Relationships of Serum Insulin-Like Growth Factor II Concentrations to Growth, Compositional, and Reproductive Traits of Swine 1,2

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ABSTRACT: Insulin-like growth factors I and II (IGF-I and -II) are peptide hormones involved in metabolic regulation of growth. The objective of this study was to determine whether IGF-II concentration was predictive of growth, compositional, and reproductive traits of pigs. Forty male and sixty female pigs, divided equally between two locations, were weighed at 3-wk intervals from birth to 21 wk and bled at 9 and 21 wk of age. At each sampling, two blood samples were collected via jugular venipuncture at an interval of at least 1 h. Serum was separated and IGF-I, IGF-II, and growth hormone (GH) concentrations were determined via RIA. Traits measured included age at puberty and first parity litter size for gilts and backfat and longissimus muscle area. Blood was collected from a random sample of 52 progeny from 13 litters at 9 wk of age and serum was assayed for IGF-II concentrations. Effects of age, sex, location, and pig within sex × location on square-root transformed IGF-II concentrations were determined via RIA. Traits measured included age at puberty and first parity litter size for gilts and backfat and longissimus muscle area. Blood was collected from a random sample of 52 progeny from 13 litters at 9 wk of age and serum was assayed for IGF-II concentrations. Effects of age, sex, location, and pig within sex × location on square-root transformed IGF-II concentrations were determined by analyzing data as a split-plot. Performance traits were fitted to a model including the effects of IGF-II concentration and combinations with IGF-I concentration, sex, location, and interactions. Concentrations of IGF-II were greater at 9 than at 21 wk of age (226.7 vs 159.3 ng/mL, respectively; P < .001) but did not differ between sexes. The correlation between serum IGF-II concentrations assayed from samples collected at 9 and 21 wk was .08. The partial correlations between IGF-I and IGF-II concentrations were .33 and .14 at 9 and 21 wk, respectively. The heritability of IGF-II concentration estimated from offspring-midparent regression was .08 ± .20. Nine-week IGF-II concentration was positively associated with increased weight from weaning to 12 wk (P < .001). However, the sum of 9-wk IGF-I and IGF-II concentrations had a greater relationship to weight and gain in the growing phase than the concentration of either hormone alone. Concentration of IGF-II at 9 or 21 wk alone did not affect backfat thickness, longissimus muscle area, percentage lean, days to 100 kg, weight at 21 wk, age at puberty, or litter size. The sum of IGF-I and -II concentrations was, however, associated with increased backfat and decreased days to 100 kg.

Key Words: Pigs, IGF-I, IGF-II, Growth, Composition, Reproduction

Introduction

Genetic trends in traits of economic importance to swine producers, such as growth rate and backfat thickness, have been lower than is potentially possible primarily because of low selection differentials. Selection differentials may be less than expected because selection emphasis is placed on other traits or because whole-herd testing is not practiced (Lamberson, 1994). Failure to test all males may result from inability to market a high proportion of males as breeding boars and economic disadvantage in marketing intact males for slaughter. Development of a selection criterion for swine that can be measured early in life and can accurately predict future growth would aid in selection by allowing producers to measure a high proportion of males, make selection decisions, and castrate and market those with low genetic merit to avoid incurring economic loss associated with selling boars for slaughter. Boars predicted to be superior based on the early criterion could be retained for further testing and sale as breeding animals.
Insulin-like growth factors are hormones involved in regulation of growth (Daughaday and Rotwein, 1989). It has previously been suggested that these hormones may be potential selection criteria, and selection for increased IGF-I concentration has been shown to produce favorable correlated responses in growth and reproduction in mice (Kroonsberg et al., 1989; Baker et al., 1991). Relationships of IGF-I concentration to performance and reproductive traits in swine have been reported by Lamberson et al. (1995). The objective of this study was to determine whether serum IGF-II concentration was predictive of growth, compositional, and reproductive traits of pigs.

Materials and Methods

Sixty gilts and forty boars were assigned equally to be housed in a modified open-front confinement building in single-sex groups of 10 pigs per pen or in an environmentally controlled confinement building in single-sex groups of three pigs per pen for growing and finishing. Animal care followed the guidelines suggested by the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (Consortium, 1988). Management of these animals through breeding and farrowing has been previously described by Lamberson et al. (1995). Pigs were weighed at 3-wk intervals from birth to 21 wk. Tenth rib backfat thickness and 10th rib longissimus muscle area were measured at 15, 18, and 21 wk using B-mode ultrasound. Percentage lean at 21 wk of age was predicted using the equation 

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\text{Percentage lean} = 85 - 0.92 \times \text{live weight} (kg) - 0.643 \times 10\text{th rib fat} (mm) + 0.71 \times 10\text{th rib longissimus muscle area} (cm^2) \times 0.588 \quad (\text{NPPC, 1991}).
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After 21 wk of age, gilts were penned in groups of 12 in .5-ha pastures. Detection of estrus was initiated when the oldest gilt in a pen reached 160 d of age (January 1993). Detection of estrus consisted of exposure to a mature boar for 15 min each day. Positive expression of estrus was defined as a gilt standing solidly to be mounted by the boar. The age of the gilt when she first stood for the boar was age at puberty. At their first estrus after gilts reached 230 d of age, gilts were naturally mated each day they remained in estrus. They were allowed to farrow and total number of fully formed pigs was recorded and defined as litter size.

Blood samples were collected from experimental animals via jugular venipuncture at 9 and 21 wk of age. At each sampling, two samples were collected approximately 1.5 h apart, and no less than 1 h apart. A single blood sample was collected via jugular venipuncture from 52 progeny from 13 litters at 9 wk of age. Blood samples were centrifuged and serum poured off and frozen at −20°C until assayed.

Serum IGF-II concentrations were determined using procedures for extraction and assay as described by Lee et al. (1991). Recombinant IGF-II was used for iodination and standards (UBI-01-142; Upstate Biotechnology). A previously validated monoclonal IGF-II antibody (Lee et al., 1991) was purchased from Amano International Enzyme (Troy, VA; Clone S1-F2). Growth hormone concentrations were determined as previously described by Matteri et al. (1994).

Serum IGF-I concentrations were determined by extraction and RIA procedures previously described by Holland et al. (1988). Recombinant IGF-I was used for iodination and standards (UBI-01-141, Amano Corp., Thousand Oaks, CA). Antiserum (UB3-189) was provided by the National Hormone and Pituitary Program. Within- and between-assay coefficients of variation were 11.3 and 18.6%, respectively.

Statistical Analyses

Data were analyzed using analyses of variance in a two-stage sequence. Distributions of concentrations of IGF-II were skewed as tested by using a Shapiro-Wilk W test. Square-root transformations were normally distributed. Square-root transformations of hormone concentrations were fitted to a model including effects of sex, location, and pig within sex × location (error term for previously listed whole-plot effects), age, and sex × age. The sub-plot effects age and sex × age were tested with the residual error. Partial correlations between hormone concentrations were estimated after fitting data to a model including the effects of sex and location. Performance and reproductive traits were fitted to a model including the effects of IGF-II concentration, sex, location, and interactions. Litter was fitted in models for analysis of preweaning traits. Additional models, which included the effects of the sum of IGF-I and IGF-II concentrations or IGF-I, IGF-II concentration and the interaction of IGF-I concentration × IGF-II concentration or the ratio of IGF-I concentration to IGF-II concentrations, were also fitted. Performance traits of interest were weights at birth, weaning, 9, and 21 wk of age, days to 100 kg, 10th rib backfat adjusted to 100 kg, 10th rib longissimus muscle area adjusted to 100 kg, and percentage lean. Reproductive traits of interest were age at puberty of females and litter size. The heritability of IGF-II concentration was estimated using offspring-midparent regression. The results of analyses of the effects of IGF-I concentrations alone have been reported by Lamberson et al. (1995).

Results and Discussion

The regulation of IGF-II secretion has not been studied as extensively as that of IGF-I. The secretion of IGF-I is known to be influenced by developmental status, nutrition, and thermal environment (Dauncey et al., 1993, 1994; Ozawa et al., 1994). The age-related decrease in IGF-II concentration between 9 and 21 wk of age presently observed (Figure 1) was consistent with the developmental pattern of IGF-II.
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Figure 1. Concentrations of IGF-II measured at 9 and 21 wk of age in male and female swine.

The concentration reported previously (Lee et al., 1991). The present results demonstrated similar levels of IGF-II concentration between sexes, in contrast to the sex-related differences in IGF-I concentrations that occurred in this same population of animals (Lamberson et al., 1995). Insulin-like growth factor II concentrations were also not affected by location, although location was a highly significant source of variation for IGF-I concentration measured in the same animals (Lamberson et al., 1995).

The correlation of IGF-II concentration was .08 when estimated between samples measured at 9 and 21 wk. The similar correlation for IGF-I was .29 ± .02. Partial correlations between IGF-I and IGF-II concentrations were .33 and .14 at 9 and 21 wk, respectively. The partial correlation between IGF-II and GH concentrations at 9 wk of age was .07. The heritability of IGF-II concentration measured at 9 wk was estimated to be .08 ± .20. The corresponding heritability of IGF-I concentration reported by Lamberson et al. (1995) was .27.

Means and standard deviations of performance and reproductive traits are presented in Table 1. Higher IGF-II concentrations were associated (P = .07) with increased weight at 21 d (regression = .00035 ± .00019 kg/ng). Higher IGF-II concentrations at 9 wk were also associated (P = .02) with increased weight at 6 wk (regression = .010 ± .004 kg/ng; Table 2). A sex × IGF-II concentration interaction affected weight at 9 wk of age (P = .03). The regressions of weight at 9 wk on IGF-II concentration were .039 ± .010 kg/ng for males and .013 ± .007 kg/ng for females. Weight at 12 wk was also affected (P = .03) by IGF-II concentration measured at 9 wk (regression = .030 ± .013 kg/ng). There was not an effect of IGF-II concentration on birth weight or on gain from 9 to 12 wk. There were no interactions between IGF-II and IGF-I concentrations at 9 wk on weights from birth to 9 wk or on gain from 6 to 9 wk.

Table 1. Means and standard deviations of performance and reproductive traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>SD</th>
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<tbody>
<tr>
<td>Birth weight, kg</td>
<td>1.6</td>
<td>.3</td>
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<tr>
<td>21-d weight, kg</td>
<td>7.5</td>
<td>.9</td>
</tr>
<tr>
<td>6-wk weight, kg</td>
<td>15.5</td>
<td>2.5</td>
</tr>
<tr>
<td>9-wk weight, kg</td>
<td>26.7</td>
<td>4.2</td>
</tr>
<tr>
<td>21-wk weight, kg</td>
<td>109.7</td>
<td>12.6</td>
</tr>
<tr>
<td>Days to 100 kg</td>
<td>129.5</td>
<td>15.0</td>
</tr>
<tr>
<td>Percentage lean</td>
<td>48.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Longissimus muscle area, cm²</td>
<td>31.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Backfat at 100 kg, mm</td>
<td>24.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Age at puberty, d</td>
<td>197</td>
<td>18</td>
</tr>
<tr>
<td>Litter size</td>
<td>10.0</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Results from this study support previous research indicating that IGF-II concentration has its greatest effect early in life. Greater effects of the sum of concentrations of IGF-I and IGF-II than of the concentration of either hormone alone supports their combined action through one receptor (Rechler and Nissley, 1985). In addition, negative feedback between the two hormones combined with their action through a single receptor might be expected to result in the greater effect of the sum than of the components. Conversely, the correlation between the sum of concentrations of IGF-I and IGF-II measured at 9 and 21 wk was lower (r = −.07) than the correlations within hormones, indicating that it is unlikely the two hormones are regulated around a single setpoint.

Implications

Although IGF-II and the combination of IGF-I and IGF-II concentrations were related to weight early in life, IGF-II concentration was not related to backfat thickness, longissimus muscle area, percentage lean, days to 100 kg, weight at 21 wk, age at puberty, or litter size. Given the lack of a strong relationship between IGF-II concentration and economically important traits and the low heritability of IGF-II concentration, IGF-II concentration is not likely to be useful as a selection criterion for swine producers.

Literature Cited


