Osteoporosis in Egg Laying Strains of Chickens: Early Pre-pubertal Exposure to Mechanical Loading

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Introduction

Osteoporosis is a non-infectious disease caused by a progressive decrease in the amount of mineralized structural bone leading to skeletal fragility and susceptibility to fracture (Whitehead, 2004). The effect of pullet rearing on skeletal quality during egg laying has not been extensively studied. Previous research has focused on manipulating the egg laying environment to improve skeletal health which may be too late. Human studies have indicated that exercise before puberty reduces the risk of osteoporotic fractures later in life (Bass et al., 1998). Therefore, it is reasonable to assume that chickens may also need early exposure to mechanical loading to avoid fractures. The objective of the current study was to determine the effect of mechanical loading on pullet health, bone mineralization, and muscle deposition in caged White Leghorns given access to perches.

Materials and Methods

Treatment assignment included cages with and without perches. Information can be found below on floor, perch (only half of the cages received perches), and feeder space.

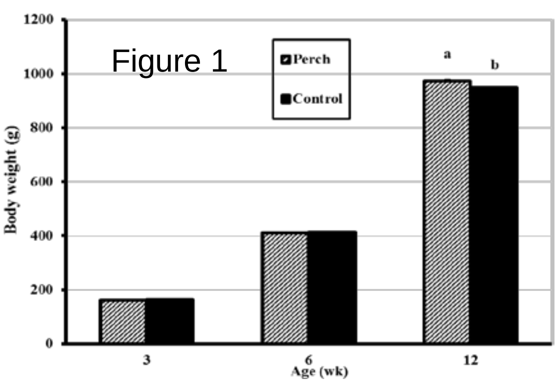
Age of bird	Birds/cage	Floor space	Perch space/bird	Feeder space/bird
wk		cm^2/bird (in^2/bird)	cm (in)	cm (in)
0	38	98 (15)	3.2 (1.3)	1.6 (0.6)
3	28	133 (21)	4.4 (1.7)	2.2 (0.9)
3.4	27	138 (21)	4.5 (1.8)	2.3 (0.9)
4.4	24	155 (24)	5.1 (2.0)	2.5 (1.0)
6	16	233 (36)	7.6 (3.0)	3.8 (1.5)
12	12	310 (48)	10.2 (4.0)	5.1 (2.0)

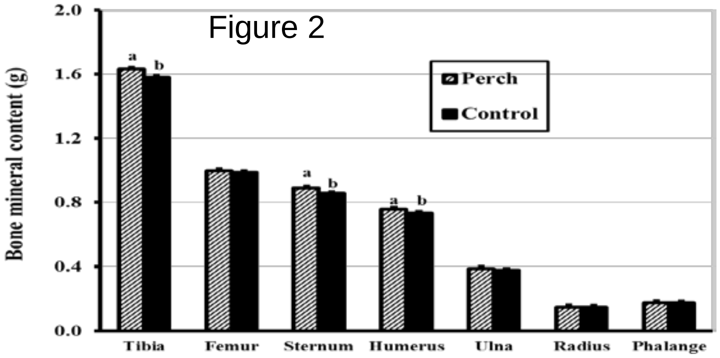
Pullets were housed in grower cages from 0 to 17 wk of age. Two Big Dutchman metal round perches, 32 mm in diameter, were used in each cage assigned the perch treatment. There was a distance of 20 cm (8 in) between the two perches and 18 cm (7 in) between the front perch and the feed trough, and between the rear perch and the back of the cage. Control cages had no perches.

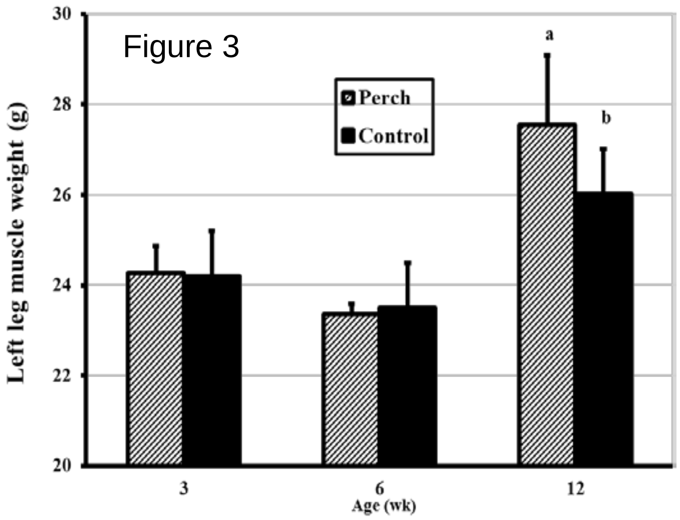
Chickens were removed from each cage at 3, 3.4, 4.4, 6, and 12 wk of age, euthanized, and weighed. At 3, 6, and 12 wk of age, the foot pad and toes were examined for hyperkeratosis. Severity of hyperkeratosis for the foot pad and toes was evaluated using a scoring system of values ranging from 1 to 4 points with 1 being the worst condition and 4 being representative of the healthy control. The whole breast and the left wing, thigh, and drum were retrieved, labeled, and frozen for later analysis. The carcass parts were thawed. Prior to scanning using dual energy x-ray absorptiometry (Norland Medical Systems, Inc., Fort Atkinson, WI 53538), the sternum and keel were dissected from breast muscle which allowed for the bone to be oriented laterally in a similar manner between samples culminating in more consistent and reliable scans. The breast muscle with respective tendons was weighed following dissection from bones. The sternum including its keel but minus its muscle and the carcass parts (left wing, thigh, and drum), were scanned using dual energy x-ray absorptiometry to determine if fractures had occurred and to quantitate bone mineral density (BMD), bone mineral content (BMC), and bone size traits of the tibia/fibula, femur, sternum, humerus, ulna, radius, and phalange. After scanning, the skeletal muscle and tendons of the drum, and thigh were excised from the bone and weighed. Muscle weight was expressed relative to BW. The sternum with respective keel and the left tibia/fibula, femur, and phalange were examined visually to confirm the presence or absence of a fracture. The keel bone was examined for deformations using the same scoring system as described for hyperkeratosis. The right adrenal was retrieved from chickens at 3, 6, and 12 wk of age, weighed, and expressed relative to BW. Duplicate packed cell volumes were determined from each chicken at 4.4, 6, and 12 wk of age after spinning the microhematocrits for 15 min. Behavior was recorded at 10 ages every 2 wk from 2 to 16 wk of age using 14 Stealth Cam STC-I540IR automatic digital cameras (Cabela's Inc., Sidney, NE). Additional recordings were done at 5 and 15 wk of age. Data were analyzed using ANOVA. The mixed model procedure of SAS (2008) was used

Results

Behavioral observations indicated that pullets began using perches as early as 2 wk of age. Perch use increased as the pullets aged with more frequent use during the time the lights were off. There were no keel bone deformations or fractures observed in any of the examined samples. There were no differences in BW, BMC, and leg muscle weight at 3 and 6 wk of age (data not presented). However, at 12 wk of age, the BW (*P* = 0.025, Figure 1), the BMC of the







tibia, sternum, and humerus (*P* = 0.015, Figure 2), and the left leg muscle weight (*P* = 0.006, Figure 3) increased in pullets with access to perches as compared to controls. Breast muscle weight, % breast muscle, % leg muscle, BMD, bone length, and bone width did not differ between treatments. Bone area was greater for chickens with access to perches as compared to controls (*P* = 0.03, data not presented).

The gross right adrenal weight was not affected by the perch treatment, but the relative right adrenal weighed less (*P* = 0.06) for pullets given access to perches as compared to controls, an indicator that pullets with perches were less stressed. Packed cell volume and hyperkeratosis of the foot-pad and toes were not affected by the perch treatment (data not presented).

Mortality from hatch to 3 wk of age increased in cages with perches as compared to controls (*P* < 0.0001). Mortalities during the first 3 wk were due to omphalitis and starve-outs with a higher incidence in cages with perches.

		Causes of mortality				
Treatment	Mortality 0 to 3 wk of age[1]	Omphalitis	Starve-outs	Enteritis	Slipped gastrocnemius tendon	Other
	—— % ——			—— % of total mortality ——		
Perch	7.0 ± 0.8[a]	34.1	29.5	6.8	6.8	4.5[2]
Control	1.5 ± 0.8[b]	9.1	4.5	2.3	0	2.3[3]

[a-b]Means within a column with no common superscript are different (*P* < 0.05).
[1]n= 14 observations per least square mean.
[2]Other cause of mortality was dehydration.
[3]Other cause of mortality was that the chick was crushed.

After 3 wk of age until the end of the study at 17 wk of age, there were 3 additional deaths due to splayed legs (n =2 for the perch treatment) or E. coli infection (control treatment, data not presented in a table).

Discussion

Past studies evaluating intervention strategies for improving bone integrity in laying hens have done so during the egg production cycle when the adult birds may already be experiencing osteoporosis. At this point, nutritional manipulation and changes in management practices such as increased exercise may not have as large an impact in alleviating bone fractures of hens as would earlier intervention with pullets. Early intervention to improve skeletal health in egg laying strains of chickens has received little attention. The results of the current study suggest that mechanical loading achieved through perching have beneficial effects on pullet health by stimulating leg muscle deposition and increasing the BMC of certain bones without causing a decrease in BMD.

Additional information gleaned from this study was to determine when bone fractures occur during the pullet phase, which is important for assessment of chronic pain. Our results show that bone fracture did not occur in caged pullet flocks prior to 12 wk of age regardless of whether pullets had access to a perch or not. Likewise, Wilkins et al. (2005) reported no problem with bone fractures in pullet flocks. Instead, perch access provided benefits to pullets as compared to those chickens without access. Perches encouraged pullet activity leading to larger pullets with perhaps larger skeletal frame and with greater BMC. These changes in pullet development as a result of perching could ultimately lead to long-term health benefits during adulthood, and particularly at end of lay when osteoporosis is especially problematic.

Keel bone deformation is perhaps caused by continued pressure exerted on the keel when chickens sit on the perch (Sandilands et al., 2009). Callus formation of the keel, as a result of bone fracture, occurs in hens with moderate to severe keel deformities (Käppeli et al., 2011). Pullets of the current study showed no keel bone deformities regardless of whether or not they had access to the perch, similar to results of Käppeli et al. (2011) who reported few deformities of the keel during rearing for pullets given access to perches.

Hyperkeratosis (hypertrophy of the corneus layer of the skin) occurs on the toe- and foot-pads of caged hens and is caused by increased compression load of the toe- or foot-pad on the wire floor of the cage as well as the perch. Our results showed that pullets up to 12 wk of age had healthy feet and that the presence of perches in the pullet cage had no effect on hyperkeratosis score.

The major downside to providing perches in pullet cages of the current study was the higher mortality experienced during the first 3 wk of age. The higher incidence of starve outs for the chicks with perches as compared to controls suggests that the perches were interfering with the chick’s ability to find or access the feeder, although BW of live chicks between treatments were similar at 3 wk of age. Although 2 chick mortalities assigned to the perch treatment were dehydrated, packed cell volume at 4.4 wk of age indicated that the perches did not interfere with drinking as hemoconcentration was not apparent. However, by this age, mortality had subsided.

Perches used in the current study have been field-tested by Big Dutchman, mainly being used by the European egg industry in aviary systems. Material cost for perches is estimated at $4.92/meter ($1.50/foot). Assuming a labor cost of US $12/h and 10 to 15 minutes to install, the estimated labor cost of the installation of metal perches is US $2 to $3/cage. (K. Krogman and T. Pollard, Big Dutchman, Holland, MI, personal communication).

Implications for the poultry industry is that the addition of perches to pullet cages offer benefits relative to pullet skeletal health, but further study is needed to investigate the high incidence of early chick mortality during the first 3 wk of life and to determine long term effects during the egg laying cycle. With the Midwest Poultry Consortium grant serving as leverage, the perch study at Purdue University received additional funding from the Agriculture and Food Research Initiative (USDA-NIFA-AFRI 2011-67021-30114) to continue the study through the laying phase, which is currently in progress.

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