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Longitudinal study of the effect of rubber slat mats on locomotory ability, body, limb and claw lesions, and dirtiness of group housed sows[1]

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ABSTRACT: This study evaluated the influence of floor type on sow welfare with particular focus on lameness, claw lesions (CL), and injuries. The study used 164 gilts housed in groups of 8 from AI to 110 d of pregnancy in pens with concrete (n = 84) slatted floor left uncovered or covered by 10-mm rubber slat mats (n = 80) through 2 parities. Lameness (0 = normal to 5 = severe), limb (0 = normal to 6 = severe) and body (0 = normal to 5 = severe) lesions, and manure on the body (MOB; score 0 to 2) were recorded at AI, 24 to 72 h postmixing, between 50 and 70 d of pregnancy, and 2 wk before farrowing. Claw lesions (score 0 = normal to 3 = severe) were recorded at AI and between 50 and 70 d of pregnancy. The dirtiness and wetness of the floors was scored weekly (score 0 = clean to 4 = >75% of the pen soiled/wet). Data from the first and second parities were analyzed separately. Sows were categorized as nonlame (score ≤ 1) or lame (score ≥ 2). Median (M_e) scores were calculated for CL and body and limb lesions and were classified as less than or equal to the median or greater than the median lesion scores. Sows on rubber slat mats had a reduced risk of lameness during both parities ($P < 0.01$) compared with sows on concrete. They also had an increased risk of scores greater than the median for toe overgrowth ($M_e = 2$ and $M_e = 3$ in the first and second parity, respectively) and heel sole crack (HSC; $M_e = 3$) during both parities ($P < 0.01$) and for cracks in the wall (CW; $M_e = 4$) and white line damage (WL; $M_e = 4$; $P < 0.01$) in the first and second parity, respectively. There was a reduced risk of lameness in sows with scores greater than the median for HSC ($P = 0.05$) in the first parity and WL ($M_e = 3$; $P < 0.01$) and CW ($M_e = 3$; $P < 0.05$) in the second parity. Wounds ($M_e = 3$) and severe lesions ($M_e = 0$) on the limbs with scores greater than the median were associated with an increased risk of lameness ($P < 0.01$) in the first and second parity, respectively. Sows on rubber slat mats had a reduced risk of scores greater than the median for swellings ($M_e = 4$) and wounds ($P < 0.01$) during both parities. Pens with rubber slat mats were dirtier than uncovered pens ($P < 0.01$); however, there was no association between MOB and flooring type. There was also no association between body lesion score and flooring type. In this study, CL were not associated with an increased risk of lameness. Therefore, even though rubber slat mats were associated with an increased risk of CL, they improved the welfare of group housed sows by reducing the risk of lameness and limb lesions.

Key words: claw lesions, lameness, longitudinal study, rubber mats, sows, welfare

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INTRODUCTION

Lameness is a common cause of compromised animal well-being and economic loss to pig producers (Dewey et al., 1993; Anil et al., 2009). Flooring is one of the main features of the animal's environment affects lameness (Heinonen et al., 2006; Zurbrigg and Blackwell, 2006). From January 2013 pregnant sows will be kept in groups from 28 d after service until 10 d before farrowing as per European Union (**EU**)

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legislation [Commission of the European Communities (European Commission), 2008]. Early indications suggest that the majority of sows will be kept on slatted flooring without bedding, and lameness is a major problem in such systems (Spoolder et al., 2009). The use of bedding is not possible on many intensive pig units because of the liquid manure disposal systems. Rubber slat mats could be a useful alternative. Rubber slat mats are more yielding and have a lower thermal conductivity than bare concrete (Boe et al., 2007). There is limited research on the use of rubber slat mats in sow accommodation. However, in two short term studies, both Tuyttens et al. (2008) and Elmore et al. (2010) reported welfare benefits for group housed sows on rubber slat mats such as lower body lesion scores and greater ease of changing posture. Poor longevity and culling for lameness in early parities (Boyle et al., 1998; Hughes and Varley, 2003) places a major financial burden on pig producers and threatens sustainability. If rubber flooring could reduce such wastage it would enhance its attractiveness to pig producers and ultimately lead to improvements in sow welfare on farm. Hence, the objectives of this study were 1) to compare the locomotory ability and claw, limb, and body lesion scores of replacement gilts housed on concrete slatted floor or rubber slat mats over 2 parities and 2) to investigate the relationship between lameness and claw and limb lesions.

MATERIALS AND METHODS

The commercial farm on which this experimental work was conducted was in compliance with Statutory Instrument number 311 of 2010 European Communities (Welfare of Farmed Animals) Regulations 2000.

Care and Use of Animals

The farm was also certified by An Bord Bia under the Irish Pigmeat Quality Assurance Scheme, which further ensures high animal welfare standards. No invasive measures were used so the experiment did not require licensing under the European Communities (Amendment of Cruelty to Animals Act, 1876) Regulations (2002).

The study was conducted on a 1,000 sow integrated commercial farm in County Cork, Ireland, from October 2010 to February 2012. A total of 164 (123 Large White × Landrace and 41 Landrace) replacement gilts were included in the study. Measurements were recorded for 2 consecutive parities; hereafter gilts and sows are referred to as sows. Sows were housed in pens with concrete slatted floors either uncovered (**CON**; $n = 84$) or covered with rubber slat mats (**RUB**; $n = 80$; EasyFix Rubber Products, Ballinasloe, County Galway, Ireland), in groups of 8, where they remained until d 110 of pregnancy. The gestation house had a total of 96 pens with the capacity to house 8 sows each. The CON pens had 8 free access feeding stalls (each 1.51 m length by 0.75 m width by 1.23 m height) with a group area (2.40 m length by 2.94 m width) that could be used for exercise and dunging. The sows were not confined in the stalls and they were free to move about the pen at all times. The entire pen had conventional concrete slatted flooring (slat width 13 cm, gap width 2 cm, gap length 76 cm, and void area = 9.7%). Sixteen pens randomly distributed throughout the gestation house were covered with rubber mats. These pens were identical to the CON pens except that the slats in both the feeding stalls and the group area were covered with rubber slat mats (2.60m length by 0.30 m width by 0.01 m height; void area = 6%). The rubber mats consisted of a 10-mm thick 2-strip system with circular-shaped patterns on the surface and wedges underneath. Each mat covered 2 slats and 1 gap. The length of each opening over the gap was 20 cm and there were 7 openings per gap. The rubber slat mats were attached to the concrete slats by hammering the wedges underneath into the underlying gaps. This unavoidably reduced the void area of the pen slightly compared with the uncovered concrete slatted pens. No additional means of fixation was required. The house was ventilated by a door ventilation system whereby fresh air entered the building through an opening in the lower part of the doors and was extracted by fans in the roof. Sows were wet fed a liquid diet (water-to-meal ratio 5.7:1) twice per day. Troughs were filled once per day with fresh water between feeds and no drinkers were provided.

Management of Replacement Gilts – Assigning Animals to the Trial

Replacement gilts were produced from the nucleus of purebred Landrace sows on the farm. They were identified at birth by an ear notch and reared in groups of 10 to 12 animals in fully slatted pens with ad libitum access to dry feed (standard gilt diet consisting mainly of wheat, barley, and soya meal) until 150 kg, when they were moved to the service house where they were kept in groups of 8 in fully slatted pens and were artificially inseminated on their second heat. On average gilts spent 4 d in the service house (after service) and once 8 gilts were served they were moved to the experimental pens in the gestation house. The farm followed a rotational arrangement to allocate sows to the different pens in the gestation house. Due to the low number of RUB pens available compared with the number of CON pens and so as not to interfere with farm management practices, CON sows went on trial between October 2010 and March 2011 and RUB sows went on trial between October 2010 and May

2011. In total, 40 sows were inseminated in spring, 62 sows were inseminated in autumn, and 62 sows were inseminated in winter.

Management of Sows after the First Lactation

Sows were kept in conventional farrowing crates with plastic coated woven wire floors during lactation and were weaned 28 d postpartum and moved to the service house where they were kept in gestation stalls (2.10 m length by 0.55 m width by 1.06 m height) with fully slatted concrete floors. They were moved into the gestation house within 1 wk of AI. Eighty-four sows were inseminated in spring, 51 sows were inseminated in summer, and 6 sows were inseminated in autumn. Due to returns to service it proved impossible to keep experimental sows together in the same groups as they were in during the first pregnancy. Hence, for the second parity, they were mixed with unfamiliar experimental sows as well as with nonexperimental sows.

The nonexperimental sows were generally but not necessarily second parity animals. Older sows that were particularly thin or compromised in some other way were sometimes mixed with the younger ones. As the identification of the nonexperimental animals in the pens was not recorded we cannot be 100% certain that all nonexperimental animals were second parity sows. The ratio of experimental to nonexperimental sows for CON was 1:1.4 and for RUB was 1:1.2, suggesting slightly more remixing in the CON groups. Nevertheless, unfamiliar experimental sows were also remixed with each other. On average, second parity RUB groups were made up of sows coming from 2.6 different first parity RUB groups. On the other hand, second parity CON groups were made up of sows coming from 2.4 different first parity CON groups. Hence the overall effect of remixing was likely to have been similar between the treatments.

Scoring Methodology

All the measurements were taken by 1 trained observer (**JACD**) to avoid interobserver variation. The observer was trained to use the scoring systems by an experienced researcher (**LB**) over a period of approximately 4 wk. Training involved repeated measurements of 20 sows by both JACD and LB and continued until at least 90% intra- and interobserver scores for repeatability were achieved.

Sows were inspected for different measures at different times during their pregnancy. Locomotory ability, limb and body lesions, and manure on the body (**MOB**) were recorded at AI, 24 to 72 h postmixing, between 50 and 70 d of pregnancy, and 2 wk before farrowing. Claw lesions (**CL**) were recorded at AI and between 50 and 70 d of pregnancy. Body condition was recorded at AI, between 50 and 70 d of pregnancy, and 2 wk before farrowing. The dirtiness and wetness of the floors was scored weekly.

Locomotory Ability

Locomotory ability was assessed using aspects of the procedure of Main et al. (2000) and included evaluation of the standing posture and gait of the sow. Sows were given a score of 0 (not lame) to 5 (severely lame, and cannot stand). Sows were removed from their pen and walked on the concrete slatted floor of the alleyway. All sows were observed for at least 6 consecutive steps. The majority of sows walked much farther distances but for ethical reasons very lame sows (e.g., scores >3) were not forced to take more than 6 steps. For the greater scores this distance was sufficient to attribute an appropriate score to the locomotory ability of the sow.

Claw Lesions

Sows were raised in a hydraulic chute (FeetFirst Sow Chute; Zinpro Performance Minerals, Eden Prairie, MN) without sedation to inspect their claws. Only the hind claws were inspected as most of the sows placed their front feet on the supporting bar inside the crate, making it impossible to score them. The lateral and medial claws were inspected and scored separately for lesions in the toes, dew claws, heels, and sole area. A modified version of the lesion scoring scale developed by FeetFirst (Zinpro Corporation) used to score the different CL recorded is shown in Table 1. The modification comprised the inclusion of a score 0 = normal for all the claw areas examined. Additionally, toes torn and/or partially or completely missing was included in the score 3 for toe overgrowth (**TOE**). We also included a new type of lesion classification called "dew claw injuries" (**DCI**). Each lesion score per claw was summed to provide a total score for each sow for each lesion type per inspection.

Limb Lesions

Lesions on the front fetlock, carpal joint, humerus, elbow, carpus, hock, tarsus-metatarsus joint, hind fetlock, and metatarsus were scored according to their severity using a method adapted by Boyle et al. (2000) from de Koning (1985). The lesions were classified under these categories: i) score 0 = normal, ii) score 1 = alopecia (hair loss), iii) score 1 = callus (thickening of the epidermis and atrophy of glands), iv) score 2 = swellings (abnormal enlargement of a part of the body,

Table 1. Categorization, description and associated scores according to the modified lesion scoring scale developed by FeetFirst (Zinpro Performance Minerals, Eden, MN) of 8 different claw lesions recorded in a study comparing claw health in group housed sows during 2 consecutive parities

Scores	Toe length	Dew claw length	Dew claw injuries	Heel overgrowth and erosion	Heel sole crack	White line damage	Cracked wall horizontal	Cracked wall vertical
0	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	One or more toes slightly longer than normal	Slightly longer than normal.	Short crack or cracks	Slight overgrowth and/or erosion in soft heel tissue	Slight separation at the junction	Shallow and/or short separation along white line	Hemorrhage evident, short/ shallow horizontal crack in toe wall	Short/shallow vertical crack in wall
2	One or more toes significantly longer than normal	Significantly longer than normal	Long but shallow crack or cracks in dew claw wall	Numerous cracks with obvious overgrowth and erosion	Long separation at the juncture	Long separation along white line	Long but shallow horizontal crack in toe wall	Long but shallow vertical crack in wall
3	One or more claws much longer than normal and/or the toes are torn and/ or partially or completely missing	One or more claws much longer than normal and/or the claws are torn	Multiple or deep crack or cracks in dew claw and or/partially or completely missing	Large amount of erosion and overgrowth with cracks	Long and deep separation at the juncture	Long and deep separation along white line	Multiple or deep horizontal crack or cracks in toe wall	Multiple or deep vertical crack or cracks in the wall

typically as a result of an accumulation of fluid), v) score 3 = wounds (where the epidermis is interrupted but not ulcerated and there is no evidence of secondary infection), vi) score 3 = bursitis (acquired fluid-filled sac that develops in the subcutaneous connective tissue; usually occurs on the hind legs below the point of the hock or on the lateral sides of the elbow), vii) score 4 = severe wounds (these ulcerated lesions may or may not be accompanied by infection) or viii) severe swellings (characterized by redness and swelling accompanied by heat and pain), and ix) score 6 = severe wounds plus severe swellings. Addition of scores yielded a total score for each sow for each lesion type per inspection time.

Body Lesions

Five regions of the body of the sow were examined on the left and right: (1) ear, (2) neck and shoulder, (3) hindquarter, (4) belly and back, and (5) the tail/anogenital region. The lesions were classified and scored as follows: i) 0 = no lesions, ii) 1 = one small, superficial lesion, iii) 2 = more than one small, superficial lesion or just one red (deeper than score 1) but still superficial lesion, iv) 3 = 1 or several big and deep lesions, v) 4 = one very big, deep, red lesion or many big, deep, red lesions, and vi) 5 = many very big, deep, red lesions. Addition of scores across all sites yielded a total score for each sow per inspection.

Limb Conformation, BCS, and Manure on the Body

At AI the rear limbs were inspected according to the guidelines for uniform swine improvement (National Swine Improvement Federation, 1997). Each limb received a score from 1 = poor to 5 = normal. Scores were summed for the final evaluation and sows were classified into 3 categories: i) limb conformation score $\leq$ 3 = unacceptable, ii) limb conformation score 4 to 7 = good, and iii) limb conformation score $\geq$ 8 = excellent. Body condition was scored using the Royal Society for the Prevention of Cruelty for Animals, Inc. (RSPCA, 2007) scoring guide with a scale from 0 (emaciated) to 5 (grossly fat) and including the evaluation of the (sows) backbones and ribs. Manure on the body was assessed according to the Welfare Quality Consortium (2009) assessment protocol for pigs, sows, and piglets (scoring guide). The sows were made to stand up for inspection and received a score from 0 to 2 where 0 = up to 10% of the body surface was soiled, 1 = 10% to 30% of the body surface was soiled, and 2 = more than 30% of the body surface was soiled.

Flooring Cleanliness

Ten pens with uncovered concrete slats and 10 pens covered with rubber slat mats were randomly selected from the house. The feeding stalls and the group area were scored separately. Each of the locations received a score between 0 and 4 where 0 = pen clean/dry, 1 = 25% of the area covered with manure/wet feces, water, or urine, 2 = 26 to 50% of the area covered with manure/ wet feces, water, or urine, 3 = 51 to 75% of the area covered with manure/wet feces, water, or urine, and 4 = more than 75% of the area covered with manure/wet feces, water, or urine.

Culling Reasons

Reasons for culling sows from the study were based on decisions taken by the stockperson in charge of the sows and were retrospectively acquired from the farm records.

Statistical Analysis

To account for the change in the composition of the groups in the second parity, data from the first and second parities were analyzed separately. In the first parity, BCS was classified as moderate = score ≤ 2 and good = score ≥ 3 due to the low number of scores < 2 and scores > 3. In the second parity there was greater variability in BCS, therefore, a 3 level variable was created: poor = score 1, moderate = score 2, and good = score ≥ 3. For all the predicted variables, scores at the start of each parity (i.e., scores at AI) were used as covariates in the model. To account for clustering of sows within pens random effect models were used with day of inspection (level 1) nested within sow (level 2) nested within pens (level 3). Logistic binomial regression analysis by use of the Wald statistic was used to investigate the association between locomotory ability, CL, limb lesions, body lesions, and the predictor variables. Predictor variables with a $P \leq 0.35$ (Niranjan et al., 2005) were included in the final model. Flooring type was forced into the model irrespective of its P-value. Statistical differences were reported when $P < 0.05$ and statistical trends were reported when $P > 0.05$ and $P < 0.10$. Results are reported as odds ratios (**OR**) with the associated 95% confidence intervals (**CI**). All analyses were performed using PROC GENMOD (SAS Inst. Inc., Cary, NC).

Locomotory Ability. Sows were categorized as nonlame (≤1) or lame (score ≥ 2). The final model included flooring type, limb conformation, time of inspection, breed, and locomotion score on entering the study. Univariate models were built to identify the association between the different CL, wounds, swellings, and severe lesions on the limbs and locomotory ability.

Claw, Limb, and Body Lesion Scores. Severe wounds, severe swellings, and severe wounds plus severe swellings were reclassified into a single variable (severe lesions). Horizontal and vertical cracks in the wall were also reclassified into a single variable [cracks in the wall (**CW**)] due to the low number of sows with positive scores. Medians ($\mathbf{M_e}$) were calculated for claw, body, and limb lesions and values were classified as less than or equal to the median or greater than the median lesion scores. The final model included flooring type, time of inspection, BCS, breed, MOB, limb conformation, and lesion scores on entry to the study.

Manure on the Body. Manure on the body was classified as clean = score ≤ 1 or dirty = score 2 and the final model included flooring type, time of inspection, and MOB on entry to the study.

Flooring Condition. Soiling and wetness were classified into 2 categories: 0 = score ≤ 1 and 1 = scores ≥ 2. The final model included flooring type and season.

RESULTS

The number, percent, and median score of lame (i.e., locomotion score ≥ 2) sows, and the percent of sows with CL, and/or limb and body lesion scores greater than the median, and sows with MOB score = 2 are presented in Tables 2 and 3. Twenty-four sows were culled during the experimental period, 12 sows from each treatment. Eleven sows were culled due to leg problems (10 CON sows and 1 RUB sow), 6 sows were culled due to reproductive failure (1 CON sow and 5 RUB sows), and 7 sows were culled or died due to other reasons (1 CON sow and 6 RUB sows).

Factors Associated with Locomotory Ability

First Parity. Thirty-four percent of CON sows and 30% of RUB sows were lame at the start of the study. Having controlled for the locomotory score of the sow at the start of the study in the model, RUB sows had a significantly reduced risk of lameness compared with CON sows ($P < 0.01$). Sows whose limb conformation was good or excellent at the first AI had a reduced risk of lameness ($P < 0.01$) compared with sows whose limb conformation was classified as unacceptable (Table 4).

Second Parity. Forty-four percent of CON sows and 45% of RUB sows were lame at the start of the second pregnancy. Having controlled for the locomotory score of the sow at the start of the second pregnancy in the model, RUB sows had a significantly reduced risk of lameness compared with CON sows ($P < 0.01$; Table 4). There was no significant association between lameness and the other explanatory variables.

Factors Associated with Claw Lesions

First Parity. Sows on rubber slat mats had an increased risk of scores greater than the median for TOE ($M_e = 2$), heel sole crack (**HSC**; $M_e = 3$), and CW ($M_e = 4$) compared with CON sows ($P < 0.01$). Sows whose limb confirmation was excellent had an increased risk of heel overgrowth and erosion (**HOE**; $M_e = 2$) scores greater than the median ($P < 0.01$) compared with sows whose limb conformation was classified as unacceptable. Sows with dew claw overgrowth (**DC**; $M_e = 1$), white line damage (**WL**; $M_e = 3$), and DCI ($M_e = 4$) scores greater than the median later in the study were more

Table 2. Number and percent of gestating sows with lameness (i.e., locomotion score ≥ 2), body and limb (alopecia, calluses, swellings, wounds, bursitis, and severe limb lesion) lesions scores greater than median (M_e), and manure on the body score = 2 housed on concrete slats either uncovered or covered by rubber slat mats at each of 3 inspections during 2 parities

	Time of Inspection											
	Postmixing				Mid pregnancy				Prefarrowing			
	Concrete		Rubber		Concrete		Rubber		Concrete		Rubber	
Variable	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
First parity												
Lameness		*n* = 163				*n* = 155				*n* = 127		
	47	28.83	27	16.56	43	27.74	28	18.06	49	38.58	17	13.39
Body lesions (M_e = 7)		*n* = 162				*n* = 155				*n* = 145		
	61	37.65	50	30.86	18	11.11	19	11.73	30	18.52	24	14.81
Limb lesions		*n* = 156				*n* = 155				*n* = 148		
Alopecia (M_e = 3)	17	10.90	21	13.46	23	14.84	35	22.58	45	30.41	33	22.30
Calluses (M_e = 7)	28	17.95	37	23.72	43	27.74	39	25.16	27	18.24	48	32.43
Swellings (M_e = 4)	41	26.28	24	15.38	28	18.06	20	12.90	32	21.62	14	9.46
Wounds (M_e = 6)	39	25.00	27	17.31	30	19.35	20	12.90	22	14.86	8	5.41
Bursitis (M_e = 6)	34	21.79	26	16.67	20	12.90	26	16.77	28	18.92	26	17.57
Severe lesions (M_e = 0)	27	17.31	11	7.05	17	10.97	7	4.52	13	8.78	8	5.41
Manure on the body		*n* = 145				*n* = 155				*n* = 145		
	25	17.24	13	8.97	22	15.17	30	20.69	21	14.48	21	14.48
Second parity												
Lameness		*n* = 135				*n* = 140				*n* = 91		
	47	34.81	31	22.96	48	34.29	38	27.14	35	38.46	11	12.09
Body lesions (M_e = 8)		*n* = 136				*n* = 140				*n* = 137		
	51	37.50	37	27.21	30	21.43	29	20.71	17	12.41	25	18.25
Limb lesions		*n* = 125				*n* = 141				*n* = 137		
Alopecia (M_e = 3)	17	13.60	19	15.20	23	16.31	35	24.82	38	27.74	32	23.36
Calluses (M_e = 7)	28	22.40	36	28.80	41	29.08	39	27.66	27	19.71	48	35.04
Swellings (M_e = 4)	38	30.40	21	16.80	26	18.44	19	13.48	33	24.09	13	9.49
Wounds (M_e = 3)	34	27.20	24	19.20	28	19.86	20	14.18	21	15.33	8	5.84
Bursitis (M_e = 6)	31	24.80	22	17.60	21	14.89	25	17.73	32	23.36	26	18.98
Severe lesions (M_e = 0)	22	17.60	9	7.20	13	9.22	7	4.96	12	8.76	7	5.11
Manure on the body		*n* = 135				*n* = 140				*n* = 137		
	34	25.19	34	25.19	8	5.71	7	5.00	21	15.33	14	10.22

likely to have had greater lesions scores when entering the study compared with sows with lesion scores less than or equal to the median when entering the study for the same CL. There was a tendency for sows with MOB "very dirty" to have a reduced risk of WL scores greater than the median compared with sows with MOB scores "clean" or "dirty" (P = 0.06). Cross-bred sows had a tendency to have a reduced risk of HSC scores greater than the median compared with pure-bred sows (P = 0.07). There were no significant associations between BCS, breed, or MOB during the first parity and the CL studied (Table 5). There was a tendency for a reduced risk of lameness in sows with HSC (OR = 0.59; CI = 0.34 to 1.00; P = 0.06) and HOE (OR = 0.63; CI = 0.37 to 1.04; P = 0.07) scores greater than the median during their first parity compared with sows with less than or equal to the median lesion scores.

Second Parity. Sows on rubber slat mats had a significantly increased risk of greater than the median scores for TOE (M_e = 3; $P < 0.01$), WL (M_e = 4; $P < 0.01$), and HSC (M_e = 3; $P < 0.01$) compared with CON sows during the second parity. Sows whose BCS was moderate (score = 2) had a reduced risk of WL ($P < 0.01$) and CW (M_e = 3; $P < 0.05$) scores greater than the median compared with sows whose BSC was good (score = 3). Cross-bred sows had a reduced risk of DC (M_e = 4; $P < 0.001$) and WL ($P < 0.01$) compared with pure-bred sows. Sows with MOB score "dirty" had reduced risk of WL score greater than the median compared with sows with MOB score "clean" ($P < 0.01$). Sows with TOE and CW scores greater than the median later in the study were more likely to have had greater lesions scores when entering the study compared with sows with lesion scores less than or equal to the median when entering the study ($P < 0.01$). There tended to be an increased risk of HOE (M_e = 4) scores greater than the median if sows had HOE scores greater than the median when entering the study (P = 0.08). There was no significant

Table 3. Median score, number and percent of gestating sows housed on concrete slats either uncovered or covered by rubber slat mats during 2 parities with lesion scores greater than median for toe overgrowth, dew claw overgrowth, heel overgrowth and erosion, heel sole crack, white line damage, cracks in the wall, and dew claw injuries

Claw lesions[1]	First parity (n = 133)					Second parity (n = 121)				
	Median	Concrete		Rubber		Median	Concrete		Rubber	
		n	%	n	%		n	%	n	%
TOE	2	10	7.52	22	16.54	3	23	19.01	36	29.75
DC	1	26	19.55	32	24.06	4	23	19.01	26	21.49
HOE	2	33	24.81	31	23.31	4	30	24.79	29	23.97
HSC	3	11	8.27	43	32.33	3	14	11.57	39	32.23
WL	3	13	9.77	41	30.83	4	13	10.74	26	21.49
CW	4	17	12.78	31	23.31	3	25	20.66	20	16.53
DCI	4	22	16.54	32	24.06	7	22	18.18	16	13.22

[1]TOE = toe overgrowth; DC = dew claw overgrowth; HOE = heel overgrowth and erosion; HSC = heel sole crack; WL = white line damage; CW = cracks in the wall; DCI = dew claw injuries.

Table 4. Two binomial mixed effects models of the risks associated with lameness in gestating sows housed on concrete slats either uncovered or covered with rubber slat mats during 2 parities

Explanatory variables	First parity		Second parity	
	OR[1]	CI[2]	OR	CI
Floor type				
Concrete				
Rubber	0.32[a]	0.21 to 0.50	0.56[a]	0.35 to 0.91
Time of inspection				
24 to 72 h postmixing				
50 to 70 d of pregnancy	NI[3]	NI	1.26	0.76 to 2.08
2 wk before farrowing	NI	NI	0.72	0.44 to 1.18
Breed				
Pure-bred				
Cross-bred	NI	NI	1.51	0.88 to 2.60
Limb conformation				
Unacceptable				
Good	0.41[a]	0.22 to 0.79	NI	NI
Excellent	0.31[a]	0.14 to 0.69	NI	NI
Locomotion score at AI				
Nonlame				
Lame	NI	NI	1.36	0.86 to 2.16

[a]Significantly different from reference category; $P < 0.01$.

[1]OR = odds ratios.

[2]CI = 95% confidence interval.

[3]NI = not included in the model.

association between limb conformation and the 7 types of CL studied (Table 6). There was a reduced risk of lameness in sows with WL (OR = 0.46; CI = 0.24 to 0.87; $P < 0.01$) and CW scores greater than the median (OR = 0.50; CI = 0.27 to 0.93; $P < 0.05$) compared with sows with scores less than or equal to the median. Sows with HOE scores greater than the median tended to have an increased risk of lameness ($P = 0.06$).

Factors Associated with Limb Lesions

First Parity. Sows housed on RUB tended to have an increased risk of callus ($M_e = 7$) scores greater than the median compared with CON sows ($P = 0.08$). There was a reduced risk of swelling ($M_e = 4$; $P < 0.01$) and wound ($M_e = 6$; $P < 0.01$) scores greater than the median associated with RUB sows compared with CON sows. Sows had an increased risk of callus scores greater than the median ($P < 0.05$) and a reduced risk of swelling ($P < 0.05$) and severe lesion ($P < 0.01$) scores greater than the median between 50 and 70 d of pregnancy compared with 24 to 72 h after mixing. Sows tended to have swelling scores greater than the median 2 wk before farrowing compared with 24 to 72 h after mixing ($P = 0.08$). Cross-bred sows had an increased risk of bursitis ($M_e = 6$) scores greater than the median ($P < 0.01$) and tended to have an increased risk of swelling scores greater than the median ($P = 0.08$) compared with pure-bred sows. Sows with MOB scores "dirty" or "very dirty" had a reduced risk of callus scores greater than the median ($P < 0.01$) and sows with MOB score "very dirty" had a reduced risk of wound scores greater than the median ($P < 0.05$) compared with sows with MOB score "clean." Sows with scores greater than the median for calluses, swellings, bursitis, and severe lesions later in the study were more likely to have had greater lesion scores when entering the study compared with sows with lesion scores less than or equal to the median when entering the study. Sows with alopecia ($M_e = 3$) scores greater than the median later in the study were more likely to have had greater alopecia scores when entering the study compared with sows with lesion scores less than or equal to the median when entering the study ($P = 0.06$). There was no association between BCS, limb conformation, and the 6 types of limb lesions studied (Table 7). Sows with severe limb lesion scores greater than the median were at greater risk of being lame during their first parity (OR = 2.02; CI = 1.20 to 3.41; $P < 0.01$). There were no other significant associations between lameness and wounds and severe limb lesions

Second Parity. There was a reduced risk of swellings ($M_e = 4$; $P < 0.01$) and wounds ($M_e = 3$; $P < 0.01$) and an increased risk of callus ($M_e = 7$; $P < 0.01$) scores greater than the median associated with RUB sows compared with CON sows. There was a significantly increased risk of alopecia ($M_e = 3$; $P < 0.01$) and wound ($P < 0.01$) scores greater than the median between 50 and 70 d of pregnancy and 2 wk before farrowing compared with 24 to 72 h after mixing in all sows. Sows whose BCS was poor (score = 1) or moderate (score = 2) had an increased risk of

Table 5. Seven binomial mixed effects models of the risks associated with toe overgrowth, dew claw overgrowth, heel overgrowth and erosion, heel sole crack, white line damage, cracks in the wall, and dew claw injuries in gestating sows housed on concrete slats either uncovered or covered by rubber slat mats during the first parity

Explanatory variables	TOE[1]		DC[2]		HOE[3]		HSC[4]		WL[5]		CW[6]		DCI[7]	
	OR[8]	CI[9]	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI
Floor type														
Concrete														
Rubber	3.81[a]	1.17 to 9.28	1.05	0.34 to 3.26	1.21	0.58 to 2.54	6.77[a]	1.95 to 23.49	3.01	0.72 to 12.52	3.18[a]	1.52 to 6.64	1.48	0.43 to 5.02
Limb conformation														
Unacceptable														
Good	NI[10]	NI	NI	NI	2.38	0.67 to 8.39	NI	NI	NI	NI	NI	NI	1.49	0.32 to 6.84
Excellent	NI	NI	NI	NI	5.51[a]	1.36 to 22.39	NI	NI	NI	NI	NI	NI	0.54	0.09 to 3.00
BCS														
Good														
Moderate	2.07	0.75 to 5.72	3.8	0.96 to 15.11	NI	NI	0.32	0.08 to 1.27	NI	NI	NI	NI	0.39	0.11 to 1.38
Breed														
Pure-bred														
Cross-bred	2.13	0.72 to 6.28	2.96	0.77 to 11.32	NI	NI	0.29	0.07 to 1.12	1.77	0.61 to 5.09	NI	NI	NI	NI
Manure on the body														
Clean														
Dirty	NI	NI	NI	NI	NI	NI	NI	NI	0.31	0.05 to 2.00	NI	NI	NI	NI
Very dirty	NI	NI	NI	NI	NI	NI	NI	NI	0.14	0.02 to 1.12	NI	NI	NI	NI
Lesion score at AI														
Less than or equal to median														
Greater than median	NI	NI	4.23[a]	1.42 to 12.63	NI	NI	1.9	0.66 to 5.46	3.4[b]	1.21 to 9.55	NI	NI	5.59[a]	1.70 to 18.33

[a,b]Significantly different from reference category; [a]$P < 0.01$; [b]$P < 0.05$.

[1]TOE = toe overgrowth.

[2]DC = dew claw overgrowth.

[3]HOE = heel overgrowth and erosion.

[4]HSC = heel sole crack.

[5]WL = white line damage.

[6]CW = cracks in the wall.

[7]DCI = dew claw injuries.

[8]OR = odds ratios.

[9]CI = 95% confidence interval.

[10]NI = not included in the model.

alopecia and swelling scores greater than the median compared with sows whose BCS was good (score = 3). Cross-bred sows were at greater risk of swelling and bursitis ($M_e = 6$) scores greater than the median compared with pure-bred sows ($P < 0.05$). Sows with MOB score "dirty" had an increased risk of alopecia scores greater than the median and sows with MOB score "very dirty" had reduced risk of callus scores greater than the median compared with sows with MOB score "clean" ($P < 0.01$). Sows with MOB score "dirty" or "very dirty" tended to have an increased risk of swellings compared with sows classified as clean ($P = 0.08$ and $P = 0.06$, respectively). Sows with alopecia, callus, swelling, bursitis, and severe lesion ($M_e = 0$) scores greater than the median later in the study were more likely to have had greater lesion scores when entering the study compared with sows with lesion scores less than or equal to the median when entering the study. There were no associations between limb conformation and the 6 types of limb lesions studied (Table 8). Sows with wound scores greater than the median were at increased risk of lameness compared with sows with wound scores less than or equal to the median (OR = 2.02; CI = 1.26 to 3.22; $P < 0.01$). There were no significant associations between lameness and swellings and severe limb lesions.

Factors Associated with Body Lesions

First Parity. There was no association between body lesion score and flooring type. There was a reduced risk of body lesion ($M_e = 7$) scores greater than the median between 50 and 70 (OR = 0.15; CI = 0.09 to 0.24; $P < 0.001$) d of pregnancy and 2 wk before farrowing (OR = 0.29; CI = 0.18 to 0.45; $P < 0.001$) compared with 24 to 72 h after mixing.

Second Parity. There was no association between body lesion score and flooring type or with body

Table 6. Seven binomial mixed effects models of the risks associated with toe overgrowth, dew claw overgrowth, heel overgrowth and erosion, heel sole crack, white line damage, cracks in the wall, and dew claw injuries in gestating sows housed on concrete slats either uncovered or covered by rubber slat mats during the second parity

Explanatory variables	TOE[1]		DC[2]		HOE[3]		HSC[4]		WL[5]		CW[6]		DCI[7]	
	OR[8]	CI[9]	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI
Floor type														
Concrete														
Rubber	3.17[a]	1.34 to 7.47	1.60	0.64 to 4.01	0.99	0.45 to 2.21	6.68[a]	2.99 to 14.92	4.85[a]	1.73 to 13.54	0.78	0.32 to 1.88	0.74	0.32 to 1.71
Limb conformation														
Unacceptable														
Good	NI[10]	NI	0.92	0.34 to 2.50	1.91	0.75 to 4.88	NI	NI	7.73	1.95 to 30.63	NI	NI	NI	NI
Excellent	NI	NI	0.30	0.05 to 1.87	2.91	0.68 to 12.43	NI	NI	4.42	0.71 to 27.42	NI	NI	NI	NI
BCS														
Good														
Moderate	NI	NI	0.36	0.11 to 1.22	NI	NI	NI	NI	0.18[a]	0.05 to 0.70	0.29[b]	0.09 to 0.92	NI	NI
Breed														
Pure-bred														
Cross-bred	0.34	0.10 to 1.11	0.17[a]	0.05 to 0.62	NI	NI	NI	NI	0.20[a]	0.06 to 0.72	NI	NI	0.45	0.16 to 1.25
Manure on the body														
Clean														
Dirty	NI	NI	NI	NI	NI	NI	NI	NI	0.45[a]	0.14 to 1.49	NI	NI	NI	NI
Very dirty	NI	NI	NI	NI	NI	NI	NI	NI	1.50	0.25 to 9.07	NI	NI	NI	NI
Lesion score at AI														
Less than or equal to median														
Greater than median	5.01[a]	1.86 to 13.52	2.00	0.69 to 5.79	2.20	0.89 to 5.44	NI	NI	NI	NI	3.82[a]	1.59 to 3.17	1.59	0.69 to 3.65

[a,b]Significantly different from reference category; [a]$P < 0.01$; [b]$P < 0.05$.

[1]TOE = toe overgrowth.

[2]DC = dew claw overgrowth.

[3]HOE = heel overgrowth and erosion.

[4]HSC = heel sole crack.

[5]WL = white line damage.

[6]CW = cracks in the wall.

[7]DCI = dew claw injuries.

[8]OR = odds ratios.

[9]CI = 95% confidence interval.

[10]NI = not included in the model.

lesion scores when entering the study. There was a reduced risk of body lesion ($M_e = 8$) scores greater than the median between 50 and 70 d of pregnancy (OR = 0.38; CI = 0.24 to 0.62; $P < 0.001$) and 2 wk before farrowing (OR = 0.25; CI = 0.15 to 0.41; $P < 0.001$) compared with 24 to 72 h after mixing

Factors Associated with Manure on the Body

First Parity. There was no association between MOB score and flooring type. Additionally, there was no association between MOB score on entering the study and at other inspection times.

Second Parity. There was no association between MOB score and flooring type or MOB score when entering the study and at other inspection times. Sows had a reduced risk of being dirty between 50 and 70 d of pregnancy (OR = 0.10; CI = 0.05 to 0.19; $P < 0.01$) and 2 wk before farrowing (OR = 0.28; CI = 0.17 to 0.48; $P < 0.01$) compared with 24 to 72 h after mixing

Factors Associated with Flooring Cleanliness

Pens covered with rubber slat mats had greater risk of being soiled in both the feeding stalls and group area compared with the uncovered concrete pens ($P < 0.01$). There was no association between floor type and the wetness of the pen (Table 9). The group area had greater risk of being more soiled during winter ($P < 0.001$) compared with autumn. Also, the group area had greater risk of being wetter during the winter ($P < 0.01$) and summer ($P < 0.001$) compared with autumn. The feeding stalls had greater risk of being more soiled during winter and summer ($P < 0.001$) and cleaner during spring ($P < 0.001$) compared with autumn and of being dryer during winter ($P < 0.05$) and wetter during summer ($P < 0.01$) compared with autumn.

Table 7. Six binomial mixed effects models of the risks associated with alopecia, calluses, swellings, wounds, bursitis, and severe lesions on the limbs of gestating sows housed on concrete slats either uncovered or covered by rubber slat mats during the first parity

Explanatory variables	Alopecia		Callus		Swellings		Wounds		Bursitis		Severe lesions	
	OR[1]	CI[2]	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI
Floor type												
Concrete												
Rubber	1.28	0.80 to 2.04	1.53	0.94 to 2.51	0.52[a]	0.34 to 0.82	0.50[a]	0.31 to 0.80	0.99	0.62 to 1.58	0.65	0.35 to 1.21
Time of inspection												
24 to 72 h postmixing												
50 to 70 d of pregnancy	1.55	0.92 to 2.62	1.83[b]	1.06 to 3.16	0.62[b]	0.39 to 0.97	NI	NI	0.63	0.37 to 1.05	0.48[a]	0.26 to 0.88
2 wk before farrowing	2.11[a]	1.17 to 3.80	1.54	0.85 to 2.78	0.67	0.42 to 1.06	NI	NI	0.97	0.59 to 1.60	0.46[a]	0.25 to 0.85
BCS												
Good												
Moderate	0.67	0.41 to 1.08	0.69	0.43 to 1.10	NI	NI	1.39	0.89 to 2.18	NI	NI	NI	NI
Breed												
Pure-bred												
Cross-bred	0.77	0.44 to 1.36	NI	NI	1.57	0.94 to 2.63	NI	NI	2.19[a]	1.19 to 4.01	NI	NI
Limb conformation												
Unacceptable												
Good	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	0.65	0.26 to 1.63
Excellent	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	0.48	0.17 to 1.33
Manure on the body												
Clean												
Dirty	NI[3]	NI	0.48[a]	0.28 to 0.84	NI	NI	0.92	0.54 to 1.54	NI	NI	NI	NI
Very dirty	NI	NI	0.41[a]	0.22 to 0.77	NI	NI	0.52[b]	0.29 to 0.92	NI	NI	NI	NI
Lesion score at AI												
Less than or equal to median												
Greater than median	1.58	0.98 to 2.53	1.91[a]	1.18 to 3.10	1.54	0.99 to 2.39	1.27	0.79 to 2.04	4.46[a]	2.57 to 7.75	5.60[a]	3.06 to 10.26

[a,b]Significantly different from reference category; [a]$P < 0.01$; [b]$P < 0.05$.

[1]OR = odds ratios.

[2]CI = 95% confidence interval.

[3]NI = not included in the model.

DISCUSSION

Fully slatted floors increase the risk of abnormal gait in pigs in groups and the sows used in this study had been housed on such floors from birth. Our findings for lameness appear high but are similar to the prevalences reported by KilBride et al. (2009a) of 18.9% of gilts and 44.7% of pregnant sows affected by lameness when housed on slatted floors. Both ourselves and KilBride et al. (2009a) consider that a low cutoff should be used to define lameness as lower scores associated with abnormal gait (i.e., score 2 in this study) are associated with a biological cost to the animal because of increased strain on the locomotory system.

Sows housed on rubber slat mats during pregnancy had a reduced risk of becoming lame in both parity 1 and 2. This is in contrast to Elmore et al. (2010) who reported no difference in locomotory ability between sows housed on rubber or concrete floors. However, in that study, only the feeding stalls were covered with rubber mats. Furthermore, sows were observed for a much shorter period (10 d) compared with the present study and it is unlikely that the potential benefits of housing on a softer surface would become evident in this time. However, our findings are in agreement with findings for dairy cows (Vanegas et al., 2006) where cows with access to rubber flooring were less likely to become lame compared with cows housed on bare concrete. Rubber can protect against lameness in a number of ways. Firstly as it is a more yielding underfoot surface it provides more secure footing (Flower et al., 2007) compared with concrete floors. This means that there is a greater area of contact between the claw and the floor, which could improve the claw pressure distribution (Rushen and de Passillé, 2006; Carvalho et al., 2009). This in turn reduces the impact load on joints and claws (Platz et al., 2008; Carvalho et al., 2009) when walking and standing. Second, the cushioning effect of rubber might improve circulation in the foot (Singh et al., 1993; Galindo and Broom, 2000). These authors suggest that standing on bare concrete for long periods of time results in circulatory problems that could lead to irritation of

Table 8. Six binomial mixed effects models of the risks associated with alopecia, calluses, swellings, wounds bursitis, and severe lesions in the limbs of gestating sows housed on concrete slats either uncovered or covered by rubber slat mats during the second parity

Explanatory variables	Alopecia		Callus		Swellings		Wounds		Bursitis		Severe lesions	
	OR[1]	CI[2]	OR	CI	OR	CI	OR	CI	OR	CI	OR	CI
Floor type												
Concrete												
Rubber	0.95	0.59 to 1.54	2.20[a]	1.34 to 3.61	0.43[a]	0.27 to 0.70	0.53[a]	0.34 to 0.84	0.91	0.56 to 1.49	0.75	0.38 to 1.49
Time of inspection												
24 to 72h postmixing												
50 to 70 d of pregnancy	4.40[a]	1.71 to 11.32	NI	NI	NI	NI	0.51[a]	0.29 to 0.87	0.63	0.36 to 0.12	0.36[a]	0.18 to 0.73
2 wk before farrowing	6.17[a]	2.35 to 16.18	NI	NI	NI	NI	0.26[a]	0.14 to 0.45	0.9	0.54 to 1.52	0.46[b]	0.43 to 0.90
BCS												
Good												
Moderate	1.93[b]	1.00 to 3.69	1.26	0.75 to 2.11	2.05[a]	1.22 to 3.46	NI	NI	NI	NI	NI	NI
Poor	4.79[a]	1.61 to 14.26	0.88	0.48 to 1.62	2.48[a]	1.29 to 4.76	NI	NI	NI	NI	NI	NI
Breed												
Pure-bred												
Cross-bred	0.62	0.33 to 1.17	NI	NI	1.89[b]	1.00 to 3.55	NI	NI	2.15[b]	1.01 to 5.48	1.68	0.73 to 3.87
Limb conformation												
Unacceptable												
Good	NI[3]	NI	1.14	0.61 to 2.13	NI	NI	NI	NI	0.66	0.37 to 1.18	0.49	0.21 to 1.15
Excellent	NI	NI	0.57	0.25 to 1.28	NI	NI	NI	NI	1.02	0.42 to 2.47	0.5	0.20 to 1.22
Manure on the body												
Clean												
Dirty	2.64[a]	1.18 to 5.92	0.73	0.35 to 1.54	1.89	0.91 to 3.94	1.77	0.90 to 3.48	NI	NI	NI	NI
Very dirty	1.86	0.75 to 4.61	0.38[a]	0.17 to 0.86	2.11	0.98 to 4.52	0.94	0.45 to 1.97	NI	NI	NI	NI
Lesion score at AI												
Less than or equal to median												
Greater than median	1.89[a]	1.20 to 2.99	1.92[a]	1.18 to 3.13	1.62[c]	1.02 to 2.58	NI	NI	3.87[a]	2.31 to 6.46	5.42[a]	2.83 to 10.39

[a,b]Significantly different from reference category; [a]$P < 0.01$; [b]$P < 0.05$.

[1]OR = odds ratios.

[2]CI = 95% confidence interval.

[3] NI = not included in the model.

the corium, development of CL, and other locomotory disorders. Indeed, studies with humans report that softer floors reduced discomfort related to prolonged standing particularly for the lower extremities (Rys and Konz, 1994; Redfern and Cham, 2000). Additionally, as rubber flooring is often less slippery (Platz et al., 2008) falls due to slipping are reduced. However, in terms of the current study it is doubtful that the rubber flooring was less slippery than concrete, particularly as it was likely to be covered with a film of slurry. Nevertheless, if an animal does slip and fall on rubber the flooring absorbs more of the shock than concrete (Pedersen and Ravn, 2008) reducing the likelihood of lameness arising from traumatic injuries to the joints.

In agreement with other authors (Gjein and Larssen, 1995; Anil et al., 2007; Pluym et al., 2011) all the sows in this study had at least one claw lesion. However, in apparent contrast to the findings for locomotory ability, sows housed on rubber slat mats were at greater risk of TOE and HSC scores greater than the median during the first and second parities compared with CON sows. Additionally, they were at greater risk of CW scores greater than the median during the first parity and WL scores greater than the median during the second parity. It is important to note that median scores were mild (i.e., not severe) for most of the lesions. Nevertheless, the results suggest an increased risk of CL in sows on rubber flooring and it cannot be discounted that these lesions may have worsened if the animals were kept on rubber during subsequent pregnancies. Equivalent findings regarding the effect of rubber flooring on CL only relate to dairy cows and are contradictory. Ahrens et al. (2011) reported that covering concrete slatted floor with rubber slat mats partially damaged the claws of the cows. Meanwhile, Jungbluth et al. (2003) reported that some types of CL (i.e., sole hemorrhages) were less severe in cows housed on rubber. Finally, both Vokey et al. (2001) and Boyle et al. (2007) reported no difference in the severity of CL between cows with access to rubber floor and cows housed on bare concrete. Several studies (Mouttotou et al., 1999; Scott et al., 2006; Gillman et al., 2009; KilBride et al., 2009b) using younger pigs showed benefits to claw

Table 9. Four binomial mixed effects models of the risks associated with soiling and wetness on concrete slats either uncovered or covered by rubber slat mats scored during the 66 wk of a longitudinal study in a commercial farm

Explanatory variables	Soiling				Wetness			
	Group area		Feeding stalls		Group area		Feeding stalls	
	OR[1]	CI[2]	OR	CI	OR	CI	OR	CI
Floor type								
Concrete								
Rubber	21.49[a]	8.17 to 56.54	78.95[a]	57.16 to 109.05	0.82	0.50 to 1.35	0.74	0.45 to 1.21
Season								
Autumn								
Winter	2.80[a]	1.88 to 4.19	3.26[a]	2.04 to 5.22	1.36[a]	1.06 to 1.75	0.75[b]	0.57 to 0.98
Spring	1.10	0.64 to 1.89	0.65[a]	1.70 to 4.12	1.50	0.90 to 2.51	1.02	0.71 to 1.47
Summer	0.81	0.57 to 1.16	3.43[a]	2.11 to 5.58	2.64[a]	1.88 to 3.72	2.23[a]	1.45 to 3.44

[a,b]Significantly different from reference category; [a]$P < 0.01$; [b]$P < 0.05$.

[1]OR = odds ratios.

[2]CI = 95% confidence interval.

health associated with softer floors (i.e., solid floors with straw bedding) in terms of a reduced prevalence of heel and sole erosions. However, these authors also showed that softer floors potentially increase other types of CL such as toe erosion. Studies with both cows (Phillipot et al., 1994; Borderas et al., 2004) and pigs (Sobestiansky et al., 1999; KilBride et al., 2010) suggested that contact with manure and wet surfaces can reduce claw hardness. This combined with the chemical and bacterial challenges associated with dirty conditions (Pell, 1997) make the hooves more susceptible to injury (Milne et al., 1974). Hence, it is possible that the risk of scores greater than the median for some lesions in the sows on rubber was related to the fact that these animals had dirtier conditions underfoot (KilBride et al., 2010). This would likely have the greatest impact on lesions to the white line and heel sole junction as these locations represent the weakest parts of the hoof (Budras et al., 1996). It is also likely that the rubber slat mats were less abrasive than the concrete slats (Telezhenko et al., 2008). Hence the greater scores for toe length in RUB sows could be explained by insufficient wear of the claws (McKee and Dumelow, 1995; Kremer et al., 2007; Platz et al., 2007).

Apart from the tendency for sows with HOE scores greater than the median to have an increased risk of lameness the majority of the CL studied were not related to an increased risk of lameness. This is in spite of the fact that CL are considered a major cause of lameness in sows (Dewey et al., 1993; Anil et al., 2007). This result is in general agreement with Anil et al. (2007) and Pluym et al. (2011) with the exception that the former authors found that sows with white line lesions were more likely to be lame. This could be explained by differences in the way that the relationship between CL and lameness was evaluated between the current study and the study conducted by Anil et al. (2007). They linked the presence or absence of CL with lameness and disregarded the potential effect of lesion severity whereas we used the median of the scores assigned to the 4 claws because there were so few sows without lesions.

Surprisingly, in several instances, namely for HSC and HOE in the first parity and WL and CW in the second parity, scores above the median were associated with a lower risk of lameness. It seems biologically unlikely that supposedly more severe CL (i.e., lesions receiving greater scores) should be associated with a reduced risk of lameness. However, it is possible that in sows, lesions that look serious on the exterior, and therefore receive greater scores, do not necessarily extend into the corium and cause discomfort leading to lameness, although KilBride et al. (2009b) examined the claws of the piglets postmortem and reported that internal damage was often more severe than the visual scores attributed to the lesions. Further longitudinal work is needed because lesions might only be painful for a short period of time but are evident for a longer period as it takes time for new horn to grow. If sows were observed at more frequent intervals it might be possible to observe the temporal association correctly. Additionally, future work of this kind should also include postmortem examinations of the claws of the sows to ascertain how the severity of exterior lesions relates to the degree to which they penetrate the corium. The most likely explanation for the negative association between lesions and lameness is that sows with these lesions were more likely to be on RUB where lameness was reduced and that these CL were not directly associated with lameness.

Lying on hard surfaces causes swellings and wounds on the limbs of the sows (Mouttotou et al., 1998; Rushen et al., 2007; Gillman et al., 2008; KilBride et al., 2008; von Wachenfelt et al., 2008). The fact that sows housed on rubber slat mats were at reduced risk of scores greater than the median for swellings on the limbs during both parities reflects the cushioning properties of the rubber

floor. Furthermore, the reduced likelihood of having wounds combined with the greater risk of having calluses reflects the protective benefit from abrasion of rubber compared with concrete flooring. Unlike wounds, injuries such as calluses and bursitis are chronic in nature. Hence it is unsurprising that sows with scores greater than the median at the beginning of the study continued to have greater lesion scores throughout the 2 parities. Unlike many of the CL, sows with wounds and severe lesion scores greater than the median were at greater risk of being lame. KilBride et al. (2009a, 2010) suggested that limb lesions could cause discomfort and alter locomotion or that wounds and severe lesions could develop as a result of lame sows spending more time lying down, which was also suggested by Bonde et al. (2004).

Skin lesion scores were greater after mixing, which was expected because unfamiliar sows fight to establish a social hierarchy (Sadler et al., 2011). As sows may terminate fights earlier if they are unsure of their footing (Walker and Beattie, 1994) we hypothesized that flooring effects on aggression might be reflected in skin lesion scores. The absence of a difference in skin lesion scores between treatments suggests that the amount or severity of aggression at mixing were not affected by the rubber flooring. It also confirms that the degree of remixing in the second parity did not differ between the experimental treatments.

Pens covered with rubber slat mats had greater risk of being soiled in both the feeding stalls and the group area. The way in which the rubber was fixed to the concrete slats meant that the void area of the pen was reduced from close to 10% down to 6%. It is likely that this made it more difficult for feces to pass between the slats thereby impacting on the cleanliness of the pen. Season had an anomalous effect on the pen soiling and wetness scores, which is impossible to interpret particularly in the absence of temperature or humidity recordings from the gestation house.

There was no difference in the dirtiness of the bodies of the sows between floor types. This is surprising considering that pens covered with rubber slat mats were more soiled in both the feeding stalls and in the group area compared with the uncovered concrete pens. It is possible that the MOB scoring system used in this study was not sensitive enough to detect potential treatment differences. Greater scores for MOB were associated with a reduce risk of calluses and wounds on the limbs probably because the manure covered the lesions making them more difficult to score.

In conclusion, based on the results from this study, there was evidence that covering concrete slatted floors with rubber slat mats has potential to improve the locomotory ability of the sows. Sows housed on rubber slat mats had a reduced risk of lameness, swellings, and wounds on the limbs during the first and second parity and a greater risk of calluses during the second parity compared with sows on concrete slatted floor. Additionally, RUB sows had an increased risk of CL such as TOE, HSC, CW, and WL. Slurry accumulation on the rubber flooring used in this study suggests that if the sows were to have been housed on it long term their CL may have deteriorated to the point where they exacerbated lameness. However, as the dirtiness problems were likely related to the low void area in the rubber slat mats this problem could be overcome by improvements to the design of the flooring. We are confident that the concept of a cushioned flooring for pregnant sows leads to welfare improvements. Nevertheless, the results from this study should be treated with caution as they relate to an experiment conducted on a commercial farm using relatively small groups sizes and a liquid feeding system. Further testing of different types of rubber flooring with different group sizes, etc., is required before the results can be generalized. In addition, future work should include postmortem examination of the feet of the sows to clarify the extent to which scores attributed to lesions on the claw exterior relate to damage to the corium and to elucidate their relationship with locomotory abnormalities.

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