ORIGINAL RESEARCH

Murphy KA, Friendship RM, Dewey CE. Effects of weaning age and dosage of supplemented iron on the hemoglobin concentrations and growth rate of piglets. *Swine Health and Production*. 1997;5(4):135–138.

Effects of weaning age and dosage of supplemented iron on the hemoglobin concentrations and growth rate of piglets

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Summary

Objective: To determine the effect of weaning age and dosage of supplemented iron dextran on the hemoglobin concentrations and growth rate of piglets.

Method: One hundred and thirty-six piglets (from 22 litters) were randomly assigned to one of two treatments. Half (n = 68) of the piglets received 200 mg and the other half received 300 mg of iron dextran administered intramuscularly as a single dose into the neck at approximately 3 days of age. Pigs were randomly assigned to wean groups (7, 14, and 28 days) by litter. Piglet hemoglobin concentrations and body weight were measured at days 7, 14, and 28.

Results: Pigs weaned at 14 days of age and treated with 300 mg of iron were found to have significantly higher ($P = .017$) hemoglobin concentrations than piglets weaned at the same time that received 200 mg of iron. Iron treatment did not affect weight gain and almost all pigs weaned at 14 and 28 days were found to have biologically adequate (> 9 g per dL) concentrations of hemoglobin at 28 days of age. Piglets weaned at 7 days weighed less at 28 days than piglets weaned at 14 and 28 days ($P < .05$) and had lower hemoglobin concentrations ($P < .05$) regardless of iron treatment.

Implications: Increasing iron supplementation of suckling pigs from 200 mg to 300 mg did not result in improved growth.

Keywords: swine, iron, anemia, weaning age

Received: Nov 18, 1996
Accepted: Apr 22, 1997

In offsite nurseries there are often small, pale, long-haired piglets that weigh less at weaning than penmates, or that were weaned at a very early age (<10 days) in order to accommodate strict all-in–all-out (AIAO) protocols. These small pigs are frequently slow to adjust to solid food and remain unthrifty for several weeks. We have speculated that low feed intake for the first week or two postweaning might predispose pigs to anemia due to iron deficiency.

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This article is available on the AASP Web site at:

http://www.aasp.org/shap/issues/v5n4/index.html

It is well established that pigs are born with a limited store of iron (approximately 50 mg) and that sow's milk contains an inadequate amount of iron (about 1 mg per day) to meet the continuing requirements (7–11 mg per day) of the rapidly growing piglet.[1–3] Research conducted in the 1950s found that 200 mg of an iron dextran product given to piglets by intramuscular (IM) injection was sufficient to maintain hemoglobin concentrations until weaning at 6–8 weeks.[4,5] In the 1970s, as weaning ages were reduced to 3–4 weeks, several researchers[4,5] examined the issue of iron supplementation and generally concluded that 200 mg of iron dextran was an appropriate dosage.

Recently, as a result of multisite production or segregated early weaning management, piglets are commonly being weaned at even earlier ages. In theory, if piglets are weaned at 1–2 weeks of age and they immediately begin to eat a solid diet that is supplemented with iron, then there is less requirement for intramuscular injection of iron dextran during the first week of life than there is for piglets weaned at the traditional age of 3–4 weeks. However, if piglets are slow to adapt to solid food, there may be a continued or even an increased requirement for IM iron supplementation.

The objective of this study was to determine the effect of two different concentrations of iron supplementation (200 mg versus 300 mg) on the growth rate and hemoglobin concentrations of pigs weaned at 7 days, 14 days, and 28 days of age.

Materials and methods

The study was conducted at the Arkell Swine Research Centre, University of Guelph. Twenty-two litters (136 piglets) were used. All animals were previously unmated purebred Yorkshires. Farrowing took place between May and July 1996. Within each litter, piglets were alternately assigned to a low-iron (200 mg Fe) or a high-iron (300 mg Fe) group. Treatment was distributed evenly by sex. Iron dextran (Ferroforte®, MTC Pharmaceuticals, 420 Beaverdale Road, Cambridge, Ontario, N3C 2W4 Canada) at a concentration of 200 mg per mL was administered by IM injection in the neck muscle of piglets at approximately 3 days of age. Litters were randomly selected to be weaned at either 7, 14, or 28 days of age.

From birth until weaning, piglets were housed in conventional farrowing crates with plastic-coated expanded metal floors. A heat lamp and plastic mat were used to create a warm comfort area for piglets. At weaning, the piglets were divided into a "light" weight group and a "heavy" weight group and transferred to flat deck weaning pens.

Flooring was plastic-coated wire mesh. Supplemental heat was supplied by a heat lamp.

Pelleted creep feed (Phase I Starter Feed, Premiere Agri-Technologies, Box 217, Woodstock, Ontario, N4S 7W8 Canada) containing >195 mg per kg iron was offered ad libitum to all piglets beginning at 5 days of age. Phase II Starter Feed (Premiere Agri-Technologies), containing 215 mg per kg iron, was introduced and offered ad libitum to all piglets at 14 days of age, followed by Phase III Starter Feed (iron >240 mg per kg) (Premiere Agri-Technologies) fed from 21 days onward. This feeding program was followed regardless of whether or not pigs were weaned.

Piglets were weighed individually at farrowing and at 7, 14, and 28 days of age. A 1 mL blood sample was drawn (from equal numbers of piglets from the high-iron and low-iron groups) from the suborbital sinus of all piglets at 28 days, and from half the piglets from the groups weaned at 7 and 14 days of age. The blood was collected into a 2-mL EDTA tube and hemoglobin concentrations were determined using a Coulter S + IV (Coulter Electronics Inc., Hialeah, Florida).

Statistical analysis

Student t-tests were used to compare hemoglobin concentrations and body weights between low-iron and high-iron groups within each of the three weaning age treatments. Hemoglobin concentrations for each age group were regressed on treatment protocol, age of weaning, gender, and body weight for each of the age groups using multiple linear regression. Similarly, body weight was regressed on treatment protocol, age at weaning, gender, and birth weight. Variables were removed in a backward elimination method to reveal possible confounding. Pearson's correlations were used to investigate the relationship between piglet weight and weaning age, and piglet weight and hemoglobin concentrations, respectively. Pigs were deemed anemic if their hemoglobin concentrations were less than 9 g per dL at 28 days of age. The odds of being anemic at 7, 14, and 28 days were compared for each treatment group and each age at weaning using multiple logistic regression. All analyses were conducted with Statistix 4.1® (Analytical Software, 1958 Eldridge Avenue, PO Box 130204, St. Paul, Minnesota 55113).

Results

One litter was removed from the study because the piglets did not receive iron supplementation until 8 days of age. The mean hemoglobin level at 28 days of age was higher for piglets given 300 mg of iron and weaned at 14 days of age (Hb = 11.21 g per dL) compared to piglets given 200 mg of iron and weaned at 14 days of age (Hb = 10.15 g per dL) ($P = 0.017$) (Figure 1). In the final model, controlling for the effect of weaning age and sex, we observed that piglets receiving 300 mg of iron had a mean hemoglobin concentration at 28 days of age that was significantly greater than that of piglets treated with 200 mg of iron. However, the mean hemoglobin concentration for both groups was greater than 10 g per dL. There was no association between hemoglobin concentrations and treatment protocols after controlling for age of weaning, gender, and body weight.

Piglet weight at 28 days was correlated to weaning age ($r = 0.80$, $P < 0.01$) (Figure 2). The 28-day weights of pigs weaned at 7 days are lighter than 28-day weights of pigs weaned at 14 days and 28 days ($P < .05$). There was no association between body weight and treatment protocol after controlling for age at weaning, gender, and birth weight.

We observed an association between relative hemoglobin concentrations and age at weaning (Figure 1). Hemoglobin concentrations at 14 days of age and 28 days of age were moderately correlated with piglet weight at 14 days ($r = 0.57$, $P < 0.001$) and 28 days ($r = 0.41$, $P < 0.001$), respectively. The hemoglobin concentrations of piglets at 7 days were not associated with body weight at 7 days ($r = 0.17$, $P = 0.3$).

Pigs weaned at 7 days of age were 12 times more likely to be anemic than pigs weaned at 14 days of age. Almost half of the pigs (16 of 34) weaned at 7 days of age were anemic (i.e., had hemoglobin concentrations below 9 g per dL) at 28 days of age. Interestingly, birthweight was correlated with hemoglobin concentrations at 7, 14, and 28 days ($r = .53$, $P < .02$; $r = .65$, $P < .01$; and $r = .42$, $P < .07$, respectively).

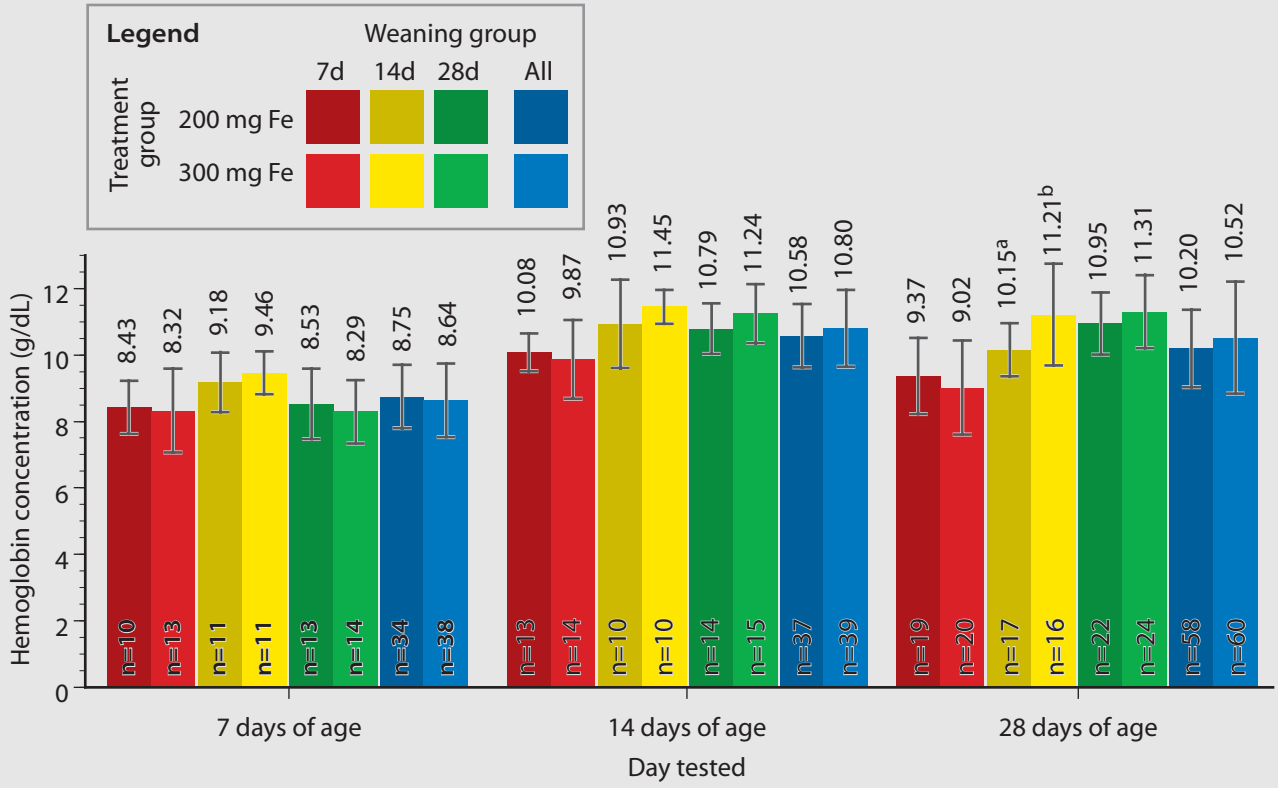
Discussion

In order to assess whether 300 mg of iron dextran IM was a better treatment to prevent iron deficiency anemia than the traditional level of 200 mg, we followed the criteria used by Dakin, et al.[4] These authors chose hemoglobin concentrations below 9 g per dL as an arbitrary definition of anemia. Assuming that boosting hemoglobin concentrations higher than 9 g per dL will provide no further biological advantage, we conclude that increasing iron dextran supplementation in this experiment to 300 mg provided no improvement in growth. Piglets weaned at 14 days of age and treated with 300 mg did demonstrate significantly higher hemoglobin concentrations compared to piglets treated with 200 mg of iron dextran, but the mean hemoglobin level for both groups was well above 10 g per dL and anemic pigs were not recorded in either treatment group. The fact that piglet weights at day 28 for each treatment group were similar supports the interpretation that supplementation with iron does not improve growth.

Piglets that were weaned at 7 days of age did not perform well during the first few weeks postweaning, gaining on average only 300 g in the first 7 days. Many of these pigs did develop anemia by 28 days of age. However, the problem of low hemoglobin concentrations was similar for both treatment groups. It would appear that these pale, unthrifty pigs cannot be helped by increasing iron supplementation during the suckling period. In all likelihood, steps to improve feed intake postweaning and attention to management and housing factors to reduce stress are the most useful methods to solve this problem.

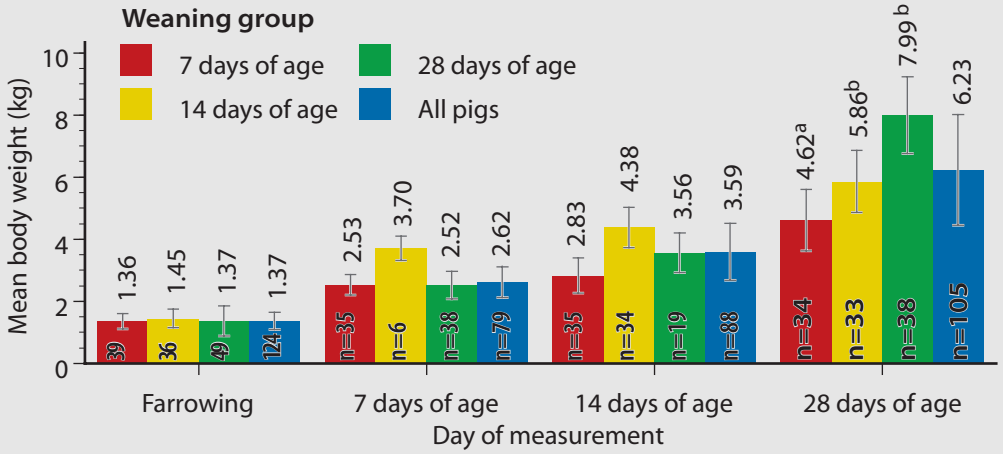
A recent study[6] has suggested that the injection of 200 mg iron dextran at 1 day of age results in an iron overload. Most bacterial species require iron for growth and excess iron in the bloodstream of neonatal piglets can be associated with the occurrence of polyarthritis, septicemia, and colibacillosis. This is an additional argument against using higher concentrations of supplementary iron. In fact, as weaning ages are reduced, it seems probable that injectable iron supplementation to

Figure 1



Hemoglobin concentrations at 7, 14, and 28 days by weaning group (color) and treatment (shade)
Pigs were treated with 200 mg or 300 mg iron dextran intramuscularly on day 3.
ab Different superscripts are different, $P = .02$.

Figure 2



Mean body weight of pigs at farrowing, 7, 14, and 28 days by weaning group
ab Different superscripts are different, $P < .05$

the neonatal pig can be reduced, providing pigs can be encouraged to eat sufficient quantities of a prestarter ration that is adequately supplemented with iron. We suggest that a follow-up study examining the efficacy of using 100 mg compared to 200 mg of iron dextran be performed in a setting where piglets are weaned at 10 to 14 days of age.

Implications

- Some of the piglets (from both the high-iron and the low-iron groups) that were weaned at 7 days developed anemia by day 28.
- Increasing iron dextran supplementation from 200 mg to 300 mg IM at 3 days of age did not result in improved growth performance and did not appear to be advantageous.
- Hemoglobin concentrations at 7, 14, and 28 days of age were moderately correlated with piglet weight.

Acknowledgements

This work was supported, in part, by the Ontario Ministry of Agriculture, Food, and Rural Affairs, and by MTC Pharmaceuticals.

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