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Testing post-weaning food motivation in low and normal birth weight pigs in a runway and operant conditioning task

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ABSTRACT

Low birth weight (LBW) pigs face more welfare challenges than their normal birth weight (NBW) siblings. Understanding the underlying mechanisms of cognitive and learning abilities in these pigs may help to improve their welfare. Early competition in life over resources, combined with the higher need for nutrient intake, make it likely that LBW pigs have a higher motivation for food than NBW pigs. This study aimed to compare the motivation to obtain food rewards between LBW and NBW pigs, using variable numbers of rewards in two separate tasks; a runway and an operant conditioning task (the nose wheel task). Ten pairs of littermates were used. From each litter, one low birth weight piglet (mean birth weight ± SEM: 854 ± 33 g) and one normal birth weight piglet (1332 ± 53 g) was selected. Pigs were tested in the runway task at 12 weeks of age and the operant nose wheel task at 19 weeks of age. Both tasks consisted of a baseline phase (two rewards), a high reward phase (eight rewards) and an extinction phase (no rewards). Statistical analyses using mixed models showed that NBW animals left the start box faster than LBW animals in the high reward phase in the runway task. However, their run time in this phase was not shorter and no other birth weight effects were found in any other phase or measure in this task nor in the nose wheel task. All animals decreased their run time in the runway task between the baseline phase and high reward phase, and increased their run time in the extinction phase ($p < 0.05$). Likewise, in the nose wheel task, all animals reached a higher number of total rewards gained and spent a lower percentage of time away from the feeder in the high reward phase compared to the baseline phase ($p < 0.05$). Additionally, they showed a decrease in motivation during the extinction phase ($p < 0.05$). Our results indicate that there is no difference in motivation to obtain food rewards between LBW and NBW pigs. However, both the results of the runway and the nose wheel task show a phase effect between the baseline, high reward and the extinction phase. This is in accordance with the underlying theory that animals have a higher motivation for resources that are more desired. Therefore, we show that both tasks are sensitive enough to measure motivation for food rewards in pigs, and are consequently useful to study factors influencing pig motivation.

1. Introduction

In current pig husbandry, there is a strong selection for high sow fecundity. This has resulted in an average litter size increase of 0.25 piglets per year (Hazeleger et al., 2007). Consequently, there is an increased birth weight variation within litters (Rutherford et al., 2013). The mean birth weight of a litter decreases with approximately 35 g for each piglet additionally born in a litter (Quiniou et al., 2002). This causes an increased incidence of piglets that are born with a low birth weight (LBW).

LBW in piglets has several negative consequences for their survival and welfare. Pigs experience both pre- and postnatal competition for resources. Colostrum intake as soon as possible after birth is essential for piglet survival, which is difficult for LBW piglets as they need to compete with their larger siblings for teats. Teat competition is accompanied by aggression, and usually the piglets

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with higher birth weights win these fights (Scheel et al., 1977). LBW piglets are slower to respond to their environment than normal birth weight (NBW) piglets, causing increased early mortality risks due to crushing by the sow (Baxter et al., 2008). Additionally, LBW piglets have lower body reserves and a higher risk to suffer from hypothermia and starvation (Herpin et al., 2002). Moreover, weight gain is reduced lifelong in LBW piglets (Douglas et al., 2013).

Understanding the underlying mechanisms of cognitive abilities in pigs may help to improve their welfare (Gieling et al., 2011). Although many studies have investigated the effects of LBW on production and welfare (*e.g.* Baxter et al., 2008), to our knowledge, no studies have yet examined the effects of LBW in pigs on food motivation.

There are some indications that LBW pigs have an increased motivation for food. Murphy et al. (2013) found that LBW piglets learned a discrimination task faster than NBW pigs, hypothesized to be due to higher (food) motivation. The results of another study on LBW pigs' cognitive functioning showed that LBW piglets outperformed their NBW siblings in a spatial cognitive holeboard task (Antonides et al., 2015). The authors argued that this may have been due to increased motivation for food.

In studies on both rats and humans it has been found that LBW alters feeding preferences. LBW rats have a higher overall food intake (Vickers et al., 2000). LBW (in humans: small for gestational age, SGA) individuals who experienced prenatal nutrient restriction showed a higher preference for fatty diets (Lussana et al., 2008) and SGA women favor carbohydrates over proteins in their diet (Barbieri et al., 2009). It has been suggested that restricted nutrient supply and a stressful prenatal environment prepare the body for the postnatal environment by adjusting metabolic patterns that favor energy storage (Gluckman and Hanson, 2004). In livestock, prenatal stress caused by malnutrition has an impact on health and behavior in later life (Rutherford et al., 2012). Hair cortisol as a long-term measure for stress can provide an indication of the differences in the stress physiology between LBW and NBW piglets.

The early competition over resources, combined with the possible higher need for energy intake, make it likely that LBW piglets have a higher motivation for food (rewards) than NBW pigs. The current study aimed to compare the motivation to obtain food rewards between LBW and NBW pigs. To this end, we subjected ten LBW pigs from different litters and their ten NBW siblings to two food motivation tasks. Different tools can be used to induce a cost for a desired resource in order to measure motivation (Kirkden and Pajor, 2006). In the first task, food motivation was assessed in a runway. In the second task, the pigs' motivation was tested using a nose wheel in a feeding station as a cost mechanism to gain access to the reward (da Silva et al., 2012).

We expected to find a higher food motivation in LBW pigs than in NBW pigs in both tasks. As animals show a higher motivation for more desired resources (Kirkden and Pajor, 2006), we expected all pigs to show increased motivation for a higher number of rewards, and a decrease in motivation when no rewards were offered (extinction). Additionally, we measured hair cortisol as a long-term measure for stress. In accordance with previous findings in LBW pigs' hair cortisol (Antonides et al., 2015), we expected the LBW pigs to have lower hair cortisol values than NBW pigs.

2. Materials and methods

2.1. Ethical note

This study was reviewed and approved by the local ethics committee (DEC, DierExperimenten Commissie) and is in accordance with the recommendations of the EU directive 86/609/EEC.

2.2. Animals and housing

Ten NBW and ten LBW pigs [Duroc × (Terra × Finnish landrace)], born in conventional farrowing crates on the commercial pig breeding farm of Utrecht University were selected. Ten litters in which at least 10 piglets were born were used, born in two batches of five litters each in two successive weeks, to ensure that enough LBW piglets could be selected. All piglets of each litter were weighed on the day of birth, including all stillborn piglets and piglets that died shortly after birth. From each litter, one LBW piglet was selected, with a maximum weight of 1 SD below the average birth weight of 484 piglets weighed in previous experiments. This yielded a maximum weight of 1050 g for the LBW piglets. Moreover, the selected piglets were at least 1 SD below the average birth weight of the litter they were born into. The lightest piglet of the litter which met both criteria and that was healthy and lively was selected from each litter. The selected NBW sibling was the piglet with a birth weight closest to the average birth weight of the litter. Preferably, NBW and LBW pigs with the same sex were selected per litter. For one pair, no NBW sibling with the same sex as the selected LBW pig close to the birth weight average was born. Therefore, the final selection consisted of five pairs of males, four pairs of females and one male-female pair. For two pairs, the originally selected NBW piglet was crushed by the sow. Selection of the new NBW piglet was based on the weight closest to the average of the litter on week four instead of day one, since birth weight information of the remaining NBW pigs in the litter was not saved at the time. As the weight of LBW piglets remains lower compared to NBW piglets throughout life (Douglas et al., 2013; Antonides et al., 2015), we assumed that these two pigs did not have a LBW. To check for asymmetrical growth as an indicator of intra-uterine growth retardation (IUGR), head size (snout to back of cranium) and total body length (snout to tail base) were measured on the day of birth (Amdi et al., 2013).

Selected piglets were weaned at four weeks of age and housed in groups of five of the same age, with NBW and LBW piglets housed separately. This was done to avoid strong competition for hierarchy within the pen. Since the NBW and LBW pigs were thus separated, littermates were divided over groups and not housed together. Groups were housed in four similar pens (ca. 5 m × 6 m) with concrete flooring, with straw bedding and toys. Each pen contained a covered piglet nest containing a rubber mat and a thick layer of sawdust and straw bedding. A heat lamp was suspended approximately 1 m above ground in the piglet nest to avoid chilling of the piglets. The heat lamps were removed at 14 weeks of age, by which time the pigs were no longer observed lying under the lamps or showing huddling behavior. Lights in the stable were on between 7:30 h and 16:30 h. Ambient temperature in the stable was recorded daily during the experiment and ranged from −1 °C to 14 °C. The stable was naturally ventilated (no heating aside from the above-mentioned heat lamps). Water and feed was provided *ad libitum*, except for two hours prior to testing when pigs were mildly food deprived by removing all feed. This was done to prevent saturation before testing. Feed was offered in a large feeding trough (2.5 m × 0.3 m) to avoid feeding aggression. Radios played continuously at the pens and in the testing area at a moderate volume to prevent sudden background noises from startling the pigs during testing. Pigs were weighed on the day of birth and then weekly from week four until week 20. Each task was performed in a separate test area with an adjacent waiting area.

After weaning and prior to testing, all pigs were habituated to the experimenters, waiting areas and testing areas for approximately one hour per day. The waiting and testing areas were located in the same building as the home pens. At the age of 12 weeks, all pigs were tested in the runway task. At the age of 19 weeks, pigs were tested in the nose wheel task (progressive ratio task).