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Original Research Article

To Study the Association Between Body Mass Index (BMI) and Hand Grip Strength on Bone Mineral Density in Type 2 Diabetic Males and Females of North Bihar

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Abstract

Aim: This work aims to study the association between body mass index (BMI) and hand grip strength (HGS) on bone mineral density(BMD) in type 2 diabetic males and females of North Bihar.

Materials and Methods: This study involves five hundred(500) subjects comprising of both diabetic and nondiabetic, males and females, of age group 30–70 years. Quetelet index was used to calculate BMI and handgrip dynamometer was used for measurement of Hand Grip Strength (HGS) using a. maximum isometric tension i.e., T max in kg and endurance time (ET) in seconds, i.e., time of onset of fatigue for 70% of the Tmax. BMD is measured in distal end of tibia by using bone sonometer. WHO compliant- T score and Z score were used for analysing results.

Results: BMI had a weak negative correlation with BMD and HGS max ($P = 0.037$) among diabetic patients. BMD had a weak positive correlation with HGS max ($P = 0.0139$) and ET. Non-diabetic males have significantly higher HGS($P = 0.05$). In non-diabetic females, both HGS($P < 0.001$) and ET($P = 0.04$) were significantly higher. There was no significant difference in the BMD between T2DM and non-diabetics.

Conclusion: We observed no significant difference in BMD among non-diabetics and diabetics in our study, whereas osteoporosis was more likely common in diabetics though not significant statistically. Muscle strength(HGS) was found to be lower among diabetics as compared to non-diabetics. Hence, regular assessment of muscle strength by HGS and timely assessment for osteoporosis is advised.

Keywords: Body Mass Index, Type 2 Diabetes Mellitus, Bone Mineral Density, Handgrip Strength, Endurance time, Osteopenia, Osteoporosis.

Introduction

Besides being one of the world's leading health problem, diabetes mellitus (DM) has arisen as a very important health concern in India. Almost all the organ systems are inflicted by DM and there is an increased prevalence of morbidity and mortality associated with it. [1] Another very common metabolic bone disease in elder people is osteoporosis.

Bone mineral density (BMD) is commonly used to assess bone health. It measures the amount of mineral in bone tissue, and dual-energy X-ray absorptiometry (DXA) has been established as a standard method to test BMD and analyse the risks of osteoporosis. [2]

Studies indicate that abdominal obesity and bone mineral density (BMD) are related with insulin resistance (IR), which is a special feature of type2DM. [3–5] The documented risk for fracture among people suffering with type2DM has risen by 40-70% despite BMD being normal or increased. [6] In type1DM, bone density was decreased but in type2DM such results were inconsistent as compared to healthy subjects.[7,8,9] Advanced age is an important risk factor for osteoporosis and DM may be linked with an even more increased rate of bone loss. Hence bone decay leading to increased risk for fracture may be prevented by prior recognition of reduced bone mass in the diabetics. [10]

T_2DM has also been associated with musculoskeletal syndrome resulting in weakness of muscles. Grip strength is notably decreased among the diabetics. [11] Hand grip strength (HGS) is an objective test which can be used to foretell the susceptibility of the subjects to fractures as a result of fall. Also, this can be used independent of BMD. [12,13]

Since the studies regarding T_2DM and its effect on BMD and HGS are quite limited and inconsistent, this study aimed to see the effect of T2DM on BMD and also to understand the relation of T2DM with BMI, BMD and HGS.

Materials and Methods

This was a cross-sectional study involving five hundred (500) subjects comprising of both diabetic and nondiabetic males and females of age group 30–70 years. In the course of study, there were eight (08) dropouts. Study was done after obtaining informed consent from the subjects who were examined in the Department of Physiology, Patna Medical College, Patna, Bihar, India. The duration of our study was around one years.

Exclusion Criteria

1. The subjects who were hypertensives.
2. Subjects who were alcoholic and smoker.
3. Bed ridden / patients having fracture.
4. Those who were on drugs known to affect bone mineral metabolism.

Weight of all participants was obtained in Kg. Body height was measured without shoes using a measuring tape to the nearest centimeters. BMI was calculated using Quetelet index [BMI (kg/m^2) = wt.(kg)/Ht.(m^2)]. Participants were then categorized into three groups according to the WHO classification of BMI, as normal weight [BMI 18.5–24.9 kg/m^2], overweight [BMI 24.9–29.9 kg/m^2] and obese [BMI >30 kg/m^2].

Measurement of Hand Grip Strength (HGS) was done using a handgrip dynamometer. HGS is the maximal power exerted by forceful voluntary flexion of all fingers. HGS was measured in participants in seated position with elbow by their side and flexed to right angles and a neutral wrist position and provision of support underneath the dynamometer. In this position, the participant is asked to compress the HGS dynamometer with maximal strength. HGS can be obtained by measuring the amount of static force that the hand can compress around a

dynamometer. The mean of three attempts of grip strength is taken. This is referred to as maximum isometric tension, T max in kg and endurance time (ET) is measured by the time of onset of fatigue for 70% of the Tmax which is expressed in seconds. [14-16]

BMD is recorded using the bone sonometer over the shin region of distal end of tibia. The results were analyzed on the basis of the WHO–compliant T-score and Z-score. T-score measure is most directly applicable to patient risk assessment. The T-score relates speed of sound (SOS) value to the scores obtained for subjects in our study. [17] The T-score value is the number of standard deviations by which the current patient's SOS value exceeds or falls below the mean. T-score above −1.0 is normal. T-score between −1.0 and −2.5 is osteopenic and osteoporosis with T-score below −2.5. Osteopenia and osteoporosis were considered as abnormal BMD. Bone ultrasound has high sensitivity and specificity in predicting low bone mass and hence can be used as a screening tool. [18]

Statistical Analysis

SPSS version 20 software was used in statistical analysis using descriptive statistics and inferential statistics. Descriptive statistics include mean, standard deviation, frequency and percentages while inferential statistics use mean scores between two groups and were compared using unpaired "t-test." Chi-square test was used to assess BMD scores between diabetics and non-diabetics. Correlation between all variables was assessed by Pearson's correlation.

Results

Table 1: Descriptive statistics of subjects and controls

Variables	Diabetics		Controls	
	N	Mean ±SD	N	Mean ±SD
Age	195	51.8432±8.4682	297	46.6384±10.9876
Height	195	1.6088±0.1231	297	1.5869±0.13180
Weight	195	71.6723±10.8630	297	67.6305±9.9846
BMI	195	27.6941±4.5406	297	28.0505±7.13480
HGS max	195	23.3158±8.9189	297	26.0505±9.1472
ET in seconds	195	14.2932±6.9726	297	16.1800±7.62680
BMD	195	-1.0847±1.1906	297	0.0148±1.0729

Table 2: Pearson correlation between BMD, BMI, HGS max, and ET

Variables	BMI	HGS max	ET in sec
BMI			
R		-0.176 (WNC)	-0.061 (WNC)
P		0.037 (SS)*	0.437 (NS)
N		195	195
BMD			
R	-0.042 (WNC)	0.242 (WPC)	0.148 (WPC)
P	0.598 (NS)	0.0139 (SS)*	0.128 (NS)
N	195	195	195
HGS Max			
R			0.418 (WPC)
P			<0.001 (SS)*
N			195

Pearson correlation showed that there was a week negative correlation i.e. WNC(r = −0.176) between BMI and HGS max in sec and it was statistically significant i.e. SS(P = 0.037). There was a week negative correlation (r = −0.061) between BMI and ET and it was not statistically significant i.e. NS (P = 0.437).

There was a week negative correlation (r = −0.042) between BMD and BMI and correlation was not statistically significant (P = 0.598) but there was a week positive correlation i.e. WPC (r = 0.242) between BMD and HGS max in sec and correlation was statistically significant (P = 0.0139). Also, a weak positive correlation (r = 0.148) was observed between BMD and ET and it was not statistically significant (P = 0.128).

There was a week positive correlation (r = 0.418) between HGS max and ET and it was statistically significant (P < 0.001). (Table 1 and Table 2)

Table 3: Unpaired T-Test

Variable	DM status	N	Mean ±SD	p
Males BMI	DM	105	23.98±3.56	0.269
	Non DM	117	26.58±3.12	
HGS max	DM	105	29.75±8.43	0.05*
	Non DM	117	34.47±8.35	
ET in sec.	DM	105	15.73±7.02	0.081
	Non DM	117	19.65±6.05	
BMD	DM	105	-1.160±1.019	0.812
	Non DM	117	-1.159±1.032	
Females BMI	DM	90	27.31±5.13	0.692
	Non DM	180	29.01±4.44	
HGS max	DM	90	18.19±5.80	<0.001*
	Non DM	180	24.60±7.21	
ET in sec.	DM	90	13.12±6.22	0.04*
	Non DM	180	17.16±6.25	
BMD	DM	90	-1.562±1.151	0.172
	Non DM	180	-1.321±1.124	

TABLE -3 shows that among males, the result was not statistically significant when BMI, HGS max, ET, and BMD were compared between diabetics and non-diabetic group. However, more HGS and ET was observed in non-diabetic males as compared to diabetics with significantly higher HGS value (0.05). BMI and BMD were not statistically significant among female diabetics and non-diabetic group but HGS and ET were observed to be statistically significant with P < 0.001 and 0.04 respectively.

Table 4: Distribution of osteopenia and osteoporosis among diabetics and non-diabetics

Males (BMD)	Diabetic (%)	Non-diabetic (%)	P-value
Normal (0-1)	48 (45.7%)	54 (46%)	0.869
OPE (1-2.5)	47 (44.76%))	52 (44.4%)	
OPO (>−2.5)	10 (9.5%)	11 (9%)	

Females (BMD)	Diabetic (%)	Non- Diabetic (%)	P-value
Normal (0-1)	35 (38.89%)	68 (37.78%)	0.653
OPE (1-2.5)	37 (41%)	86 (47.78%)	
OPO (>−2.5)	18 (20%)	26 (14%)	

OPE- osteopenia; OPO- osteoporosis

Chi-square test was used to distribute subjects with different BMD grading among male diabetics and non-diabetics and no statistically significant difference was found between them (P = 0.869). Similarly, Chi-square test was also used among female diabetics and non-diabetics and it was found to be non-significant statistically (P = 0.653).

Discussion

In our study we found a positive association between HGS and BMD, in the general population of Bihar, across genders which adds to the importance of grip strength as an indicator of general BMD and risk of osteoporotic fracture

In this study, a weak negative correlation was observed between BMI and BMD in T2DM but it was not statistically significant. BMD among diabetic patients had a weak positive correlation with HGS max (statistically significant) and ET (statistically non-significant). Weak negative correlation exists between BMI and BMD, though statistically not significant and was similar to the study done by Leslie et al. [18] Fawzy et al. and Mishra et al. have shown in their study that BMI is a good indicator for BMD measurement. BMD measures bone mineral density. Low BMI values are an important risk factor in the incidence of lower BMD. [17,19]

According to Ashok et al., ceiling effect was found when there is increase in BMI on BMD, and osteopenia may not be prevented by moderate to morbid obesity. In present study, average BMI among study participants was high which could be a cause for having a weak negative correlation. [20] In our study, subjects show that BMD had a weak positive correlation with HGS max and ET.

Our findings show statistically significant results when BMI and HGS max were compared, but had a weak negative correlation. Ilich et al. concluded that the obese osteopenic women with increased adiposity, decreased BMD and muscle mass had the lowest HGS scores. [21]

In the present study HGS was significantly higher in non-diabetic males whereas in non-diabetic females, both HGS and ET were significantly higher with HGS value being highly significant (P < 0.001). Our results were consistent with a study by Ezema et al., reporting T2DM is associated with poorer muscle strength and hence lower HGS max [22] Reduction in muscle strength in diabetics compared to age-matched healthy individuals is explained by increased insulin tissue resistance and hyperglycemia. Insulin resistance leads to decreased postprandial muscle protein synthetic response, leading to a greater reduction of muscle mass in patients with T2DM. In our study, BMD of diabetic patients was compared with apparently healthy age and sex matched controls. We observed that there was no significant difference in the BMD between two groups. Our findings were consistent with Asokan1 who observed that there was no significant difference in the BMD between two groups. Sosa et al. also noted that bone mineral metabolism was normal in non-insulin-dependent DM. [23] However, in our results, we noted that osteopenia was more in non-diabetic males and females, whereas incidence of osteoporosis was more among diabetic males and females though statistically not significant. Shan et al. [24] concluded that women with T2DM had higher BMD and

lower risk of osteoporosis and fracture; hyperinsulinemia could cause this positive association between T2DM and elevated BMI.

Diabetes affects bone through various ways. One explanation for decreased bone strength in diabetes may be a series of non-enzymatic reactions between proteins and glucose resulting in the deposition of advanced glycation end products (AGEs) in bone collagen. AGEs leads to the vascular complications of diabetes by causing an increase in the permeability of the blood vessels and reduction in the elasticity. AGEs in collagen are found to inhibit osteoblastic activity and to increase osteoclast-induced bone resorption. This leads to increased bone fragility. [25] Each patient needs to be evaluated individually as the potential mechanism underlying associations between T2DM and BMD is quite complex and also previous studies have shown that T2DM patients may have lower, similar, or higher BMD at different ages and anatomical regions. So, Hamilton et al., in their study, have also focused upon evaluation of all T2DM patients for increased risk of osteoporosis so that appropriate preventive and healthy lifestyle measures such as regular exercise, calcium and Vitamin D supplementation should be advised. [26,27]

Conclusion

We observed no significant difference in BMD among non-diabetics and diabetics in our study, whereas osteoporosis was more likely common in diabetics though not significant statistically. The reason for having no significant difference in BMD between non-diabetics and diabetics may be the regular use of antidiabetic drugs and good glycemic control in the subjects. HGS was found to be lower among diabetics as compared to non-diabetics. Hence, regular assessment of muscle strength by HGS and timely assessment for osteoporosis is advised. It helps in planning recent lifestyle modifications needed and relevant prophylactic treatment among T2DM.

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