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Wolff's Law and the Interplay between Bone Structure and External Loading

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Although the proposition of Wolff's law as bone's ability to adapt its structure to mechanical needs is nowadays hardly questioned, the consequences of adaption in mechanical terms resist a clear-cut description. To understand the interplay between the habitual loading conditions on the bone and the local bone structure, the proximal femora of four primates with dissimilar locomotor habits were imaged with high resolution micro-computed tomography. A previous study revealed different strategies of how the bone volume fraction (BV/TV) of the trabecular bone is locally adapted: high values of BV/TV are obtained by a thickening of the trabeculae with trabecular number (Tb.N) being relatively constant, while low BV/TV values are obtained by a reduction of Tb.N, whereas Tb.Th remains constant.[1] Here we go beyond a structural analysis and calculate the local tissue strains using microfinite element analysis. Proper boundary conditions reflecting prevalent loadings were estimated based on muscle insertion locations and pulling directions. The forces were applied on the femoral head and great trochanter with magnitudes proportional to the animal weight. The design of the computer experiment was to test the mechanical properties of all 16 combinations of the four proximal femora under the four different loading conditions. In all animals, the femoral neck always showed not only the highest strains but also the most heterogeneous strain distributions. The strain distributions did not provide features that clearly indicated when there was a match between bone structure and loading conditions. A comparison between the different scenarios further allows a consideration whether differences in bone structure or differences in the external loading has a stronger influence on the resulting strains.

Disclosure: The authors declared no competing interests.

Reference

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Changes in Fase Content of the Biominerals in Rat Pelvic Bone after 60-Days' Influence of the Epychlorhidrine Vapours and Possible Ways of its Correction

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Background: The aim was to study the reaction of the biomineral fractions in the pelvic bones of the rats of the different ages under the 60-days influence of the epychlorhidrine (E) vapours and possible correction by thiotriazoline (Th) and Echinacea Purpura (Ech) tincture.

Methods: Four hundred and twenty white male rats were divided into three groups including ages: young, reproductive, old. 1 group stay intact; in 2ndgroup– rats have the inhalations of the E at the dose 10 DL, 5 hours/daily; 3rd–4thgroups – rats were injected 2.5% Th at the daily dose 117.4 mg/kg or the Ech at the daily dose 0.1 mg per 100 g of the body weight orally. Experiment finished at the 1, 7, 15, 30 and 60 days via the decapitation of the rats. Pelvic bones were fractionised and revised by X-ray structure analysis. The content of the hydroxylapathite, vithlokite and calcite were measured. Data were processed by statistical analysis.

Results: After the E inhalations in young rats, the vithlokite and calcite content in bone mineral matrix were over the control rates by 9.15% - 15.60%, in old rats – by 6.48% and 8.64%. The hydroxylapathite content exceed the control rates by the 4.95%, 5.20% and 3.12%. After the finish of the inhalations during the re-adaptation period in young and reproductive animals rats the biomineral status was improved to the control levels, and in old rats the biomineral content remained unimproved, but administration of Th or Ech obviously have modulated the biomineral status towards the reparation. Application of the Th during the E inhalations increased the crystallisation in the bone minerals through the whole re-adaptation period, administration of the Ech increase the mineralisation only temporary.

Conclusion: Administration of Th or Ech prevents the distortion of the bony biominerals after the 60-days' influence of the epychlorhidrine vapours, but Th has more reparative potency.

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Bone Quality is Altered by Hypoactivity in the Chicken: a FTIR study

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Background: Disuse induces a rapid bone loss in adults; sedentarity is now recognised as a risk factor for osteoporosis. Hypoactivity or confinement also decrease bone mass in adults but their effects are largely unknown and only few animal models have been described. The hypodynamic chick confined in small cages has been recognised as a suitable model of bone loss during growth. However, the effects on the quality of the bone matrix have not been studied.

Methods: We have used 10 chickens of the rapidly growing strain 857K bred in a large enclosure (FREE group); 10 others were confined in small cages with little space to move around (HYPO group). They were sacrificed at 53 days and femurs and tibias were evaluated by microcomputed tomography (microCT) and histomorphometry on undecalcified bone sections. Sections (4 µm thick) were analysed by FTIR to see the effects on mineralisation and collagen.

Results: Hypoactivity had no effect on the length and diameter of the bones. Bone mass measured by microCT (trabecular bone volume and trabecular microarchitecture) was significantly reduced in the animals of the HYPO group. An increase in osteoid volume and surfaces was noted in