Growth Performance in Livestock with Stress-Induced Low Birthweight is Recovered by Clenbuterol Administration

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Summary with Implications

Stress in pregnant livestock causes pathological low birthweight of the offspring and diminishes their muscle growth capacity. Using sheep as a model for beef cattle, this study determined that the limited growth capacity of offspring with stress-induced low birthweight could be recovered by postnatal treatments. Muscle in these animals has less growth-promoting β2 adrenergic activity and thus the injectable β2 adrenergic stimulant clenbuterol was used as a daily treatment. Lambs with stress-induced low birthweight continued to exhibit impaired muscle growth and feed efficiency well past the normal age for weaning. In addition, they began to put on excess fat around the age of weaning, making them destined to produce less meritorious carcasses even at equivalent liveweights. Daily clenbuterol injections improved growth rates, metabolic efficiency, and body composition in lambs with stress-induced low birthweight. By demonstrating that changes in β2 adrenergic activity are valid targets for recovering growth performance and body composition, these findings provide the basis for practical on-farm strategies to improve outcomes in low birthweight livestock such as oral supplementation of clenbuterol or other β2 agonists.

Introduction

Pathological low birthweight in livestock most commonly results from stress-induced intrauterine growth restriction of the fetus. Stressed fetuses become programmed to grow muscle at slower rates so that more of their energy can be devoted to coping with the stress. However, this "thrifty" growth persists after birth even when the stress does not, leading to slow, inefficient growth and less desirable body composition that diminishes carcass yield and merit. Stress-induced low birthweight occurs naturally in about 1 out of every 10 animals but can affect entire herds during times of drought, overgrazing, or other stressful conditions. Thus, effective postnatal treatment strategies to improve growth outcomes are warranted. This study examined the benefits of using the injectable β2 adrenergic stimulant clenbuterol to target reductions in growth-promoting β2 adrenergic activity that was previously observed in stress-induced low birthweight muscle. The objective was to specifically evaluate how these growth deficits manifested in inferior body composition and muscle mass at and around the weaning age, and whether daily clenbuterol treatment would at least partially recover growth and body symmetry. Because of the limitations associated with using cattle for such experiments, the study used a well-characterized proxy model of heat-stressed pregnant sheep to produce low birthweight offspring for this study.

Procedure

These studies were approved by the Institutional Animal Care and Use Committee at the University of Nebraska–Lincoln, which is accredited by AAALAC International. To produce stress-induced low birthweight lambs, Polypay ewes were housed under heat stress (105°F, 35% humidity) during mid-gestation (40th to 95th day of gestation, birth is at 150 days), which stunted the placenta and in turn created fetal stress/growth restriction. Ewes birthed lambs naturally, and lambs were raised on milk replacer for the first 30 days followed by an *ad libitum* grain diet. Beginning at birth, one-half of the low birthweight lambs were randomly assigned to receive daily injections of 0.04 µg/lb clenbuterol. The other low birthweight lambs and all control lambs were injected with saline. Bodyweights (BW), head circumference, front cannon bone length, body girth, and body length were measured at birth, 30 days of age, and 60 days of age. Lambs were then euthanized and hindlimbs and flexor digitorum superficialis muscles were weighed. Lamb carcasses were chilled for 24 hours and loin-eye area was measured between the 12th and 13th ribs. To estimate body composition in the live animal, bioelectrical impedance analysis was performed in live lambs at 30 and 60 days of age. It was also performed on the loin muscle at necropsy. Proximate analysis was performed on loin muscle to determine fat and protein content. All data were analyzed as an ANOVA using the mixed procedure of SAS, with lamb as the experimental unit. Data are presented as mean ± standard error.

Results

This study found that the poor growth and body composition previously observed in stressed fetuses and young low birthweight lambs persisted past weaning. Hindlimb weights and flexor digitorum superficialis muscle weights indicated that muscle growth capacity was reduced by stress-induced low birthweight. Likewise, bodyweight relative to head circumference, front cannon bone length, body girth, and body length indicate that muscle growth relative to skeletal growth was impaired by stress-induced low birthweight. At this older juvenile age, stress-induced low birthweight lambs also began to deposit more body fat, which was not observed at younger ages. However, daily treatment with injectable clenbuterol for the first 2 months after birth improved muscle growth and body composition in these lambs. Biometrics and lean tissue estimates at weaning age reflected asymmetrical growth patterns that were compounded by deficits in feed efficiency, bodyweight gain, and muscling. This manifested in reduced bodyweights

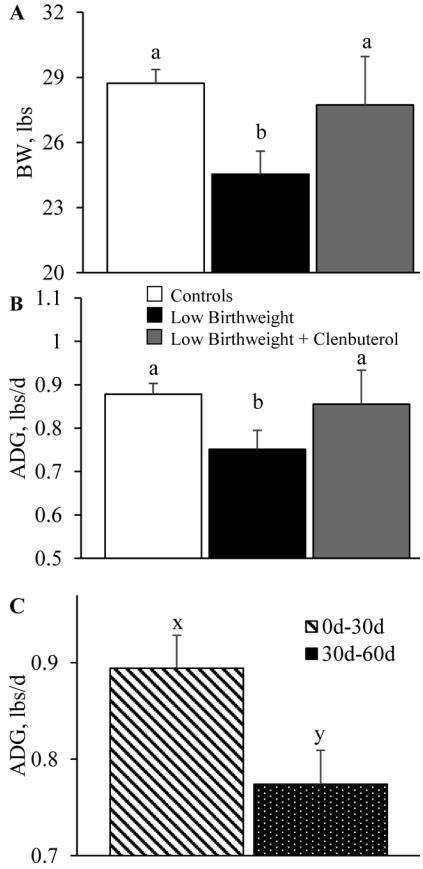

Figure 1. Bodyweight at 60 days of age and average daily gain in stress-induced low birthweight lambs treated daily with injectable clenbuterol. [a,b]Means with different superscripts differ ($P \leq 0.05$).

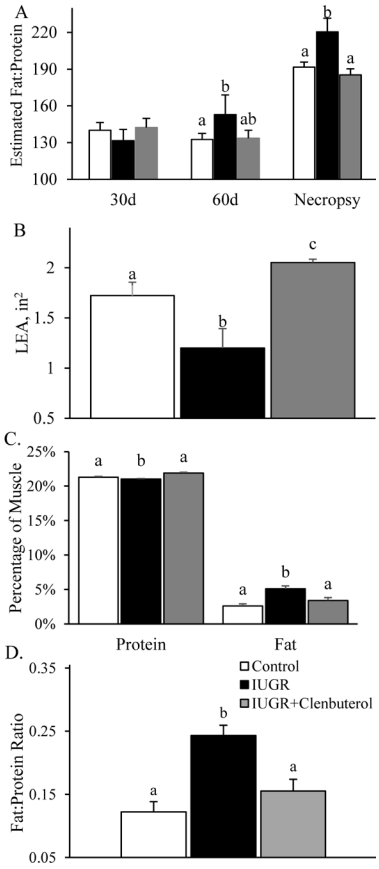

Figure 2. Muscle growth and composition at 60 days of age in stress-induced low birthweight lambs treated daily with injectable clenbuterol. [a,b,c]Means with different superscripts differ ($P \leq 0.05$).

at 60 days of age and reduced average daily gain from birth to 60 days, both of which were recovered by clenbuterol treatment (Figure 1). Additionally, weight gain was slower for all lambs in the 2nd month compared to the 1st month, which indicates that the opportunity for recovering growth may wane over time. The impact of stress-induced low birthweight on muscle growth was particularly evident in reduced loin-eye areas and in estimations of lean mass (Figure 2). Studies have previously shown that poor muscle growth following fetal stress/low birthweight is the result of faulty muscle stem cells and protein synthesis, and these problems were clearly not reconciled at the weaning age. Additionally, although stress-induced low birthweight lambs had less total fat mass at weaning, their percentage of fat was increased and protein-to-fat ratios were reduced, which further diminished body composition. Persistence of poor muscle growth and greater fat at this age helps to explain the reduced yield and carcass merit known to exist in low birthweight animals at harvest. Treatment with clenbuterol improved indicators of muscle growth body composition.

Conclusion

The conclusion from this study is that the impact of stress-induced low birthweight on growth in general and on muscle growth in particular extends beyond early life and in fact continues through the weaning age. However, daily treatment with clenbuterol demonstrated a potential avenue to recover muscle growth and weight gain in these stress-induced low birthweight livestock. Although daily injections might not be a practical strategy for many livestock producers, this study lays the foundation for investigation of similar pharmaceutical products, including oral versions of clenbuterol or other β agonists.

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