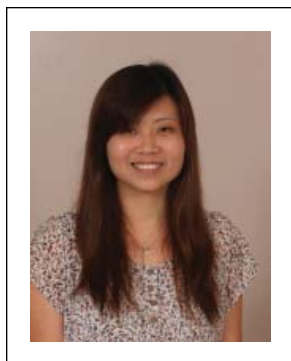
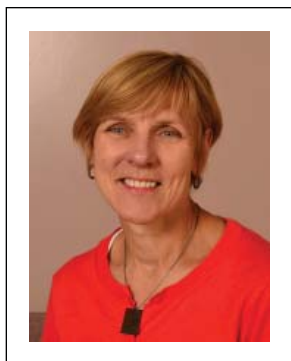


Effect of Dietary Calcium and Phosphorus in Sows on Bone Development in Piglets

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SUMMARY

This study was designed to determine the influence of Ca and P intake by young, gestating sows on the growth and skeletal development of their developing piglets and if smaller birth-weight piglets are at greater risk from mineral insufficiency during gestation. A total of 30 sows were randomly assigned to 1 of 3 dietary Ca:P treatments. At birth, the smallest and a normal-sized piglet from each litter were euthanized, and the left femur extracted for peripheral quantitative computed tomography (pQCT) scanning. Number of piglets born, body weight (BW) at 3 d of age, and piglet ADG were unaffected by diet. At birth, the highest serum Ca level was seen in the small piglets from sows fed a high Ca diet however, at weaning, this value had the smallest change from the initial value. Femurs of piglets from sows fed the low Ca diet had the highest cortical density. Piglet size had no effect on cortical density. Bone ash %, ash Ca %, ash P %, and serum bone markers were unaffected by diet or piglet size.

In conclusion, moderate changes in Ca and P intake by young, gestating sows, does not negatively affect the growth or skeletal development of their piglets.

INTRODUCTION

Adequate nutrition, including minerals, is important for gestating sows, particularly gilts, as growth and development of their piglets needs to be supported while their own growth is maintained. Nutrient requirements obtained from older studies may not be applicable to the modern, highly prolific sow as they were based on sows farrowing smaller litters. Analysis of data collected from 1994 to 2004 showed that genetic improvements resulted in approximately 1 to 2 piglets more per litter in commercial sows. Larger litters however, results in decreased average birth weight.

The objective of this study was to determine the influence of Ca and P intake by young, gestating sows on the growth and skeletal development of their piglets and determine if smaller birth-weight piglets are at greater risk of mineral deficiency.

MATERIAL AND METHODS

The study was carried out at the Prairie Swine Centre Inc. (Saskatoon, SK, Canada). Sows were cared for according to the Prairie Swine Centre Inc. standard operating procedures and the experiment was approved by University of Saskatchewan's Committee on Animal Care and Supply for compliance with the Canadian Council on Animal Care guidelines.

Treatments

A total of 30 sows (gilts and parity 1) were randomly assigned to 3 treatment groups consisting of 3 dietary Ca and P levels. The control treatment for the gestation phase was based on guidelines in the National Research Council (NRC) 1998 and the National Swine Nutrition Guide (2010). The control level for the lactation phase was based on the sow model in NRC (2012). The other treatment diets were formulated with Ca and P levels 15 % lower and 15 % higher than the control, primarily by increasing limestone and monocalcium P content. The ratio of Ca and P was maintained across diets within each phase.

Table 1. Feed allotments and dietary Ca and P levels used in gestation

Nutrients	Treatment 1 (-15 % Ca:P)	Treatment 2	Treatment 3 (+15 % Ca:P)
Gestation			
Daily feed intake, kg/d	2.30	2.30	2.30
Ca, %	0.60	0.70	0.81
Total P, %	0.47	0.55	0.63

Animals and animal care

Gilts (parity 0) and parity 1 sows were randomly assigned to 1 of the 3 treatment groups at breeding. All sows were housed in individual stalls during gestation. The stalls contained partially slatted concrete flooring. Sows were moved to the farrowing room 1 wk prior to the anticipated farrowing date and maintained in farrowing crates. Piglets were cross-fostered within the first 24 h of birth but only within the dietary treatment assigned during gestation.

Gestation phase feeding began when sows were moved to the gestation room from breeding (approximately d 28 of gestation). Sows were fed 2.3 kg/d until 2 wk prior to farrowing, when this allotment was increased to 3.0 kg/d. The standard lactation diet was available ad libitum to all sows on study during lactation period.

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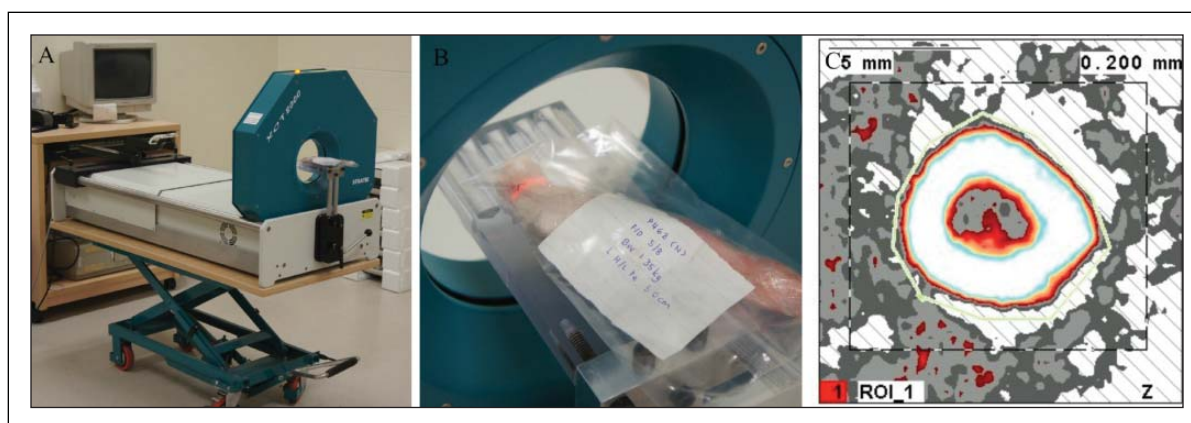


Figure 1. Peripheral quantitative computed tomography (pQCT) scan in the midshaft of the femur in a newborn piglet left hind limb; (A) Norland/Stratec pQCT, (B) Limb positioned perpendicular to the laser of the gantry, (C) Scanned region of interest (ROI) at femur midshaft.

Table 2. Main effects of dietary Ca and P (15% variance from 1998 NRC recommendations) on serum Ca and P and bone markers, osteocalcin and pyridinoline, in sows¹

Serum constituent	Diet			SEM	P-value
	-15%	Control	+15%		
Serum Ca, mmol/L					
d 100 Gestation	2.51	2.45	2.47	0.03	0.30
Wean ²	2.66 ^a	2.52 ^b	2.52 ^b	0.03	<0.01
Serum P, mmol/L					
d 100 Gestation	2.33	2.23	2.27	0.05	0.37
Wean ²	2.21	2.17	2.15	0.07	0.83
Serum osteocalcin³, ng/mL					
d 100 gestation	375.2	397.0	327.2	35.9	0.39
Wean ²	181.2	184.8	139.9	18.9	0.19
Serum pyridinoline⁴, nmol/L					
d 100 gestation	6.8	7.4	7.0	0.3	0.37
Wean ²	7.4	6.9	7.2	0.5	0.79

¹ A total of 30 sows (gilts and parity 1) were randomly assigned to 3 dietary Ca and P treatments.

² Serum samples collected at lactation d 26 ± 2 from all 30 sows.

³ Marker of bone formation.

⁴ Marker of bone resorption.

^{ab} Within a row, means without a common superscript differ (P < 0.05).

Data collection

Only sows farrowing 12 or more piglets remained on the experiment. Piglets were weighed on d 3 post-farrowing and prior to weaning. In each litter, the smallest or second smallest piglet (SMALL) and a piglet representing the heaviest 20 % of the piglets (NORM) were selected and birth weight recorded.

RESULTS AND DISCUSSION

Sow reproductive performance

Calcium and P content of the diet fed to the gestating sows did not influence reproductive performance. The young sows in this study were highly prolific, averaging 16 piglets per litter. The smallest piglets had an average birth weight of 0.86 kg while the normal-sized piglets averaged 1.36 kg.

Sow and piglet serum constituents

An effect of dietary Ca and P during gestation on serum total Ca of sows was observed at weaning (P < 0.01; Table 2). Sows that were fed lower Ca during the gestation period had the highest level of serum Ca prior to weaning while sows fed the high Ca:P treatment had serum Ca levels comparable to the control. There was no effect of dietary Ca on serum Ca at d 100 of gestation (P > 0.10). Dietary Ca and P had no effect on concentration of serum P, serum osteocalcin, a marker of bone formation or serum pyridinoline, a marker of bone resorption, at late gestation or prior to weaning (P > 0.10).

A diet by piglet size interaction was observed on serum total Ca of piglets at birth (P = 0.04; Fig. 2). The SMALL piglets from sows fed the high levels of Ca during gestation had the highest level of serum Ca at birth while those from control sows had the lowest level of serum Ca. In contrast, no differences were observed in the serum Ca concentrations of NORM piglets.

Values at weaning calculated as a change from d 0 showed a diet by size interaction where the SMALL piglets produced by sows fed the high Ca diet had the smallest increase in serum Ca prior to weaning (P = 0.02). Neither gestational diet Ca and P concentration nor piglet size affected serum P levels of the piglets at birth, but NORM piglets had higher concentrations of serum P prior to weaning (P = 0.01). NORM piglets had a greater increase in serum P from d 0 to weaning (P = 0.05) compared to SMALL piglets. Comparable to that seen with the sows, dietary Ca and P did not affect the levels of the bone biomarkers of formation (osteocalcin) or resorption (pyridinoline) of piglets either at birth or at weaning (P > 0.10).

Piglets' bone parameters

The expected differences in the fresh weight, dry weight and ash weight of femoral bones were observed between the SMALL and NORM piglets at birth; femoral bones from NORM piglets were heavier (fresh, dry or ash weights) (P < 0.01). Except that SMALL piglets had a tendency for higher ash % compared to the NORM piglets (P = 0.07), the fresh weight, dry weight and ash weight, when calculated as percentages of DM showed no differences due to dietary treatments or piglet size (P > 0.10). Femoral bone ash Ca and P were also not affected by sows' dietary Ca and P or piglet size (P > 0.10).

Femoral bone scans using pQCT revealed significant differences in bone parameters between the SMALL and NORM piglets. Based on the scans, SMALL piglets had smaller total area, cortical bone area, cortical bone content and SSI ($P < 0.01$). Femoral bones of piglets from sows fed the low Ca and P diet during gestation had the highest cortical density while the lowest cortical density was seen in piglets produced from sows fed the control diet ($P = 0.03$). Piglet size did not influence the cortical density of the femoral bone ($P > 0.10$).

CONCLUSION

Based on this study, the smaller piglets at birth do not have a higher risk of mineral deficiency. Although small piglets from sows fed the control diet had lower serum Ca at birth, serum Ca was similar regardless of the size of piglets at weaning. On the other hand, although serum P was similar between the small and normal-sized piglets at birth, small-sized piglets had lower serum P at weaning. These results combined with the lack of significance on the bone markers would suggest that apart from the mobilization of Ca and P from the bones, other adaptive mechanisms may play a role in maintaining the levels of Ca and P in the blood. The gestational diets did not negatively affect the cortical density of the newborn piglets. In fact, sows fed the low Ca diet produced piglets with the highest cortical density. The gestational diets, however, were fed for a single parity and further research is required to examine if similar results will be obtained over consecutive parities. Femoral bone analysis showed that cortical density of the small piglets were similar to the normal-sized piglets despite the size differences thus, suggesting that the smaller piglets at birth did not appear to have a higher risk of mineral deficiency. Sketal development and serum Ca concentration will not be compromised with a moderate Calcium deficiency of the sows diet for one parity

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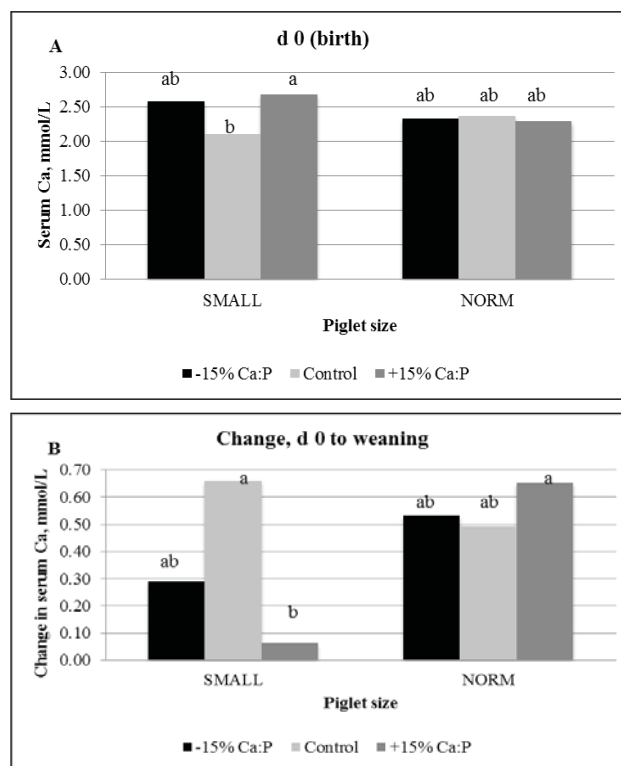


Figure 2. The effects of dietary Ca and P (15 % variance from 1998 NRC recommendations) for gestating sows and piglet size on serum Ca concentration of piglets (SMALL = smallest or second smallest piglet in each litter; NORM= heaviest 20 % of the piglets in each litter) on serum Ca of glets ($P < 0.05$); (A) d 0; SEM = 0.13, (B) Change, d 0 (birth) to weaning (d 26); SEM = 0.12. Means with the same letter are not significantly different ($P > 0.05$).