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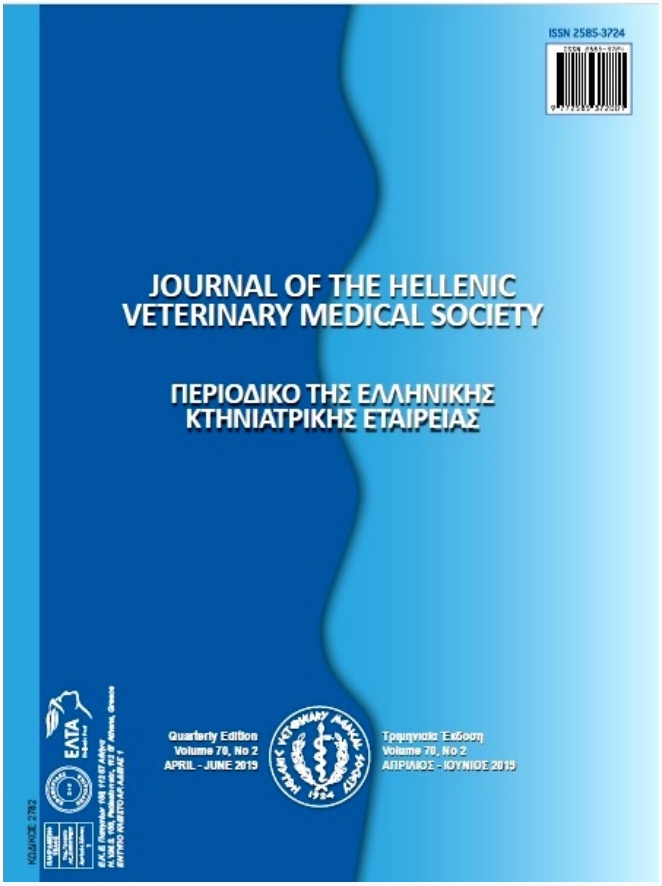

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Research article
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Evaluation of Abnormal Limb Conformation in Jumping Thoroughbred Horses

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ABSTRACT. Subjective, objective and photographic image using software Auto CAD programme were used for evaluation of limb conformation in 51 jumping thoroughbred horses. The abnormal limb conformations were included: standing under in front (58%), steep shoulder (55%), carpus valgus (45%), calf knee (31%), standing under behind (31%), short pelvis (31%) and straight hocks (16%). Linear and angular limb measurements showed standing under in front had increased elbow joint lateral angle, and decreased fore fetlock joint lateral angle. Steep shoulder displayed a significant increase ($P< 0.05$) in shoulder joint lateral angle and significant decrease in forearm front length. calf knee horses had significant decrease in the lateral angle of carpus joint. Short pelvis had a significant decrease in lateral length of pelvis and significant increase in croup angle and stifle joint lateral angle. Straight hocks showed the lateral length of both pelvis and gaskin showed a significant decrease and significant increase in the stifle joint lateral angle. Therefore, the current use of linear and angular measurements in relationships to abnormal limb conformation in the present study will allow for estimation of the future performance and soundness in jumping thoroughbred horses. In addition can be considered for selection athletic horse with less risk of lameness.

Keywords: abnormal conformation, limb, jumper, horses, Auto CAD program me.

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INTRODUCTION

Conformation, simply defined as "the relationship of form to function", is an indicator of performance and orthopedic health of athletic horses (McIlwraith et al., 2003). Many conformational faults were thought to play a role in musculoskeletal problems predisposition (Globe, 1992). The biomechanical loading of horse limbs and the risk of musculoskeletal injuries were attributed to conformation and the position of the limbs during stance phase of the stride (Dyson, 2018a). Good conformation is not synonymous with success and on the other hand, faulty conformation is not unsoundness, but it is a warning sign (Ross and McIlwraith, 2011). Poor conformation can produce abnormal strain on particular part of the body or limbs resulting in stretching or fracture and consequently lameness (Hawcroft, 1993).

Evaluation of horse conformation is carried out through subjective (Stashak, 1987) and objective methods (Johnston, 1996; Barrey, 1999, Clayton and Schamhardt, 2001). The subjective evaluation of conformation is the traditional and still the primary used method for evaluating equine conformation. However, it varies greatly between judges because it is based mainly on experience or opinion and very little on research (Magnusson and Thafvelin,1985). Both linear measurements and linear scoring system are the most popular methods to judge conformation in horses. Duensing et al. (2016) and Padilha et al. (2017) affirmed that the use of linear and angular measurements allowed an efficient selection of durable and competitive sport horses and could used as performance indices useful in a study of a bread specific conformation of athletic horses.

Limbs are essential for the functionality of the horse and conformation faults are strongly predisposed to limb pathology and lameness. Various conformation faults such as standing over at the knees, standing under at the knees, bench knees, cow hocks, and sickle hocks are reported to cause bog spavin, bone spavin, curb and many other affections (Pretorius, 2003). Therefore, the aim of this study was to evaluate objectively the fore and hind limbs conformation faults in relationship to lengths and angles measurements in jumping thoroughbred horses in Egypt.

MATERIAL AND METHODS

This study was carried out on 51 jumping thoroughbred horses (38 geldings and 13 females) bred in Armed Forces Equestrian Club, Egypt. Their average age was 8 years (5-15 years) and weighted 450-600 kg. All horses received the same management procedures, same training courses, and almost joined the same number of jumping courses/year.

Subjective evaluation of body conformation was carried out according to Stashak (1987). Objective method of evaluation of lengths and angles were performed according to Holmstrom *et al.* (1990), Magnusson and Thafvelin (1990); Anderson and McIlwraith (2004) and Robert *et al.* (2013). All horses were photographed standing on a flat, horizontal solid surface and were haltered. Reference points were established on the skin of the horse according Anderson and McIlwraith (2004a).Two views were taken for each horse; lateral (from the left side) and front photographs using Samsung PL80 28-mm digital camera 5X, 12 Megapixel. These photographs were digitally analyzed using computer aided image analysis; AutoCAD 2013 v19 program, a commercial software application for 2D and 3D computer-aided design, developed by Autodesk, Inc., available since 1982, California, USA. Finally, lengths and angles were measured for each horse using a measuring tape and goniometer used for calibration and scaling the measurements taken on the photos by AutoCAD 2013 v19 program.

Statistical analysis:

Descriptive statistical analysis for lengths and angles was done by IBM®SPSS® statistics v 20 program (IBM Corporation, 2009, New York, USA). All data were presented as mean and standard Deviation (SD) values. Kolmogorov–Smirnov test was conducted and $P > 0.05$ so the distribution was normal. Independent samples t-test was used to compare the normal and abnormal lengths and angles. A p value <0.05 was considered significant.

RESULTS

Seven varieties of abnormal limb conformation were recorded in the examined horses. These abnormal conformations included standing under in front (Fig.2), steep shoulder, carpus valgus (Fig3) and calf knee (Fig.4) in the forelimb and standing under behind (5) short pelvis (Fig.6) and straight hocks in the hind limb. The abnormal horse conformation showed characteristic variable lengths and angles of the limbs compared to the normal horses as shown in (Tables 1 & 2).

Figure 1. Thoroughbred jumper horse showing standing under in front the fore limb under the body when the horse is viewed from the side.

Figure 2. Thoroughbred jumper horse with carpal joint is directed medially from the front (Capus Valgus) and base narrow.

Figure 3. Thoroughbred jumper horse showing the carpal joint is directed backward from the lateral view (Calf knee).

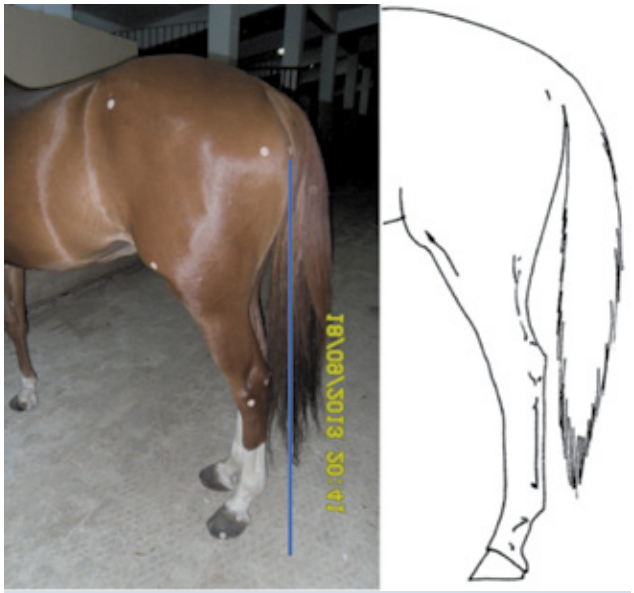

Figure 4. Thoroughbred jumper horse (lateral view): the hind limb is placed too far forward. The perpendicular line drawn from the point of the buttock (tuber ischii) would strike the ground slightly far behind the limb.

Figure 5. Thoroughbred jumper horse showing short and long pelvis.

The forelimbs abnormal conformations (Table 1) were included standing under in front (58%) of the total examined animals. The measured lateral lengths of the arm and hind cannon showed significant (P<0.05) increase. Lateral angle of elbow joint had significant (P<0.05) increase and the fetlock joint angle displayed significant (P<0.05) decrease in comparison with normal horses.

Steep shoulder represented (55%) of examined horses and displayed a significant (P<0.05) increase in shoulder joint lateral angle. Fore arm front length revealed a significant (P<0.05) decrease in comparison with normal horses. *The* findings results of carpus valgus represented (45%) of the total examined horses and the carpal joint angles had significant (P<0.05) decrease. The lateral and front lengths of fore arm showed a significant (P<0.05 increase in comparison with normal horses.

Calf knee abnormal conformation was recorded in 16 horses (31%) of the total examined horses and had a significant (P<0.05) decrease in the lateral angle of carpal joints compared to normal horses (Fig. 4).

The abnormal hind limbs conformation recorded (Table2) were Standing under behind and represented (31%) of the total examined animals. Thigh lateral length and stifle joint lateral angle showed a significant (P<0.05) increase compared and Gaskin length showed a significant decrease in comparison with normal horses. Short pelvis represented (31%) of the total horses examined had a significant (P<0.05) decrease in lateral pelvis length compared to normal horses. Short pelvis displayed a significant (P<0.05) increase in croup angle and stifle joint lateral anglein comparison with normal horses**.**

Straight hock was found in (16%) of the total examined animals. The lateral length of both pelvis and gaskin showed a significant (P<0.05) decrease and the stifle joint angle displayed a significant (P<0.05) increase compared to normal horses.

Table 1. Lengths and angles of normal and abnormal forelimbs conformations in the examined jumping thoroughbred horses.

Trait	**Lengths (cm)**			**Angles (°)**		
	Variable	**Normal**	**Abnormal**	**variable**	**Normal**	**Abnormal**
Standing under in front	Shoulder	69±3.5	70±5.3	Shoulder	98±3.8	99±3.4
	Arm	33±2.6	35.8±2.7*	Elbow	136±4.3	139±3.7*
	Fore arm	45±2.3	46±2.5	Fore fetlock	143±3.8	140±5.6*
	Fore cannon	27.5±2.7	28.7±2.1			
	Hind cannon	34.85±2.6	37.85±3.5			
Steep shoulder	Shoulder	69±5.8	69.92±4.19	Shoulder	97±3.8	100±3*
	Arm	34±2.8	34.89±2.8	Elbow	137±5	139.4±3.5
	Fore arm	48.3±2.9	46.5±2.5*			
Carpus valgus	Fore arm (lateral view)	46±2.5	48±2.9*	Right dorsal carpal	177.8±1.6	174±2*
	Fore arm (front view)	44.7±2.4	46±2.5*	Left dorsal carpal	178.5±1	174±1.3*
	Fore cannon	28.98±2.3	28.15±2.5			
Calf knee	Fore arm	47.8±2.9	49±3.2	Lateral carpal	178.78±1	176.38±2.2*
	Fore cannon	27±2.3	28.8±2.4			

*Significant at P< 0.05.

Table 2. Lengths and angles of normal and abnormal hind limb conformations in the examined jumping thoroughbred horses.

Trait	Lengths (cm)			Angles (°)		
	variable	Normal	Abnormal	variable	Normal	Abnormal
Standing under behind	Pelvis	53±4.7	51±4.4	Croup	143±3.8	145±5.8
	Thigh	47±4.8	51±4.2*	Hip	85±5.8	89±8.4
	Gaskin	56±3.4	51±4.4*	Stifle	105.33±7	119±11.6*
	Hind cannon	36.5±3.1	36±3.1	Tarsal	147±4.9	148±4.4
	Pelvis	54±4	48±4*	Hind fetlock	151±8	151±7
Straight hocks				Hip	85.9±5.7	90.5
	Thigh	47±5	47±5.3	Stifle	106±7	117.8±11.6*
	Gaskin	56±3	48.9±4.9*	Tarsal	148°±3.2°	150.7±4.7
	Hind cannon	35.8±2	37±3.6	Hind fetlock	151±8.4	156±6.3
Short pelvis	Pelvis	54± 4	49 ± 4.1*	Croup	143° ± 5°	145° ± 5.7*
				Hip	89.6°± 9°	87.5°± 5.9°
				Stifle	110°±9.3°	118°±13*
				Tarsal	147°± 3.9°	149°± 5.9°
				Hind fetlock	150°± 6.6°	156°± 7°

*Significant at P< 0.05.

DISCUSSION

In the current study, 7 abnormal conformations of fore and hind limbs in jumping thoroughbred horses were recorded and categorized. Each conformation was standardized objectively and the corresponding lengths and angles of each were evaluated.

Standing under in front represented 58% of the total examined horses. In contrast, HÖlmstrom et al,. (1990) reported the incidence of standing under in front in Swedish Warmblood horses as 5.6%. This difference could be attributed to the difference between the examined breeds in both studies. Thus, the horse's breed may play a role in the development of this abnormal conformation. Meanwhile, this high incidence ranks the standing under in front as the most common abnormal conformation in jumping thoroughbreds horses. This finding agreed with Marks (2000) who reported that many of the outstanding jumpers were extremely camped under.

Stashak (1987) and Marks (2000) reported that steep shoulder was more common in jumping horses. In this respect, Marks (2000) observed that long upright scapula with shoulder joint angle of about 105° and laid-back withers provides the vertical propulsion from the front legs that is necessary for jumping big fences. Interestingly, there were no significant differences in shoulder length between steep and normal shoulder in the present study. This finding disagrees with the previous findings (Anderson et al., 2004b). Moreover, statistical analysis of the present results revealed a significant decrease (P< 0.05) in fore arm length in horses with steep shoulder compared to horses with sloping shoulder. This could explain the role of fore arm length in the sloping and steep shoulders.

The elbow joint angle in steep shoulder in jumping thoroughbred horses was 140°. This agrees the finding reported previously (Stashak, 1987). Additionally, HÖlmstrom et al., (1990) found that a more flexed elbow with a horizontal scapula results in a longer stance duration, improved gait quality and collection in the fore limbs during jumping.

Carpus valgus with mean carpus joint angle of 186°±2° was observed in 45% of the examined horses. However, HÖlmstrom *et al.* (1990) reported the 'narrow at knees' with front carpal angles >180° in 11.8% of Swedish Warmblood trotters (HÖlmstrom et al. 1995 and Anderson et al. 2004). This great difference in the incidence of carpus valgus in thoroughbred jumping horses and Swedish Warmblood trotters suggesting again the role of horse's breed in development of this abnormal limb conformation. In addition, Weller et al., (2006) reported that carpus valgus of 5° is normal and doesn't stop horses from pursuing their racing career. Furthermore, the lateral and front fore arm length had significant increase (P< 0.05) in the examined thoroughbred jumping horses which play an important role in jumping horses.

Jumping thoroughbred horses had' calf knee' with mean carpus joint lateral angle of 176.38°± 2.2° in 31% of examined horses. However, HÖlmstrom *et al.* (1990) reported this abnormal conformation in 18.7% of elite show jumpers of Swedish Warmblood breed. Therefore, the horse's breed could be playing a role in the development of this abnormal conformation. Furthermore, Anderson et al., (2004) stated that carpus joint angle < 180° considered calf knee and played a major role in carpal fractures and joint disease due to the additional stress on knee joints (Thomas, 2005). In contrast, Marks (2000) and Weller et al., (2006) considered the carpal joint angle of 186° ± 3° 'normal' in National Hunt racehorses and much less of concern for jumpers and dressage horses.

Standing under behind was found in 31% of the population. In contrast, HÖlmstrom et al, (1990) found this abnormal conformation in 4.3% of show jumpers of Swedish Warmblood horses. These different incidences could be attributed to the horse's breed. The affected horses had significant increase (P< 0.05) in thigh length and stifle joint angle. Similar findings were reported by (HÖlmstrom et al., 1990) who concluded that the femur is the most individual conformational detail in sport horses. They added that a long and forwardly sloping femur allowed the horse to keep its balance more easily by placing the hind limbs more under the horse, closer to the center of gravity. On other hand, Magnusson and Thafvelin (1990) concluded that the better performing horses had straighter stifle angles. In the present study, gaskin length was found to be smaller in horses with 'standing under behind'. Furthermore, the most interesting observation in the present study is that pelvis, thigh and gaskin lengths had equal length in horses suffering from standing under behind.

Short pelvis was reported in 31% of the examined horses. The affected horses had pelvis length < 49± 4.1 cm, associated with decreased croup angle and increased stifle joint angle in comparison with normal horses. Short pelvis provides less length of muscular attachments to the thigh and gaskin that diminishes the engine power in jumping events. Flat croup helps the horses to go faster by encouraging long and flowing strides (Senna et al, 2015, Thomas, 2005 and Keegan, 2005).

Straight hocks were found in 16% of the population. It is worth mentioning that stifle joint angle showed significant increase (P< 0.05) while pelvis and gaskin lengths showed a significant decrease (P< 0.05) in the affected horses. However, all joints of the hind limb of the affected horses showed marked increase in their measurements compared to normal horses. While the pelvis and gaskin lengths decreased, the hock joint tended to be straighter in the examined thoroughbred jumping horses. Moreover, Dyson et al. (2018b) observed increased tarsal joint angles was associated with proximal suspensory desmopathy, oscillation of the hock during stance, rotation of the distal aspect of the limb and the foot placed further under the trunk. Furthermore, Straight hock conformation may lead to thoroughpin (Thomas, 2005) upward fixation of patella, bone and bog spavin, hoof bruises and quarter cracks (Dyson 1995) and Mostafa et al. (2014 a&b).

In conclusion, horses standing under in front have an increased elbow joint lateral angle, and decreased fore fetlock joint lateral angle. Horses with a steep shoulder have a decreased forearm front length, meanwhile horses with carpus valgus show an increased length of forearm. Horses with calf knee display a decreased lateral angle of carpus joint; however, horses with short pelvis

have increased croup and stifle joint lateral angles. Therefore, the current use of linear and angular measurements in relationships to abnormal limb conformation in the present study will allow for estimation of the future performance and soundness in jumping thoroughbred horses. In addition can be considered for selection athletic horse with less risk of lameness.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the Publication of this article.

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