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THE PIG AS A QUADRUPED MODEL OF MODIFIED BODY MOVEMENT AND INTER-LIMB SUPPORT COORDINATION CHANGES IN THE PRESENCE OF LAMENESS

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SUMMARY

The objective of this study was to investigate movement changes in juvenile female pigs with advanced lameness compared to those with clinically sound locomotion based on a biomechanical method, to develop an additional tool in the assessment of superior breeding animals.

Although the number of lame pigs was relatively low, lameness caused consistent changes in the movement pattern of the head and trunk and the temporal leg movement characteristics.

INTRODUCTION

Lameness is a common cause of lost productivity for the pig industry worldwide and a significant threat to animal welfare. Lameness may arise from poor conformation, lesions in the hoof or integument and other disorders in the musculoskeletal and nervous systems. Common diagnostic methods require assessors with accurate diagnostic abilities and time for individual assessment, raising questions about the reliability of subjective gait assessment [1]. Also, increases in herd sizes in modern agriculture have led to the need for novel techniques in which large numbers of livestock can be monitored in an efficient, reliable, accurate and consistent way [2]. Automated biomechanical techniques could provide a valuable means to fulfil this purpose. It was hypothesized that lameness would result in measurable movement changes along the long axis of the body (head, neck and trunk) and the temporal hoof placement characteristics during the walk of a pig with potential differentiation according to site of lameness. During normal walking speeds in quadrupedal animals, there are typically interchanging 2- and 3-, or 4-leg support phases [1, 3] and there is a regular up- and downward movement of the trunk, neck and head [4].

METHODS

A total of 84 young female pigs (gilts) were enrolled in a longitudinal gait study in a period from January to July 2012. The experimental population grew gradually, increasing typically by five animals every three weeks, reflecting the three-week batch rotation system used for sow management on the Newcastle University pig unit. A multiple camera-based motion capture was applied at regular intervals to the pre-breeding gilts, during which 3D coordinate data of reflective skin markers attached to head, neck, trunk and leg anatomical landmarks were collected (Figure 1). About 15% of the gilts developed spontaneous lameness at some point during the enrolment period and before they entered the breeding herd at 220±10 days. On scheduled dates animal movement was captured when there was willingness to follow a human along a walkway with an apple reward. Lameness was clinically diagnosed on the day of capture using a subjective scale from 0 to 3 (where 0=normal gait, 1=stiffness, 2=lameness detected, 3=minimal weight bearing on affected limb; adapted from Main et al., [5]). Score 3 lameness (N=5) was identified to arise from the left side (front or hind), except for one uncertain case among affected hind limbs. Although the full marker model is presented in Figure 1, a specific selection of markers was used for parameter calculation here. Head, neck and trunk marker trajectories and support overlaps between all four hoofs of five lame pigs (of lameness score 3, 114kg (SD 20) bodyweight (BW)) were compared against the same movement parameters of five normal pigs (lameness score 0, 124kg (SD 2) BW). Depending on whether the data were normally distributed or not, Mann-Whitney tests and t-tests were applied (Minitab v.16, USA) to compare key intervals (differences between local maxima and minima (amplitudes)) on displacement curves over time and hoof stance overlaps for normal pigs and pigs with front (N=2) and hind limb (N=3) lameness.

RESULTS AND DISCUSSION

Walking speed of the lame pigs was 0.9m/s (SD 0.16) and that of the sound pigs 0.98m/s (SD 0.11); mean leg length was 620mm (SD 39mm) for lame pigs versus 662mm (SD 20mm) for sound pigs, thus functional speed was very similar among compared groups. The amplitudes of the vertical head, neck and spine displacement and the mediolateral displacement of the pelvis over time were different in normal pigs compared to pigs with front or hind leg lameness. Within a gait cycle (stride), pigs with front limb lameness had greater head (P=0.003, +59mm), neck (P=0.003, +62mm) and spine (P=0.024, +28mm) displacement, but decreased frequency of vertical head (P=0.008) and neck (P=0.019) movement. Pigs with hind leg lameness showed increased pelvic mediolateral displacement (P=0.046, +18mm) and greater vertical spine displacement (P=0.009, +22mm). However, the frequency of such movements in these pigs was not dissimilar to that of clinically normal pigs. Hoof support overlap was characterised by an increase in ipsilateral and contralateral double support time in lame pigs (Table 1), whilst diagonal double support phases remained largely unaffected. While the relative frequency of multiple leg support overall (79%) was higher in pigs with hind leg lameness, this increase was observed in 3-leg support phases and may be due to increases in ipsilateral and contralateral double support times. Pigs with front leg lameness showed a substantial shift toward 4-leg support which could be associated with a compromised supportive function of the front legs in quadrupedal animals.

Table 1:

Support overlaps (% gait cycle) between (a pair of) feet (diagonal, ipsilateral and contralateral) in lame and non-lame pigs (N=10). L=left, R=right, F=front and H=hind.

Lameness	**Diagonal**		**Ipsilateral**		**Contraleral**				3 leg support*	4 leg support*
	RF LH	LF RH	LH LF	RH RF	RF LF	RH LH	LF RF	LH RH		
Front	30^{ab}	34	27^{a}	26^{ab}	6^{a}	3^{a}	14^{a}	4^{a}	14%	55%
Hind	29^{a}	33	29^{a}	26^{a}	4^{b}	6^{b}	6^{b}	8^{b}	43%	36%
None	32^{b}	35	22^{b}	22^{b}	4^{b}	2^{a}	7^{b}	4^{a}	34%	34%

*relative frequency of observations.
[abc] Within a column, means followed by a different superscript are significantly different at P<0.05.

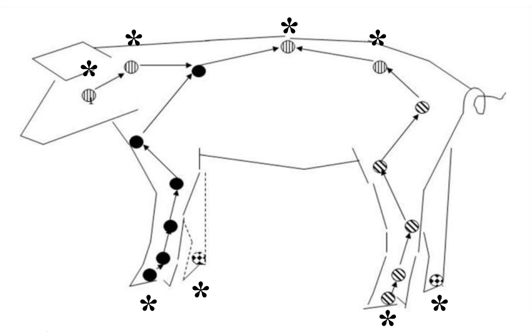

Figure 1: Reflective marker model captured with a 3D optoelectronic technique (* denotes sites where significant movement changes were observed in lame pigs).

CONCLUSIONS

Although the number of clinically lame pigs was relatively low, lameness in front legs caused pronounced changes in the vertical movement pattern of the neck and head. Both front and hind lameness affected the vertical movement of the spine, and hind-leg lameness provoked additional side movement changes of the posterior trunk. Confirmation of such clear changes in gait may provide the basis for development of a simple, automatic lameness tracking device for continuous livestock monitoring. Increases in double support times of ipsilateral and contralateral legs in lame pigs may not necessarily entail increases in 3-leg and 4-leg support phases, but rather expand the duration of such multiple support phases, meaning that measuring simply the number of hoofs on the ground without considering the time may be misleading and result in underestimated lameness prevalence on farms.

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