humerus in extended trot in 4-5 years old Hannoverian horses are more closed and significantly lower by 4.7°(P>0.999) in comparison with 4-5 years old Trakehner horses. The angle of gaskin and cannon in 3 and 4-5 years old Hannoverian horses are less by 8°-12° compared to the Trakehner, by 4.8-5.1° compared to the sports crossbreed. When the horse moves, more closed angles contribute to their opening at the maximum range providing precise, flowing and steady trot.

Counter canter plays a significant role in a show ring. It improves not only the horse's innate gallop but also develops directness, helps to achieve collection.

A collection is a form of riding in a show ring where the horse must possess a high impulsion and be able to concentrate physical and mental exertion. It is possible to achieve collection by the high rising of the neck, increased flexion in the croup, the head bending in the poll, and arc-shaped rounding of the back. With reference to the research of Gorbovskaya (2009), the horse's neck should be slightly raised and rounded without tension forming a smooth blend from the withers to the poll. When the croup flexes to the center of gravity, the horse's back is rounded and the horse reaches full collection (Table 4).

Table 4: Angles of limb flexion in gallop, °(X±Sx)

Criteria	Breed					
	The Trakehner		The Hannoverian		Sports crossbreed	
	Age, years					
	3	4 – 5	3	4 – 5	3	4 – 5
Scapula – shoulder	102*±2.08	96±0.65	90*±1.02	88±0.63	95±0.36	94±0.72
Shoulder – forearm	82*±2.55	81*±1.28	83*±1.97	78 *±0,84	86±0,92	84*±0,64
Forearm – cannon	95*±1.69	94*±0.90	104*±1.77	97*±2.26	93*±1.24	92*±0.79
Gaskin – cannon	112±1.28	111±1.25	107 ±3.46	102*±1.35	123±2,26	121*±1.30

*P≥0.95; **P≥0.99; ***P≥0.999

The data of Table 4 show that the angle between scapula and shoulder in gallop of 3 years old Hannoverian horse is significantly higher (P> 0.999) in comparison with 3 years old Trakehner horses by 12 °. 3 years old Hannoverian horses are also significantly surpass 4-5 years old horses of sports crossbreed in the angle between gaskin and cannon – by 19° (P> 0.999).

The horse's jump implies a strong flexion of the hind and forelimbs (Figure 1).

Figure 1: Leap of the horse.

The work of the forearm depends on the grouping of the limbs and the relaxation of the horse 's head and neck (Figure 2).

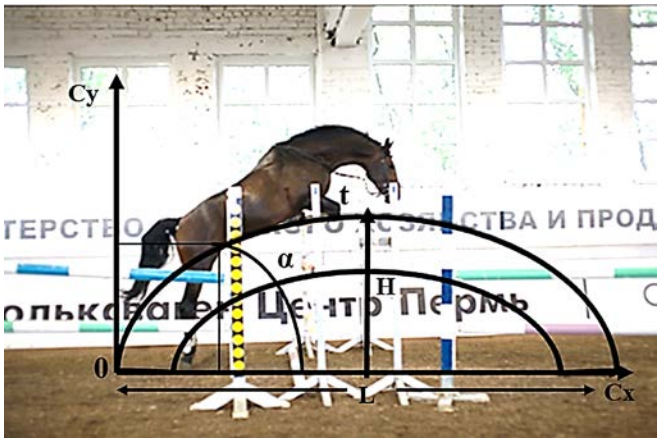

Figure 2: Biomechanics of horse jumping.

The jump of a horse includes a variety of mechanisms of action, of which, the main one is the grouping of the fore and hind limbs. The relaxed head and neck of the horse, as well as the grouped limbs, have a great influence on the work of the forearm (Table 5).

The horse's jump implies a strong flexion of the hind and forelimbs. The work of the forearm depends on the grouping of the limbs and the relaxation of the horse 's head and neck.

Table 5: Angles of limb flexion in the flight phase jumping, °(X±Sx)

Criteria	Breed					
	The Trakehner		The Hannoverian		Sports crossbreed	
	Age, years					
	3	4 – 5	3	4 – 5	3	4 – 5
Scapula – shoulder	69±2.11	58*±0.94	57*±1.04	51*±0.48	63±4.11	60±2.30
Shoulder – forearm	55±1.54	48±0.61	55±1.04	53±0.66	48*±1.56	47±0.95
Forearm – cannon	67*±0.88	66±0.76	66±1.28	62*±0.50	72±1.88	69±1.07
Gaskin – cannon	77±2.99	77±1.02	76 ±2.17	69*±0.38	89±1.62	86±1.07

*- P≥0.95; **- P≥0.99; ***- P≥0.999

Analyzing the obtained data, it can be noted that the angle between scapula and shoulder in the flight phase of jump is more closed in 3 and 4-5 years Hannoverian horses compared to 3 years old Trakehner horses by 12°. The angle between gaskin and cannon in 4-5 years old Hannoverian horses is more closed in comparison with 4-5 years old horses of sports crossbreed by 18º. Therefore, the more acute the flexion angles of limbs in jump, the stronger the probability to jump cleanly over the obstacles.

It is revealed in the course of research that the cleanliness of overcoming the obstacles and effectiveness in show jumping competitions depends on the values of flexion angles of poll and withers. The closure of sacroiliac joint angles occurs due to their opening. As the research data show, 3 and 4-5 years old Hannoverian horses significantly surpass 4-5 years old horses of sports crossbreed in the angle of withers by 4° (P> 0.999). Precision, accuracy, and rhythm of show ring elements completely depend on the values of flexion angles of fore and hind limbs. The stronger the horse flexes its limbs, the less the angles between scapula and shoulder, shoulder and forearm, forearm and cannon as well as gaskin and cannon. The spread of scapula and humerus will be greater and, respectively, the horse will move easily and broadly.

The results of horses' participation in show jumping competitions allow us to determine their performance capacity (Table 6). The data of Table 6 show that the horses of Hannoverian breed represent a high index of success in show jumping competitions 2019 – 64%.

Table 6: Horses' index of success in show jumping competitions, (X±Sx)

Breed	Year		
	2017	2018	2019
The Trakehner	40±5.98	51±4.86	59±6.29
The Hannoverian	40±6.59	56±7.80	64±2.37
Sports crossbreed	50±7.91	51±6.97	61±8.76

Table 7: Horses' index of success in the show ring, (X±Sx)

Breed	Year		
	2017	2018	2019
The Trakehner	40±7.64	42±7.65	48±6.78
The Hannoverian	35 ±8.56	47±7.98	50±8.16
Sports crossbreed	31±7.73	31±7.53	42±8.31

The results Table 7 of participation of horses in riding competitions allow us to determine their performance, indicating that the Hannoverian horses have a higher index of success in 2019 – 50% according to the results of the show ring.

4. CONCLUSION

The horses of Hannoverian breed are characterized by a high index of success in show jumping and show ring. Their values of flexion angles of fore and hind limbs provide their more effective opening in movement and, therefore, efficient use. Consequently, the use of Hannoverian horses in classical equestrian sports in the Perm Krai is most preferable.

5. AVAILABILITY OF DATA AND MATERIAL

Information about this study can be made available by contacting the corresponding author.

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