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Kinematics as objective tools to evaluate lameness phases in multiparous sows

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ABSTRACT

Lameness has been ranked as the third most common reason for culling sows, comprising 15% of the culls marketed in the U.S. Producers assess sow lameness using subjective evaluation, which have been shown to be variable in their application. Objective empirical tools to measure sow lameness on farm are required. Therefore, the purpose of this study were to evaluate the embedded force plate and the GAITFour gait analysis walkway system as objective assessment tools to discriminate between sound and lame phases in multiparous sows. Twenty-four mixed parity crossbred sows were anesthetized and injected with Amphotericin B in the distal interphalangeal joint of both claws of one hind hoof to induce transient lameness. Kinematic data was collected on D−1, D+1 and D+6 relative to induction (D0). For the embedded force plate, weight distributions on each hoof were collected. Gait analysis measures collected were stride time (defined as the time (s) between 2 successive footfalls by the same hoof), *stride length* (defined as the distance (cm) between 2 sequential footfalls from the same hoof), *maximum pressure* (defined as the greatest amount of weight (kg/cm^2) placed on a single hoof) and *stance time* (defined as the duration of time (s) the sensors were activated by a hoof in a single stride). For the embedded microcomputer-based force plate system weight placed on the induced hoof decreased on D+1 when compared to D−1 ($P<0.0001$). For the GAITFour® pressure mat gait analysis walkway system, *stride time* increased on D+1 for all hooves, *stride length* decreased on D+1 compared to D−1 and m*aximum pressure* placed on the induced hoof decreased on D+1 compared to baseline levels ($P<0.05$). *Stance time* increased for all sound hooves on D+1 compared to D−1 ($P<0.05$). In conclusion, the embedded force plate and GAITFour walkway system all demonstrated differences for mature sows during sound and most lame phases indicating promise as objective tools for use on farm.

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1. Introduction

Lameness has been defined by Merriam–Webster Lameness (2012) as "*having a body part and especially a limb so disabled as to impair freedom of movement*." Locomotor disorders can be associated with neurological disorders, hoof or limb lesions, mechanical–structural problems, traumas, or metabolic and infectious diseases (Smith, 1988; Wells, 1984). The United States Department of Agriculture (USDA, 2007) reported that lameness was the third most common reason for culling gilts and sows from the breeding herd (15.2%), following old age (36.6%) and reproductive failure (26.3%). With approximately 15% of pigs being removed from the breeding herd, this in turn affects the economical return to the industry (Stalder et al., 2004), worker morale (Deen and Xue, 1999) and the individual pigs well-being (Anil et al., 2009). Different methodologies have been employed to quantify lameness. Numerical rating- and visual analog scoring systems have been reported to be highly subjective with varying degrees of inter- and intra-observer correlation (Main et al., 2000; O'Callaghan et al., 2003; D'Eath, 2012). In a study by Main et al. (2000), 600 finishing pigs were scored on a 6-point numerical scale based on severity of lameness; a score of 0 represented no observed abnormalities whereas a score of 5 characterized a severely lame pig. Two observers who were familiar with the scoring system had a 94% lameness score agreement. Nineteen of these previously scored pigs were then scored by 7 unfamiliar observers. The proportion of scores identical between unfamiliar and familiar observers ranged from 26% to 53% indicating that the score test was relatively unreliable when used by observers unfamiliar with the tool. Similarly, D'Eath (2012) found that inter-observer reliability improved with more experience; however the farm manager consistently scored fewer animals as lame than the other observers. If the farm personnel become less sensitive to lameness, it may go undetected. Espejo et al. (2006) also found prevalence of locomotion scores collected on 5626 dairy cows were 3.1 times lower on average when estimated by the herd managers on each farm relative to other observers.

In comparison, biomechanic analysis tools could be used to objectively quantify differences in weight distribution and gait characteristics when determining animals' lameness status (Maertens et al., 2011; Pluym et al., 2013). Currently on U.S. swine farms the majority of gilts and sows are still housed in stalls limiting their movement. Sun et al. (2011) and Pluym et al. (2013) designed a force plate system that could be fitted in a standard stall to record weight distributions. Pastell et al. (2008) developed a system used for automatic detection of leg problems while cows stood in milking robots. The authors concluded that monitoring changes in weight distribution continuously could detect leg problems, including lameness, and that cows with injured legs put less weight on the affected limb. A limitation on testing the tool sensitivity and accuracy for lameness is based on understanding your animal population. Karriker et al. (2013) created an amphotericin B-model to induce transient lameness in sows so that known sound and lame populations of sows were being applied to the tools. Karriker et al. (2013) tested the micro-embedded force plate system and the GaitRite to validate their induction model and reported promising preliminary weight changes over sound and lame states.

Retailers have begun requiring that pork purchased come from systems that do not use the gestation stall (Johnson, 2008). Therefore, systems that could capture weight distribution and gait when sows are in motion are important to investigate (Anil et al., 2009). Gait analysis systems have been used to assess chickens (Corr et al., 2003), dogs (Evans et al., 2005) and dairy cattle (Flower et al., 2005; Kotschwar et al., 2009; Maertens et al., 2011). More recently, Karriker et al. (2013) used a GAITFour® system to collect preliminary data on the amphotericin B model of induced lameness. Again, this tool indicated promise in discriminating between sound and lame states in sows. Therefore, the purpose of this study were to evaluate the embedded force plate and the GAITFour gait analysis walkway system as objective assessment tools to discriminate between sound and lame phases in multiparous sows.

2. Materials and methods

The project was approved by the Iowa State University Institutional Animal Care and Use Committee. The experiments were conducted over two trials, trial one occurred from July to August, 2011 and trial two from October to November, 2011. The investigators established humane endpoint criteria such that any sow that progressed to non-weight bearing lameness by 12 h and did not approach water by 12 h or feed by 48 h were removed from the study and humanely euthanized. One sow was removed in trial 2 during the second round prior to lameness induction because she was unable to stand for complete data collection of the force plate but was not euthanized.

2.1. Animals and housing

A total of 24 (220.15 ± 21.23 kg) open, clinically sound, mixed-parity, crossbred sows were purchased from a producer in Iowa. To avoid confounding injury due to aggression, each sow was housed individually in concrete pens providing 5.1 m^2 and a 0.6 m deep concrete ledge along the rear wall of the pen where sows were fed. The floor was solid concrete and a rubber mat (2.4 m length × 2 cm height × 1.4 m width) was provided for comfort. Pens were set up in two rows with a central aisle and allowed for nose to nose contact between sows.

Sows had ad libitum access to water via one nipple water drinker (Trojan Specialty Products Model 65, Dodge City, KS) that was positioned over a grate. Sows were hand-fed in their home pens, receiving 2.3 kg of feed in the morning and 0.46 kg in the afternoon. On each data collection day, the morning ration was given in the test stall housing the embedded force plate to facilitate standing behavior and any remaining ration was given in the home pen. Feed was composed of ground corn, soybeans, and nutrients formulated according to Swine NRC guidelines with no antimicrobials. A total of 6.8 ml (15 mg) of Matrix (Intervet/Schering-Plough, Milsboro, DE) was

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