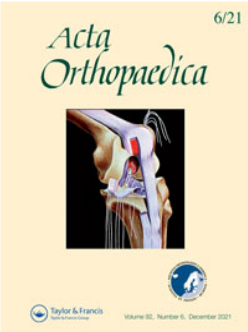

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BONE MINERAL CONTENT AND PHYSICAL ACTIVITY

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The treatment of osteoporosis is an unsolved medical problem. This study was designed to examine whether increased physical activity can raise the amount of bone mineral in the skeleton, or, at least, retard the reduction with age (cf. Smith 1971, Nilsson & Westlin 1971). The bone mineral content of chosen parts of the skeleton was measured after long-term physical activity and before and after a relatively short period of increased physical activity.

METHODS AND MATERIAL

The bone mineral content was determined by x-ray spectrophotometry (Gustafsson et al., in press). This method is based on attenuation measurements employing a scintillation detector. The mineral content at a particular site is determined by scanning with a well collimated slit-shaped x-ray beam. The attenuation by the soft tissues is compensated for by using two radiation energies.

By the x-ray spectrophotometric method the amount of bone mineral in the radiation beam is measured per unit area (mg/cm^2). By scanning over a site, the bone mineral content is obtained per unit length of the bone (mg/cm). In the present study the bone mineral content is thus obtained in mg/cm.

The measuring sites were selected so as to obtain representative values for trabecular and cortical bone, body weight loaded and unloaded bone, and axial and appendicular bone. When possible, sites used by other investigators were chosen to enable a comparison to be made. The sites and their precision are given in Table 1 (cf. Dalén & Jacobson, in press).

The long-term physical activity group consisted of 15 cross-country runners who had been practising the sport for at least 25 years. This branch of athletics was considered to be particularly suitable for the purpose of the study because it is often pursued to an advanced age. The runners, aged 50–59, (mean 54.6) were chosen by stratified random selection from all participants in the 1970 Stockholm district championship. Throughout the study attendance was 100 per cent.

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Table 1. Measuring sites and their precision as obtained from replicate measurements in 19 male office employees.

	Precision*, %
Radius + ulna, distal	3.5
Radius + ulna, shaft	.95
Humerus, head	2.1
Third lumbar vertebra	10 (2.8§)
Femur, neck	2.0
Femur, shaft	2.2
Calcaneus	3.9

* Precision: Standard deviation, expressed as a percentage of the mean bone mineral content at the respective sites.

§ Manual setting of the zero base-line.

By stratified random selection from the Stockholm population a control group of 31 men was formed. The study was incomplete, there being 7 absentees. (Age distribution of measured controls: 45–49; (n = 10) and 55–59; (n = 14), mean 52.8).

The cross-country runners and the controls were of similar body size, mean body height 176 and 176 cm, and mean body weight 73 and 75 kg, respectively.

The short-term physical activity group consisted of 19 male office employees, aged 25–52 (two others were excluded before the completion of the study because they withdrew from the training program). The group trained for three months: 10 persons walked 3 kilometers five times a week and 9 persons ran 5 kilometers three times a week. The maximum oxygen capacity was determined before and after the training period.

RESULTS

The bone mineral content was, on average, greater for the cross-country runners than for the control group (Table 2, Figure 1). The difference between the groups, expressed as a percentage of the values for the controls, was greater for the sites containing trabecular bone—for example, the calcaneus, head of the humerus and distal radius and ulna. The difference between the groups at these sites was investigated with an F-test (Discriminant analysis, BMD 07M, Dixon 1967), and the difference was found significant ($P < 0.01$). The largest F-value, however, was obtained for the shaft of the femur; this is due to a very small biological variation for this site (Dalén & Jacobson, in press).

The short-term physical activity group did not show any significant increase ($P > 0.05$) in the amount of bone mineral at the end of the training period (Table 3). A mean increase of 0.5 per cent in the aver-

Table 2. Bone mineral content for cross-country runners and control subjects. The deviation for the runners is expressed as a percentage of the mean values for the controls.

Measuring site	Mean bone mineral content		Deviation %	F1.37*
	Cross-country runners (mg/cm)	Controls (mg/cm)		
Radius + ulna, distal	2029	1712	+19	12
Radius + ulna, shaft	2455	2327	+ 6	2.8
Humerus, head	2886	2425	+19	14
Third lumbar vertebra	5404	4975	+ 9	1.2
Femur, neck	3764	3496	+ 8	1.9
Femur, shaft	6457	5738	+13	18
Calcaneus	3487	2890	+21	17

* A value of F greater than 7.3 is significant, $P < 0.01$, n = 39.

age bone mineral content of the individuals would have been significant (Student's t-test, $P < 0.05$); but in fact it was – 0.21 per cent (standard error of mean 0.22 per cent).

During the training period there was an increase in the maximum oxygen capacity of all the participants, and the mean increase for the group was 11 per cent (standard error of mean 1.2 per cent).

The difference in the change of bone mineral content between those trained by walking and those trained by running, the difference between individual subjects, and the difference between the 7 measuring

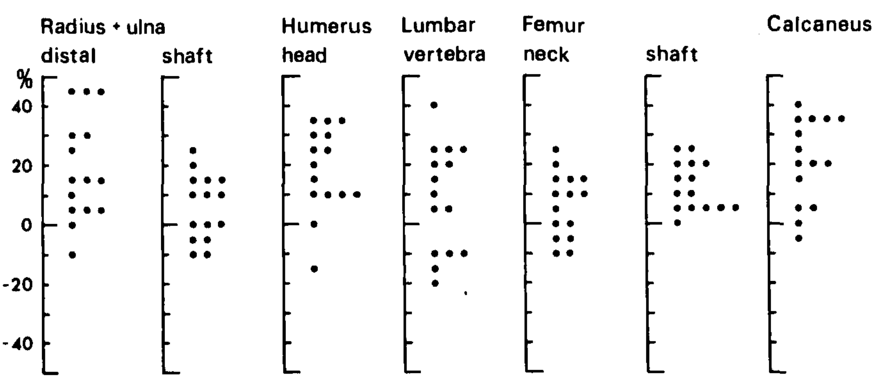

Figure 1. Bone mineral values for cross-country runners. The values are expressed as the per cent deviation from a control group matched for age, sex and body size.

Table 3. The difference in bone mineral content before and after the physical training period.

	Mean difference*, %
Radius + ulna, distal	+1.66
Radius + ulna, shaft	+0.08
Humerus, head	—1.51
Third lumbar vertebra	—0.47
Femur, neck	+0.75
Femur, shaft	—1.72
Calcaneus	—0.26

* Expressed as a percentage of the mean bone mineral content at the respective sites.

sites was not significant ($P > 0.05$); (Analysis of variance, BMD 08V, Dixon 1967). The correlation between the observed change in bone mineral and the increase in the maximum oxygen capacity was not significant ($P > 0.05$); (Correlation, BMD 03D, Dixon 1967).

DISCUSSION

The values for the bone mineral content in Table 2 have not been corrected for age and body size, the cross-country runners and the control group being very similar in these respects (mean age 55 and 53 years, mean body height 176 and 176 centimeters, and mean body weight 73 and 75 kilograms, respectively). If such corrections were made the difference in bone mineral content between the two groups is even greater than that reported.

The high bone mineral content of the skeleton of cross-country runners is in accordance with the results reported by earlier investigators regarding athletes (Nilsson & Westlin 1971). It is remarkable, however, that the mean bone mineral content is 20 per cent higher for the runners than the controls not only for the calcaneus but also for the head of the humerus and the distal radius and ulna. Moreover, the values for the clinically relevant measuring sites in the axial skeleton, namely, the neck of the femur and the third lumbar vertebra, were only 8 and 9 per cent, respectively, higher than those for the controls. To judge from the result of this study, physical training would seem to have little effect on the amount of bone mineral in the axial loaded skeleton, but there is some evidence that it is of importance for the appendicular skeleton. This is in agreement with the results obtained by Oeser & Krokowski (1963).

In spite of an 11 per cent increase in the maximum oxygen capacity durihg the three-month training period, no increase in the bone mineral content was observed. It would thus seem impossible to obtain a rapid increase in the amount of bone mineral in the skeleton of healthy normal male subjects by means of physical training. No conclusions can be drawn from these results regarding the effect of physical training under pathological conditions.

SUMMARY

The bone mineral content at seven measured sites was, on average, greater for 15 cross-country runners than for a control group. The difference between the groups was about 20 per cent for the trabecular, appendicular measuring sites (distal radius and ulna and calcaneus), but less than 10 per cent for the axial sites (lumbar vertebra and the neck of the femur).

A three-month period of increased physical activity in 19 male office employees did not result in an increased bone mineral content in spite of an 11 per cent increase in maximum oxygen capacity.

REFERENCES

Dixon, W. J. (1967) *Biomedical computer programs.* BMD 03D, Correlation, BMD 07M, Stepwise discrimination analysis, BMD 08V, Analysis of variance. University of California Press. Berkeley and Los Angeles.

Dalén, N. & Jacobson, B. Bone mineral assay—choice of measuring sites. *Invest. Radiol.* (in press).

Gustafsson, L., Jacobson, B. & Kusoffsky, L. X-ray spectrophotometry for bone mineral determinations. *Bio-med. Engng.* (in press).

Nilsson, B. & Westlin, N. (1971) Bone density in athletes. *Clin. Orthop.* **77**, 179–182.

Oeser, H. & Krokowski, E. (1963) Quantitative analysis of inorganic substances in the body, a method using X-rays of different qualities. *Brit. J. Radiol.* **36**, 274–279.

Smith, E. L. (1971) *Bone, changes with age and physical activity.* Thesis, University of Wisconsin.

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