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Original Article

The Relationship Between Type 2 Diabetes Mellitus and Osteoporosis in Elderly People: a Cross-sectional Study

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Diabetes mellitus (DM) and osteoporosis are common diseases and their prevalence increases with age. Several investigations have indicated that type 1 DM has a significant relationship with bone loss, whereas in type 2 diabetes, this relationship is controversial. Therefore, this study was conducted to determine the relationship between osteoporosis and type 2 DM in elderly people. This population-based study had been carried out on 1151 elderly people in Amirkola, northern Iran. L2-L4 lumbar spine bone mass and the left femoral neck density were measured by dual-energy X-ray absorptiometry (DEXA). In addition, diagnosis of diabetes was done by measuring fasting blood sugar (twice times FBS ≥ 126 mg/dl), according to the WHO criteria or self-reported as well as based on a doctor's prescription. Of total, 362 (31.45%) of patients had DM. The average age of diabetic patients was 68.9± 6.93 years and in non-diabetic group was 68.68± 7.09 years (P= 0.18). The mean L2-L4 lumbar spine bone mass in the diabetic group was 0.90± 0.19 g/cm2 and in the non-diabetic group was 0.85± 0.18 g/cm2 (P= 0.001). The mean lumbar bone mineral density was higher (P= 0.0001) in diabetic men than in non-diabetic men, as well as in women (P= 0.0001). In addition, the mean femoral neck density in diabetic group was 0.85± 0.16 g/cm2 and in the non-diabetic group was 0.84± 0.15 g/cm2 (P= 0.48). Moreover, the femoral neck bone mineral density in diabetic men was higher than in non-diabetics (P= 0.03), whereas in diabetic and non-diabetic women, there was no significant difference (P= 0.52). Our results demonstrated that the mean lumbar and femur bone mineral densities in older people with type 2 DM was higher than people without DM.

Key words: Type 2 diabetes mellitus, osteoporosis, bone mineral density

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Decreased bone density and reduction in the bone strength are most common metabolic bone problems, which are usually diagnosed after bone fractures, especially in the femoral neck and lumbar spine. The incidence of these fractures in USA is 3.1 million cases and also 20% of all deaths result from hip fractures (1). In addition to aging and menopause which are known risk factors for osteoporosis, other factors could also act as a risk factor for osteoporosis, including diabetes mellitus (DM) (2). Several reports indicated that type 1 DM has a strong relationship with osteoporosis (2-4); whereas in the case of the relationship between type 2 diabetes and osteoporosis, there has been inconsistency in the studies (5, 6). In some studies, people with type 2 diabetes had a higher bone mineral density (BMD) than the control group (6, 7). However, some other studies have not found significant differences (5, 8). The results of a study in Saudi Arabia revealed higher prevalence of osteoporosis in postmenopausal diabetic women compared to normal women (9). In addition, in Rotterdam study, men and women with type 2 diabetes had higher BMD and a lower risk for non-vertebral (6). Moreover, obtained results from Health ABC study demonstrated that people with type 2 diabetes had higher BMD at the hip area (10). Shahin et al. showed that BMD in the lumbar spine and femur was higher in diabetic patients than normal people (11). Given the controversies in the above-mentioned studies, this study aimed to determine the relationship between BMD and type 2 DM in elderly people aged 60 years and over.

Materials and methods

Study population

This study is a part of a comprehensive cohort study entitled Amirkola Health and Ageing Project (AHAP) (No. 892917), which has been in progress since 2011 on all 60 years and over population of Amirkola located in north of Iran (12). The elderly were invited to participate in the study through letters and phone calls providing the necessary information about the project. Among 2234 elderly people in Amirkola, 1616 people have participated in this comprehensive program, of which 1151 cases have sufficient information for inclusion in this study and others were excluded.

Classification and diagnosis of diabetes

Diagnosis of diabetes in this study was accomplished by measuring fasting blood sugar (twice times FBS $\geq$ 126 mg/dl), based on the WHO criteria (13) or self-reported and based on a doctor's prescription. Then, the participants were divided into two groups of diabetics (n= 362) and non-diabetics (n= 789).

Bone mineral density measurement

BMD was measured by dual-energy X-ray absorptiometry (DEXA) using Lexxos densitometry in left femoral neck and lumbar spine (L2 – L4) and the results were expressed based on T-Score. T-Score$\leq$ -2.5 SD was considered as osteoporosis, -2.5< T-Score $\leq$ -1 as osteopenia and T-Score>-1 was considered as normal (14). Smoking, hypothyr-oidism and hyperthyroidism, liver disease, kidney disease, cancer, fractures and the use of steroids were obtained from the self-report and interview.

Statistical analyzes

Data were analyzed by SPSS 18 statistical software using t-test, chi-square and Pearson correlation statistical tests and P$\leq$ 0.05 was considered as statistically significant.

Results

Among 1151 cases of elderly individuals who participated in this study, 362 cases were diabetic and 789 were non-diabetic patients. The average age of diabetic patients was 68.9± 6.93 years and in non-diabetic group was 68.68± 7.09 years (P= 0.18). The

Table 1. Demographic data and measured values of the elderly people in Amirkola

Variables		Mean± SD	P-value
Age (years)	Diabetics	68.09± 6.93	0.18
	Non-diabetics	68.68± 7.09	
Spine BMD (g/cm^2)	Diabetics	0.90± 0.19	0.001
	Non-diabetics	0.85± 0.18	
Spine Z score	Diabetics	-0.079± 1.37	0.001
	Non-diabetics	-0.59± 1.26	
Spine T score	Diabetics	-1.39± 1.55	0.001
	Non-diabetics	-1.77± 1.45	
Femur BMD (g/cm^2)	Diabetics	0.85± 0.16	0.48
	Non-diabetics	0.84± 0.15	
Femur Z score	Diabetics	-0.44± 1.09	0.12
	Non-diabetics	-0.55± 0.99	
Femur T score	Diabetics	-1.38± 1.21	0.54
	Non-diabetics	-1.43± 1.13	
BMI (kg/m^2)	Diabetics	28.10± 4.53	0.001
	Non-diabetics	26.93± 4.59	

mean spine BMD in the diabetic group was 0.90± 0.19 g/cm^2 and in the non-diabetic group was 0.85± 0.18 g/cm^2 (P= 0.001). The mean femur BMD in the diabetic group was 0.85± 0.16 g/cm^2 and in the non-diabetic group was 0.84± 0.15 g/cm^2, the difference was not statistically significant (P= 0.48). Table 1 shows the demographic data and measured values of the two groups.

The prevalence of osteopenia and osteoporosis in diabetic patients was significantly lower than people without DM (Table 2). In this study, no significant differences were found between the two groups according to smoking history, hypothyroidism and hyperthyroidism, liver disease, kidney disease, cancer, fractures and the use of steroids (Table 3).

As shown in Table 4, there were significant differences between the two groups for spine BMD in elderly men (P= 0.001). In addition, our results indicated that the femur bone mineral mass in diabetic men was higher than non-diabetics (P= 0.03).

Our findings also demonstrated that diabetic women in the elderly population of Amirkola had a

Table 2. Distribution and the percentage of bone mineral density in diabetics and non-diabetics patients among the elderly population of Amirkola

Variables		Diabetics N (%)	Non-diabetics N (%)	P-value
Spine BMD	Normal	143 (39.5)	221 (28)	0.001
	Osteopenia	135 (37.3)	313 (39.7)	
	Osteoporosis	84 (32.2)	255 (32.3)	
Femur BMD	Normal	138 (38.1)	264 (33.5)	0.28
	Osteopenia	159 (43.9)	379 (48)	
	Osteoporosis	65 (18)	146 (18.5)	

Table 3. Distribution and the percentage of variables affecting the bone density in diabetics and non-diabetics patients among the elderly population of Amirkola

Variables		Diabetics N (%)	Non-diabetics N (%)	P-value
Smoking history	Yes	62 (17.1)	154 (19.5)	0.33
	No	300 (82.9)	635 (80.5)	
Hyperthyroidism	Yes	4 (1.1)	7 (0.9)	0.72
	No	358 (98.9)	782 (99.1)	
Hypothyroidism	Yes	17 (4.7)	28 (3.5)	0.35
	No	345 (95.3)	761 (96.5)	
Liver disease	Yes	11 (3)	12 (1.5)	0.08
	No	351 (97)	777 (98.5)	
Kidney disease	Yes	2 (0.6)	4 (0.5)	0.92
	No	360 (99.4)	785 (99.5)	
Fractures	Yes	102 (28.2)	208 (26.4)	0.51
	No	260 (71.8)	581 (73.6)	
Cancer	Yes	1 (0.3)	7 (0.9)	0.24
	No	361 (99.7)	782 (99.1)	
The use of steroids	Yes	34 (9.4)	74 (9.4)	0.81
	No	319 (88.1)	690 (87.5)	
	Don't know	9 (2.5)	25 (3.2)	

higher spine BMD compared to non-diabetic women (P= 0.001), whereas in femoral BMD no significant difference was observed between the two groups (P= 0. 52) (Table 5).

In elderly people with a BMI less than 25, lumbar spine BMD had a significant difference between diabetic and non-diabetic groups (P= 0.03) whereas, this difference was not significant in the

Table 4. Quantitative variables associated with diabetes in the elderly men of Amirkola

Variables		Mean± SD	P-value
Age (years)	Diabetics	68.66± 7.38	0.43
	Non-diabetics	69.16± 7.20	
Spine BMD (g/cm^2)	Diabetics	0.99± 0.18	0.001
	Non-diabetics	0.91± 0.17	
Spine Z score	Diabetics	0.19± 1.27	0.001
	Non-diabetics	-0.46± 1.20	
Spine T score	Diabetics	-0.62± 1.26	0.001
	Non-diabetics	-1.23± 1.22	
Femur BMD (g/cm^2)	Diabetics	0.91± 0.15	0.03
	Non-diabetics	0.88± 0.15	
Femur Z score	Diabetics	-0.32± 0.98	0.001
	Non-diabetics	68.66± 7.38	
Femur T score	Diabetics	69.16± 7.20	0.43
	Non-diabetics	0.99± 0.18	
BMI (kg/m^2)	Diabetics	0.91± 0.17	0.001
	Non-diabetics	0.19± 1.27	

(Number of diabetics= 175, Number of non-diabetics= 469)

Table 5. Quantitative variables associated with diabetes in the elderly women of Amirkola

Variables		Mean± SD	P-value
Age (years)	Diabetics	67.555± 6.45	0.47
	Non-diabetics	67.99± 6.89	
Spine BMD (g/cm^2)	Diabetics	0.81± 0.16	0.001
	Non-diabetics	0.76± 0.16	
Spine Z score	Diabetics	-0.33± 1.41	0.001
	Non-diabetics	-0.77± 1.33	
Spine T score	Diabetics	-2.11± 1.45	0.001
	Non-diabetics	-2.57± 1.41	
Femur BMD (g/cm^2)	Diabetics	0.79± 0.14	0.52
	Non-diabetics	٠ 0.78± 0.13	
Femur Z score	Diabetics	-0.56± 1.17	0.97
	Non-diabetics	-0.56± 1.01	
Femur T score	Diabetics	-1.75± 1.25	0.56
	Non-diabetics	-1.82± 1.11	
BMI (kg/m^2)	Diabetics	28.48± 4.97	0.26
	Non-diabetics	28.48± 4.82	

(Number of diabetics= 187, Number of non-diabetics= 320)

femoral BMD. These findings were also observed in patients with a BMI over 30, but there was no differences between patients with a BMI greater than 25 and less than 30 between the two groups (Figure 1).

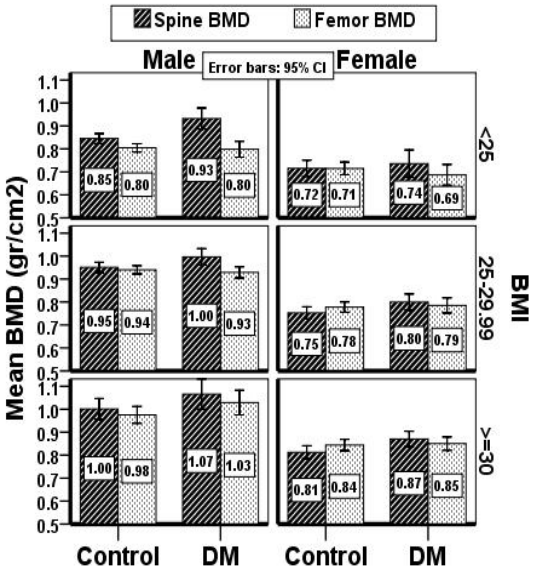

Figure 1. The relationship between lumbar spine and femoral neck bone mineral density and BMI according to gender in both diabetic and non-diabetic groups.

Discussion

Diabetes is one of the most common chronic disorders worldwide and its many complications can severely affect quality of life. In addition, DM has many long term complications affecting almost all tissues. Bone involvement is one of the complications of DM. Several lines of evidence indicate that low bone mass at the hip, femoral neck and spine in both male and female patients with type 1 DM, may eventually lead to an increased risk of bone fracture. In contrast, in type 2 DM, investigations appear conflicting, and the exact mechanism of this is still unknown. The results of this study demonstrated that BMD of the lumbar spine was significantly greater in diabetics

compared with non-diabetics patients, but no difference was observed for femur BMD between the two groups. In addition, the prevalence of osteopenia and osteoporosis was lower in diabetic patients compared with non-diabetics. Similar to our study, in a study conducted by Shan et al. on older Chinese women with type 2 diabetes, BMD at the lumbar spine was significantly higher than non-diabetic patients (15). Also, in Gupta's study in Kuwait performed on diabetic women, similar results were observed for lumbar spine BMD (16). In a study performed on women with type 2 diabetes by Hadzibegovic et al. in Croatia, the bone density of the lumbar spine and femoral neck in the diabetic group was significantly higher than the non-diabetic group (17). Similarly, Petit et al. reported a higher BMD in elderly patients with type 2 DM when compared to age-matched non-DM volunteers (18). In contrast, several other investigators reported a negative effect of type 2 DM on BMD and an increased fracture risk at several sites, including spine and hip has also been reported. For example, Bridges et al. observed no significant difference of BMD among diabetic patients (type 1 and 2) and the control group (19). In addition, Zhou et al. found that lumbar spine and femoral BMD in diabetic patients were significantly lower than the control group, which is not consistent with our study (20). The study of Anaforoglu et al. on elderly women with diabetes in Turkey showed that the prevalence of osteoporosis and osteopenia in patients with diabetes mellitus was not different from non-diabetic individuals (21). Nevertheless, these fractures and falls could have resulted from visual impairment from diabetic retinopathy, gait imbalance and overweight, all of which are common clinical features in type 2 DM. In addition, these conflicting results may be due to the different methods used to measure the bone density, the difference in duration of DM, severity and treatment of diabetes. Moreover, insulin resistance and hyperinsulinemia can result in high rate of bone mineral mass in type 2 diabetic patients. Insulin is an anabolic hormone that increases bone mass through bone formation by insulin receptor substrate 1 (IRS-1) and IRS-2 on osteoblasts and by lowering sex hormone binding globulin (SHBG) concentration, which results in increased concentrations of estradiol and testosterone (22, 23). Our findings also revealed that the lumbar spine BMD in older women with diabetes were significantly higher than non-diabetic elderly women, but there was no significant difference between the two groups in femoral bone density. One similar study on diabetic and non-diabetic elderly women over 65 years in USA indicated that bone density in both spine and femur bone among women with diabetes was higher than non-diabetic women (24). Previous studies suggested that circulating androgen levels in men with type 2 diabetes was reduced, but was increased in women with type 2 diabetes. According to the above-mentioned mechanism, it is hypothesized that the conversion of androgens to estrogens in men may occur to a greater extent (25). Therefore, the bone density in both areas (lumbar spine and femoral neck) was significantly higher in diabetic male patients than non-diabetic patients (20). In addition, due to the cessation of ovarian function in older women during the menopausal period, there is a lack of estrogen. To justify these conflicting results, the genetic complexity of diabetes may be noted. Furthermore, many factors such as exposure to sunlight, vitamin D, number of pregnancies, exercise and dairy consumption can affect the prevalence of osteoporosis.

In conclusion, the results of the present study demonstrated that osteoporosis rate in diabetic patients was lower than in normal subjects, and BMD in elderly patients with diabetes was higher than non-diabetics. Although these results were

consistent with some previous studies, more investigations are required to clarify the possible cellular and molecular mechanisms.

Conflict of interest

The authors declared no conflict of interest.

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