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Original Article

Bone mineral density evaluation of patients with type 2 diabetes mellitus

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Abstract. [Purpose] Diabetes mellitus is a metabolic disorder resulting from a defect in insulin secretion, insulin action, or both. A consequence of this is chronic hyperglycemia with disturbances in carbohydrate, fat and protein metabolism. We investigated whether there is any difference among DM patients and a control group in terms of lumbar and femur BMD (bone mineral density), and standard deviation scores (Z score and T score). [Subjects and Methods] This randomized, prospective, controlled, single-blind study was conducted in the Physical Medicine and Rehabilitation Department Faculty of Medicine, Bezm-i Alem Vakıf University. Patients with type 2 diabetes mellitus were included in the patient groups. Healthy individuals were included in the control group. [Results] A total of 126 patients completed the study (63 in the study group, 63 in the control group). There was no significant difference in the results of the laboratory examinations of the cases. The bone mineral densities of the cases were found to be significantly low in terms of the lumbar (L1–4) T scores in the type 2 diabetes group. [Conclusion] Although osteoporosis is one of the potential complications of type 1 diabetes, its effect on bone mineral density in type 2 DM is controversial. In different studies, the bone mineral density values have increased, decreased or remained normal. With the exception of the lumbar (L1–4) T score, similar results were obtained in this study.
Key words: Type 2 diabetes mellitus, Osteoporosis, Bone mineral density

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INTRODUCTION

Diabetes mellitus is a metabolic disorder resulting from a defect in insulin secretion, insulin action, or both. A consequence of this is chronic hyperglycemia with disturbances in carbohydrate, fat, and protein metabolism. Diabetes mellitus (DM) is a common disorder of carbohydrate, fat, and protein metabolism reflected by inappropriate high fasting and postprandial glucose levels (hyperglycemia). This ailment results from the absence or scantiness of insulin secretion with or without concurrent impairment of insulin action. Consequently, the disease was classified into two types known as type I (insulin dependent, IDDM) and II (non-insulin dependent, NIDDM) according to the degree of pancreatic defect. This classification has been even recognized since the time of Ibn Sinaa, who mentioned it in his book "The Canon of Medicine".

DM is not confined to abnormal blood glucose levels but progresses to affect other body systems. This fact has been confirmed by several epidemiological studies and clinical trials that have linked hyperglycemia to several complications at the macrovascular (coronary artery disease and cerebrovascular disease) and microvascular levels (renal failure, blindness, limb amputation, neurological complications and premature death)[1)].

Endocrine and metabolic alterations in diabetes mellitus can trigger disorders of calcium homeostasis, skeletal metabolism, and bone mass[1)]. It is reported that more than of 50% type 1 diabetes patients have osteoporosis (OP), which is called diabetic osteoporosis (DO), a reduced bone mass and an increased fracture risk shown to occur in type 1 diabetes mellitus[2)]. On the other hand, in type 2 diabetes, several but not all cross-sectional studies have found normal[3)] or elevated[4)] bone mass, and these results are surprising given the increased fracture risk associated with type 2 diabetes[5)]. In type 2 DM patients complicated with OP, there is a larger decrease in bone formation than bone resorption in compared with the case of postmenopausol OP, and this mainly influences the indexes of bone formation and may be a lower turnover ratio type.

We investigated whether there is any difference among DM patients and a control group in terms of lumbar and femur BMD (bone mineral density) and standard deviation scores (Z score and T score).

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SUBJECTS AND METHODS

This randomized, prospective, controlled, single-blind study was conducted in Physical Medicine and Rehabilitation Department Faculty of Medicine, Bezm-i Alem Vakıf University. Patients with type 2 diabetes mellitus were included in the patient groups. Healthy individuals were included in the control group. In addition to their demographic characteristics (age, gender, weight, height, body mass index [BMI]), waist circumference, hip circumference, waist/hip proportion, used medicines, body muscle masses, fat masses, and fat percentages were obtained. The patients included in this study were between the ages of 40 and 65. The control group in this study consisted of healthy individuals.

All the recruited subjects signed informed consent forms before participating in the study, and approval of a local ethics committee was obtained. The exclusion characteristics were early menopause, hormone replacement therapy, usage of medicines able to affect BMD (thiazide diuretics, statins, anticoagulants, antiepileptics), diseases affecting bone metabolism (hypo/hyperthyroid, Cushing syndrome, primary hiperparathyroidism, renal failure, liver disease, inflammatory bowel disease, malabsorption), alcoholism, osteoporotic breakage history, scoliosis.

The medicines taken by the patients, and their disease durations were recorded. Data about the presence of diabetic complications (retinopathy, ischemic cardiac disease, hypertension, neuropathy, nephropathy) were regularly recorded in during follow-up. The whole blood count, fasting blood glucose, urea, creatine, C-reactive protein, HbA1c (glycolysed hemoglobin), alkaline phosphatase (ALP), calcium (Ca), phosphor (P) levels, and erythrocyte sedimentation rate (ESR) were examined, and a 24-h urinalysis was carried out.

Through dual-energy X-ray absorptiometry (DEXA, DPX-LUNAR), BMD measurements of the lumbar spine (anteroposterior projection of L1-L4) and left proximal femur (total score) were executed. The BMD data are presented in g/cm^2 and standard deviation scores (Z and T scores). T scores between −1 and −2.5 were considered to indicate osteopenia, and those equal or below −2.5 were considered to indicate osteoporosis (WHO Study Group, 1994).

The calculations were performed using the Statistical Package for Social Sciences for Windows software version 16.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to confirm that data within the ranges of the normal distribution in both groups. A non-parametric test was employed for the variables outside the normal distribution. The comparison of the data between the groups was carried out with the Mann-Whitney U-test. The Wilcoxon signed-rank test was used to examine the pre- and post- exercise differences within groups. Statistical significance was based on a value of $p < 0.05$ with a 95% confidence interval.

RESULTS

A total of 126 patients completed the study (63 in the study group, 63 in the control group). The clinical and demographic characteristics of the patients and the healthy controls are listed in Table 1. The mean age was 59.31 ± 8.17 years. The mean disease duration was 11.42±2.82 years. There was no significant difference in the result of the laboratory examinations of the cases (Table 2). The bone mineral densities of the cases are presented in Table 3. Regarding the medications taken by the diabetic patients, 48 patients were using oral antidiabetic, and 8 patients were using insulin, and 7 patients were using both of them. With regard to the disease durations, there were 23 patients in the 0–5 year group (36.5%), 17 patients in the 6–10 year group (27%), 14 patients in the 11–15 year group (22.2%), 4 patients in the 16–20 year group (6.3%), 1 patient in the 21–25 year group (1.6%), and 4 patients in the 26–30 year group (6.3%). No significant correlation was detected when comparing disease durations and the bone marrow densities of the Type 2 DM patients by the medicines taken ($p>0.050$) (Table 4).

Table 1. Clinical and demographic characteristics of patient and control groups (mean ± SD or n, %)

	DM group (n=63)	Control group (n=63)
Age	60.1±8.5	58.4±7.8
Male patients (n, %)	29 (46%)	30 (47%)
BMI (cm/kg^2)	32.4±4.8	28.4±5.5

DM: diabetes mellitus; SD: standard deviation
$p < 0.05$ is significant

Table 2. Clinical and demographic characteristics of patient and control groups (mean ± SD or n, %)

	DM group (n=63)	Control group (n=63)
Ca (mg/dl)	8.8±0.2	8.5±0.2
P (mg/dl)	4.2±0.8	4.3±0.8
ALP (U/l)	85.9+26.7	84.4+32.3
Fasting blood glucose (mg/dl)	162.4±44.8	98.4±15.5
24-h urea Ca	143.8±81.1	133.8±55.4
Urea (mg/dl)	48±11.2	42±8.2
Creatine (mg/dl)	0.9±0.3	0.7±0.2
ESR	15.6±8.2	18.1±7.5
CRP	0.2±0.4	0.1±0.5

DM: diabetes mellitus; SD: standard deviation
$p < 0.05$ is significant

DISCUSSION

The most important aim of our study was to compare the bone mineral densities of type 2 diabetes mellitus patients with those of a normal, healthy population. In our examinations, we determined that there was a significant decrease in the lumbar region T score in compared with the normal population.

Although osteoporosis is one of the complications of type 1 diabetes, the effect of type 2 DM on bone mineral density is controversial. In different studies, the BMD val-

Table 3. BMD, Z and T scores of patient and control groups (mean ± SD or n, %)

	DM group (n=63)	Control group (n=63)	p
Lumbar (L1–4) BMD	46.6±205.4	1.1±0.1	
Lumbar (L1–4) T Score	−0.9±1.1	0.01±1.7	
Lumbar (L1–4) Z Score	−0.01±1.1	−0.1±1.2	¥
Total femur BMD	14.9±110.6	1.0±0.1	
Total femur T Score	−0.2±1.0	−0.0±1.2	
Total femur Z Score	0.5±0.9	0.1±1.3	

DM: diabetes mellitus; SD: standard deviation.
¥p < 0.05 is significant.

Table 4. BMD, Z and T scores of drug usages of diabetic patients (mean ± SD or n, %)

	Oral antidiabetic (n=48)	Insulin (n=15)
Lumbar (L1–4) BMD	53.6±195.4	42.3±180.1
Lumbar (L1–4) T Score	−0.6±1.1	−0.8±1.7
Lumbar (L1–4) Z Score	−0.04±1.0	−0.0±1.3
Total femur BMD	14.9±110.6	13.0±100.1
Total femur T Score	−0.2±1.1	−0.1±1.2
Total femur Z Score	0.5±0.9	0.5±1.2

DM: diabetes mellitus; SD: standard deviation
p < 0.05 is significant

ues in type 2 DM have increased[6], decreased[7], or stayed normal[8]. In general, the type 2 DM patients with low BMD values have been observed to have long-term diabetes and menopause, to have poor glucose control, and to have disordered renal functions[9]. Furthermore, in some studies, it has been concluded that diabetic women are protected from osteopenia[10]. This can be explained in type 2 DM, unlike the case of type 1 DM, by the frequent observation of obesity due to increased insulin resistance and the higher of osteoarthritis in DM patients[11].

In the study of Sosa et al., 47 female type 2 DM patients and 252 nondiabetic women were compared in terms of BMD through DEXA and quantitative computerized tomography, and no significant difference was detected[12]. In the literature, it has been found that type 2 DM patients, individuals using a dietary and oral antidiabetic, and individuals taking insulin have lower BMD values[13]. It has been asserted that better glysemic control, exercise, diet, and medical therapy can decrease the complications in DM[14]. But in our study, no difference could be determined in BMD in relation to medicine usage.

In measurements from the calcaneal region, a previous study reported higher BMD values in postmenapousal women and similar values to those of a control group in diabetic men, and it has been determined that there was no difference between women and men[15].

Many mechanisms have been asserted to contribute to diabetic osteopenia. One of them is that it can lead to diabetic osteopenia due to deficiency in anabolic activation of insulin[13]. Another mechanism asserted in diabetic osteopenia is suppression of osteoblastic bone formation[16]. In previous studies, it has been shown that decreases in osteoblastic functions occurred in diabetic ostopenia[17]. Previous studies have also shown that the bone cycle speed in type 2 DM is much slower than that in healthy postmenopausal patients[18]. In another study on type 1 and type 2 diabetes patients, it has been underlined that the decrease in bone mass can be related with decrease in bone formation and microangiopathy in bone tissue[19]. In histopathologic examination of type 2 DM patients, the osteoblast surface, cortical thickness, osteoid thickness, osteoid volume, and bone volume have been found to be lower in diabetic patients. It has been concluded that the mechanism laying behind the diabetic osteopenia can be the decrease of quantitative osteoid, the decrease of osteoblasts, and finally the decrease of bone cycle[17]. In DM patients, chronic hyperglycaemia decreases estradiol synthesis by causing ovarian damage. Estradiol has a direct stimulatory effect on osteoblasts, and this may contribute to osteoporosis[20].

As a result, the BMD measurements the postmenopausal women with Type 2 Diabetes Mellitus in the present study did not show any difference in proportion to those of the control group.

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