Livestock Science 189 (2016) 91–101

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Association of conformation and riding ability in Icelandic horses

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ARTICLE INFO

Article history:
Received 10 September 2014
Received in revised form
15 May 2016
Accepted 19 May 2016

Keywords:
Gaiting Ability
Morphometric measurements
Objective quantification
DMRT3

ABSTRACT

The official breeding goal for the Icelandic horse promotes five-gaited horses with a functional and aesthetic conformation. The objectives of the present study were to assess the phenotypic and genetic relationship between standard conformational measurements and scores for riding ability. Further, to investigate if more detailed (3-D) morphometric measurements could discriminate between high-class and low-class horses based on scores for each gait. The data comprised records from standard conformational measurements and scores for the different gaits and the total score for riding ability of all assessed breeding horses in Iceland in 2000–2013 (10,091 horses). Further, records from a subpopulation of 98 haphazardly selected breeding horses that were subject to detailed quantification of the conformation in 3-D and genotyped with respect to *DMRT3* genotype, were included in the study. Most of the standard measurements had a significant and curvilinear relationship with the studied riding ability traits. They had generally high estimated heritability but weak or moderate genetic correlation with the total score of riding ability. Proportions in the top line of the horse describing the height of the horse at front compared to hind were found to be most important for the riding ability, revealing the advantage of an *uphill* conformation. Their estimated heritability and genetic correlation with total score for riding ability designate them as important indicators for performance. Certain lengths, proportions and angles between bones in the fore- and hind limbs also had a significant effect on scores for some gaits. These results can improve the assessment of the conformation and consequently the riding ability of the Icelandic horse.

1. Introduction

The Icelandic horse is bred for leisure riding and sport competitions. Selection based on defined breeding goals began in the middle of the 20th century. The international breeding goal promotes a functional, sound and aesthetically appealing conformation and the ability to perform five gaits; walk, trot, canter/gallop, *tölt* and pace. Systematic evaluations of Icelandic breeding horses are performed annually at breeding field tests in more than 10 countries in Europe and North America. The horses are subjectively assessed for 15 composite traits of conformation and riding ability (FIZO, 2014). As an aid for the subjective evaluation of the conformation, standard conformational measurements are performed on all horses. Each trait is assessed on a scale from 5 (not presented) to 10 (best). The assessment of riding abilities includes scoring of the five gaits under rider with respect to qualities such as correct beat, suppleness, stride length, leg action, speed capacity, collection and lightness (Supplementary Table). The total score for riding abilities is a combination of the weighted scores for all gaits together with the traits spirit and form under rider. Scores are also given for slow *tölt* and canter, which influence the scoring for *tölt* and gallop, respectively, although they are not weighed into the total score (FIZO, 2014).

The estimated heritability of the subjectively assessed traits of conformation and riding ability in Icelandic horses has been reported to range between 0.22–0.46 and 0.20–0.63, respectively with most of them having a positive genetic correlation (Albertsdóttir et al., 2008).

In a number of studies the conformation of horses has been related to performance where various conformational aspects are

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http://dx.doi.org/10.1016/j.livsci.2016.05.010
1871-1413/

considered favourable in certain disciplines (Saastamoinen and Barrey, 2000). These studies have involved linear type conformation traits (Rustin et al., 2009), measurements using photogrammetric methods (Holmström et al., 1990) and images provided by video records (Back et al., 1996; Crevier-Denoix et al., 2006; Weller et al., 2006a). The method of Crevier-Denoix et al. (2006) has been used to quantify the conformation of the Selle Francais horse and the Icelandic horse and found to produce repeatable data (Kristjansson et al., 2013). Reynisdóttir (2001) quantified the conformation of Icelandic horses in a pilot study, using a photogrammetric method and reported significant relationships of some conformational parameters with riding ability. These findings suggested the need for further investigation, preferably about the relationship between objectively obtained morphometric parameters and the different traits of riding ability in the Icelandic horse. It has been reported that the heritability of objective measurements is generally higher than for subjectively scored composite traits (Dolvik and Klemetsdal, 1999; Saastamoinen and Barrey, 2000; Suontama et al., 2009) and results support the practice of indirect performance selection through selection for functional conformation (Schröder et al., 2010).

A nonsense mutation in *DMRT3* (*DMRT3_Ser301STOP),* referred to as the ´Gait keeper´ mutation, has been reported to have major impact on the gaiting ability of Icelandic horses as it was found to be permissive for the ability to perform the lateral gaits *tölt* and pace (Andersson et al., 2012). Homozygosity for the mutation is required although not sufficient for the ability to pace while it has a negative effect on scores for the basic gaits (Andersson et al., 2012; Kristjansson et al., 2014).

The objectives of the present study were to assess the phenotypic and genetic relationship between the standard conformational measurements and scores for riding ability. Further, to investigate if more detailed (3-D) morphometric measurements could discriminate between high-class and low-class horses, based on scores for the different gaits. The latter study was confined to horses homozygous for the ´Gait keeper´ mutation to exclude genotype effect on the gaits.

2. Material and methods

2.1. Collection of data

Records from standard conformational measurements and assessments of the riding ability were obtained from the global database WorldFengur (www.worldfengur.com) for all horses presented at breeding field tests in Iceland in the years 2000–2013. The material included in total 20,527 records on 10,091 horses (2089 stallions and 8002 mares). The number of assessments per horse ranged from 1 to 11, with a mean of 2.03 assessments. The age range was 4-18 years, with a mean of 6.0 years. The horses were sired by 1531 sires, with 1–410 offspring each. The standard (direct) conformational measurements included stick measurements: M1 to M5; large calliper measurements: M6 to M8; small calliper measurement: M9; tape measurements: M10 and M11 (Table 1). Complete measurements were only performed on the stallions while only 6 measurements were available for the mares (M1, M3, M4, M5, M9 and M10). Calculated conformational traits included: the difference between height at withers and height at back (M1 – M2) and the difference between height at withers and height at croup (M1 – M3), both referred to as *height at front*; the difference between height at croup and height at back (M3 – M2), referred to as *back incline*; the difference between the length of the horse and height at withers (M5 – M1) and the difference between length of the horse and height at croup (M5 – M3), both referred to as *format of the horse* and the difference between the hip measurements (M7 – M8), referred to as *form of the croup*.

A subpopulation of 98 horses (25 stallions and 73 mares) was haphazardly selected at breeding field tests in Iceland in the years 2008–2010 for more detailed morphometric measurements. The age of the horses within the subpopulation ranged from 4 to 10 years, with a mean of 6.0 years, sired by 66 sires, with 1–7 offspring each. The subpopulation included 72 previously described horses (Kristjansson et al., 2013) and additionally 26 horses that were included to provide a material with a wider distribution of scores for the different gaits. The conformation of these horses was objectively quantified using a three-dimensional video morphometric method developed by Crevier-Denoix et al. (2006). The method has been described in detail by Kristjansson et al. (2013).

Table 1
Mean, range and variation of the standard conformational measurements and calculated measurements and their heritability (h^2), genetic variance (σ_a^2), permanent environmental variance (σ_{pe}^2), repeatability (t) and genetic correlation with total score for riding ability (r_g). All measurements are in cm.

Parameters[a]	Mean	SD	Range	h^2	σ_a^2	σ_{pe}^2	t	r_g[b]
Height at withers (M1)	139.6	3.15	126–153	0.67	5.92	1.69	0.87	0.06
Height at back (M2)[c]	130.9	2.89	120–143	0.58	4.87	2.10	0.83	−0.04
Height at croup (M3)	136.7	2.73	124–147	0.65	5.02	1.50	0.85	−0.05
Depth of the breast (M4)	64.2	1.72	54–71	0.50	1.49	0.64	0.71	−0.05
Length of the body (M5)	142.5	3.19	128–156	0.64	6.89	1.82	0.81	−0.06
Width of the chest (M6)	37.5	1.54	31–44	0.40	0.95	0.65	0.67	0.21
Width of the hips (M7)[d]	47.0	1.52	40–52	0.54	1.30	0.61	0.79	0.09
Width of the hips (M8)[e]	42.6	1.60	34–48	0.37	0.88	0.43	0.55	0.16
Width of metacarpus (M9)	6.6	0.22	6–8	0.85	0.14	0.03	1.00	−0.25
Circ. of carpus (M10)	28.2	1.31	23–33	0.53	0.37	0.17	0.77	−0.11
Circ. of metacarpus (M11)	18.0	0.81	15–22	0.37	0.17	0.10	0.60	−0.03
Height at front (M1 – M2)	10.3	1.62	2–19	0.25	0.65	0.44	0.42	0.25
Height at front (M1 – M3)	3.0	1.83	−5–12	0.27	0.73	0.56	0.47	0.26
Back incline (M3 – M2)	6.1	1.52	0–17	0.20	0.46	0.58	0.45	−0.08
Format of the horse (M5 – M1)	2.9	2.99	−9–15	0.40	3.17	1.59	0.60	−0.13
Format of the horse (M5 – M3)	5.9	2.78	−6–19	0.35	2.67	1.72	0.57	0.00
Form of the croup (M7 – M8)	4.4	1.46	0–10	0.25	0.50	0.54	0.52	−0.05

[a] Measurements M1, M3 – M5, M10 and M11 were performed on all horses (20,527 records on 10,091 horses). Other measurements were performed on stallions only (4871 records on 2089 stallions).
[b] Standard error of genetic correlation between measurements and total score of riding ability ranged from 0.04 to 0.20.
[c] Height at the lowest point of the back.
[d] Width of the hips between the tuber coxae.
[e] Width of the hips between the hip joints.