# Gait Analysis as an Objective Tool to Measure Hoof Lameness Phases in Multiparous Sows

## A.S. Leaflet R2910

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### Summary and Implications

The objective of this study was to compare differences in gait characteristics from sows in varying hoof lameness phases. Twelve, clinically healthy, mixed-parity, crossbred sows (228.89±19.17 kg) were used. The sow was the experimental unit and a cross-over design with a 2 (hooves: left and right hind hoof) x 3 (days: D-1, D+1 and D+6) factorial arrangement of treatments were compared. On induction day (D0), 10 mg of amphotericin B were injected in the distal interphalangeal joint space in both claws of one hind hoof. All sows served as their own control and treatment. After completion of the first round, sows were given a 7-d rest period and then the round procedures were repeated with the opposite hind hoof induced. Sows were walked in a continuous closed loop across the pressure mat. Each sow was required to complete three quality readings each day of data collection. Gait analysis measures collected were maximum pressure, stride time and stride length. All data were statistically analyzed using the PROC MIXED procedure in SAS. A *P* value of ≤ 0.05 was considered to be significant. For our study, the *GAITFour® pressure mat gait analysis walkway system*; ***maximum pressure*** placed on the induced hoof decreased on D+1 compared to D-1 ($P < 0.05$), s***tride time*** increased on D+1 for all hooves ($P < 0.05$) and s***tride length*** decreased on D+1 compared to D-1 ($P < 0.05$).Therefore, in conclusion, these kinematic measures all detected changes when sows were sound and in acute lameness phases, indicating future potential for sow lameness detection.

### Introduction

Many techniques have been employed in other species to qualify and quantify lameness. Numerical rating scoring and visual analog scoring systems are common, but highly subjective with varying degrees of inter- and intra- observer correlation. One tool to measure kinetic and kinematic gait analysis parameters is the GAITFour® analysis. The GAITFour pressure mat is a floor installed, portable walkway system which enables measurements of vertical hoof pressure, stride length and stride time in a walking animal. However, little work has been done to determine how objective such a tool is to detect differing severities of lameness in sows. Therefore, the objective of this study was to compare differences in gait characteristics from sows in varying hoof lameness states.

### Materials and Methods

***Animals and housing:*** This project was approved by the Iowa State University IACUC. Twelve, apparently healthy, mixed-parity, crossbred sows (228.89 ± 19.17 kg) were purchased from a commercial producer in Iowa. To avoid confounding injury due to aggression, each sow was housed individually. Each sow was housed in a concrete pen providing 5.1 $m^2$ and a 0.6 m deep concrete ledge along the rear wall of the pen where sows were fed. A rubber mat was provided for sow comfort. All sows were fed twice daily to meet their dietary requirements. Sows had *ad libitum* access to water via one nipple drinker that was positioned over a grate. Pens were set up in two rows with a central aisle and allowed for nose to nose contact with cohorts. Lights were on a 12:12 light dark cycle with light hours between 0600 and 1800. Sows were acclimated for 10 days before any treatments were applied. The research was conducted July through August 2011.

***Experimental design and treatments:*** The sow was the experimental unit. A cross over design with a 2 (hooves: right hind and left hind) x 3 (days: D-1, D+1 and D+6) factorial arrangement of treatments were compared. Three days were compared: D-1 (sound phase; defined as 1 day pre-induction of lameness); D+1 (most lame phase; defined as 1 day post-induction of lameness) and D+6 (resolution phase; defined as 6 days after the induction of lameness). All sows served as their own control and treatment. After completion of the first round of induction, sows were given a 7-day rest period and then a second round was conducted with the opposite hind hoof induced.

***Induction of Lameness:*** All sows were restrained in a standing position using a humane pig snare and then anesthetized using a combination of Xylazine (4.4 mg/kg),

Ketamine HCl (2.2 mg/kg), and Tiletamine HCL and Zolazepam in combination (Telazol®;4.4 mg/kg) administered IM. The assigned hind claws to be injected were washed with mild soap and water to remove obvious fecal contamination, scrubbed for 3 minutes with iodine based surgical scrub using 10 x 10 cm sterile gauze pad, and rinsed with 70 % isopropyl alcohol until no evidence of the surgical scrub remains. Ten mg of amphotericin B were injected in the distal interphalangeal joint space in both claws of one hind hoof. All sows were monitored continuously until fully recovered.

***Data Collection:*** Sows were assessed using a GAITFour® gait analysis walkway system and associated hardware. Sows were walked in a continuous closed loop across the pressure mat (4.3 m with 13,824 sensors) to acclimate the sows to the desired speed and pattern of movement needed for footfall analysis. Gait analysis measures collected were ***maximum pressure*** (defined as the greatest amount of weight placed on a single hoof), ***stride time*** (defined as the time in seconds between 2 successive footfalls by the same hoof), and ***stride length*** (defined as the distance in cm between 2 sequential footfalls from the same hoof). Each sow was required to complete three quality readings for each day. A quality reading was defined as the sow not hesitating, stopping, or running across the walkway and if at least two complete footfall cycles (all four hooves) registered in the software. Data was saved to the GaitFour software program for later analysis and validation.

## Statistical analysis

PROC UNIVARIATE determined that data was normal. Data were analyzed using the PROC MIXED procedure in SAS. The model included round, walk number (defined as the first, second or third quality reading) and the interaction of leg by day (leg defined as the measurement of weight placed on a hoof). Separate models were used to distinguish between a left and right hind hoof induction. A third code was used to assess differences between rounds of induction and hooves induced. This model included round, hoof induced, walk number and the interaction of leg by day. Sow within day and sow within round were fit as random effects with walk within day as a repeated effect for all models.

## Results and Discussion

***Maximum Pressure:*** No differences were observed between first and second rounds of induction (51.96 ± 1.44 kg and 51.11 ± 1.44 kg; $P = 0.15$) or between left vs. right hind hoof inductions (51.31 ± 1.44 kg and 51.76 ± 1.44 kg; $P = 0.41$). Maximum pressure placed on the induced hoof decreased on D+1compared to D-1 ($P < 0.05$; Table 1).

***Stride Time:*** No differences were observed between first and second rounds of induction (0.52 ± 0.02 seconds and 0.51 ± 0.02 seconds; $P = 0.13$). There was a difference between left and right hooves (0.51 ± 0.02 seconds and 0.53 ± 0.02 seconds; $P = 0.05$), although biologically these differences would be challenging to see in a walking sow. Stride time increased on D+1 for all hooves ($P < 0.05$; Table 1) compared to D-1.

***Stride Length***: No differences were observed between first and second rounds of induction (90.38 ± 2.12 cm and 89.20 ± 2.12 cm; $P = 0.35$) or between left vs. right hind hoof inductions (89.81 ± 2.12 cm and 89.77 ± 2.12 cm; $P = 0.98$). For all hooves, stride length decreased on D+1 compared to D-1 ($P < 0.05$; Table 1).

Findings from our study indicated that the GAITFour tool exhibited differences in gait characteristics between sound and most lame phases for the induced hoof, suggesting that the GAITFour is an objective tool for differentiating between sound and lame states in sows. However, because sows did not return to sound phase levels by D+6, the transient hoof lameness model modification may be needed to establish resolution of lameness when using this tool.

## Acknowledgements

This project is supported by Agriculture and Food Research Initiative competitive grant no. 2011-67021-30369 from the USDA National Institute of Food and Agriculture. I would also like to thank Becky Parsons, Monique Pairis-Garcia, Jessie Colpoys, Alex Folkmann, Brittney Nelson, and Ashley Woodley for assistance in animal care and data collection.

**Table 1. GAITFour® pressure mat gait analysis walkway system measures of maximum pressure, stride time, and stride length on D-1, D+1and D+6.**

| | | Day | | |
|---|---|---|---|---|
| **Hoof Induced** | **Hoof** | **D-1** | **D+1** | **D+6** |
| **Maximum pressure (kg)** | | | | |
| LH | LF | 63.98 ± 1.84[ab] | 61.16 ± 1.85[a] | 65.97 ± 1.84[b] |
| | RF | 59.84 ± 1.84[a] | 62.53 ± 1.85[a] | 60.74 ± 1.84[a] |
| | LH | 40.51 ± 1.84[a] | 34.44 ± 1.85[b] | 38.01 ± 1.84[a] |
| | RH | 38.86 ± 1.84[a] | 45.85 ± 1.85[b] | 43.91 ± 1.84[b] |
| RH | LF | 63.65 ± 1.88[a] | 65.52 ± 1.91[a] | 62.90 ± 1.90[a] |
| | RF | 61.79 ± 1.88[a] | 59.30 ± 1.91[a] | 61.62 ± 1.90[a] |
| | LH | 41.85 ± 1.88[a] | 46.44 ± 1.91[b] | 44.70 ± 1.90[b] |
| | RH | 40.79 ± 1.88[a] | 33.23 ± 1.91[b] | 39.48 ± 1.90[a] |
| **Stride time (sec)** | | | | |
| LH | LF | 0.49 ± 0.03[a] | 0.57 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | RF | 0.49 ± 0.03[a] | 0.56 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | LH | 0.49 ± 0.03[a] | 0.58 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | RH | 0.49 ± 0.03[a] | 0.59 ± 0.03[b] | 0.51 ± 0.03[a] |
| RH | LF | 0.48 ± 0.03[a] | 0.54 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | RF | 0.47 ± 0.03[a] | 0.54 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | LH | 0.48 ± 0.03[a] | 0.54 ± 0.03[b] | 0.51 ± 0.03[ab] |
| | RH | 0.48 ± 0.03[a] | 0.55 ± 0.03[b] | 0.50 ± 0.03[ab] |
| **Stride length (cm)** | | | | |
| LH | LF | 93.80 ± 2.62[a] | 83.68 ± 2.62[b] | 92.12 ± 2.62[a] |
| | RF | 93.56 ± 2.62[a] | 84.47 ± 2.62[b] | 92.16 ± 2.62[a] |
| | LH | 94.15 ± 2.62[a] | 83.35 ± 2.62[b] | 91.90 ± 2.62[a] |
| | RH | 93.82 ± 2.62[a] | 83.28 ± 2.62[b] | 92.00 ± 2.62[a] |
| RH | LF | 94.78 ± 2.82[a] | 83.54 ± 2.83[b] | 90.38 ± 2.83[a] |
| | RF | 94.91 ± 2.82[a] | 83.36 ± 2.83[b] | 90.22 ± 2.83[c] |
| | LH | 95.35 ± 2.82[a] | 83.24 ± 2.83[b] | 90.70 ± 2.83[c] |
| | RH | 95.35 ± 2.82[a] | 83.38 ± 2.83[b] | 90.67 ± 2.83[c] |

[ab]Within a row, means without a common superscript differ ($P < 0.05$).