

Relationships between morphometric measurements and musculoskeletal disorders in jumping Thoroughbred horses

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There is limited knowledge about causes of musculoskeletal injury in jumping Thoroughbred horses. The objective of this study was to describe the relationships between musculoskeletal disorders and linear and angular limb measurements acquired from photographs of horses with markers at specific reference points. The diagnosed musculoskeletal disorders in either fore or hind limbs were flexor tendonitis, suspensory ligaments desmitis, and osteoarthritis of the distal intertarsal and tarso-metatarsal and carpometacarpal joints. Lengths and angles in 17 clinically normal jumping Thoroughbred horses and 34 horses with musculoskeletal problems were measured. Horses with musculoskeletal disorders had significantly shorter neck, shoulder, and pelvis lengths ($P < 0.05$), significantly longer arm and forearm front lengths ($P < 0.05$), and significantly lower front shoulder, elbow, and hind fetlock joint angles ($P < 0.05$). In conclusion, this study describes significant relationships between linear and angular morphometric measurements and musculoskeletal disorders in jumping Thoroughbred horses. These data could possibly provide indicators for better selection of jumpers with less risk of developing orthopedic disorders.

Key words: jumping Thoroughbred, linear measurement, musculoskeletal disorder, neck, pelvis

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Thoroughbred jumping is the most popular equestrian discipline in Egypt. Jumpers use their hindquarters for engagement and collection and place more weight and stress on their hind limbs [19]. These stresses may contribute to the development of disorders of the pelvic regions, soft tissues, ligaments, and joints [26]. During take-off and landing, the forelimbs receive considerable impact loads and absorb the entire weight of the animal during landing, placing more stress on the foot, distal limb joints, and soft tissues [4]. Jumpers must be able to jump large fences with precision and accuracy at fast speeds and sometimes with sharp turns. They must have tremendous strength in their back and hind limbs to be able to adjust their stride length and jump [8].

Musculoskeletal injuries in showjumper horses have been attributed to gaits and jumping technique variations, leaning of the trunk, and hind limbs, repetitive overloads

during cantering, and inadequate warm-up [7].

Conformation is used as an indicator of better soundness and for selection of horses with less risk of developing lameness [21]. Recently, advances in digital photography and computer technology have allowed objective measurements in conformation research [13, 28].

The most common lameness problems encountered in show jumpers are thoraco-lumbar pain, foot pain, distal hock joint pain, joint osteoarthritis, suspensory ligament desmitis, and superficial and deep digital flexor tendonitis. These problems are interrelated, and more than one problem may occur simultaneously [4, 13, 17].

Musculoskeletal diseases are the main causes of withdrawal of horses from several sports [20]. Show jumping competition performance is linked to conformation data [18]. Various studies have discussed the cause of musculoskeletal injuries and lameness in sport horses [1, 7, 17]. However, there have been no reports on the relationships of linear and angular morphometric measurements and musculoskeletal disorders in jumping Thoroughbred horses. Therefore, the objectives of this study was to use linear and angular limb measurements to evaluate the role of limb conformation in musculoskeletal disorders among jumping Thoroughbred horses.

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Materials and Methods

This study was carried out on 51 jumping Thoroughbred horses (17 horses clinically free of lameness and radiographically and ultrasonographically free of musculoskeletal disorders and 34 lame horses with various musculoskeletal disorders at the Armed Forces Equestrian Club). Their ages ranged from 5 to 15 years old, and they ranged in weight from 450 to 600 kg. All horses received the same management and training courses and competed in the same number of jumping courses each year.

Objective evaluations of conformation for limb lengths and angles were designed using methods described by Anderson *et al.* and others [1, 15, 23]. Horses were haltered and photographed while standing on a flat horizontal solid surface. Photographs were taken while the neck settled in a position raised above the back and shoulder. The left side of the horse was positioned perpendicular to the camera while the horse stands squared on the relative to the camera; the left fore- and hind limbs were set as vertical as possible relative to the ground. The horse was present in the center of the frame. Image photographers were exactly parallel to the horizontal axis of the horse. The camera was positioned such that it was just behind the center of gravity at the midpoint of the lateral thoracic wall and not higher, lower, forward, or backward on relative to this position. During taking a photo of the horse from the front view,

the center of the camera frame was pointed in-between the front shoulder points and 2 meters distance away from the horse. The photographer positioned the camera such that it was exactly at the midpoint between the 2 forelimbs. The background of the photo was the opposite color of the horse so that the reference points on the horse could be easily distinguished in the photos. Reference points were established on the skin of the horses according to Anderson *et al.* and Senna *et al.* [1, 23]. Measurements of lengths were recorded from the lateral (left) and front views of the horse. Both the right and left front measures were the same, so only one of them was used during the statistical analysis. The lengths measured were those of the neck, back, shoulder (scapula), arm (humerous), forearm (radius), pelvis, thigh (femur), and gaskin (tibia), as well as the lengths of the fore and hind cannons (third metacarpus/tarsus). The angles measured were the scapulohumeral joint (shoulder), elbow joint, and carpal and fetlock joint angles in the forelimbs. For the hind limbs, the hip, stifle, tarsal, and fetlock joint angles were determined (Fig. 1). Photographs were taken for each horse from the left lateral and front sides using a digital camera (PL80, Samsung Electronics Co., Ltd., Seoul, South Korea). Conformation measurements were acquired from photographs using software (AutoCAD 2013 v19, Autodesk, Inc., San Rafael, CA, U.S.A.).

After objective conformation evaluations were completed, each horse was examined for lameness [22].

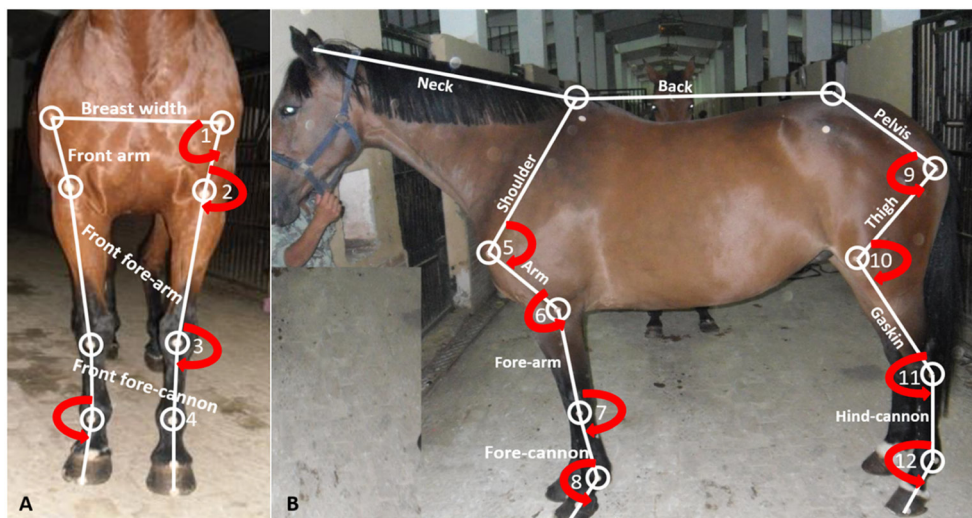


Fig. 1. Length (cm) and angles ($^{\circ}$) measurements in jumping Thoroughbred horses showing the sides of measurements of each angle. (A) Lengths and angles measured from the front view. (B) Lengths and angles measured from the left lateral view. 1) Front shoulder joint angle (measured medially), 2) front elbow joint angle (measured laterally), 3) front carpus joint angle (measured laterally), 4) front fore fetlock joint angle (measured laterally), 5) lateral shoulder joint angle (measured caudally), 6) lateral elbow joint angle (measured cranially), 7) lateral carpus joint angle (measured caudally), 8) lateral forefetlock joint angle (measured dorsally), 9) lateral hip joint angle (measured cranially), 10) lateral stifle joint angle (measured caudally), 11) lateral tarsal joint angle (measured cranially), 12) lateral hind fetlock joint angle (measured dorsally).

Diagnostic lateromedial and dorsopalmar/dorsoplantar radiographic views of the distal limb were acquired with a digital X-ray unit (Model: CR-IR 357, Fujifilm, Tokyo, Japan) for each horse according to Anderson *et al.* and Baxter *et al.* [1, 3]. Ultrasonography of the palmar/plantar aspect of the fore and hind cannons and phalangeal regions was performed (SSA-320A, Toshiba Just Vision, Japan; 8 MHz linear transducers). The horses were examined by the second author (YE).

Statistical analysis

Descriptive statistical analyses for lengths and angles were performed by ANOVA using the IBM SPSS Statistics v20 software (IBM Corp., Armonk, NY, U.S.A.). All data are presented as mean and standard deviation (SD) values. The Kolmogorov-Smirnov test was conducted, and the disruption was normal ($P>0.05$). The independent samples *t*-test was used to compare the length of each part of the body and the joint angles of horses with or without musculoskeletal disorders. $P<0.05$ was considered significant.

Results

The linear and angular biometric measurements of the 17 clinically normal horses free of lameness and 34 horses with musculoskeletal disorders are presented in Table 1.

The musculoskeletal disorders recorded in either fore- or hind limbs were digital flexor tendonitis and suspensory ligament desmitis (8 horses); osteoarthritis of the distal intertarsal, tarsometatarsal, carpometacarpal, intercarpal, or hind fetlock joints (19 horses); and tendons, ligaments, and joint disorders (7 horses).

Biometric measurements of the length and angle variables in horses with musculoskeletal disorders revealed significantly shorter neck, shoulder, and pelvis lengths ($P<0.05$), while arm and forearm front lengths were significantly longer ($P<0.05$; Table 1). Furthermore, the front shoulder joint, front elbow joint, and lateral hind fetlock joint angles were significantly lower ($P<0.05$).

However, there were no significant differences in the following lengths: back, arm lateral, forearm lateral, front and lateral forecannon, thigh, gaskin, and lateral hind-cannon. In addition, the angles of the lateral shoulder, lateral elbow, lateral and front carpal, lateral and front forefetlock, hip, stifle, and tarsal joints were not different from those of the clinically normal horses (Table 1).

Discussion

The relationships between linear and angular limb measurements and musculoskeletal disorders in Thoroughbred horses were determined from photographs of

Table 1. Length and angle variables of clinically normal Thoroughbred jumping horses and Thoroughbred jumping horses with musculoskeletal disorders

Variable	Length (cm)	
	Normal (n=17)	Musculoskeletal disorders (n=34)
Back	93.1 ± 1.7	92.1 ± 0.8
Neck	105.4 ± 2.1	98.5 ± 1.2*
Shoulder	71.3 ± 1.2	68.5 ± 0.8*
Arm lateral	35.1 ± 0.7	34.3 ± 0.5
Arm front	30.8 ± 1.1	33.2 ± 1.1*
Forearm lateral	45.5 ± 0.8	46.3 ± 0.1
Forearm front	47.9 ± 0.7	49.5 ± 0.4*
Fore cannon lateral	28.8 ± 0.5	28.4 ± 0.6
Fore cannon front	28.0 ± 0.6	28.2 ± 0.4
Pelvis	52.9 ± 1.5	50.3 ± 0.8*
Thigh	49.8 ± 1.5	48.8 ± 2.2
Gaskin	53.9 ± 1.4	52.9 ± 0.7
Hind cannon lateral	37.4 ± 0.9	37.4 ± 0.6
Shoulder lateral	99.0 ± 0.9	98.8 ± 0.6
Shoulder front	75.2 ± 0.6	73.8 ± 0.5*
Elbow lateral	139.7 ± 0.8	137.7 ± 0.9
Elbow front	169.8 ± 0.9	167.5 ± 0.7*
Carpus (lateral view)	178.0 ± 0.5	177.4 ± 0.4
Carpus (front view)	175.7 ± 0.6	176.8 ± 0.4
Fore fetlock lateral	141.0 ± 1.6	143.7 ± 1.0
Fore fetlock front	172.8 ± 1.0	173.3 ± 0.3
Hip	87.8 ± 1.7	89.3 ± 1.6
Stifle	113.5 ± 2.7	115.3 ± 2.4
Tarsal	148.9 ± 1.2	148.6 ± 0.6
Hind fetlock lateral	152.8 ± 2.0	144.7 ± 3.1*

*Significant at $P<0.05$. Values are presented as the mean ± standard deviation.

the lateral left and front sides of horses with markers at specific reference points using AutoCAD software. Similar measurements of relationships between musculoskeletal problems and conformations have been described in racing Thoroughbred horses [1]. In addition, the same measurements have been previously described in horses [5, 27].

In the present study, the measured lengths associated with musculoskeletal problems in jumping Thoroughbred horses were significantly shorter neck, shoulder, and pelvis lengths ($P<0.05$) and significantly longer arm and forearm front lengths ($P<0.05$). In addition, front shoulder, front elbow, and lateral hind fetlock joint angles were significantly lower ($P<0.05$). In this respect, previous studies reported that steep shoulder was a common finding in jumping Thoroughbred horses and associated with a longer forearm length and smaller elbow joint angle [13, 15, 16, 24]. Moreover, in other findings, it was mentioned that a wide chest with base-narrow forelimbs or narrow chest with base-wide forelimbs is undesirable in Thoroughbreds [22]. In the present study, it was found that longer front arm and

forearm lengths combined with smaller front shoulder and elbow joint angles could potentially predispose jumping Thoroughbred horses to musculoskeletal disorders. Furthermore, the anatomical differences between the reference points of the arms and forearms from the lateral and front views explained the differences in their values. Throughout the study, it appeared likely that the lateral arm and forearm lengths had an impact on the shoulder and elbow lateral inclination and the stand of the forelimb under the body, while the corresponding front lengths had an effect on breast width and tying of the elbows (tied in or tied out). Therefore, each length and angle affect the biomechanics of the body differently and predisposes jumping Thoroughbred horses to musculoskeletal disorders in different ways, so no similarities were expected among the results.

The musculoskeletal disorders in jumping Thoroughbred horses were consistent with previous findings [6, 7, 10, 14]. They confirmed that changes in conformation shifts the center of gravity forward and leads to variations in gait and jumping techniques placing asymmetrical loads on the musculoskeletal system, predisposing jumping Thoroughbred horses to forelimb lameness [22].

Short neck was a constant finding in horses with musculoskeletal disorders in the present study. A previous study concluded that short neck hinders the balancing ability of the horse, causes stumbling and adds to the weight placed on the forelimbs, and increases the concussion of the front limbs, possibly promoting the development of degenerative joint diseases [25]. However, another study reported that a long neck is more desirable in jumping horses to maintain balance over the fence [11].

The results of the present study demonstrate that jumping Thoroughbred horses with musculoskeletal disorders have a short pelvis. A short pelvis makes the length of muscular attachments to the thigh and gaskin shorter and diminishes engine power in jumping events [12].

The tarsal angles in racing horses could be considered small if $<155^\circ$ and large if $>165^\circ$ [9]. Higher tarsal angles ($<140^\circ$) predisposed performance horses to osteoarthritis of the distal intertarsal and tarsometatarsal joints and hind limb lameness [2]. On the other hand, other authors concluded that a small tarsal angle increases the compressive forces on the front aspect of the tarsus, which may contribute to the development of osteoarthritis [16]. However, no significant difference in tarsal angle was observed between the normal and diseased jumping Thoroughbred horses included in the present study.

The horses with musculoskeletal disorders in the present study had lower front shoulder joint and front elbow joint angles, shorter neck, shoulder, and pelvis lengths, and longer arm and forearm front lengths. Therefore, changes in linear and angular measurements might predispose jumping

Thoroughbred horses to musculoskeletal disorders, mainly flexor tendon tendonitis, suspensory desmitis, and osteoarthritis of the carpal, tarsal, and fetlock joints. In addition, in the present study, back, fore cannon, thigh, gaskin, and hind cannon lengths did not affect musculoskeletal disorders in jumping Thoroughbred horses

In conclusion, this study shows significant relationships between linear and angular measurements and observed musculoskeletal disorders in jumping Thoroughbred horses. These data could possibly be used for better selection of jumpers with less risk of developing orthopedic disorders.

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