13. COLLAGEN FIBER ORIENTATION IN SKELETAL TENSION/COMPRESSION SYSTEMS: A POTENTIAL ROLE OF VARIANT STRAIN STIMULI IN THE MAINTENANCE OF CORTICAL BONE ORGANIZATION. J.G. Skedros Orthopaedic Hospital/Univ. Southern Cal. Dept. of Orthopaedics, Los Angeles

There is evidence that bone tissue has the capacity to differentiate between specific mechanical strain features as signals relevant to the maintenance of an optimal cortical structure. This study examines the idea that variant mechanical factors (i.e., those whose magnitudes are dependent upon a given coordinate system, such as longitudinal tensile and compressive strain), if recognized as being relevant to the optimization of cortical bone organization, would be seen as differences in collagen orientation between regions that are habitually loaded in compression versus tension. Transverse sections from five of each of the following bones were embedded in polymethyl methacrylate: mule deer calcanei, horse calcanei, sheep radii, horse radii, and horse third metacarpals. All animals were skeletally mature. The metacarpals served as "control" bones, since in vivo studies have show that all regions analyzed are primarily loaded in compression. In the other bones, tension and compression strains prevail on opposite (cranial/caudal) cortices. Sections were milled to 100 +/- 5 microns and viewed under circularly polarized light. Collagen orientation is expressed as the mean graylevel in two to four (depending on bone area available) 50X microscopic fields (approx. $2 mm^2$) in the endocortical envelopes of the cranial, caudal, medial, and lateral cortices. Graylevels were quantified from pixel histograms obtained from digitized images. Results showed that in all of the tension/compression bones the compression cortex was significantly brighter (more oblique-to-transverse collagen) than the relatively darker tension cortex (more longitudinal collagen) ($p < 0.03$) (paired T-tests: deer calcanei 135.4 vs. 101.2; horse calcanei 167.2 vs. 113.65; sheep radius 137.3 vs. 119.2; horse radius 133.3 vs. 79.2). Only deer calcanei showed medial-lateral differences ($p = 0.03$; medial 153.8 vs. lateral 133.3). Horse third metacarpals showed no cranial-caudal ($p = 0.48$) or medial-lateral ($p = 0.10$) differences. The consistent collagen orientation differences between compression and tension cortices of these various bones, and the lack of differences in a control bone, supports the hypothesis that their cortical organization is constructed and maintained with some knowledge of specific forms of variant mechanical stimuli. It is suggested that the capacity of bone tissue to respond to variant stimuli, such as strain mode, would be most conspicuous in situations where the well-documented disparity in the mechanical properties of bone loaded in tension versus compression would yield deleterious consequences (e.g., fracture) if regional adaptation was not present. It is plausible that regional differences in ambient strain modes could also contribute to producing cytologically beneficial stimuli by enhancing other strain features, or by being part of a more complex signal that is relevant to the attainment and maintenance of cortical bone organization.

LONG-TERM RESPONSES BY MATURE SOWS TO CHRONIC DIETARY ACID LOADS: II. MID-DIAPHYSEAL FEMORAL CORTICAL BONE HISTOMORPHOMETRY. U.T. Iwaniec and T.D. Crenshaw (Intr. by F.R. Greer), University of Wisconsin, Madison WI 53706.

Retention studies indicate bone may contribute buffers in long-term response to acidogenic diets. This hypothesis was investigated with twenty non-gravid, crossbred sows fed maintenance diets with 0 (n=5), 0.5 (n=8), or 1.0% NH_4Cl (n=7) calculated to provide 190, 376, or 564 meq Cl/d for 8 mo. Cortical bone histomorphometric responses to dietary acid loads were assessed with double label fluorochrome markers administered initially (basal diet, label=tetracycline) and before termination of the study (acidogenic diets, label=calcein) using a 1-10-1:5 day labeling protocol. Complete femoral mid-diaphyseal cross sections were embedded in polymethylmethacrylate, cut, ground to 80 micrometers, and mounted. Each specimen was subdivided into 8 anatomical sections for data collection.

Averaged across all anatomical sections, no significant dietary effects were detected for periosteal labeled surface defined as dL.Pm+sL.Pm/B.Pm (basal, 0.58±0.02, average±SEM; 0%, 0.62±0.05; 0.5%, 0.54±0.05; 1.0%, 0.62±0.04), periosteal MAR assessed over the 8 month period (0%, 0.34±0.05; 0.5%, 0.37±0.05; 1.0%, 0.33±0.03) or endosteal labeled surface as dL.Pm+sL.Pm/B.Pm (0%, 0.48±0.04; 0.5%, 0.58±0.03; 1.0%, 0.49±0.04). Likewise, no significant effects were observed for intracortical labeled surface defined as N.dL.On+N.sL.On/cm^2 (basal, 20.6±1.8; 0%, 18.9±2.3; 0.5%, 22.6±1.9; 1.0%, 29.0±3.2) or osteonal MAR (basal, 1.65±0.03; 0%, 1.46±0.07; 0.5%, 1.50±0.04; 1.0%, 1.55±0.04). Significant treatment by anatomical section interactions were observed for endosteal labeled surface, periosteal MAR, and osteonal MAR. The patterns, however, were not consistent suggesting responses to dietary acid loads vary in magnitude and location within a bone cross section. In conclusion, dramatic changes in cortical bone were not observed in sows fed acidic diets for eight months.

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BONE MECHANICAL PROPERTIES AND TOTAL BONE MINERAL CONTENT MEASURED BY DUAL ENERGY X-RAY ABSORPTIOMETRY IN NEWBORN PIGLETS -- RELATIONSHIP TO WEIGHT GAIN. M.A. Vidal, T.D. Crenshaw, N.J. Benevenga, and F.R. Greer. University of Wisconsin, Madison, WI 53716.

Dual energy x-ray absorptiometry (DEXA) may be used to accurately and reliably measure total body bone mineral content (BMC, g) and bone mineral density (BMD, g/cm^2) in neonatal animals. Little information exists in neonates on the reliability of DEXA using this technique to predict mechanical properties of bone. In this study, twelve newborn piglets were placed in individual metabolic cages and fed UW neonatal pig formula (830 cal/l, 48 g protein/l, 1.6g Ca/l) for 14 days. Six piglets were given unlimited access to the formula (AD LIB), and six piglets were fed 50% of the previous day's intake by the AD LIB piglets (RES). BMC was measured by DEXA on days 2, 3, 4, 5, 9 and 14. Weight increased from 1699±206g to 6013±461g for the AD LIB piglets and to 4281±302g for the RES piglets. The animals were euthanized on day 14. Mechanical tests were conducted on excised left and right femurs to determine bending moment (BM, kg-cm), stress (BS, kg/cm^2), strain (ST, microstrain), moment of inertia (MI, cm^4) and the crossectional diameter (DIA, cm). Results for the two groups were:

Group	ASH[a]	BMC[a]	BMD[a]	BM[a]	BS	ST[a]	MI[a]	DIA[a]
AD LIB	112.8	161.5	0.555	64.3	403	5.11	0.1017	1.183
RES	76.8	95.7	0.495	42.9	485	4.45	0.0453	0.994
SEM	3.7	5.1	0.008	2.5	49	0.29	0.0085	0.023

[a] AD LIB vs. RES, $P < 0.01$

The partial correlation between BMC and ASH was 0.88; BMC and BM, 0.64; BMD and BM, 0.74; BMC and BS, 0.10; BMD and BS, 0.60. These results imply BMC and BMD are marginal predictors of BM and BS, respectively.

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CORRELATION BETWEEN BONE MASS AND BONE AGE IN NORMAL 7 YEARS OLD CHILDREN. J.H.Pessoa*, M.M.S. Marone, S.Lewin, C.A.Longui*, B.B.Mendonça*, A.C.Bianco. Department of Pediatrics, Jundiaí School of Medicine and Unidade de Densitometria Óssea, 01332 São Paulo, Brazil.

We assessed bone mineral content (BMC) and density (BMD) in children, and their relationship with bone age and antropometric parameters in 31 normal white prepuberal local children (10 girls and 21 boys), aged 7.5±0.3 y (7.2 - 8.3 y). All were within the normal range (5-95 centile) for height (123±5 cm) and weight (24± 3.4 kg) according to the NCHS charts. Spine (L2-L4) and total body were studied by DEXA (Lunar Corp, Madison WI). Bone age (BA) was estimated by the Tanner analysis of a radiograph of the left wrist and hand. There were no differences between boys and girls throughout the studies. Spine BMD averaged 0.651±0.061 g/cm^2 (0.524-0.794) and total body BMD averaged 0.824±0.051 g/cm^2 (0.725-0.893), while BA averaged 7.5±1.1 y (4.7-10.2).

CORRELATION (r) BETWEEN BMD OR BMC VS. WEIGHT, HEIGHT, BONE OR CHRONOLOGICAL AGE (†$p<.001$)

Site	Body weight	Body height	Bone age	Chron. Age
Spine BMD	.32[NS]	.28[NS]	.30[NS]	.05[NS]
Spine BMC	.54†	.68†	.60†	.18[NS]
Total Body BMD	.31[NS]	.10[NS]	.26[NS]	-.08[NS]
Total Body BMC	.70†	.61†	.54†	.24[NS]

Both spine and total body BMC correlated significantly with all parameters tested, while neither spine nor total body BMD did so. **Conclusions**: (i) the spine and total body BMD of normal children did not correlate well with antropometric parameters or bone age; (ii) spine and total body BMC, however, did correlate with all parameters tested; (iii) BMD can be used to evaluate bone mass in children because it is independent of morphology within a homogeneous population compared to BMC.