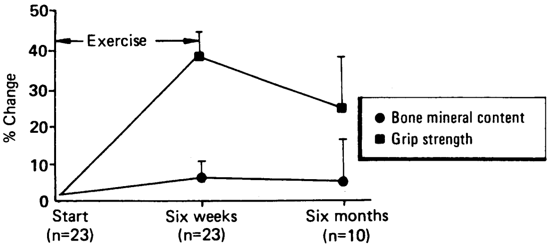

FIG 4—*Percentage changes in grip strength and bone mineral content in the exercised arm for women who had a gain in grip strength of >50 mm Hg at six weeks. Bars are 95% confidence intervals*

content (13·3%, p<0·02; 2·6 to 24·0%) in their uninjured arm. Comparison of both forearms at six months showed that the exercised arm had 29·1% (p<0·004, 11·5 to 46·7%) greater grip strength and 4·9% (p<0·14, −1·9 to 11·7%) higher bone mineral content than the arm that had been injured. The best exercisers (n=10) conserved some of their increases in strength and bone density at six months, but neither was significant.

The results at six weeks for the 33 women who were seen at six months showed a 20·6% (p<0·0001, 13·5 to 27·7%) improvement in grip and a 3·4% (p<0·036, 0·2 to 6·5%) improvement in bone mineral content in the exercised arm; their initial grip strength was 261 mm Hg (231 to 290 mm Hg) and bone mineral content 36·9 units (33·9 to 39·9 units). The initial grip strength in the exercised arm of the 66 women who did not reach the end of the study was 275 mm Hg (249 to 301 mm Hg) and their initial bone mineral content 33·9 units (31·4 to 36·4 units). Those who did not attend at six months were older (mean age 60·5 years) than those who did (mean age 56·8 years).

Discussion

As expected, our results showed that both grip strength and bone mineral content in the forearm fall with age, but we also found a close correlation between the two variables irrespective of age. In addition, the small but significant initial difference in both variables between the dominant and non-dominant arms of the 69 volunteers supports our hypothesis that a forearm's bone mineral content is related closely to the physical demands made on it by activities that require grip strength. We had assumed that a grip of maximum power stresses the skeleton of the forearm as much as any other activity that is performed commonly. We had not expected the change in grip strength in the unexercised arm, which was associated with a non-significant increase in bone mineral content. There was, however, insufficient emphasis in our instructions to prevent volunteers exercising both forearms, and several admitted to doing this.

We had also assumed that after a Colles' fracture the uninjured forearm is used more. This may be wrong: a manual worker might avoid physical stress when off work, whereas an independent retired person might be obliged to undertake more stressful activity with the intact arm. Women with fractures achieved a significant increase in bone mineral density by three weeks. Several of those with minor fractures were out of plaster before six weeks and were unlikely to attend hospital again, which may account for the non-linear results over three to six weeks. Similarly, frail volunteers were less likely to attend follow up clinics, and it was not feasible to retest some of those in old people's homes at six months. Those who attended six months after the exercise regimen ended were therefore likely to be the more motivated women who had originally done well with the exercises.

As numbers of women fell with succeeding visits the mean strength and bone mineral content rose. Measurements at six months showed a loss of the previous gains in grip strength and bone mineral content in all of the women except those who had had a fracture. It may be that after a fracture patients with apparently normal function continue to protect the injured arm from peak stresses by using the uninjured wrist for activities that require a powerful grip. They may thereby continue to increase both grip strength and bone mineral content in the non-fractured arm.

Changes in grip strength were mirrored by changes in bone mineral content at all stages, and this supports our contention that mineral content reflects quickly the physical demands made on bone. Muscle may be trained for great endurance without bulk by prolonged exercise, as in marathon runners, or for strength and bulk by isometric exercise, as in weight lifters. A similar analogy might apply to bone, in which short periods of skeletal stress may trigger osteogenesis more effectively than hours of gentler exercise.

Several questions remain—for example, Can this principle be applied to the entire skeleton? and What is the minimum daily requirement of skeletal stress? A few seconds of grip exercise each day may stress the forearm skeleton sufficiently to stimulate a local gain in bone mineral content. The best method of regularly stressing the whole skeleton of aging and reluctant women, however, remains to be shown.

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1 Anonymous. Consensus development conference: prophylaxis and treatment of osteoporosis. *Br Med J* 1987;**295**:914-5.
2 Schapira D. Physical exercise in the prevention and treatment of osteoporosis: a review. *J R Soc Med* 1988;**81**:461-3.
3 Cooper C, Barker DJP, Wickham C. Physical activity, muscle strength, and calcium intake in fracture of proximal femur in Britain. *Br Med J* 1988;**297**:1443-6.
4 Block JE, Smith R, Black D, Genant HK. Does exercise prevent osteoporosis? *JAMA* 1987;**257**:3115-7.
5 Drinkwater BL, Nilson K, Chestnut CH, Bremner WJ, Shainholtz S, Southwort MB. Bone mineral content of amenorrheic and eumenorrheic athletes. *N Engl J Med* 1984;**311**:277-81.
6 Marguiles JY, Simkin A, Leichter I, *et al*. Effect of intense physical activity on the bone mineral content in the lower limbs of young adults. *J Bone Joint Surg [Am]* 1986;**68**:1090-3.
7 Wolff JD. *Das Gesetz der Transformation der Knochen*. Berlin: Hirschwald, 1892.
8 Nilsson BE, Westlin NE. Bone density in athletes. *Clin Orthop* 1971;**77**:177-82.
9 Rubin CT, Lanyon LE. Regulation of bone formation by applied dynamic loads. *J Bone Joint Surg [Am]*1984;**66**:397-402.
10 Christiansen C, Rodbro P, Jensen H. Bone mineral content of the forearm measured by photon absorptiometry. Principles and reliability. *Scand J Clin Lab Invest* 1975;**35**:323-30.
11 Chow R, Harrison JE, Notarius C. Effect of two randomised exercise programmes on bone mass of healthy postmenopausal women. *Br Med J* 1987;**295**:1441-4.

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Retraction in the light of new data

Altered calcitonin gene in a young patient with osteoporosis

From M Alevizaki and S Legon: We recently reported the sequence of the calcitonin gene of a young male osteoporotic patient in whom no calcitonin could be detected (M Alevizaki, J C Stevenson, S I Girgis, I MacIntyre, S Legon. *Br Med J* 1989;**298**:1215-6 (6 May)). We noted a difference of a single base between this sequence and the previously published "normal" sequence in a region which may be important for the maturation of the mRNA, and we speculated that this might have caused his osteoporosis. However, using the polymerase chain reaction to screen normal subjects we now find this sequence to be widespread in the general population. We therefore conclude that this is a neutral polymorphism and is not responsible for the patient's condition. The cause of his calcitonin deficiency thus remains to be established.