BONE MINERAL CONTENT IN PATIENTS WITH DIABETES MELLITUS

M. Harmut,[1] E Kramer,[2] N. Breber[1] and Č. Tominac[1]

*Institute for Medical Research and Occupational Health, Zagreb[1] and
Faculty of Architecture, University of Zagreb, Zagreb[2]*

Bone mineral content (BMC) was measured in the proximal (BMC_0) and distal (BMC_1) parts of the forearm in 103 diabetics (56 men and 47 women) using the ^{241}Am gamma ray attenuation method. The results of measurement were compared with the values for age- and sex-matched controls. No signs of significant bone loss were noticed in any of the diabetic patients. The BMC values followed a second-degree regression curve (a parabola).

Physicians and clinicians have long recognised the shortcomings of the use of biopsy and radiographic methods for the early detection of bone diseases. In the year 1963 *Cameron and Sørenson* reported a new atraumatic, non--invasive method for quantifying bone mineral content (BMC) *in vivo* — the photon absorption technique (1). The technique has since grown in sophistication and has gained widespread clinical approval (2—6). The purpose of this investigation was to determine BMC values in patients with diabetes mellitus and to compare them to normal age- and sex-matched controls.

PATIENTS AND METHODS

Two hundred and twenty subjects participated in the study: 103 diabetics and 117 control subjects (47 men and 70 women). The diabetics were patients of the »Vuk Vrhovec« Institute for Diabetes, Zagreb.

Control subjects were randomly selected among the staff members of the Institute for Diabetes, persons reporting for a check up, visitors, their relatives and patients coming for routine control.

The diabetic subjects were suffering from an advanced form of diabetes mellitus — a juvenile or adult non-regulated type of disease — for 1—25 years and received insulin treatment. All patients with a possible other cause affec-

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ting bone content were excluded i. e. those older than 44 years (physiological osteopaenia /4/), or younger than 20 years (calcification process not yet over). Also excluded were persons suffering from chronic diseases (kidney, liver), persons with fractures, and those taking drugs affecting bone tissue and calcium metabolism.

The control group showed no signs of diabetes mellitus or other pathological conditions inducing changes of bone tissue. Their age varied from 20 to 44 years.

For BMC determination the method of *Cameron and Sørensen* (1) modified by *Nilsson* (7) was applied. The coefficient of variation reflecting the reproducibility and precision of the method was 4—6% for distal (BMC_1) measurements, and 3—5% for the proximal (BMC_6) ones (8). Our instrument was equipped with an ^{241}Am (45 mCi with a gamma energy of 60 KeV) isotope source and operated as a low-dose instrument (9).

RESULTS

Results of individual measurements are presented in Figures 1 and 2. The BMC values are plotted against age (years). The five-year means (Table 1) and standard deviations are also plotted (10). A second-degree regression curve and
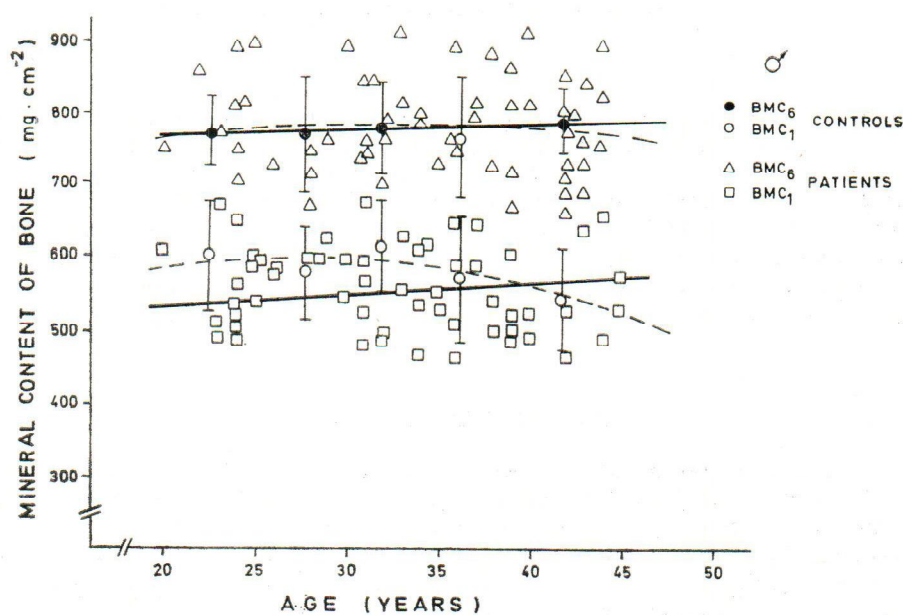

Fig. 1. *The bone mineral content in the forearm of diabetic patients plotted against age (years). Full lines — the second degree regression curves of the distribution for men. Dotted lines — control subjects; the means (± 1SD) in different age intervals.*
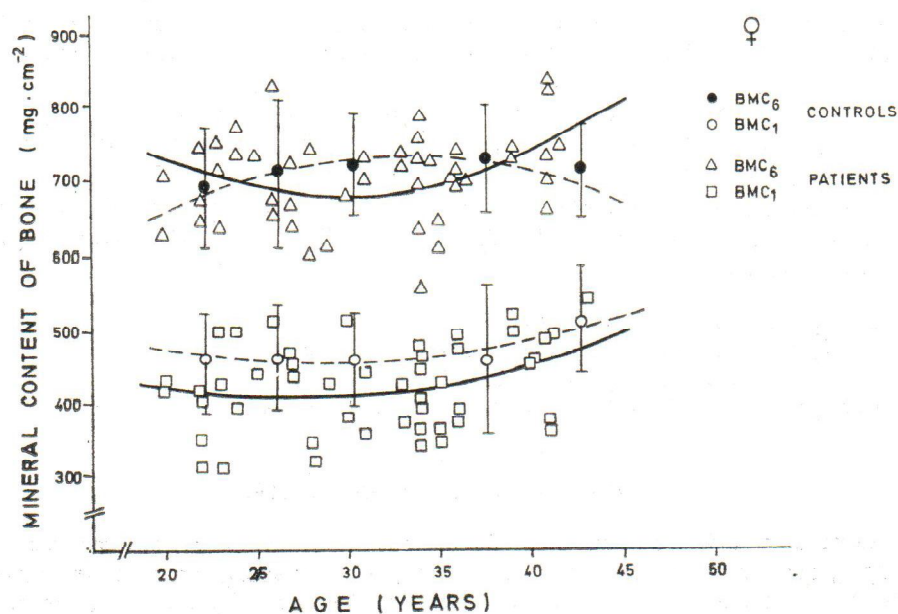
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Fig. 2. *The bone mineral content in the forearm of diabetic patients plotted against age (years). Full lines — the second-degree regression curves of the distribution for women. Dotted lines — control subjects; the means ($\pm$ 1SD) in different age intervals.*

Table 1

The means, and standard deviations of the bone mineral content (BMC) in diabetic persons of different age

Age interval	Sex	N	BMC_1 (mg.cm^{-2})	BMC_6 (mg.cm^{-2})
20—24	M	10	516 $\pm$ 47	763 $\pm$ 79
	F	9	403 $\pm$ 73	705 $\pm$ 46
25—29	M	7	558 $\pm$ 69	752 $\pm$ 71
	F	10	429 $\pm$ 53	684 $\pm$ 69
30—34	M	14	563 $\pm$ 84	781 $\pm$ 79
	F	13	412 $\pm$ 54	687 $\pm$ 73
35—39	M	13	545 $\pm$ 59	780 $\pm$ 72
	F	9	432 $\pm$ 65	695 $\pm$ 43
40—44	M	12	566 $\pm$ 98	787 $\pm$ 69
	F	6	461 $\pm$ 74	752 $\pm$ 70

the shape of parabola seem to be fairly adequate for our distribution. In both figures the dotted curves denote normal values, whereas the full ones refer to diabetic persons.

According to our measurements the effect of diabetes on BMC appears to be very small (within one standard deviation). In both figures the curves practically overlap.

The second-degree regression curves $(Y = a + bx + cx^2)$ of the measured bone mineral content (y) i.e. BMC_1 and BMC_6 distributions in relation to age in years (x) are given as:

$BMC_1 = 512 + 0.85 x + 0.009 x^2$
$BMC_6 = 720 + 2.42 x — 0.022 x^2$ for male diabetics and as
$BMC_1 = 615.22 — 15.26 x + 0.28 x^2$
$BMC_6 = 1142 — 31.46 x + 0.532 x^2$ for female diabetics.

DISCUSSION AND CONCLUSIONS

Several techniques have been described for estimating bone mineral content by observing the transmission of X-rays or low energy gamma rays through parts of the skeleton. These measurements are made by scanning the radius and ulna from the distal end. This type of measurement is particularly useful for serial studies to observe the progress of disease and therapy (11—13). The dimensions of the bone at its distal end vary with position, as noted by *Horsman and Leach* (14). It is therefore very important to reposition the arm accurately in respect to both the longitudinal position and rotation, to make sure that the bone is scanned in the same way each time. The photon absorptiometric technique in our modified version makes it possible to evaluate BMC *in vivo* with an accuracy and precision of 3—5% for distal measurements and of 4—6% for the proximal ones from the styloid process of the ulna (see *Harmut and co-workers* (8, 15) for more details).

The precision of BMC measurements in clinical work is typically 2—4% (6). The precision of our measurement, was poorer probably because of the instrument (8). The radiation dose during measurements was negligible (9). As the coefficients for the diabetics in the quadratic correlation associated with (x^2) were very small, a linear correlation i.e. linear regression could be used instead: $y = a + bx$.

The coefficients for quadratic BMC_1 and BMC_6 correlations were $r = 0.13$ and $r = 0.09$ meaning that in the age interval considered (20—44 years) the values for diabetics and those obtained for the normal population in the present study overlapped (16).

The coefficients for quadratic correlations for female diabetics were: $r = 0.13$ and $r = 0.39$. The BMC_6 parabola shows some anomalies in respect to normal values (2), but the whole curve lies within one standard deviation showing that there is no significant difference between the normal and diabetic subjects examined. The analysis of variance for the regression also confirms our conclusions.

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The initial developers of the single-photon absorptiometry (SPA) for bone mineral assessment (1), the chief proponents of the method over the past 20 years (17, 18) and the originators of the instrumentation for its clinical use (18) claim that the SPA of the appendicular skeleton is clinically a very efficient method for diagnosing and monitoring osteoporosis. It is true that the radius is indicative of overall skeletal status in normal subjects (17) and to a lesser degree in diabetic patients (18). The density of the distal radius in patients with osteoporosis is on the average significantly below that of controls (17). However, the density reduction at these sites is less than that for the spine. Single photon absorptiometry is extremely useful as a low-cost mass screening tool in elderly persons where appendicular bone loss approximates that of the spine (11—13). The usefulness of the distal forearm bone mineral content (BMC) as an index of the total body bone mineral (TBBM) was investigated by *Gotfredsen and co-workers* (19) and by *Cohn and co-workers* (20) and correlated with total body calcium. According to *Gotfredsen* BMC is linearly related to TBBM and BMC measurement gives a reliable estimate of TBBM irrespective of the disease (19).

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Sažetak

SADRŽAJ MINERALA U KOSTIMA DIJABETIČARA

Sadržaj minerala u kosti podlaktice mjeren je metodom atenuacije (gašenja) gama-zraka ^{241}Am u 103 dijabetičara (56 muškaraca i 47 žena). Sadržaj minerala u kosti određivan je u proksimalnom (BMC_6) i distalnom (BMC_1) dijelu podlaktice. Rezultati mjerenja uspoređivani su s odgovarajućim vrijednostima istih dobnih skupina normalne populacije. Nisu zapaženi znakovi značajnijeg gubitka kosti u bolesnih osoba. Zapaženo je da vrijednosti BMC slijede krivulju regresije drugog stupnja (parabola).

Institut za medicinska istraživanja
i medicinu rada, Zagreb i Arhitektonski
fakultet Sveučilišta u Zagrebu, Zagreb