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Bone Mineral Density in Weight Lifters

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Summary. The effect of intense physical training on the bone mineral content (BMC) and soft tissue composition, and the development of these values after cessation of the active career, was studied in 40 nationally or internationally ranked male weight lifters. Nineteen were active and 21 had retired from competition sports. Fifty-two age- and sex-matched nonweight lifters served as controls. The bone mineral density (BMD) in total body, spine, hip, and proximal tibial metaphysis was measured with a Lunar Dual-energy X-ray absorptiometry (DXA) apparatus and the BMD of the distal forearm was measured with single photon absorptiometry (SPA). Seventeen of the lifters had been measured earlier with SPA in the forearm and 23 in the tibial condyle during their active career in 1975. The BMD was significantly higher in the weight lifters compared with the controls (10% in the total body $P < 0.001$, 12% in the trochanteric region $P < 0.001$, and 13% in the lumbar spine $P < 0.001$). All measured regions except the head showed significant higher bone mass in the weight lifters compared with the controls. In older lifters, the difference from the controls seemed to increase in total body and lumbar vertebrae (BMD), but remained unchanged in the hip. Significant correlation was found between the SPA measurements in 1975 and the corresponding measurements 15 years later in both the forearm ($r = 0.51$, $P < 0.05$ at the 1-cm level and $r = 0.87$, $P < 0.001$ at the 6-cm level) and in the tibial condyle ($r = 0.61$, $P < 0.01$). There was no difference in BMD for any region between active and retired weight lifters that was not explained by difference in age. The weight lifters were on average 5 cm shorter but of the same weight as the controls. In the weight lifters, the body mass index (BMI) was increased as was the lean body mass, but not the fat content.

Key words: Bone mineral density – Weightlifters – DXA – Physical activity.

Previous studies have consistently shown that individuals habituated to long-term physical activity, and special weight-bearing exercise, have greater bone mineral density (BMD) than less active individuals of the same age and sex [1–8]. Prolonged bedrest or lack of gravity is followed by a reduction of the bone mineral content (BMC) in the bone [9, 10].

Prospective studies of exercising subjects have also shown promising results. Dalsky et al. [11] found that a 40-week exercise program resulted in a significant increase in the BMD of the lumbar spine in postmenopausal women and Krolner et al. [12] showed that a group that participated in an exercise program for 8 months showed a significant increase in BMD in the lumbar spine compared with a nontraining group.

The key to the prevention of age-related fragility fractures may be twofold: increase the amount of bone present at skeletal maturity and/or decrease the bone loss after the forth decade [13].

With the introduction of the dual-energy X-ray absorptiometry (DXA), we have a precise technique for examining the BMC and also the opportunity to measure the lean body mass and fat content. The purpose of this study was to determine the BMD and soft tissue composition in active weight lifters and to follow the development of the single photon absorptiometry (SPA) values in 17 lifters measured in 1975. All of these lifters had retired from competitional training in 1990.

Material and Methods

We investigated 40 male, nationally or internationally ranked weight lifters with an average age of 33 years (range 16–54). They had been on a continuous training program for an average of 12 years (range 1–32). Nineteen of them, with a mean age of 25 (range 16–33), were still active and 21, with a mean age of 40 (range 27–54), had retired from competitive sports, at mean 8.8 (range 3–15) years ago, although many continued with weight lifting as a hobby. Four had totally retired and the rest continued with "hobby lifting" for a mean of 3.2 (range 1–8) hours/week. All but one in the group of retired weight lifters admitted having used anabolic steroids at least once, usually a few months before an important competition. However, none had been on continuous steroid medication. In the still active group, none admitted having used anabolic steroids. These individuals were compared with 52 age-matched controls either hospital employees or persons randomly selected from the city files.

The measurements were done with a Lunar DXA apparatus [14] programmed to measure and calculate the BMD (g/cm^2) of the hip neck, Ward's triangle and trochanteric region, the spine (L2–L4), and the whole body. A special region of interest (ROI) was measured in the proximal tibia metaphysis. We were also interested in measuring the BMD of the skull as this region is not trained in weight lifting. Also, the body composition of fat and lean body mass was calculated. The precision for the BMD measurements at our laboratory, determined by double measurements in healthy individuals, is for total body 0.4%, spine (L2–L4) 0.5%, and hip (neck) 1.6%.

SPA, using ^{241}Am as radiation source, was also performed in the forearm. A scan was done 1 cm from the tip of the styloid process, measuring trabecular bone, and 6 cm proximal to the styloid process, measuring cortical bone. The outer diameter of the bone was calculated from grafical tracings. These data were compared to SPA measurements from the wrist and proximal tibia performed on 17 and 23 of the lifters 15 years earlier.

A questionnaire was given to the lifters, asking for training activities such as training hours per week, years as a top athlete, training hours during top athlete time, and retired time from "top training time." A training index was calculated as the total amount of training hours during active career plus total amount of training hours since then.

Statistical significance of difference between weight lifters and

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Table 1. Numeric values for weight lifters and controls (mean 1 SD)

	Lifters (n = 40)	Controls (n = 52)	Active lifters (n = 21)	Controls (n = 37)	Lifters retired from competitional training (n = 19)	Controls (n = 26)
Age	33.2 (10.7)	32.5 (9.0)	26.0 (8.7)	27.8 (4.9)	41.1 (6.2)	41.0 (8.3)
Weight (kg)	83.9 (14.5)	80.0 (10.1)	83.0 (17.7)	80.1 (10.5)	84.8 (10.3)	80.4 (9.7)
Length (cm)	175.8 (7.1)[c]	180.9 (6.9)	177.0 (6.1)[a]	181.3 (7.5)	174.4 (7.9)[a]	180.0 (6.8)
BMD total body (g/cm^2)	1.36 (0.19)[c]	1.24 (0.09)	1.38 (0.25)[b]	1.26 (0.09)	1.33 (0.11)[b]	1.22 (0.10)
BMD head (g/cm^2)	2.24 (0.22)	2.27 (0.24)	2.18 (0.23)	2.30 (0.24)	2.31 (0.19)	2.27 (0.24)
BMD L2–L4 (g/cm^2)	1.42 (0.20)[b]	1.26 (0.15)	1.46 (0.18)[c]	1.29 (0.14)	1.38 (0.19)[b]	1.23 (0.24)
BMD neck (g/cm^2)	1.23 (0.28)[b]	1.08 (0.16)	1.30 (0.29)[b]	1.09 (0.19)	1.16 (0.18)[b]	1.02 (0.13)
BMD Ward's (g/cm^2)	1.18 (0.28)[b]	1.02 (0.21)	1.29 (0.29)[b]	1.09 (0.19)	1.05 (0.18)[a]	0.93 (0.12)
BMD troch (g/cm^2)	1.09 (0.19)[c]	0.97 (0.14)	1.14 (0.18)[b]	1.00 (0.14)	1.04 (0.18)[a]	0.92 (0.12)
BMD tib cond (g/cm^2)	1.27 (0.21)[c]	1.13 (0.14)	1.31 (0.21)[a]	1.17 (0.14)	1.22 (0.21)[a]	1.10 (0.14)
Total body fat (%)	16.5 (6.3)	18.4 (7.1)	13.6 (6.1)[a]	17.5 (7.0)	19.7 (4.9)	19.8 (6.2)
Lean body mass (kg)	66.3 (9.5)[a]	62.9 (6.8)	67.4 (10.9)	63.9 (7.3)	65.1 (7.8)	61.2 (6.2)
BMI (kg/m^2)	26.9 (3.6)[c]	24.5 (2.8)	26.3 (4.6)[a]	24.4 (2.8)	27.6 (2.2)[c]	24.6 (2.8)

Some of the controls were used twice as to create age-matched control groups both for active lifters and for lifters retired from competitional training. It is important to notice that most of the lifters retired from competitional training maintained supernormal level of activity
[a] $P < 0.05$; [b] $P < 0.01$; [c] $P < 0.001$

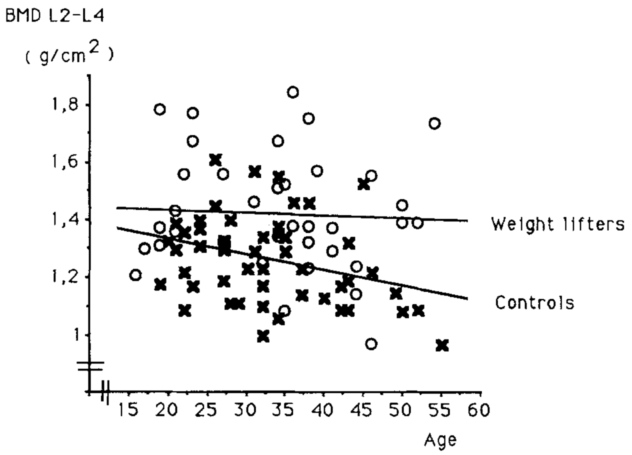

Fig. 1. BMD in the lumbar spine (L2–L4) in relation to age. The two lines represent the regression lines for weight lifters (o) and controls (x).

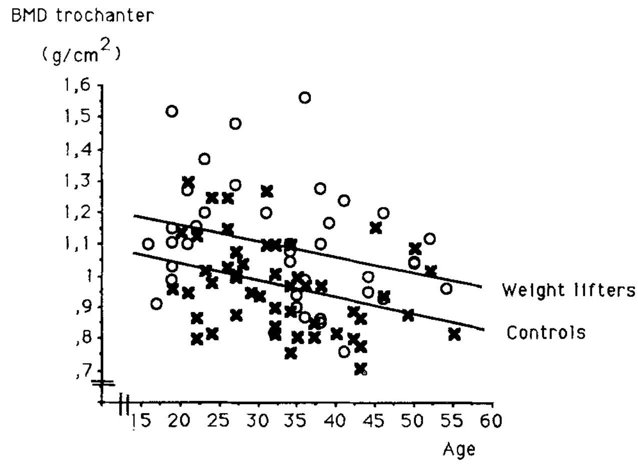

Fig. 2. BMD in the trochanteric part of the hip in relation to age. The two lines represent the regression lines for weight lifters (o) and controls (x).

controls was determined by using Student's *t*-test between means. When comparing different variables, simple regression equation was used. Also co-variance analysis was performed adjusting for body mass index and age when differences in BMD were found.

Results

The BMD was significantly higher in the weight lifters compared with the controls in all measured regions, except for the head (Table 1). As the body mass index was increased in weight lifters, a co-variance analysis was performed for the bone mineral measurement, adjusting for the BMI. The results still remained the same.

When age was taken into account, the controls seemed to have lower bone mineral in the total body measurements. Also, the difference of lumbar BMD, as judged by the regression slope lines, seemed to increase with age (Fig. 1). In all three hip measurements, however, the difference between weight lifters and controls was unchanged with age (Fig. 2).

The BMC in the distal forearm as measured with SPA is listed in Table 2. The SPA measurements in the forearm and proximal tibia from 1975 (during the active career) correlated significantly with the SPA and DPX values in 1990 ($r = 0.51$, $P < 0.05$ at the 1 cm level, $r = 0.87$, $P < 0.001$ at the 6 cm level, and $r = 0.61$, $P < 0.01$ at the proximal tibia) (Fig. 3).

The weight lifters were on average 5 cm shorter than the controls ($P < 0.001$) (Table 1). In spite of this, their lean body mass was higher ($P < 0.05$) but not their total fat body content. The body mass index (BMI) was thus also higher ($P < 0.001$).

When the BMI was compared with the BMD, there was a positive correlation in all regions for both weight lifters and controls ($r = 0.44$, $P < 0.01$ and $r = 0.38$, $P < 0.01$ for total body, respectively) (Fig. 4).

There was no significant correlation between training intensity, as measured by training index, and BMD. However, in all measured regions except for the hip, a tendency towards a positive effect on BMD of intensive and long-duration training was found. When looking at actual training hours per week there was a tendency, although not signifi-

Table 2. BMC in the distal forearm as measured by single photon absorptiometry in heavyweight lifters measured in 1975 and 1990 (mg/cm^2)

	SPA 1 cm 1975	SPA 1 cm 1990	SPA 6 cm 1975		SPA 6 cm 1990
Lifters (n = 17)	644.6 ± 110.7[a]	524.6 ± 107.9	808.2 ± 79.7	ns	765.2 ± 98.8

Mean 1 SD
[a] $P < 0.01$

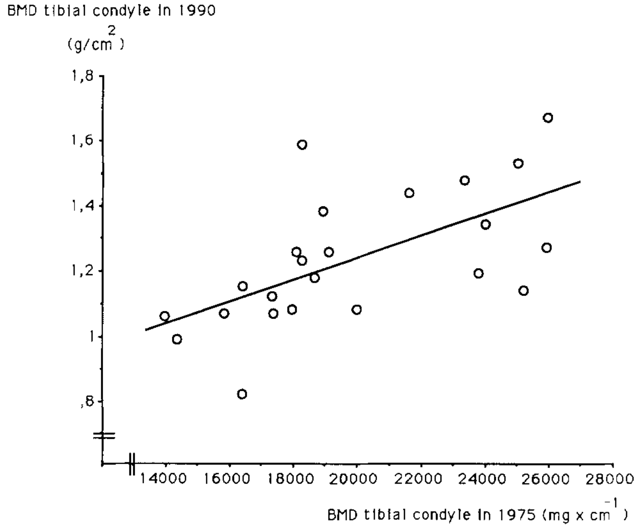

Fig. 3. Relationship between the BMD in the tibial condyles measured with SPA in 1975 and the same region measured with DXA in 1990 in 23 longitudinally followed weight lifters.

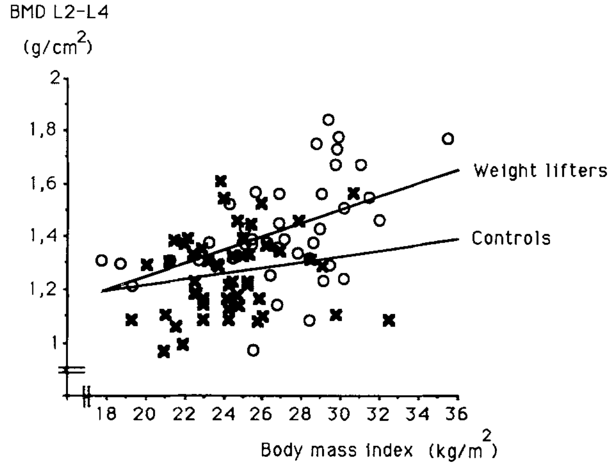

Fig. 4. BMD in the spine (L2–L4) in relation to BMI. The two lines represent the regression lines for weight lifters (o) and controls (x).

cant, in all measurements, for higher density in the training-intense group.

Discussion

Although numerous studies have shown that exercise increases bone mass, the intensity, frequency, duration of activity, and type of training is still controversial [6–8, 15]. The BMD responds slowly to intense physical activity, whereas muscle adapts relatively rapidly and the cardiovascular system even faster [16].

The consensus is that physical activity can increase bone mass, and this seems to be true for all adult ages and for both women and men. Infantry recruits have also increased their BMC [17] after 14 weeks of intense physical training. Postmenopausal women subjected to physical training also increase their total body calcium [18] and bone mass in trunk and proximal femur [19]. Over 70 tennis players have increased BMD only in the dominant forearm [20]. It seems as if the intensity of training is important as brisk walking for 1 hour three times a week does not alter the rate of bone loss in postmenopausal women [21].

It has also been suggested previously that the type of physical activity necessary to build and maintain bone density must be weight bearing. This has been suggested as an inverse evidence of the fact that weightlessness and loss of ambulation result in marked skeletal atrophy [22]. Weight-bearing activity has therefore been widely recommended as prophylaxis for age-related bone loss [23]. The BMD does not seem to increase in swimmers [2, 4]. Also rigorous, non-weight-bearing exercise may, however, increase bone mass but these data must be interpreted cautiously because all the participants in these studies are exceptional athletes [4, 24]. We have not been able to find any evidence in the literature of a long-lasting effect of training activity on BMD. It is therefore not known whether a short period of training activity followed by a sedentary lifestyle gives rise to a higher BMD decades later in life. Although in weight lifters after the cessation of an active career the BMD decreases, the difference in controls seems to increase for certain regions such as the lumbar spine (Fig. 1). The higher peak bone mass found in this study, and the high correlation between the values during the active career in 1975 and today, may indicate a decreased future risk of fragility fractures. The weight lifters retired from competitional training in this study have maintained supernormal physical activity, so it is impossible to judge what would have happened if they had returned to a sedentary way of life.

In this study we found a higher lean body mass and BMI but an unchanged percentage of fat content in all weight lifters. It is not surprising that the soft tissue composition changes so much quicker than the hard tissue composition after an active career.

It is impossible to determine what the importance was of the anabolic steroids taken during an active career. It is possible that the now active weight lifters may take anabolic steroids now and then, but are unwilling to admit it. Nevertheless, none of the retired weight lifters continued to take anabolic steroids and many years after retiring, their BMD was increased.

It is interesting that we did not find any difference in BMD in the head, although all other parts of the skeleton were engaged. This suggests that the higher BMD in the other regions is the result of the training program, and not because of any genetic or acquired higher bone density in the lifters during childhood. It is evident that the head is the only region not trained in weight lifting.

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