Title: Building a handling course to document sow locomotion when sows are afflicted with different naturally occurring lameness **- #16-075 IPPA**

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Industry Summary:

Sow lameness is a major production disease affecting welfare and profitability. In 2014, Karriker and colleagues created a comprehensive swine lameness diagnostic manual which incorporated several diagnostic tools and pre- and post-mortem assessments. However; the manual had not been used to determine if it could classify lameness etiology. In 2015, Johnson and colleagues were awarded a grant through the Iowa Attorney General Office to begin the swine lameness diagnostic manual validation. The research team identified that a "handling course" needed to be added to the Iowa Attorney General Office objectives. The objectives of this proposal were to (1) build a handling course (a ramp and wooden boards) and (2) to detail sow locomotion by identified lameness etiology from the manual. A ramp and wooden boards were constructed. A total of 58mixed parity sows (20 non-lame [control] and 38 naturally occurring lame) were walked over the ramp and the wooden boards. After completion of the handling course a swine veterinarian used the swine lameness diagnostic manual to categorize lame sows into one of three etiology systems; (a) integumentary, (b) musculoskeletal, and (c) integumentary/musculoskeletal.

Our results from this project showed:

- Control- and musculoskeletal sows were the slowest to traverse the ramp.
- Sow lameness etiology did not affect the time needed to traverse the wooden boards.
- Sow lameness etiology did not affect the time needed to traverse the entire handling course.
- Control sows needed more animal-human interaction to traverse the ramp compared to lame sows.
- Sow lameness etiology did not affect the animal-human interaction needed to traverse the wooden boards.

Keywords: Handling course, lameness diagnostic manual, naturally occurring lameness, sow

Scientific Abstract:

Sow lameness is a major production disease affecting welfare and profitability (Anil et al., 2005). In 2014, Karriker and colleagues created a comprehensive swine lameness diagnostic manual which incorporated several diagnostic tools and pre- and post-mortem assessments. However; the manual had not been used to determine if it could classify lameness etiology. The objectives of this proposal were to (1) build a handling course (a ramp and wooden boards) and (2) to detail sow locomotion by identified lameness etiology from the manual. A wooden ramp and wooden boards were constructed. The ramp had the ascending and descending slopes set at 1.70 m (5.57 ft.) length x 0.82 m (2.69 ft.) internal width x 1.1 m (3.60 ft.) external width x 1.06 m (3.47 ft.) height. The ascending and descending slopes were at an 11° slope. Connecting the ascending and descending ramp is a walkway set at 1.21 m (3.96 ft.) length x 0.82 m (2.69 ft.) width x 1.06 m (3.47 ft.) height. Forty two cleats (0.71 m (2.32 ft.) length x 0.05 m (0.16 ft.) width x 0.02 m (0.06 ft.) height) were spaced at 0.16 m (0.52 ft.) intervals in both ascending and descending slopes (Figures 2, 3, 4). Ten wooden boards measured 0.08m (0.26 ft.) length x 0.76 m (2.49 ft.) width x 0.03 m (0.09 ft.) depth were spaced 0.3 m (0.98 ft.) apart and attached to a wooden frame. The wooden frame measured 3.12 m (10.23 ft.) length x 0.83 m (2.72 ft.) width x 0.08 m (0.26 ft.) height. A total of 58 commercially crossbred (PIC 1050; parity 1 to 8) were removed from their home pens and individually walked over the ramp and the wooden boards. One observer (who was standing outside the ramp and wooden boards and was hidden from the sow) recorded the time needed to traverse the ramp and wooden boards using a stop watch. Three color cameras (Panasonic, Model WV-CP-484, Matsushita Co. LTD., Kadoma, Japan) were positioned over the ramp and 2 color cameras (Panasonic, Model WV-CP-484, Matsushita Co. LTD., Kadoma, Japan) were positioned over the wooden boards to record the animal-human interaction which was scored over five levels; (1) noise maker, (2) sorting panel, (3) handler's hands, (4) feed, (5) rattle paddle. After completion of the handling course a swine veterinarian used the swine lameness diagnostic manual to categorize lame sows into one of five etiology systems; (1) central nervous- (2) digestive-/metabolic issue (3) integumentary- (4) musculoskeletal- and (5) the peripheral nervous systems. Time and animal-human interaction were shown to be highly correlated and were therefore analyzed separately using generalized linear mixed model methods (PROC GLIMMIX) of SAS. The significance level was set at $P < 0.05$. A total of 20 sows were classified as non-lame (control etiology), and 38 sows displayed naturally occurring lameness. Of the 38 lame sows, 14 were classified as integumentary, 13 were classified as musculoskeletal and 11 were classified as the integumentary/musculoskeletal. Sows classified in the integumentary (100.63 seconds) and integumentary/musculoskeletal sows (88 seconds) traversed the ramp quicker than control (270.13 seconds) and musculoskeletal sows (175.03 seconds; $P = 0.02$). Lameness etiology was not a source of variation when

comparing time to traverse the wooden boards (control sows: 54.45 seconds; integumentary sows: 29.94 seconds; musculoskeletal sows: 34.59 seconds; integumentary/musculoskeletal sows: 43.61 seconds; P = 0.16). Lameness etiology was not a source of variation when comparing time to traverse the handling course (control sows: 324.58 seconds; integumentary sows: 130.57 seconds; musculoskeletal sows: 209.62 seconds; integumentary/musculoskeletal sows: 131.61 seconds; P = 0.19). Lameness etiology was a significant source of variation (P < 0.0001) when comparing the animal-human interaction needed for sows afflicted with different lameness etiologies to traverse the ramp, with control sows needing the most interaction (19.05 interactions) compared to the other lameness etiologies (integumentary sows: 5.43 interactions; musculoskeletal sows: 13.19 interactions; integumentary/musculoskeletal sows: 6.01 interactions). Lameness etiology was not a source of variation (P = 0.06) when comparing the animal-human interaction needed for sows afflicted with different lameness etiologies to traverse the wooden boards. In conclusion, understanding how lameness etiology affects the sows movement and animal-human interaction can help in recommendations and on-farm education. This study is the first to assess the usefulness of the Swine Lameness Diagnostic Manual. Based on these behavioral results future studies need to include a. all the lameness etiologies, b. compare and contrast different obstacles, c. include more validated pain tools, and d. complete post mortem analysis.

Introduction:

Sow lameness is a major production disease affecting swine welfare and profitability. After reproductive problems, lameness is the most important reason for premature sow culling from breeding herds (Anil et al., 2005),with approximately 32% of animals culled for lameness having only produced one litter (Boyle et al., 1998). Direct lameness costs include increased work load, medical treatment and reduced productivity (Metz and Bracke, 2005; Jensen et al., 2007) and it is estimated to cost ~$230 million/year (Deen, 2009).

Several clinical diagnostic lameness tools have been successfully validated in a controlled laboratory setting using an induced transient synovitis model (Karriker et al., 2013).These diagnostic tools were able to differentiate between lame and sound states and included mechanical and thermal nociceptor threshold tests (et al., 2014b; Pairis-Garcia et al., 2014; Tapper et al., 2013), behavioural assessment (Pairis-Garcia et al., 2014; Parsons et al., 2016), standing and walking lameness scoring (Karriker et al., 2013) and biomechanical tools (Mohling et al., 2014b; Pairis-Garcia et al., 2014; Sun et al., 2011). From these efforts a comprehensive swine lameness diagnostic manual (Karriker et al., 2014) was created that provided additional pre- and post-mortem assessment. The manual clusters lameness etiologies into five systems (1) central nervous- (2) digestive-/metabolic issue (3) integumentary- (4) musculoskeletal- and (5) the peripheral nervous systems. Johnson et al. (2015) were awarded a grant through the Iowa Attorney

General Office to begin swine lameness diagnostic manual validation. It was recognized that a "handling course" needed to be added to the Iowa Attorney General Office objectives, and sow locomotion when afflicted with different etiologies needed to be added, therefore these latter efforts were the focus of this proposal.

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Objectives:

To build a handling course to document sow locomotion when sows are afflicted with different naturally occurring lameness.

Research questions

How does the sow lameness etiology affect the time needed to traverse the ramp?

H0: All sows regardless of lameness etiology would traverse the ramp at the same speed.

H1: Control sows would not be experiencing lameness pain and would traverse the ramp quickest.

How does the sow lameness etiology affect the time needed to traverse the wooden boards?

H0: All sows regardless of lameness etiology would traverse wooden boards at the same speed.

H1: Lame sows would traverse wooden boards the slowest.

How does the sow lameness etiology affect the time needed to traverse the handling course?

H0: All sows regardless of lameness etiology would traverse the handling course at the same speed.

H1: Lame sows would traverse the handling course slowest.

How does the sow lameness etiology affect the animal-human interaction during the handling course?

H0: All sows regardless of lameness etiology would require the same animal-human interactions during the handling course.

H1: Control sows would not be experiencing lameness pain and would require fewer animal-human interactions during the handling course.

Materials & Methods:

This protocol was approved by the Iowa State University Institutional Animal Care and Use Committee.

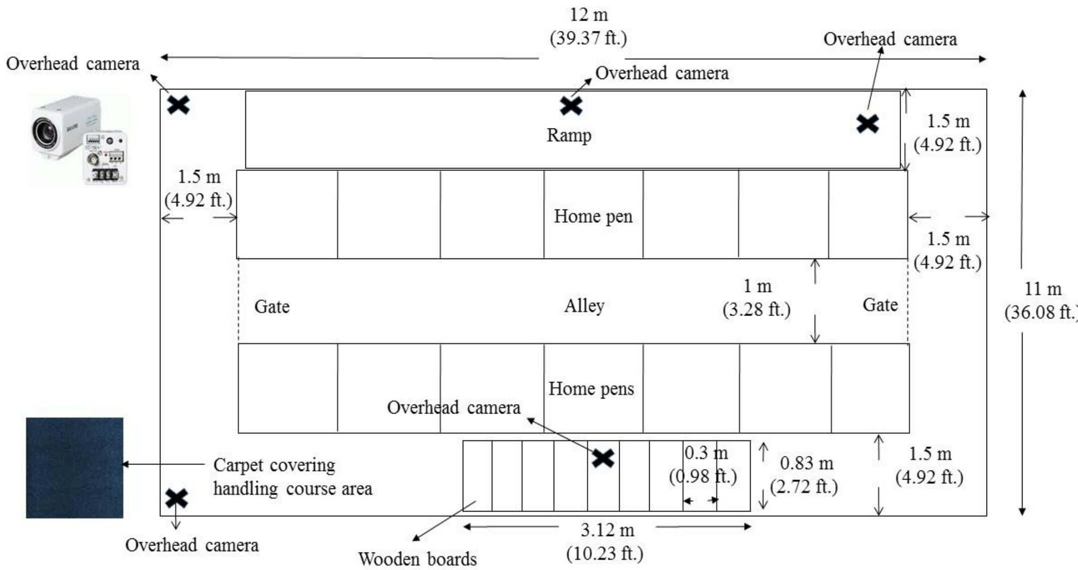
Animals and housing

A total of 58 commercially crossbred (PIC 1050) sows (BW: 183.14 ± 17.73 kg or 403.77 ± 39.09 lbs.) ranging in parity from 1 to 8 were enrolled in the study. The sows were visually assessed for lameness on the commercial farm using the standing lameness score (score 0 = non lame with no toe tapping; score1 = lame with toe tapping) and/or the presence of gross lesions associated with one or multiple limbs. Sows were transported from the commercial farm to the Swine Intensive Laboratory at Iowa State University (Ames, IA) and allowed to rest and acclimate for 1 day. To avoid confounding injury due to aggression, each sow was housed individually in a concrete pen providing 5.10 m^2 (54.89 ft^2) and a 0.60 m (1.96 ft.) deep concrete ledge along the rear wall of the pen where the sows were fed. A rubber mat was provided for sow comfort. All sows were fed 2.20 kg (4.85 lbs.) a ground ration 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. Caretakers observed all sows twice daily and verified they were able to rise and were ambulatory on all 4 limbs. A veterinarian specializing in swine medicine selected 2-3 animals for assessment daily, prioritizing animals that were displaying progressively worsening lameness.

Handling course (the ramp and wooden boards)

Each sow was removed from the home pen and were directed through the handling course by a designated trained handler. The handling course measured 45 m (147.63 ft.) long × 1.50 m (4.92 ft.) wide and included two obstacles.

Figure 1. Sow handling course at the Iowa State University Swine Intensive Laboratory



Measures

One observer (who was standing outside the ramp and wooden boards and was hidden from the sow) recorded the time needed to traverse the ramp and wooden boards using a stop watch. Table 1 displays the definition for the time measurements.

Table 1. Time needed to traverse ramp, wooden boards and handling course (ramp + wooden boards)

Measurement (seconds)	Description
Traverse total ramp	Sow shoulders cross onto the ramp incline and concludes when the sow hind quarters comes off the ramp decline.
Traverse the wooden boards	Sow's two front legs and shoulders are inside the wooden boards and concludes when the entire sow's body is outside of the wooden boards and her four feet are in contact with the handling course floor.
Traverse the handling course	Summation of time to traverse ramp and wooden boards.

Animal-human interaction

Five color cameras (Panasonic, Model WV-CP-484, Matsushita Co. LTD., Kadoma, Japan) were placed around the handling course (Figure 1; designed by Azarpajouh, 2018). Three cameras were positioned over the ramp and 2 cameras were positioned over the wooden boards. Video was collected and saved to a hard disk using Handy AVI (HandiAvi version 4.3 D, Anderson's AZcendant Software, Tempe, AZ, USA) at a speed of 10 frames/seconds.

One experienced handler defined as approximately 10 years of sow handling moved all sows for the current study. Handler interaction occurred if the sow stopped making a forward motion for 10 continuous seconds at any point on the handling course. Each interaction level between the sow and the handler occurred in 20 second intervals. The following interaction order occurred until the sow resumed a forward movement:

1) Noise maker, a plastic coffee can was filled with metal pieces,
2) Sorting panel used to apply pressure to the sow's caudal region,
3) Handler used their hands to make contact with the sow's back,
4) Feed placed in front of the sow,
5) Rattle paddle used to make contact with the sow's back.

After all five interaction levels had been applied, the sow was left to rest for 5 minutes. In the event that a sow went down on 2 legs or laid down on the obstacle course, she was left to rest for 10 minutes without interaction. After periods of rest, sows were encouraged to continue moving through the course beginning with interaction 1/noise maker. If the sow did not complete the handling course in 40 minutes, she was returned to her home pen.

Lameness Diagnostic Manual to Determine Sow Lameness System:

A physical examination was performed by a veterinarian on each sow in their individual home pen after the handling course completion. The physical examination findings directed the veterinarian to a lameness system (1) central nervous- (2) digestive-/metabolic issue (3) integumentary- (4) musculoskeletal- and (5) the peripheral nervous systems.

Inter-reliability training:

A veterinary medicine student was trained to score the animal-human interaction from the video clips played at real time at the ISU Animal Behavior Laboratory. Four, 30-minute video clips were selected using the Excel random number generator software; 2 video clips were from the ramp and 2 video clips were from the wooden boards. The trainer and the student scored the same four video clips using Table 1 to achieve a 90% inter-reliability.

Data Analysis:

The sample size for this study was verified through a power calculation using published data by McGeown et al. (1999) on broiler speed to move around a handling course when not lame (with and without carprofen) and lame (with and without carprofen). To detect an 80% difference in walking speed at two standard deviations from the mean using an alpha 0.05 a total of 60 sows were required. Each sow was considered an experimental unit. Time and interaction were shown to be highly correlated and were therefore analyzed separately using generalized linear mixed model methods (PROC GLIMMIX) of SAS (v9.4, SAS Inst. Inc., Cary, NC). Time needed to traverse the ramp, time needed to traverse the wooden boards and time needed to traverse the handling course were transformed to log scale using the Gamma distribution option of the model statement. Animal-human interaction during the ramp and wooden boards were transformed to log scale using the Poisson distribution option of the model statement. Fixed effects of group and suspected lameness system were used across all models. Weight was fit as a linear covariate in all models. Statistical differences were reported when individual model main effects were a significant source of variation ($P \leq 0.05$). Further, when individual model main effect was a significant source of variation, main effect levels were separated using the PDIFF option (SAS v 9.4), which returns the P values for least squares means differences between different levels within each level of fixed class effects. Results for fixed effects were reported as least squares means ± SE (LSMeans ± SE) after being back transformed from the log scale using the ILINK option in the LSMEANS statement (SAS v 9.4). Results for covariates were reported as regression coefficients ± SE.

Results:

Building the handling course

Obstacle 1, Ramp: this was designed and built by an Iowa State University agricultural engineering specialist. The ramp was constructed of wood and colored red and gray to be consistent with the panel boards and the carpet color that is found in the Swine Intensives Laboratory. The ramp had the ascending and descending slopes set at 1.7 m (5.57 ft.) length x 0.82 m (2.69 ft.) internal width x 1.1 m (3.6 ft.) external width x 1.06 m (3.47 ft.) height. The ascending and descending slopes were at an 11° slope. Connecting the ascending and descending ramp is a walkway set at 1.21 m (3.96 ft.) length x 0.82m (2.69 ft.) width x 1.06 m (3.47 ft.) height. Forty two cleats (0.71 m (2.32 ft.) length x 0.05 m (0.16 ft.) width x 0.02 m (0.06 ft.) height) were spaced at 0.16 m (0.52 ft.) intervals in both ascending and descending slopes (Figures 2, 3, 4).

Obstacle 2, Wooden boards: Ten wooden boards that measured 0.08m (0.26 ft.) length x 0.76 m (2.49 ft.) width x 0.03 m (0.09 ft.) depth were spaced 0.3 m (0.98 ft.) apart and attached to a wooden frame. The wooden frame measured 3.12 m (10.23ft.) length x 0.83 m (2.72 ft.) width x 0.08 m (0.26 ft.) height (Figure 5).All sows completed the handling course (the ramp (Figures 6, 7, 8) and wooden boards (Figure 9)) 1 time during the study.

Figure 2: Ascending slope of ramp

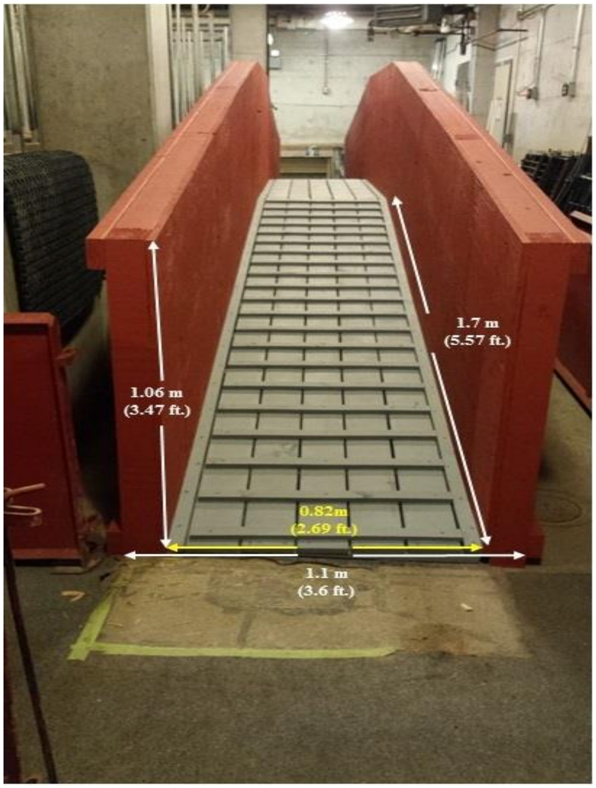


Figure 3: Walkway section of ramp

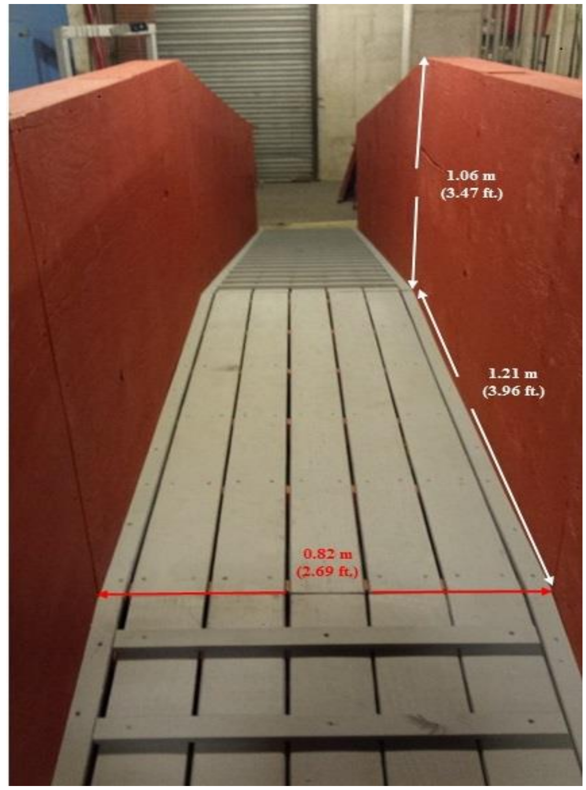


Figure 4: Descending slope of ramp

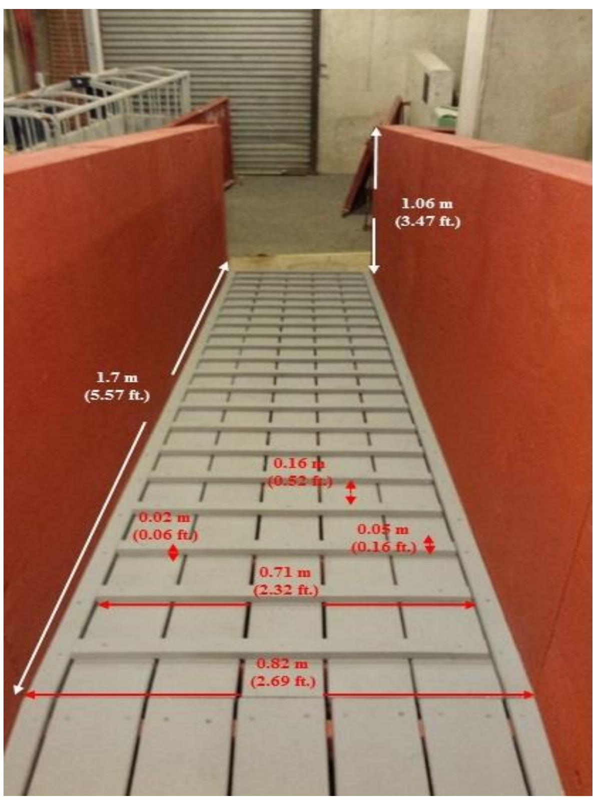


Figure 5: Wooden boards

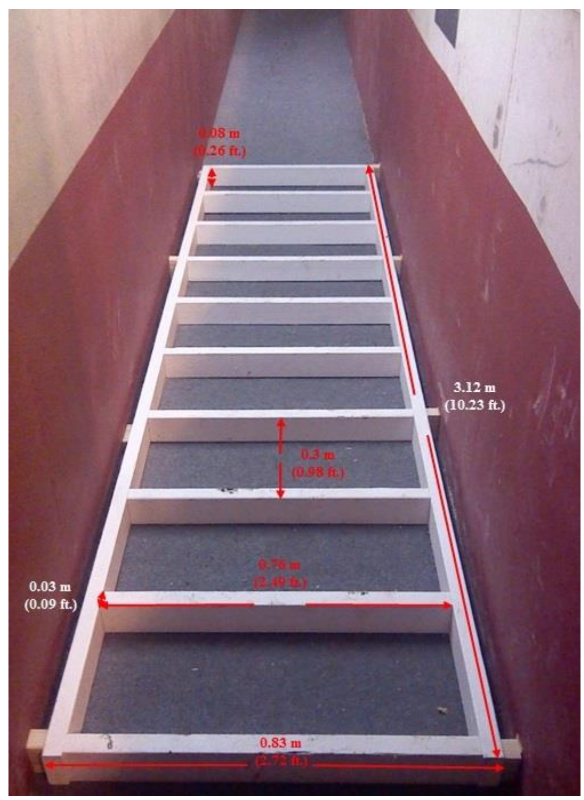


Figure 6: Sow walking on ascending slope of ramp

Figure 7: Sow on walkway section of ramp

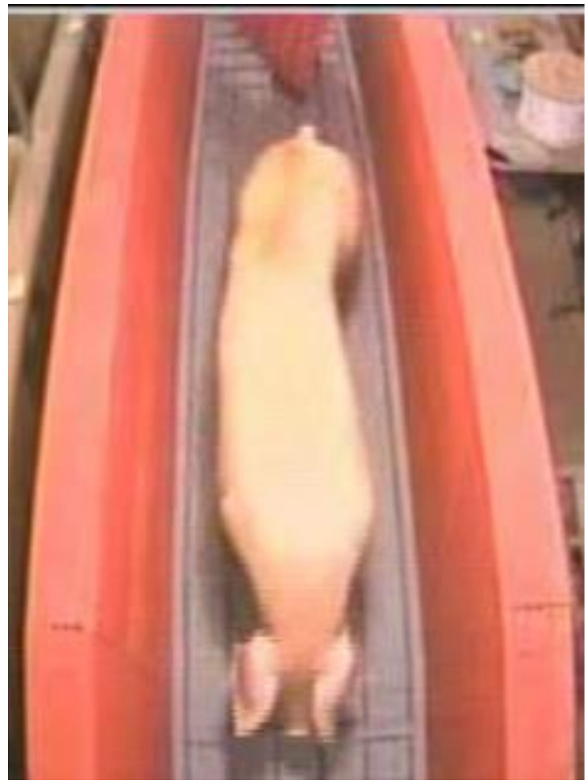


Figure 8: Sow walking on descending slope of ramp

Figure 9: Sow walking on wooden boards

Lameness Diagnostic Manual to Determine Sow Lameness System

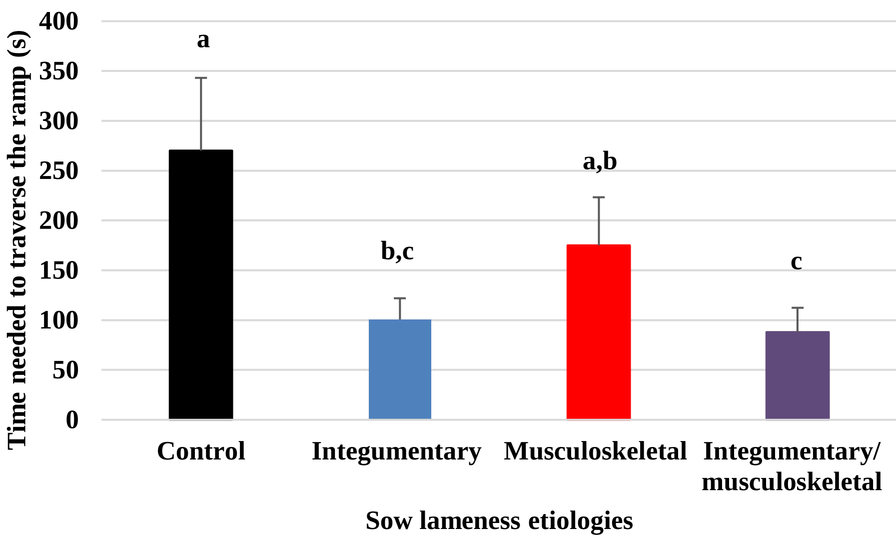
A total of 20 sows were classified as non-lame or control etiology and 38sows displayed naturally occurring lameness. Of the 38 naturally occurring lame sows, 14 were classified as integumentary, 13 were classified as musculoskeletal and 11 were classified as the integumentary/musculoskeletal.

Research questions:

How does the sow lameness etiology affect the time needed to traverse the ramp?

Integumentary (100.63 seconds) and integumentary/musculoskeletal sows (88 seconds) traversed the ramp quicker than control (270.13 seconds) and musculoskeletal sows (175.03 seconds; P = 0.02; Figure 10).

Figure 10: Time (seconds) for sows afflicted with different lameness etiologies to traverse the ramp (P = 0.02)



How does the sow lameness etiology affect the time needed to traverse the wooden boards?

The data suggested that lameness etiology was not a significant source of variation when comparing time to traverse the wooden boards (control sows: 54.45 seconds; integumentary sows: 29.94 seconds; musculoskeletal sows: 34.59 seconds; integumentary/musculoskeletal sows: 43.61 seconds; P = 0.16).

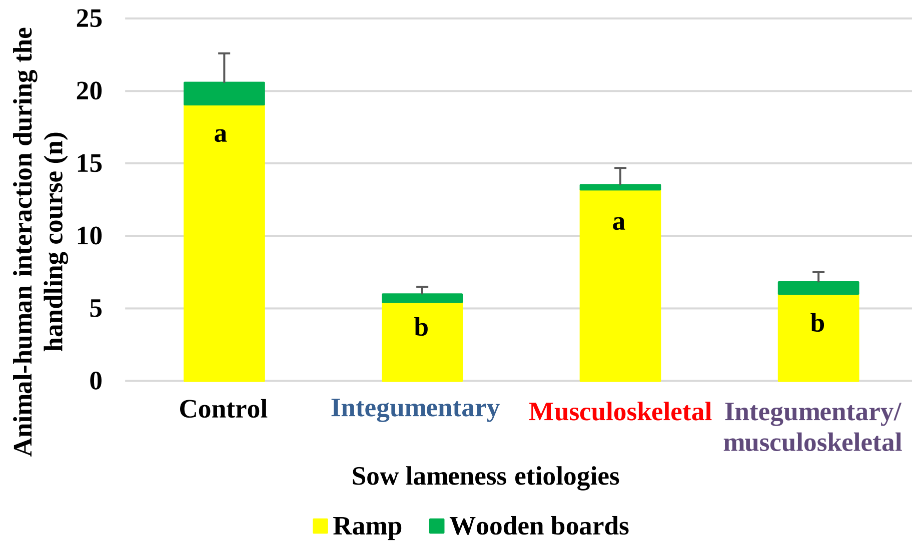
How does the sow lameness etiology affect the time needed to traverse the handling course (ramp + wooden boards)?

The data suggested that lameness etiology was not a significant source of variation when comparing time to traverse the handling course (control sows: 324.58 seconds; integumentary sows: 130.57 seconds; musculoskeletal sows: 209.62 seconds; integumentary/musculoskeletal sows: 131.61 seconds; P = 0.19).

How does the sow lameness etiology affect the animal-human interaction during the handling course?

The data suggested that lameness etiology was a significant source of variation ($P < 0.0001$) when comparing the animal-human interaction needed for sows afflicted with different lameness etiologies to traverse the ramp, with control sows needing the most interaction (19.05 interactions). The data suggested that lameness etiology was not a significant source of variation ($P = 0.06$) when comparing the animal-human interaction needed for sows afflicted with different lameness etiologies to traverse the wooden boards (Figure 11).

Figure 11: The number (n) of animal-human interaction during the handling course for sows afflicted with different lameness etiologies



Discussion:

Lameness has been defined as "*having a body part and especially a limb so disabled as to impair freedom of movement*" or as "*impaired movement or deviation from normal gait*" (Corr, 2003). Locomotor disorders can be associated with neurological disorders, hoof or limb lesion(s), a mechanical-structural problem, trauma, or metabolic and infectious diseases that might result in pain and discomfort depending on the severity and type of disorder (KilBride et al., 2009; Main et al., 2000; Wells, 1984). Behavior commonly associated with lameness pain in swine include vocalizations, abnormal standing posture and/or gait, stiff movements or reluctance to move, lowered ability to accelerate and change direction, increased inactivity and decreased appetite (Anil et al.,2009;Corr, 2003;Underwood 2002). Numerous studies using a validated chemical synovitis sow lameness model supports the previously mentioned changes in behavior. Roco et al. (2016) reported that sows spent less time standing on the most lame day compared to sound and resolution days. Sows performed fewer standing and sitting postural adjustments on the most lame day compared to the sound day. Lame sows transitioned through fewer postures on the most lame day compared to sound and resolution days. Sows had a higher percentage of time lying laterally on the most lame day compared to sound and resolution days regardless of which foot was injected. There were no observed differences in time(s) for sows to reach the feeder over treatment days. Parsons et al. (2015) reported that observations of sows drinking, standing, lying sternal and being in the drinker location decreased after lameness induction. Lying lateral frequency, regardless of side, increased after sows were induced lame. Frequency in the home pen location increased, but no differences were observed for feed bunk location after sows were induced lame. The induced lame foot had no observed effect on lying side preference. By the end of the round, all behavioral and location frequencies returned to baseline levels. Standing, lying and drinking frequencies seem to be promising sow behavioral tools when transitioning from sound to lame states. Mohling et al. (2014a) reported that for the embedded microcomputer-based force plate system weight placed on the induced hoof decreased on D+1 (one day after lameness induction) when compared to D−1 (one day before lameness induction). For the GAIT Four® 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 maximum pressure placed on the induced hoof decreased on D+1 compared to baseline levels. Stance time increased for all sound hooves on D+1 compared to D−1. Pairis-Garcia et al. (2015) reported that sows administered flunixin meglumine or meloxicam tolerated more weight on their lame leg compared with saline sows. Sows administered flunixin meglumine or meloxicam had smaller differences in stance time, maximum pressure, and activated sensors between the sound and lame legs compared with saline-treated sows between 37 and 60 h after lameness induction. Ala-Kurikka et al. (2017) reported that lame sows were more passive, they laid more and stood and explored pen fixtures less than the control sows before treatment. After 5-days treatment, placebo-treated sows were in contact with the wall and lying more often when compared to control sows. Ketoprofen-treated sows were more seldom in contact with the wall and exploring bedding more often than placebo-treated sows. Placebo sows tended also to move and explore bedding less than control sows. The behaviour of sows with relieved lameness did not differ from that of control sows on day 5. Sows with non-relieved lameness were in contact with the wall and lying more and moving and standing less than control sows. When compared to control sows, sows with non-relieved lameness tended to be more passive. When compared to sows with relieved lameness, sows with non-relieved lameness showed a tendency to be in contact with the wall more often.

Finding one: Control- and musculoskeletal sows were the slowest to traverse the ramp.

According to the Swine Lameness Diagnostic Manual (Karriker et al., 2014), lameness signs associated with the musculoskeletal system are; swollen joints, bruises, laceration, abrasions and fracture of limb(s), spine curvature, atrophy or pain in topline, asymmetrical hindquarter, spinal cord injury and evidence of paralysis.

In addition, lameness signs associated with the integumentary system include skin abnormalities such as vesicle, ulcer and erosion present on the snout, hooves or within the oral cavity, swelling or enlargements present over the joint space, abscess, wound puncture or skin discoloration, hoof wall separation from underlying tissue, evidence of fracture, malalignment, crepitus or bone protrusion, inter digital lesion and hooves or dew claw overgrowth. No published studies have compared lameness pain associated with a suspected lameness system. In this study, integumentary/musculoskeletal sows traversed the ramp the fastest compared to the other suspected systems. We thought that control sows would not be experiencing lameness pain and would move quickest. However, no pain may result in a sow allocating increased time in exploring her surroundings, hence an increased ramp time. Future work should include additional validated pain measurements i.e. mechanical nociceptive threshold tests and embedded microcomputer-based force plate system combined with the handling course to provide an explanation to the previous supposition. In addition, combining the Swine Lameness Diagnostic Manual, with validated pain tools and using analgesics would provide information on sows lameness severity and pain management tools. A previous study by McGeown et al. (1999) provides an exciting lameness pain model. The authors compared the time for control and lame broiler chickens to traverse an obstacle course after treatment with carprofen. Sound birds traversed the course in approximately 11 seconds, irrespective of treatment. Lame birds without carprofen took approximately 34 seconds. However, lame birds with carprofen traversed the handling course in 18 seconds similar to control birds.

Finding two: Sow lameness etiology did not affect the time needed to traverse the wooden boards.
Finding three: Sow lameness etiology did not affect the time needed to traverse the entire handling course.

The data suggested that lameness etiology was not a significant source of variation when comparing time to traverse the wooden boards and the entire handling course. The manual clusters lameness etiologies into five systems (1) central nervous- (2) digestive-/metabolic issue (3) integumentary- (4) musculoskeletal- and (5) the peripheral nervous systems. In this study lame sows were categorized into one of three following etiology systems; (a) integumentary (n = 14), (b) musculoskeletal (n = 13), and (c) integumentary/musculoskeletal (n = 11) and none of the sows were diagnosed with lameness associated with either central or peripheral nervous system. Additionally, in this study the ramp ascending and descending slopes were at an 11° slope but the wooden boards were flat which might explain why the sow lameness etiology did not affect the time needed to traverse the wooden boards and the entire handling course but it affected the time needed to traverse the ramp. We thought that the wooden boards would not be challenging for lame sows to walk over. Additionally, sows affected with central and peripheral nervous systems may show front leg paralysis, staggering, uncoordinated movements, head tilting, and severe ataxia. Therefore, further work should include

(a) central and peripheral nervous system sows and (b) obstacle courses with different height and slope to investigate the lameness etiology affect on the time needed to traverse an obstacle course.

Finding four: Control sows needed more animal-human interaction to traverse the ramp compared to lame sows.

Finding five: Sow lameness etiology did not affect the animal-human interaction needed to traverse the wooden boards.

In this study control sows moved slower and required more animal-human interaction to traverse the ramp. Lame sows walked more consistently (stopped walking less) in the area with an incline and/or a decline than control sows which could be a behavioral compensation due to lameness pain. We thought that control sows would not be experiencing lameness pain and would require fewer animal-human interactions. However, with sows increasing their environmental exploration time it required the handler more interactions to keep the sow moving forward over the ramp. Additionally while walking over the ramp, sow had all four feet on the ramp and felt more solid to explore the environment but while walking on the wooden boards, sow needed to lift the legs, hence feel less solid to explore the environment. In the Pork Quality Assurance Program (PQA-Plus, 2016), *"It is important to understand the potential effects that human interactions have on pigs and pig behavior. A person's intentions are not always understood by the pig and this may create fear or a negative reaction to a handler. Pigs should be moved at their normal walking pace. Aggressive handling should be avoided as it can lead to injured or stressed pigs. Understanding the interactions between people and pigs will help handlers create positive handling and transportation experiences for pigs, keeping them calm and free of stress throughout the process"*. Caretakers need to be trained that non lame sows may need more time to walk.

Conclusion:

Understanding how lameness etiology affects the sows movement and animal-human interaction can help in recommendations and on-farm education. This study is the first to assess the usefulness of the Swine Lameness Diagnostic Manual. Based on these behavioral results future studies need to include a. all the lameness etiologies, b. compare and contrast different obstacles, c. include more validated pain tools, and d. complete post mortem analysis.