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Effects of confinement duration and parity on stereotypic behavioral and physiological responses of pregnant sows

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ABSTRACT

The aim of this study was to evaluate the effects of space restriction stress on the stereotypic behavioral and physiological responses of different parity sows, and it is necessary to understand such effects due to space restriction to improve the welfare of the sows in confined conditions. We selected fifty pregnant sows (Large White) at primiparity and first to fifth parity in a confined farm with the same body condition and due date (3 ± 1.5 days). Behavioral observations and physiological analysis were carried out during spatial confinement throughout pregnancy. The results showed that there were no significant changes in vacuum-chewing, bar-biting, trough-biting and the concentrations of serum IL-6 in primiparous sows during the initial confinement (0–8 days). With the increase of the confinement duration, the serum cortisol, IgA, IL-6 concentrations and the vacuum-chewing frequency of sows in all groups increased significantly, and the serum concentrations of C-reactive protein and Pig-MAP increased significantly except for the sows in the first and second parity groups. The serum cortisol, IgA, IL-6 concentrations and the vacuum-chewing frequency of older sows were significantly higher than those of the young sows throughout the entire restricted feeding period, but the serum C-reactive protein concentrations of primiparous gilts was significantly higher than those of the other groups. The serum cortisol, IgA, IL-6 concentrations and bar-biting and trough-biting frequencies of all parity sows decreased significantly after entering the delivery bed. In conclusion, long-lasting and recurrent environmental constraints can significantly increase the frequency of stereotypical behavior and serious psychological and physical stress, seriously damaging sow welfare.

1. Introduction

In modern pig production systems, confinement in locations such as gestation stalls is a chronic stressor to sows [1,2] because space restriction limits the expression of innate behaviors of pregnant sows, and the sows cannot turn around, move and investigate in confined conditions [3,4]. Sows cannot exhibit the behaviors that meet their specific needs, such as rooting behavior, among others, so they exhibit abnormal behaviors (such as stereotypic behavior), resulting in physiological and psychological stress [5–9]. Previous studies have shown that long-lasting confinement of sows not only leads to abnormal behavioral responses and physiological reactions but also negatively influences the psychology of sows such as frustration or depression [10]. Therefore, the welfare of sows in production is a matter of concern.

The welfare of livestock is related to its adaptability [11]. Short-term stress does not cause harm to an individual, but when stress persists beyond the scope of the body's adaptability, it has adverse effects on the body and on mental health [12]. The acute phase reaction is a congenital, nonspecific immune response mediated by proinflammatory cytokines (IL-6, IL-1 and TNFα) accompanied by a change in blood protein content in the body. This group of proteins is called acute phase proteins (APP); when pigs suffer from stress, the cytokine levels in the body are significantly increased [13]. Thus, monitoring changes in APP and cytokine levels is an objective measure of farm animal health [14,15].

To study the effects of long-term confinement on the behavioral and physiological responses in sows of different parities, in this study, we selected gestation sows as the research object. The stereotypic behavior of sows and changes in the physiological responses were observed at different confinement time intervals. The aim was to observe behavioral and physiological responses in sows with different parity and confinement duration. We evaluated the degree of adverse effects of confined feeding technology on the sows' physiological and psychological responses and provide an important scientific basis for improving the welfare of sows in production systems.

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Table 1
Experiment grouping design.

	G[a] (20 pigs)	P1[b] (20 pigs)	P2[c] (20 pigs)	P3[d] (20 pigs)	P4[e] (20 pigs)	P5[f] (20 pigs)
Behavior observation	12	12	12	12	12	12
Physiological analysis	8	8	8	8	8	8

[a] G: Primiparous gilt.
[b] P1: First parity sow.
[c] P2: Second parity sow.
[d] P3: Third parity sow.
[e] P4: Fourth parity sow.
[f] P5: Fifth parity sow.

2. Materials and methods

2.1. Animals

All experimental pigs were Xinmin pigs (Xinmin Pig Breeding Farm, Haerbin, China), i.e., 20 sows of every parity group were from the same genetic line (Large White), their body condition was similar, and they were bred and reared under the same intensive breeding conditions (Table 1) and by the same experienced breeder.

2.2. Feeding and management

There was sufficient space for the primiparous gilts (at least 2.2 m^2 floor space was available for each sow) from postnatal weaning to the fattening period. The primiparous gilts were transferred into confinement crates at approximately 200 days of age with a body weight of 90–120 kg. The initial restricted stress test began from the first day of gilt rearing in confined crates. The long-term restricted stress test for pregnancy in each group started on the 1st day of gestation. After weaning, the sows immediately returned to the original confinement crates that they inhabited during the gestation period and were prepared to breed again after 1–2 days of adaptation. In general, multiparous sows will re-estrus on the 9th day after weaning and start a new round of gestation. Primiparous gilts and multiparous sows from the same group experienced the same restricted crate feeding stage. In this experiment, the restricted crate size during the gestation period was 200 cm × 65 cm × 92 cm, and the farrowing pen size during farrowing and lactation was 210 cm × 65 cm × 90 cm.

Sows were fed twice daily during pregnancy at 4:30 am and at 2:00 pm. Each sow was fed 3 kg sow pellets per day during pregnancy, and 2–3 days before delivery to the farrowing pens, the feeding amount was reduced to 2 kg per day. There was no feeding on the day of delivery, and after delivery, the sows were fed 3 kg lactating pellet feed during the lactation period. After 35d of lactation, the sows returned to the pregnancy restriction crates. All experimental sows were fed a premixed feed with the same nutrient composition during the lactation period. The formula of the feed was corn:wheat bran:soybean meal:-premixed feed = 54:24:18:4. The feed contained per kg 12.9 MJ ME, 145 g crude protein, 40 g crude fat, 75 g crude ash, and 12.0 g of lysine.

The gestation and farrowing rooms were ventilated by natural ventilation. The temperature of the room was 20.9 ± 1.1 °C with a relative humidity of 86 ± 2%. The room temperature during gestation was 18.2 ± 2.8 °C, and the humidity was 66.5 ± 3.5%. Free drinking and management was the same, as was the daily detection of room temperature and humidity and the regular inspection of the physical condition of all experimental sows. Disinfection was performed once a month.

Table 2
Behavioral categories and their definitions [23].

Behavioral categories	Definitions
Bar-biting	Nosing, rubbing, licking or biting any metal component of the stall or pen other than the feeding pipe
Trough-biting	Nosing, rubbing, licking, or biting the trough or the feeding pipe
Vacuum chewing	Continuous chewing while no feed is present in the mouth

2.3. Behavioral observations

In each experimental group, 12 sows were randomly selected for behavioral observation. The experimental site was recorded by a video surveillance system (Hikvision DS-IT5, China) for data acquisition to prevent artificially delimited observation times from impacting the test results. We continuously observed the video of gestational sows from 6:00 am to 6:00 pm, avoiding the half hour before and after feeding, which occurred from 8:00 am to 8:30 am and from 2:00 pm to 2:30 pm, as well as the half hour when the breeder cleaned manure, which occurred from 8:30 am to 9:00 am and from 2:30 pm to 3:00 pm (stereotypic behavior and definition see Table 2). On each behavioral observation day, each sow was continuously recorded for a total of 4 h of daily activity, 2 h in the morning and 2 h in the afternoon. The key observation times were from 9:30 am to 11:00 am and from 3:30 pm to 5:30 pm. Behavioral observations of short-term confinement test was performed on the 1st, 4th, 8th, and 15th day after the primiparous gilts entered the restricted crate, and all of the test groups were then subjected to a long-term confinement test on the 25th, 40th, 55th, 70th, 85th, and 100th day of gestation and the prenatal day.

2.4. Physiological analysis

Eight blood samples were obtained from different experiment groups. The samples to measure cortisol, CRP, Pig-MAP, IgA and IL-6 levels were collected in anticoagulant-free tubes from each sows between 6:30 and 7:00 am on every test day. Physiological detection of short-term confinement test was performed on the 1st, 4th, 8th, and 15th day after the primiparous gilts entered the restricted crate, and all of the test groups were then subjected to a long-term confinement test on the 25th, 40th, 55th, 70th, 85th, and 100th day of gestation and the prenatal day. The samples were kept at room temperature for 1 h before serum was isolated (centrifugation at 2000 rounds × 10 min at 20 °C). They were stored at −70 °C until the assay. The serum cortisol, CRP Pig-MAP, IgA and IL-6 levels were measured through enzyme-linked immunosorbent assay (ELISA) using a commercially available kit (Sigma, USA) according to the manufacturer's instructions.

2.5. Statistical analysis

Behavioral observations and records: The collected images were observed by visual inspection using the scan-sampling method with 1 min as the time unit over a 2-hour observation period with 120 behavioral record points that constituted the behavioral record of all of the treatment groups. The stereotypic behaviors that were observed included vacuum-chewing, bar-biting and trough-biting, and the behaviors were recorded once for each occurrence. Stereotypic behavior was scored as the number of 1-minute periods in which the behavior occurred.

The collected data of the behavioral and physiological tests were analyzed with the Statistic Package for Social Science (SPSS 23.0; software IBM Institute Inc., Chicago, USA). Data from the behavioral and physiological observations were analyzed for agreement with a normal distribution using the Kolmogorov–Smirnov test. In the long-term space restriction experiment, the data on the bar-biting behavior