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Original Research

The Forelimb and Hoof Conformation in a Population of Mongolian Horses

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ABSTRACT

This article describes the lower limb and hoof conformation of a population of semi-feral Mongolian horses living on an open tundra/steppe environment. Data were collected from a convenience sample of 120 Mongolian horses used in the 2011 Mongolian Derby. Digital images of the hooves were obtained, and the lower limb conformation was assessed by four veterinarians involved in the screening of the horses offered for the derby. The horses were predominantly geldings (96%, 100/104), approximately 8.6 ± 2.5 years old, and 137 ± 8 cm at the withers. None of the horses were subjected to routine hoof trimming. Based on a 7-point linear score, lower limb conformation was normal, with a trend (>1 linear score deviation) slightly toward carpal valgus, mildly offset cannon (third metacarpal), and valgus at the matacarpophalangeal joint. Hoof measurements were within the norm for horses of this size. Fetlock valgus was associated with a smaller hoof width:length ratio ($P = .016$). None of the other hoof measurements were significantly associated with abnormal conformation scores. Overall, few conformation abnormalities were observed, and hoof shape and size was within the normal expected range for horses of this size. The hoof conformation in this population of Mongolian horses represented the natural interaction of the hoof with the environment.

1. Introduction

Ideal hoof and lower limb conformation has been the subject of much attention within the technical manuals and the lay equine literature [1,2]. Much of this information has been the result of the observations and associations identified by equine practitioners over many years. However, there is little scientific or empirical evidence to support the ideal hoof and limb conformation proposed. Only recently, in relation to our domestication and use of the horse, we have had the ability to measure the forces and loads within the hoof and lower limb or the data collection and statistical techniques to quantify risk factors for injury [3,4] or longevity [5]. These data provide an understanding of the effect of different trimming and shoeing techniques [6] and also a scientific framework around which we can examine and quantify current practice [7].

Often the feral or wild horse population is promoted as the “gold standard” for hoof conformation [8]. A pattern of trimming and hoof conformation has been developed from observations of feral horses in semi-arid environments. Recent data have indicated that hoof shape and conformation is a by-product of genetics and the environment [4,9,10]. In semi-arid environments, hoof shape and conformation is relatively homogeneous [8,9]; however,

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a wide range in hoof conformation has been reported in the presence of a softer substrate and an environment with easy access to pasture and water [9]. This heterogeneity in conformation was greater than that expected owing to the seasonal patterns of natural hoof trimming [11], reported gross asymmetry within feet, altered mediolateral balance, long toes, and large wall flares [9].

Exercise has also been implicated in altering hoof conformation, with racehorses in work having a decrease in hoof circumference during training [12,13]. Modern management systems reduce access to free exercise, which has implications for development of the equine musculoskeletal system [14]. Within modern management systems, such as confinement within a yard or a loose box, it is reported that horses will travel only 1.1 (range: 0.2-1.9) km/d compared with an average of 15.9 $\pm$ 1.9 km/d for feral horses [15]. In a feral environment, this free access to exercise would encourage a different type of hoof conformation compared with that observed with domesticated horses within intensive management systems.

Within intensive management systems, the farrier attempts to provide optimal hoof balance in relation to the lower limb conformation. It is important that hoof shape and conformation is interpreted in relation to the lower limb conformation [16]. To date, it seems there are limited reports within the literature regarding the effect of deviations from the ideal lower limb conformation and the association of these with hoof shape and conformation. The Mongolian horse provides a unique model of a horse managed under semi-feral environment with little to no hoof care or intensive husbandry. Therefore, the aim of this study was to investigate the typical lower limb and hoof conformation in a population of Mongolian native horses maintained on an open tundra environment and to investigate the association of lower limb conformation with hoof conformation and shape.

2. Materials and Methods

Data were collected as part of a convenience sample of horses offered for the 2011 Mongolian Derby: a 1,000-km race where riders travel the entire distance but each horse is ridden only on one occasion for a distance of approximately 40 km. Digital images of hooves and linear assessment of lower limb conformation were collected by four veterinarians involved in the screening of the horses offered for the riders during the derby.

The Mongolian native horses were from the Töv, Övörkhangai, Arkhangai, and Bulgan regions of Mongolia, which are characterized by 250-mm of annual rainfall, a temperature range of $-22°C$ to $33°C$, and open tundra grasslands or steppe. The horses were managed extensively (no confinement in paddocks) as semi-feral herds grazing the rangeland/steppe.

At each transition point during the race, the veterinarian's role was to screen the suitability of the horses offered for the competing riders. During this process, a random sample of horses was selected, and data were recorded on the limb and hoof conformation. A brief one-page survey was completed by the horse owner, via an interpreter, to provide data on the age and gender of the horse, the general hoof care procedures, and typical weekly riding activity.

2.1. Linear Assessment of Lower Forelimb Conformation

Lower forelimb conformation was assessed via a 7-point linear scale based on the system developed by Mawdsley et al. [17], where a score of 4 represented ideal or normal conformation, and a score of 0 or 7 represented the maximal deviation in either direction from the ideal. Briefly; the linear scale was used to measure seven parameters: knee 1 (bucked to calf/back at the knee), knee 2 (tied in to chopped), hoof pastern axis (broken forward to broken back), cannon (3rd metacarpal bone) angle (carpal varus to carpal valgus), knees relative to cannon (bench knee [lateral deviation] to inset cannon), metacarpophalangeal angle (varus to vulgus), and upstandingness (base wide to base narrow). The asymmetry of the hoofs was also scored as a univariable trait (symmetric or asymmetric).

Digital images were obtained using compact digital cameras, and images were subsequently saved as png files for later analysis. For each horse, lateral and solar views of each hoof were obtained with the camera at a focal distance of approximately 1 m. Within the field of view, the images were identified by a 100-mm pro forma identification card, held in the same transverse plane as the hoof, which provided the object for calibration for subsequent image analysis.

Digital images were uploaded into ImageJ V1.44 (National Institute of Mental Health, Bethesda, Maryland, USA) (NIH) for linear and angle measurements. Data were collected on the dorsal hoof wall angle, the angle of the pastern (line bisecting pastern) relative to the hoof solar surface, hoof width (width of the hoof at its widest point), hoof length (length of the solar ground bearing surface), frog length (the distance buttress of heels/palmar hoof line to the point of frog) [18], and distance from the widest point of the hoof to the most caudal solar surface (buttress of heel/palmer hoof line). Within-operator trials based on five repeated measurements per parameter demonstrated high repeatability of measurement with coefficients of variation $<2\%$.

A variable to describe limb asymmetry was created to quantify the difference in lower limb score for a given conformation trait between the left and the right leg. This was obtained by calculating the absolute difference between the score of the left and the right leg for each conformation trait.

2.2. Statistical Analysis

Data were entered into excel for manipulation, and preliminary descriptive statistics were performed to check for errors. All analyses were conducted using PASW statistics 18 (IBM Corporation, Somers, NY). The differences in hoof measurements between horses with normal (linear score of 4) and abnormal lower limb conformation (a deviation of greater than 1 point from the ideal score of 4) were tested using a univariate general linear model, with a significance level of $P < .05$.

3. Results

Demographic data and initial images of 120 horses were collected from a pool of approximately 630 horses offered for the derby. Complete digital images of hooves suitable