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Control of Bone Remodelling by Applied Dynamic Loads

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Final Report

Progress in the third, and final, six month period of this grant has continued in the following areas.

1) The data showing the relationship between bone mass and peak strain magnitude have been prepared and submitted to Science for publication. Manuscript attached.

2) The data from experiments relating remodelling activity with static or dynamic loads have been prepared and submitted to Journal of Biomechanics for publication. Manuscript attached.

3) Development of programmes to relate the location of remodelling activity with the natural and artificial dynamic strain distributions are continuing but, at present, the data are insufficient to reach any definitive conclusions.

4) Experiments on the effect of different strain rates on the remodelling response have continued. These experiments are confirming our previous reports that strain rate is critical in determining the character and extent of the remodelling response to loading. Experimental numbers as yet are inadequate to reach definitive conclusions. However, when using a train of 100 consecutive 1 Hz load cycles on the functionally isolated avian preparation, it appears that if the peak strain magnitudes are similar, and the strain rates altered from 1,000 to 10,000 to 50,000 microstrain per second, then both 1,000 microstrain and 50,000 microstrain produce greater remodelling changes than 10,000. This result was not anticipated from our previous data over a more limited range of 2,500 to 40,000 microstrain per second. The extent to which this effect is the result of differences in strain rate and/or the consequent differences in frequency and total time during which loading occurs remains to be assessed.

All data produced over the period of this grant are consistent with those from our previous experiments, which indicate that the remodelling processes on which the mechanical competence of the skeleton depends are sensitive to a number of aspects of the bones' strain regime. Use of exercise regimes chosen for their empirical "convenience" rather than being related to such location-dependent specific, strain related behaviour is liable to be unsuccessful in preserving bone mass under conditions of weightlessness. Further experiments on the relationship between remodelling and customary strains will depend upon the availability of funds to continue our investigations.

The following articles arising from research conducted over the grant period have been published or submitted for publication.

Rubin, C.T., J. McA. Harris, B.H. Jones, H.B. Ernst, & L.E. Lanyon (1984) Stress fractures: the remodelling response to excessive repetitive loading. 30th Annual ORS, Atlanta, Georgia, Feb. 7-9, Trans. p. 303.

Rubin, C.T., G.W. Pratt, A.L. Porter, D.M. Whiteneck, G.F. Middleton, B.H. Jones, L.E. Lanyon & B. Poss (1984) Acute change in bone properties caused by long distance running: Ultrasound measurements of tibia and patella before and after the Boston Marathon. 30th Annual ORS, Atlanta, Georgia, Feb. 7-9, Trans. p. 350.

Rubin, C.T. and L.E. Lanyon (1984) Regulation of bone mass by mechanical strain. (Submitted to Science.)

Lanyon, L.E. and C.T. Rubin (1984) Static versus dynamic loads as an influence on bone remodelling. (Submitted to Journal of Biomechanics.)

Lanyon, L.E. (1984) Functional strain as a determinant for bone remodelling. Calcif. Tissue Int. 36: (in press).