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INDIVIDUALITY OF CENTRE OF BODY MOVEMENT AT WALK AND TROT WITHIN THE HAFLINGER BREED

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Original scientific paper

SUMMARY

Kinematic measurements of fourteen Haflinger horses without lameness, walking and trotting on a treadmill were taken to document the location of the centre of the body (CB), defined as the centre between markers on the head, on the withers, on the sacral bone and on the lateral wall of all four hooves in relation to the sacral bone marker. During walk and trot, there are three dimensional CB position (x: forward-backward, y: side-to-side, and z: up and down). For each horse minimum of eight motion cycles were considered in walk as well as in trot. For all three axes, mean CB location, its standard deviation and its 95% confidence interval (CI) were calculated. For statistical analysis, Shapiro-Wilk test and Spearman's correlation test were carried out. Mean body mass was 463±42 kg, CI (439, 487); mean height at the withers was 131±5 cm, CI (128, 134); mean height at the sacrum was 128 ± 2 cm, CI (127, 130). Mean CBx was in front of the sacrum (walk 74±2 cm, CI (72, 75); trot 73±2 cm, CI (72, 74); walk vs trot p=0.008). Mean CBz was below the sacrum (-71±2 cm, CI (-73, -70) in walk; -69 ± 2 cm, CI (-70, -68) in trot; walk vs trot p=0.001). Positive correlations were found between MeanCBx and trunk length in walk and trot, which could highlight the biomechanical importance of the trunk as it plays a crucial role in deceleration and acceleration. The analysis of the body location centre may be used to identify differences between horses of the same breed, and thus support evaluation of the quality of the horse during locomotion.

Key-words: motion analysis, conformation, centre of body, walk, trot, Haflinger horses

INTRODUCTION

In the horse, conformation traits include body measures as well as locomotion characteristics of limbs and different parts of the trunk. Such objective locomotion traits have been documented in a variety of horse breeds, and in the present study a single synthetic parameter, the centre of the body is documented, containing the information of all limbs and the head and trunk of the horse. Specifically, the Haflinger breed was investigated in the present study.

These horses have been developed from multipurpose, sturdy mountain horses, used mainly for carrying loads and driving, to a calm, robust, all-round leisure horse used mainly for riding and driving over the last century. In the Italian Haflinger breed a study was carried out to estimate variance components and breeding values for general conformation, and to develop an aggregate selection index including three conformation traits (breed type, general harmony and gaits) and one body measurement (height at the withers) based on more than 4500 records. Based on this the authors suggested a total merit index for breed selection process which has been approved by the Italian Haflinger Association (Miglior et al., 1998). Samore et al. (1997) estimated genetic parameters and breeding values for linear type traits in the Italian Haflinger population. They included the withers prominence and a tight upper line as being desired in their breeding program, whereas the correlation between these traits was 0.66.

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Three traits for the croup were also investigated, and while there was a strong correlation between width and length, the slope of the croup was only weakly correlated. The introduction of these objective measurements of horse's conformation, breeding values and gait characteristics offers the possibility of improving the classification quantitatively and qualitatively. This gives an additional system of measurements to the time-proven system of subjective evaluation by experts. However, the movement quality of the horse, probably its most important quality is not objectively assessed. A computerised motion analysis system enables such a locomotion parameters measurement in 3D (van Weeren, 2012). Therefore, the aim of the current study was to establish a single objective synthetic parameter, based on the locomotion of limbs, head and trunk, for the horse at walk and trot.

MATERIAL AND METHODS

Fourteen horses without clinical sign of back pain and lameness were used in this study (14 Haflingers mares, mean age was 8±3 years, CI (6, 9), range 4-14 years; mean body mass was 463±42 kg, CI (439, 487), range 396-526 kg; mean height at the withers was 131±5 cm, CI (128, 134), range 125-145 cm, mean height at the sacrum was 128±2 cm, CI (127, 130), range 124-135 cm and mean trunk length (considered as the distance between withers and sacral markers) was 76±4 cm, CI (74, 79), range 67-185 cm). Horses were warmed up and accustomed to the experimental set up on the treadmill. The following procedure was applied to reach the optimal measurement speed; the horses were walked and trotted on the treadmill until they were at ease with the situation, indicated by a rhythmic pattern of movement and the absence of overt signs of distress. The speed of the treadmill was gradually increased and the gait of the horse observed at which speed the horse showed the most rhythmical movement pattern with all strides at similar length and height, and then the horse was measured at that speed (Peham et al., 1998).

Seven reflective skin markers were positioned on each horse using adhesive tape; one on the forehead, one on the highest point of the withers, on the sacrum and lateral side of each hoof to identify motion cycles. Three-dimensional kinematic data in walk and trot were collected using ten high-speed cameras recording at 120 Hz. Three-dimensional coordinates of each marker during the time course of each experiment were calculated from the data using kinematic software. These time series were then smoothed by use of a Butterworth low-pass filtered (cut-off frequency, 10 Hz). The data was split to motion cycles by a custom-made MATLAB script starting with the left forelimb stance phase and the duration of the motion cycle was calculated. For each horse eight motion cycles were considered in walk as well as in trot. For the centre of body (CB) three dimensional marker positions CBx (forward-backward direction), CBy (side-to-side direction) and CBz (up-and-down direction) (as shown in Figure 1) were summed up and divided by the number of markers and normalized for the local position with the sacrum marker.

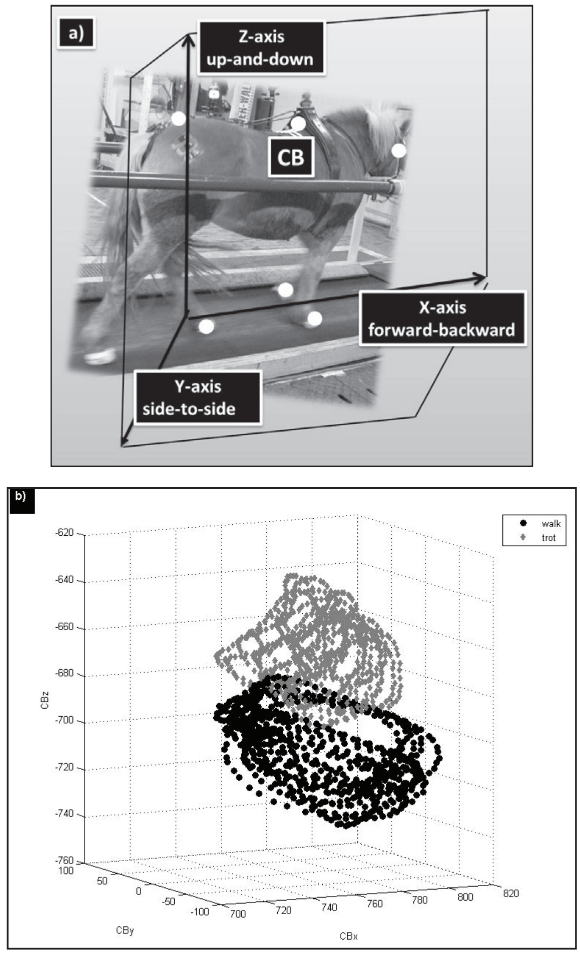

Figure 1. a) Horse with the reflective markers used for tracing of the movement of the limbs (markers placed on the hooves), the head (marker placed on the forehead), and the trunk (one marker was placed on the mid-thoracic area and one marker on the sacrum). The horse was walking on the treadmill. The right-handed coordinate system used is also shown, and the centre of body (CB) as determined as the centre of all of the markers. b) The position of the CB during 12 motion cycles in relation to the sacral bone marker in Horse 12 during walk (black circles) and during trot (grey diamonds). The axes of the coordinate system are: forward-backward (CBx), side-to-side (CBy) and up-and-down (CBz)

Statistical analyses were done in SPSS. Normality of distributions was tested with Shapiro-Wilk tests. The analysis of parametric data consisted of an independent T-test and the analysis of non-parametric data consisted of a Mann-Whitney U test. Correlations between the different conformation traits and centre of body parameters were sought with Spearman's correlation test. Alpha level (α) level of significance was set as 0.05. The results are expressed as mean±S.D. (standard deviation) CI (95% confidence interval for mean).

RESULTS AND DISCUSSION

The results of the present study are presented in Table 1, Table 2 and in Figure 2.

Table 1. Results of the position of the CB during walk and trot and statistically significant differences between walk and trot

cm		MeanCBx		MeanCBy		MeanCBz		Forward-backward movement		Side-to-side movement		Up-and down movement	
								SdCBx		SdCBy		SdCBz	
		walk	trot	walk	trot	walk	trot	walk	trot	walk	trot	walk	trot
Mean		74	73	0.6	0.5	-71	-69	0.6	0.8	2.6	2.0	0.7	0.9
Standard deviation		2	2	3.3	4.1	2	2	0.4	0.9	3.3	1.1	0.4	0.9
95% CI for Mean	Lower Bound	72	72	-1.3	-1.8	-73	-70	0.4	0.3	0.7	1.4	0.5	0.4
	Upper Bound	75	74	2.4	2.9	-70	-68	0.8	1.3	4.5	2.7	0.9	1.4
Minimum		70	68	-2.6	-7.3	-75	-73	0.2	0.2	0.5	0.6	0.4	0.2
Maximum		77	77	6.1	6.1	-66	-66	1.3	3.8	13.7	5.2	1.6	3.3
p		0.008				0.001							

Statistical significant correlation coefficients were found to be from moderate to very strong positive correlations (Table 2).

Table 2. Statistically significant correlations between the body measures and centre of body values

		Spearman's rho	P
Heigth at the sacrum	Heigth at the withers	0.80	0.001
Trunk length	Body mass	0.72	0.004
	Heigth at the withers	0.59	0.026
MeanCBx(walk)	Body mass	0.73	0.003
	Heigth at the withers	0.60	0.022
	Trunk length	0.86	0.000
MeanCBx(trot)	Body mass	0.57	0.034
	Trunk length	0.65	0.012
	MeanCBx(walk)	0.78	0.001
MeanCBy(trot)	MeanCBy(walk)	0.75	0.002
SdCBx(trot)	SdCBx(walk)	0.71	0.004

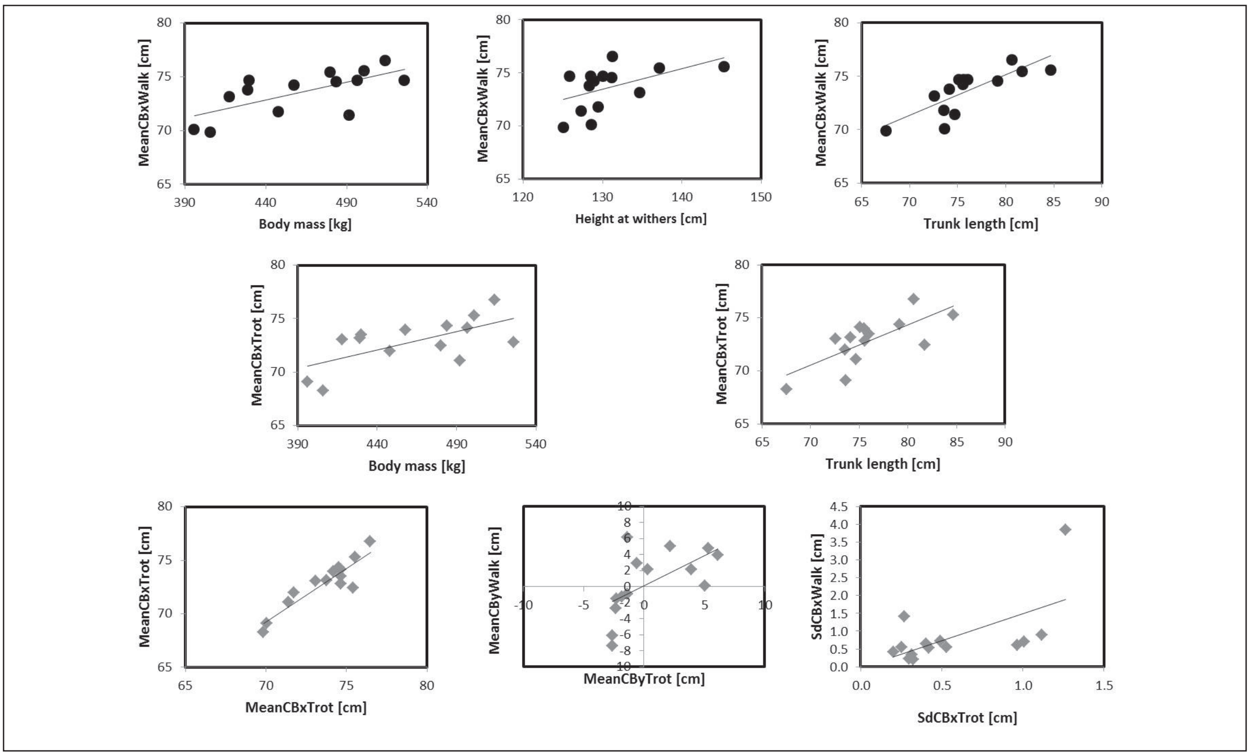

Figure 2. Scatter plot of statistically significant correlations showing all horses (n=14)

The present study was out to analyse within breed characteristics in order to highlight its potential use for selection within a breed. While the Haflinger breed developed originally as a working horse, now the use of these horses turned to leisure activity. Therefore, the conformation of these horses also needed to be adapted to this kind of use. These 14 mares show that the effect of this process is still visible and also measurable; as the current study showed highly variability between the horses' body measures. Haflingers used in this study were of a variety of shapes and body masses – within the breed specifications – e.g. body measures such as the height at the sacrum and the height at the withers are positively highly significantly correlated. The same is also true for the trunk length and the horse's height at its withers. In the present study, average mares of the Haflinger breed were used. They did not have an excellent breeding pedigree, conformation or gait, and therefore the method described could not be evaluated for its use in determining such breeding characteristics. Had such a population of Haflinger mares been used, the use of CB for determining excellence might have been tested.

In the previous studies (Nauwelaerts et al., 2009, 2013), the centre of body mass of horses was studied using a variety of methods and it is presumably closely related to the centre of body. However, body mass and its centre during locomotion are difficult to determine (Nauwelaerts et al., 2009) as segmental masses and segmental shapes change during motion. In the present study the centre of body was calculated relatively easily and accurately with the standard seven marker set-up used for many kinematic studies (Clayton et al., 2013). It is also important to consider during these calculations that the three top line markers and four hoof markers were used, giving more relevance to the relatively light limbs, and therefore the gait over the posture of the head and the trunk. This could easily be balanced out by adding one more marker along the top line. With the CB location of these horses, we are getting a general representative value of their overall movement picture, but not necessarily of the forces required or exerted on the body. In the breeding selection process the movement picture is one of the most important selection criterions. So, with the current method CB offers a way to objectively measure the overall movement picture of these horses and with these delivering also closer results to the subjective breeding evaluation process which is regularly done by breeding experts. The normalization of the data was done in relation to the sacral makers while it was the most stable of the markers in all directions including both gaits. Is is very suitable to document the limb movement in relation to the body. However, an important characteristic of gaits graded highly for the Haflinger breed is the vertical movement of the body. This characteristic is not represented by the CB, and probably limits its use as a single quality criterion for horse locomotion.

In the present study, there was a significant difference in the mean positions along the forward-backward axis (MeanCBx) and the mean positions along the up-and-down axis (MeanCBy) between walk and trot, with the walk showing a CB located more forward and lower in the body. However, there were no significant differences found between the forward–backward movement (SdCBx), side-to-side (SdCBy) and up-and-down

(SdCBz) centre of body movements between walk and trot, showing that the horses moved with similar stability in both gaits. MeanCBx marker position was in correlated with body mass at walk and trot, and also with height at the withers and trunk length, similarly in trot correlated with body mass and trunk length. The lack of correlation between MeanCBx and height at the withers at trot indicates that in this gait the variation in trot stride associated X axis positions of the relevant markers is larger between individuals than the variation of height at the withers – i.e. one small horse can throw its legs relatively further forward than a larger horse. This effect is gait specific; despite walk and trot MeanCBx marker positions of the centre of body were strongly positively correlated. This also supports the use of the trot as the main gait for breeding selection. Lateral position of the CB as indicated by MeanCBy was closely related between walk and trot but not to any of the body measurements of the horses. Also, this position was almost exactly in the midline of the horses, an indication that they were sound, and not favouring one side. The height of the body centre (MeanCBz) was not correlated to any of other body measures, nor was it correlated to either MeanCBy or MeanCBx. This was probably due to the rather smaller differences in height at the withers in the population studied, than in the other parameters.

The forward – backward movement of the body centre during motion, as indicated by the (SdCBx) was highly correlated between walk and trot, despite the difference in the gait characteristics, and the reported differences in back movement, with shortening of the back during the stance and extension of the back during the suspension phases in walk (Johnston et al., 2002).

No correlation was found for side-to-side centre of body movements (SdCBy) between walk and trot, most likely due to the much larger lateral trunk movement at walk, which is a gait with single, two, and three limb stance phases occurring, and therefore asymmetric body positions during parts of the movement cycles (Dunbar et al., 2008). We have found out positive correlations between MeanCBx and trunk length in walk and trot, which could highlight the biomechanical importance of the trunk as it plays a crucial role in deceleration and acceleration. Similarly Williams et al. (2009) showed based on their pitch-avoidance model, that polo ponies during rapid deceleration moved their centre of mass towards the hip, which also increased the length between the shoulder joint and the centre of mass.

CONCLUSION

Analysing the body centre in 14 Haflinger mares in the current study it was shown that distinction was allowed between individual's gait characteristics, and their relation to commonly analysed body measures. Using this parameter, trot as a main breed selection criterion for the Haflinger breed was confirmed. Also, the soundness of the horse can also be easily determined using the same analysis.

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