The Effects of Housing System, Feeding Level and Genetic Line on Osteochondrosis in Pigs

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Introduction

Osteochondrosis (OC) is a disturbance of the endochondral ossification during skeletal growth, which occurs in many species including cattle, pigs, horses and humans (Grøndalen, 1974). Osteochondrosis is the main cause of leg weakness in pigs (Reiland *et al.*, 1978). Leg weakness may result in lameness, which is an important cause for premature culling in sows and reduces welfare of fattening pigs. Reduction of the prevalence of OC could, therefore, improve wellbeing and reduce economical losses due to premature culling.

Solutions to reduce prevalence of OC may either come from genetic improvement, improvement of the environment, or a combination of both. The etiology of OC is still not fully understood, but it is agreed that the disorder is multifactorial in origin (Philipsson *et al.*, 1993) and genetic influences play a role. A review of the literature reveals variable heritability estimates for the disorder, estimated around 0.21, creating possibilities for selection against OC as performed in Sweden since 1988 (Yazdi *et al.*, 2000). Existing results on environmental factors show substantial inconsistency (Carlson et al., 1988; Ytrehus *et al.*, 2004). Pigs housed on straw bedding showed less leg weakness compared to pigs housed on conventional floors. An advantage of genetic solutions is that response of selection is additive over generations, but time consuming, whereas improvement of the environment can be realized in shorter time. At present, public concern and legislation change housing systems in which pigs are kept. Current systems commonly have barren, partially concrete floors, with little space per pig. Future systems are likely to have more space per pig and floors covered with a substrate. An important question is whether this shift in housing systems will indeed reduce welfare problems such as OC. If such improvement of the environment substantially reduces prevalence of OC, genetic solutions may no longer be required. Hence, to make an informed choice on the need for, and the potential of, genetic solutions for reducing prevalence of OC, the relative contributions of environmental and genetic factors to OC need to be known.

Material and methods

Materials. A total of 345 pigs divided in two batches were exposed to a 2 by 2 factorial design of a housing and feeding treatment. The 187 pigs from batch 1 were Tempo*Topigs 40 crossbreds, descending from 23 dams. The 158 pigs from batch 2 were Pietrain*Topigs 40 crossbreds, descending from 18 dams. Litters were equally divided over the treatment groups, to avoid confounding of genetic effects with treatment effects.

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Pigs of both batches originated from a weaning experiment (Gerritsen *et al.*, 2008). Intact boars (56%) and gilts were separated at an age of 69 days. In total, 64 groups were composed of 5 or 6 individuals, based on a balanced distribution of weaning treatment, sex, litter, and bodyweight.

Experimental design. The treatments, conventional or deep litter housing, and ad libitum or restricted feeding, were applied to the pigs. A conventional pen consisted of a 50% metal slatted (ridged round bars), 50% solid concrete floor over 5 m^2. A deep litter pen consisted of a solid concrete floor with approximately 25-50 cm of wood shavings over 8.5 m^2. The *ad libitum* fed pigs had unlimited access to feed using an automatic feeding unit. The restricted fed pigs received two equal portions of feed each day. The amount of feed supplied to restricted fed pigs was 80% of the *ad libitum* average daily intake in the preceding week.
For each individual, the left limbs were dissected in the shoulder and hip joints, tagged, and stored at - 21 ºC until further dissection and scoring of the joints. Since OC prevalence in the left and right joints of pigs showed correlations close to one in a previous study (Jørgensen and Andersen, 2000), only the left limbs were used in this study.

Scoring. Pigs were scored for OC in five joints of the left front and hind limb. The elbow, metacarpophalangeal, the femoropatellar, the tarsocrural, and metatarsophalangeal joint were scored, in total on 24 locations. The cartilage of a location was macroscopically scored on a categorical scale from A-E, as used in a previous study for macroscopic OC examination in horses (Van Weeren and Barneveld, 1999). *Score* A represented no abnormalities, *score* B flattening of cartilage, *score* C slight irregular cartilage, *score* D severe irregular cartilage, and *score* E 'classic' lesion with osteochondrotic cyst. *Score B* and *score C* are referred to as mild OC, and *score D* and *score E* are referred to as severe OC. An experienced veterinarian who is a specialist in judging OC, scored all joints without knowing the experimental treatment. To use the OC-scores in a statistical analysis, we transformed the categorical observations into quantitative traits. For the transformation of categorical scores into quantitative values, we assumed a continuous normally distributed liability underlying the categorical scores (Falconer, 1965).

Statistical analysis. To investigate the effects of the treatments, all above described parameters were tested in a linear model. The following linear mixed model was used.

$$Y_{ijklmn} = \mu + Batch_i + Housing_j + Feeding_k + Sex_l + Housing*Feeding_{jk} + \mathit{Pen}_m(\mathit{Batch}_i) + \mathit{Mother}_n + e_{ijklmn},$$

where Y_{ijklmn} is the quantitative OC value (animal or joint level) of a pig from batch i, with housing system j, feeding level k, sex l, in pen m of mother n; μ is the mean; Batch i is the fixed class effect of the Line effect (i=genetic sire line 1 or 2); Housing j is the fixed class effect of housing system (j =conventional, deep litter); Feeding k is the fixed class effect of feeding level (k =*ad libitum*, restricted); Sex l is the fixed class effect of sex (l = boar, gilt); Housing*Feeding jk is the fixed interaction effect of housing system and feeding level; Pen(Batch) is the random effect of pen m in which treatments were applied nested within batch i; Mother is the random mother effect n; e_{ijklmn} is the random residual. Statistical analysis was performed using PROC MIXED of SAS 9.1.3 (©2002-2003 SAS Institute Inc.).

Results and discussion

Mean slaughter weight of the total experimental population was 102 kg. Ad libitum fed pigs, either conventionally (110 kg) or deep litter housed (110 kg) were significantly heavier than restrictedly fed pigs either conventionally (98 kg) or deep litter housed (93 kg). Fifty-nine percent of the animals had *score A* at all locations. Animals with *scores B* to *E* had either one location (33%), two locations (8%) or three locations (1%) affected. In total, 12% of the animals showed severe OC (*score* D or E).

Table 1: Observed prevalences of OC (in % at animal level) of *scores* A-E.

Prevalence	**Treatment**				**Sex**		**Total**
	conventional floor		**deep litter floor**				
	ad libitum	**restricted**	***ad libitum***	**restricted**	♂	♀	
=A	42.5	64.8	59.3	66.3	56.6	61.1	58.6
≤ B	7.5	2.3	8.6	4.5	5.3	6.0	5.6
≤ C	36.2	22.7	18.5	16.8	23.8	22.8	23.4
≤ D	6.3	4.5	1.2	0.0	3.2	2.7	2.9
≤ E	7.5	5.7	12.4	12.4	11.1	7.4	9.5

Genetics. Batches consisted of two distinct sire lines. Thus, the batch effect represents a sire line effect. The sire line effect was not significantly different from 0 (P = 0.73), and the confidence interval of the effect was between -0.30 and +0.43. Thus the sire line effect is small. The mother variance was estimated to be 0.036 (P = 0.34), indicating an estimated heritability of ~3 – 6%, depending on whether or not dams were mated to multiple sires. This estimate, together with its standard error, indicates an upper bound for heritability of ~16%. The contributions of genetic line and mother are small, which is contradictive to the result of previous studies (Yazdi *et al.*, 2000; Reiland *et al*,, 1978). This may be caused by the lack of pedigree, and the small number of dam families within the study.

Treatments. As a result of the model, the p-values for the significant effects of sex, the treatments, and their interaction on OC values at animal and joint level are presented in Table 2.

Table 2: The effect of housing system, feeding and sex on the quantitative OC values, based on all five joints on animal level, and joint level[1]. The results are expressed as p-values.

Level	**Animal**	**Elbow joint**	**Tarsocrural joint**
Conventional vs deep litter	0.021	0.068	0.003
***Ad libitum* vs restricted**	0.003		0.0004
Gilts vs boars		0.002	
Housing × Feeding	0.040		0.047

[1] Femoropatellar, metacarpophalangeal and metatarsophalangeal joints showed no significant(p>.1) treatment effects

OC was most prevalent (57.5%) in pigs that received the treatment conventional floor with *ad libitum* feeding (Table 1). The effect of weight bearing in combination with a more slippery floor gives extra disadvantage leading to more cartilage damage (Jørgensen, 2003). OC was least prevalent (33.7%) in pigs kept in deep litter floor with restricted feeding. Although, the overall prevalence was highest with conventional floors, score E was more frequent with deep litter floors and extra space. Bone growth, strength and metabolism are positively affected by exercise or physical activity, which is reduced in situations with limited opportunities for locomotion (Jørgensen, 2003). Consequently for our study, the positive effects on bone development of deep litter housing and greater space allowance could possibly have decreased OC. On average, *ad libitum* fed pigs showed the highest prevalence of OC, and restrictedly fed pigs showed least OC. The imbalanced development during ossification due to *ad libitum* feeding may cause local overload, which may result in a greater frequency of skeletal problems (Weiler et al., 2006). The total OC prevalence (B-E) was 43.4% in boars and 38.9% in gilts. Boars had more severe OC (14.3%) than gilts (10.1%). Based on literature, boars and barrows were often more affected than gilts and sows, possibly due to sexual behaviour, like mounting (Boyle and Bjorklund, 2007).

Conclusion

The OC prevalence of the total population was 41.4%, of which 12.4% was severely affected. Deep litter housed pigs, in combination with a greater space allowance, showed less OC than conventionally housed pigs. Restricted feeding reduced the prevalence of OC. The prevalence of OC in conventionally housed *ad libitum* fed animals was 57.5%. The prevalence reduced to 33.7% when applying deep litter housing with more space and restricted feeding, and thereby increasing the welfare of pigs. The contributions of genetic line and family effect of the dam are small, which is contradictive to the result of previous studies. The indicated upper bound for a heritability of 16% indicates that there is genetic variation among the individuals that can be used for selection against OC.

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