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Effects of Transport Stress, Sex, and Weaning Weight on Postweaning Performance in Pigs

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ABSTRACT

To examine the effects of transport, sex, and weaning weight on postweaning performance, pigs were weighed and blood was collected immediately before weaning (d 0; with or without a 3-h transport) and on d 1 and 7 postweaning. Corticosteroid-binding globulin concentrations decreased by d 1 and remained suppressed through d 7 regardless of transport. Cortisol concentrations in males increased from d 0 to 1 and then decreased to preweaning levels by d 7; females had higher preweaning cortisol levels that did not change on d 1 but that decreased by d 7 to lower levels than in males. The free cortisol index was elevated on d 1 in all groups but returned to preweaning levels by d 7. Low weaning weight was associated with lower corticosteroid-binding globulin concentrations and higher free cortisol index on d 1. White blood cell counts increased from d 0 to 1, and then decreased by d 7. The percentage and number of neutrophils as well as the neutrophil:lymphocyte ratio followed a similar pattern. Females had higher numbers of neutrophils than males on d 1. Low weaning weight was associated with greater numbers and percentages of neutrophils before weaning, but not after; weaning appeared to uncouple the relationship between BW and circulating immune cell populations. The stress caused by weaning was greater than that associated with transport and was, in part, related to weaning weight. Understanding how factors influence postweaning performance will yield new strategies to reduce their effects and increase uniform and efficient growth.

Key words: swine, transport stress, weaning weight

INTRODUCTION

Maternal separation, relocation to new housing, introduction into new social groups, and changing to a dry diet can suppress growth in the recently weaned pig. The physiological mechanisms that underlie growth-related responses to these stressful situations, transport in particular, are poorly understood. Typical of the endocrine profile seen during undernutrition, weaning of the pig increases concentrations of somatotropin and decreases serum concentrations of IGF-I and IGF-II (Carroll et al., 1998; Matteri et al., 2000). Increased plasma and urinary cortisol concentrations and decreased plasma corticosteroid-binding globulin (**CBG**) have been reported after weaning (Le Dividich and Seve, 2002; Heo et al., 2003; Kojima et al., 2008). Considering the immunosuppressive effects of weaning (Kojima et al., 2008) and transportation (McGlone et al., 1993; Hicks et al., 1998) and the elevated exposure of the pig to pathogens through feces during transport (Jones et al., 2001), the risk of being exposed to and succumbing to disease is greatly enhanced.

The extent to which weaning (with or without transport) affects pig physiology and immune status may be related to many factors, such as weaning weight (**WW**; Matteri et al., 2000; Bruininx et al., 2001; Kojima et al., 2007, 2008) and sex (Bruininx et al., 2001). This experiment was designed to assess the extent to which sex and WW influence the effects of weaning with and without transport in the pig.

MATERIALS AND METHODS

Animals

All animal procedures were reviewed and approved by the University of

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Tennessee Animal Care and Use Committee. Crossbred pigs (of Landrace, Duroc, and Hampshire breeding) were farrowed in standard farrowing pens and processed according to usual University of Tennessee Experiment Station practice at 4 to 7 d of age. Procedures included needle teeth clipping, tail docking, iron supplementation, ear tagging, and castration of males. Pigs were kept in farrowing pens with their dams until weaning, with creep feed (Diet 554PE, Tennessee Farmer's Cooperative, LaVergne, TN) available at all times.

Experimental Design

Sixty-four weanling pigs (32 males and 32 females) were allocated into either transported or nontransported groups of either sex, so that the following treatment groups existed: transported (**YT**) males, nontransported (**NT**) males, YT females, and NT females. On d 0 (21 to 24 d of age), unweaned pigs were bled, weighed, and assigned to their treatment groups. Pigs in the NT groups were weaned into nursery pens (16 m^2), and pigs in the YT groups were mixed and transported by truck for 3 h before being brought back to the nursery and similarly allocated. The stocking density of the trailer was approximately 1.625 ft^2/pig, and the weather conditions were mild, dry, and typical for mid-October in eastern Tennessee. There were a total of 16 pens with 4 pigs in each pen, and 4 pens for each sex × transport group. Pigs within a sex were allocated to pens such that pigs in each pen were of a similar BW, so that smaller pigs would not have to compete with larger pigs for food, creating additional stress. Pigs were allowed feed and water ad libitum. All pigs were weighed and bled on d 1, 7, and 14 postweaning.

Blood Collection

Blood samples (4 mL) were collected via anterior vena cava puncture and allotted as follows: 1 mL was placed into a tube spray-coated with 5.4 mg K_2-EDTA (BD Vacutainer, Franklin Lakes, NJ), and 3 mL was placed into a tube spray-coated with 86 IU heparin for plasma collection. The EDTA-containing tubes were sent on ice immediately to a commercial clinical laboratory (Vet Path Laboratories, Tulsa, OK) for differential white blood cell (**WBC**) analysis. The heparinized blood samples were centrifuged at 2,000 × g for 10 min and the recovered plasma was stored at −20°C until analyzed for cortisol and CBG concentrations. During blood collection, animals were temporarily placed in a V-trough and restrained gently by hand. Collection of the sample was often achieved within 1 min of initial restraint.

Determination of Circulating Concentrations of Cortisol and CBG, and Calculation of the Free Cortisol Index

Plasma total cortisol concentrations (nmol/L) were determined by RIA as reported previously (Kojima et al., 2008). Intra- and interassay CV were 2.9 and 5.3%, respectively. Plasma CBG concentrations (mg/L) were measured by direct ELISA as described previously (Roberts et al., 2003). Intra- and interassay CV were less than 15%. The free cortisol index (**FCI**, reported as nmol/mg) was calculated using the ratio of plasma total cortisol to CBG concentration.

Determination of Circulating Numbers and Relative Abundance of Neutrophils and Lymphocytes

Reports generated by the commercial laboratory provided the total WBC concentration per microliter, the concentration of neutrophils and lymphocytes per microliter, and also the percentages of neutrophils and lymphocytes relative to total WBC concentration. The neutrophil:lymphocyte (**N:L**) ratio was calculated from absolute numbers.

Statistical Analysis

Data were analyzed with mixed model ANOVA, using a model for a randomized block design with factorial arrangement of treatments. Pig was the experimental unit, represented by block × treatment interactions. The statistical model included transport and sex as main effects with repeated measures and WW as a covariate. Least squares means were compared using Fisher's protected least significant difference. These analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC). To determine the effects of WW on stress and immune variables, Pearson's correlations and Fisher's r to z transformations were performed using the software package Statview (SAS Institute Inc.). A significance level of $P < 0.05$ was used for all testing. All graphical and textual descriptions of results are reported as least squares means. Graphical representations are of simplified models, with nonsignificant effects ($P > 0.05$) removed for ease of viewing.

RESULTS AND DISCUSSION

Weaning resulted in a loss of BW at 1 d postweaning regardless of sex or transport status of the animals (Figure 1). Body weights at 1 and 7 d postweaning were strongly associated with WW (Table 1) and did not differ because of sex or transport status ($P > 0.05$).

Basal (preweaning) plasma concentrations of cortisol were different between sex such that females had greater concentrations than did males (Figure 2A). At 1 d postweaning, cortisol concentration in male pigs increased and was not different from that measured in female pigs ($P > 0.1$). By 7 d postweaning, cortisol levels had decreased substantially in both sexes, although concentrations were higher in males than in females. Transport status did not affect cortisol levels at any time. Weaning resulted in sharply decreased plasma concentrations of CBG at both 1 and 7 d postweaning (Figure 2B). Con-