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Metabolic syndrome is negatively associated with trabecular bone score and bone mineral density in normal weight adults with central obesity

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ABSTRACT

Introduction: Metabolic syndrome (MetS) is comprised of a clustering of various cardiovascular risk factors that can also affect bone health. We aimed the associations between MetS and bone mineral density (BMD) and trabecular bone score (TBS) in subjects with abdominal adiposity.

Methods: Individuals with body mass index less than 25 kg/m2 were enrolled from the SUVINA study and allocated into two groups according criteria of IDF for metabolic syndrome. TBS T-score and Z/T score of fore skeletal region were measured using dual-energy X-ray absorptiometry (DXA). SPSS software was used for statistical analysis and p value 0.05>0 was considered significant.

Results: DXA measurements were made in 201 participants, of whom 75 had MetS and 126 did not. Scores related to the neck of femur and total femur, radius Z-score and TBST-score were lower in subjects with MetS (all P<0.05). Subjects with FBG≥100 had lower TBST-score (p < 0.05). SBP≥130 and DBP≥85 in subjects, led to the lower TBST-score, and lumbar T-score (both P < 0.05). Subjects with (LDL-C≥160 mg/dl) had lower TBST-score, neck of femur Z score, and total femur T/Z scores (all P < 0.05). TBST-score and scores related to neck of femur, and total femur were lower in participants with serum cholesterol≥200 mg/dl (P < 0.05).

Conclusion: MetS is negatively associated with TBS and BMD scores. Higher levels of LDL-C and cholesterol were the most associated factors related to TBST-score decrease. The neck of femur was the most vulnerable skeletal against the MetS components increment.

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Introduction

Metabolic syndrome (MetS), also known as insulin-resistance syndrome, or syndrome X is a constellation of cardiovascular risk factors comprising abdominal obesity, hyperglycemia, dyslipidemia (low high-density lipoprotein cholesterol and high triglyceride) and hypertension (1, 2). Individuals considered to have metabolic syndrome in case of having at least three of these medical conditions (2). A negative impact on bone health is one of the consequences of this metabolic disturbance (3). The prevalence of MetS varies with age, gender, race and ethnicity differs from 10% to 84%. In addition, almost 25% of people in the world have metabolic syndrome, makes it an important health care issue for further investigations (2).

The presence of MetS can also affect bone remodeling. Each component of MetS may influence bone metabolism. For instance, obesity may stimulate bone accrual by increasing mechanical load of the body but adipose tissue promotes bone reabsorption by the effects of its pro-inflammatory cytokines further it is linked with bone marrow adipogenesis which result in decreased osteoblast formation through mesenchymal stem cell deprivation (4).

A high body mass index (BMI), body fat mass, body weight and visceral fat accumulation are associated with obesity which had various effects on bone health in human studies (2). However, it is reported that the visceral adiposity explicitly related to reduced bone mass in men another study revealed that the visceral fat and insulin resistance are two most advantageous factors for method for assessment of fracture risk (8). It have pointed out that various characteristics of body size, as well as hormonal impact like endogenous estrogen, are related to elevated BMD (9).

Use of estrogen hormone therapy, being obese, peri-menopause and having high physical activity are factors bone health by reducing vertebral fracture in men and women (5, 6). BMI decline resulted in pathological skeletal fracture (6). So low BMI is considered as a risk factor for all fractures independent of sex and age, however; it's also dependent on bone mineral density (BMD) as De Laet reported that (7).

BMD evaluation is a fundamental predicting high BMD in early post-menopausal women which decrease hazard of fracture in this women's (10). BMD is not an adequate parameter for fracture risk prediction, for this reason, Trabecular Bone Score (TBS), an additional diagnostic method independent of BMD has been used. It can measure grey-level texture by using 2D projection images variograms and quantifying conversions in grey-level texture of 1 pixel to the adjacent pixels. Increased TBS exhibit potent fracture-resistant microarchitecture though, a low TBS remarks a weak microarchitecture which is prone to fracture (8, 11).

It is reported that TBS positively related with lumbar spine BMD and femoral neck but it is negatively associated with utilization of glucocorticoid, rheumatoid arthritis, chronic obstructive pulmonary disease, high alcohol drink and more BMI (12). Fat mass increment may also not prominent for bone mass but accurate characterization of skeletal metabolism is effective for inhibition of fragility fracture of overweight individuals in future (13,14).

The aim of this essay is to investigate the association of metabolic syndrome and bone mineral density including BMD and trabecular bone score (TBS) in normal weight individuals with abdominal obesity.

Materials and Methods

Study design and population

We administrated this cross-sectional study as a part of the survey of ultraviolet intake by nutritional approach (SUVINA study) (15). We enrolled our research on 201 normal-weight (BMI<25kg/m2) participants with 30-50 years old age among screening data of SUVINA study who were adults requited from staff and student of Mashhad University of Medical Sciences. Participants with no history of bone disorders (such as osteoporosis, Paget disease, etc.) and also no history of using drugs interfering on bone metabolism (such as corticosteroids and bisphosphonates) were included in this study. Conversely our exclusion criteria were as follow: participants with special diet, like vegan, smoking or drinking alcohol, using drugs with damaging effect on bone health or having a history of disease influencing bone health (such as diuretics, rheumatoid, chronic kidney disease (CKD)), who not filled more than 10% of the FFQ items or missing data regarding metabolic syndrome components (waist circumference, systolic blood pressure, diastolic blood pressure, triglyceride, glucose, and High-density lipoprotein cholesterol).

We informed all individuals about the methods and aim of our research. Then they filled a written consent for participating in our study. This present study was related to the Research Ethics Committee of the Iran National Institute for Medical Research Development (NIMAD) approved written consent. (Protocol ID: IR.NIMAD.REC.1396.027).

Data collection

We assembled all demographic data of individuals by using a questionnaire at baseline by health care professionals and a nurse interview. We computed Height, and weight of participants using

standard approaches (cm and kg respectively) and by using a tape and scale. The BMI (body mass index) was calculated with using height2/ weight formula. The Hip circumference (HC) and Waist Circumference (WC) was determined by flexible scales. Blood pressure was evaluated twice with a 30-min interval for all patients in seated and rested position using a standard mercury sphygmomanometer. The average of two measurements reported as final blood pressure.

Participant's blood samples were collected into plain tubes after 14 hours fasting and was used to determine the levels of serum triglycerides (TG), total cholesterol (TC), fasting blood glucose (FBG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) which were assessed enzymatically using commercial kits.

Metabolic syndrome diagnosis

The International Diabetes Federation (IDF) characterized five components for metabolic syndrome as follow: fasting blood glucose ≥100 mg/dl, systolic or diastolic blood pressure ≥130 or ≥85 mmHg; HDL-C <50 mg/dl for women or <40 mg/dl for men; triglyceride ≥150 mg/dl; and central obesity (waist circumference ≥80 cm for women or ≥94 cm for men)) (16). The individuals who have central obesity plus two or more mentioned above factors (n=75) were identified as metabolic syndrome patients and healthy individuals were considered as control group (n=126).

Bone health measurements

We measured TBS T-score, Z-score, and T-scores of lumbar, neck of femur, total femur, and distal of Radius based on the age and sex of the participants. All assessments were accomplished by using the DXA imagine machines at the radiology section of Ghaem hospital. DEXA scanning is used by a hologic discovery Wi (S/N 93045M) device chucago, USA. DEXA scanning is used to compute femoral bone density. We performed Bone mineral densitometry for the fourth first lumbar spine vertebrae, left femur and radius bone of the non-dominant forehand.

Statistical analysis

Statistical analysis was done with using the SPSS version 18.0. We used The Kolmogorov-Smirnov test, t-tests, and Mann-Whitney U tests for comparing variables between metabolic syndrome +and Metabolic syndrome - groups. Logistic regression analysis was used to adjust age and sex as confounding variables. P-value less than 0.05 was considered as significant.

Result

Of total 201 participants, 30-50 years old with normal weight and abdominal adiposity, underwent DXA measurement, 75 individuals had the metabolic syndrome and 126 did not. Baseline anthropometrics and biochemical factors were different in subjects with and without MetS (Table 1). Subjects with the MetS were older, reported higher levels of SBP, DBP, FBG, TC, and LDL (p value<0.001). In addition, those without the MetS had higher HDL (p <0.001). Other factors had a similar distribution in both subjects.

Table 1 displays lumbar TBS and BMD scores in various mentioned skeletal sites in subjects with and without MetS. Subjects with MetS had lower TBS T-score, neck of femur T/Z-score, total femur T-score, and radius Z-score (all P<0.05). Differences between other scores of remained skeletal sites were not significantly associated with MetS.

Table 1: Anthropometrics, biochemical factors and bone health indexes according to metabolic syndrome in normal weight subjects

	MetS- (N=126)	MetS+ (N=75)	p-value
Anthropometrics			
Age (years)	40.57±7.56	43.94±8.38	0.004
Weight (Kg)	71.62±8.05	72.88±7.65	0.27
WC (cm)	90.28±5.92	92.7±7.02	0.01
HC (cm)	103.23±4.88	103.1±4.49	0.84
SBP (mmHg)	114.77±13.73	125.25±17.48	<0.001
DBP (mmHg)	73.64±11.5	79.58±10.84	<0.001
Biochemical factors			
FBG (mg/dl)	**94.27±14.27**	**103.47±21.81**	**<0.001**
TC (mg/dl)	187.28±32.82	211.16±46.22	<0.001
TG (mg/dl)	112.56±57.75	205.63±129.43	<0.001

HDL-C (mg/dl)	48.85±8.56	44.27±6.79	<0.001
LDL-C (mg/dl)	107.48±24.7	123.03±34.11	<0.001
Cr (mg/dl)	1.04±0.17	1.01±0.17	0.14
BUN (mg/dl)	28.98±7.22	27.44±6.54	0.13
Uric Acid (mg/dl)	4.73±1.14	4.98±1.12	0.14
hs-CRP (mg/dl)	1.81±2.6	2.39±3.41	0.18
AST (mg/dl)	21.62±8.99	23.05±15.65	0.19
ALT (mg/dl)	20.10±16.1	23.05±15.65	0.2
ALP (mg/dl)	208.18±67.87	216.21±52.67	0.3
CPK (mg/dl)	121.84±67.87	123.12±100.67	0.91
	TBS and BMD scores		
TBS T-score	**-0.21±0.87**	**-0.58±0.92**	**0.007**
Lumbar T-score	-0.49±1.07	-0.53±1.24	0.83
Lumbar Z-score	-0.22±1.13	-0.098±1.3	0.52
Neck of Femur T-score	-0.27±.0.9	-0.62±0.91	0.011
Neck of Femur Z-score	0.13±0.92	-0.16±0.85	0.042
Total Femur T-score	-0.18±0.78	-0.47±0.78	0.016
Total Femur Z-score	.0.91±0.84	-0.17±0.82	0.056
Radius T-score	-0.86±0.96	-1.19±0.79	0.017
Radius Z-score	-0.52±1.02	-0.7±0.85	0.260

WC, waist circumference; HC, hip circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TG, triglycerides; TC, total cholesterol; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; Cr, creatinine; BUN, blood urine nitrogen; hs-CRP, high sensitive C reactive protein; AST, aspartate aminotransferase; ALT, alanine transaminase; ALP, alkaline phosphatase; CPK, Creatine phosphokinase, TBS, trabecular bone score; BMD, bone mineral density

Table 2 illustrates the relation between high and low levels of MetS components and lipids with lumbar TBS and BMD scores and in subjects with normal weight. Participants with TG≥150 mg/dl, TBS-T score, neck of femur T/Z scores, total femur T/Z scores, and radius T-score were lower (p value<0.05). TG more than 150 mg/dl was not associated with scores of other skeletal sites.

Levels of HDL-C was related to none of the scores related to lumbar, neck of femur, total femur, and radius as well as, TBST-score of subjects with normal weight as P value is more than 0.05 for all association. Subjects with FBG equal or greater than 100 mg/dl were reported to have lower TBST-score (P< 0.05) and remained scores didn't have any correlation with FBG levels. In normal weight subjects with BP including SBP≥130mmHg and DBP≥85mmHg, TBS T-score, and lumbar T-score were decreased (P< 0.05) and amounts of BP were not associated with other scores. LDL-C≥160 mg/dl in subjects with normal weight were correlated with bone indexes by lowering just TBST-score, neck of femur Z score, and total femur T/Z scores (all P < 0.05) and didn't associated with other scores (Table 2).

Normal weight subjects with cholesterol≥200 mg/dl reported to have lower TBST-score, neck of femur T/Z scores, and total femur T/Z scores (P < 0.05 for all associations). Total cholesterol was not linked with other scores.

Correlations between bone indexes and lipid profile, FBG, SBP, and DBP in normal weight subjects were shown in Table 3. Increase in levels of serum cholesterol, TG, FBG, LDL-C, SBP, and DBP were reported to reduce TBST-score (all P< 0.05). High SBP and DBP was related to lumbar T-score decrease and amounts of other components were not linked with this score. On the other hand, just higher rates of FBG and HDL-C associated with reduction in lumbar Z-score (both P < 0.05).

Neck of femur T-score decrease was associated with higher levels of cholesterol, TG, LDL-C, and SBP whereas, reduction in neck of femur Z-score was just significantly associated with higher levels of cholesterol and LDL-C (all P< 0.05).

Increment of cholesterol and LDL-C levels was related to the decrease of total femur T/Z scores (P<0.05 for all correlation). Radius T-score was negatively associated with levels of cholesterol, TG and LDL-C (all P < 0.05). Conversely, none of the MetS components were correlated with radius Z-score.

Table 2: TBS and BMD scores and TG, TC, HDL-C, Blood pressure, FBG, LDL-C and total cholesterol in normal weight subjects

	TBS T-score	Lumbar T-score	Lumbar Z-score	Neck of Femur T-score	Neck of Femur Z-score	Total Femur T-score	Total Femur Z-score	Radius T-score	Radius Z-score
Triglyceride									
TG<150	-0.21±0.89	-0.44±1.03	-0.15±1.09	-0.23±0.89	0.20±0.87	-0.16±0.76	0.15±0.78	-0.88±0.93	-0.50±0.97
TG≥150	-0.61±0.90	-0.64±1.32	-0.22±1.38	-0.73±0.89	-0.29±0.88	-0.54±0.82	-0.29±0.86	-1.19±0.87	-0.76±0. 94
P value	0.003	0.830	0.720	<0.001	<0.001	<0.002	<0.001	0.032	0.120
HDL-C									
HDL-C≥40 in male & ≥50 in female	-0.38±0.93	-0.63±1.18	-0.33±1.06	-0.44±0.87	-0.05±0.84	-0.31±0.79	-0.05±0.83	-0.93±0.99	-0.59±1.015
HDL-C<40 in male & <50 in female	-0.32±0.89	-0.34±1.06	0.02±1.15	-0.36±.99	0.09±0.98	-0.27±0.82	0.03±0.86	-1.07±0.80	-0.61±0.90
P value	0.610	0.120	0.079	0.550	0.310	0.690	0.530	0.290	0.910
FBG									
FBG<100	-0.26±0.86	-0.46±1.05	-0.19±1.15	-0.35±0.97	0.01±0.98	0.01±0.98	-0.01±0.89	-0.92±0.91	-0.58±0.99
FBG≥100	-0.54±0.98	-0.61±1.30	-0.13±1.34	-0.52±0.83	-0.01±0.73	-0.01±0.73	-0.04±0.74	-1.13±0.91	-0.63±0.89
P value	0.049	0.370	0.770	0.200	0.840	0.840	0.810	0.150	0.760
Blood pressure									
SBP>=130 or DBP≥85	-0.22±0.87	-0.42±1.16	-0.14±1.18	-0.37±0.92	0.01±0.92	-0.28±0.80	-0.05±0.84	-0.96±0.96	-0.65±1.02
SBP <130 or DBP<85	-0.62±0.99	-0.80±1.03	-0.29±1.22	-0.49±0.91	0.03±0.88	-0.35±0.79	0.03±0.84	-1.11±0.81	-0.53±0.80
p-value	0.007	0.04	0.5	0.4	0.9	0.65	0.61	0.31	0.5
LDL-C									
LDL-C<160	-0.31±0.91	-0.52±1.08	-0.19±1.15	-0.38±0.92	0.05±0.91	-0.26±0.80	0.02±0.85	-0.96±0.89	-0.57±0.96
LDL-C≥160	-0.91±0.83	-0.44±1.80	0.07±1.86	-0.85±0.83	-0.51±0.63	-0.70±0.67	-0.51±0.49	-1.45±1.09	-1.02±0.87
P value	0.023	0.81	0.51	0.077	0.05	0.05	0.05	0.64	0.19
Cholesterol									
TC<200	-0.24±0.92	-0.44±1.06	-0.08±1.16	-0.22±0.91	0.22±0.93	-0.16±0.74	0.18±0.81	-0.88±0.87	-0.51±0.93
TC≥200	-0.51±0.88	-0.61±1.23	-0.30±1.26	-0.65±0.88	-0.26±0.80	-0.46±0.84	-0.26±0.82	-1.14±0.96	-0.71±0.99
P value	0.04	0.31	0.26	0.001	0.001	0.011	0.001	0.065	0.19

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TG, triglycerides; TC, total cholesterol; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; TBS, trabecular bone score; BMD, bone mineral density

Table 3: Correlations between bone indexes and lipid profile, FBG, SBP and DBP in normal weight subjects

		TBS T-score	Lumbar T-score	Lumbar Z-score	Neck of Femur T-score	Neck of Femur Z-score	Total Femur T-score	Total Femur Z-score	Radius T-score	Radius Z-score
Cholesterol	r	-.210	-.122	-.074	-.297	-.312	-.237	-.258	-.175	-.120
	p	.004	.096	.362	.000	.000	.001	.001	.019	.150
Triglyceride	**r**	-.143	-.063	-.060	-.155	-.152	-.114	-.128	-.160	-.141
	p	.049	.392	.464	.035	.062	.123	.118	.032	.090
FBG	**r**	-.154	-.081	.008	-.124	-.040	-.101	-.062	-.139	-.059
	p	.034	.273	.924	.092	.627	.173	.448	.062	.480

HDL-C	r	.050	-.019	.034	-.076	-.086	-.094	-.092	.059	.053
	p	.497	.793	.677	.306	.294	.205	.261	.429	.527
LDL-C	r	-.229	-.120	-.081	-.251	-.271	-.202	-.216	-.169	-.117
	p	.002	.103	.322	.001	.001	.006	.008	.023	.159
SBP	r	-.285	-.165	-.055	-.153	-.058	-.100	-.013	-.013	.091
	p	.000	.027	.512	.042	.491	.188	.876	.860	.282
DBP	r	-.187	-.166	-.109	-.135	-.070	-.092	-.027	-.050	.019
	p	.012	.027	.190	.072	.406	.225	.751	.508	.824

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TG, triglycerides; TC, total cholesterol; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; TBS, trabecular bone score; BMD, bone mineral density

Risk of decreased bone indexes adjusted for age and sex has been shown in Figure 1.

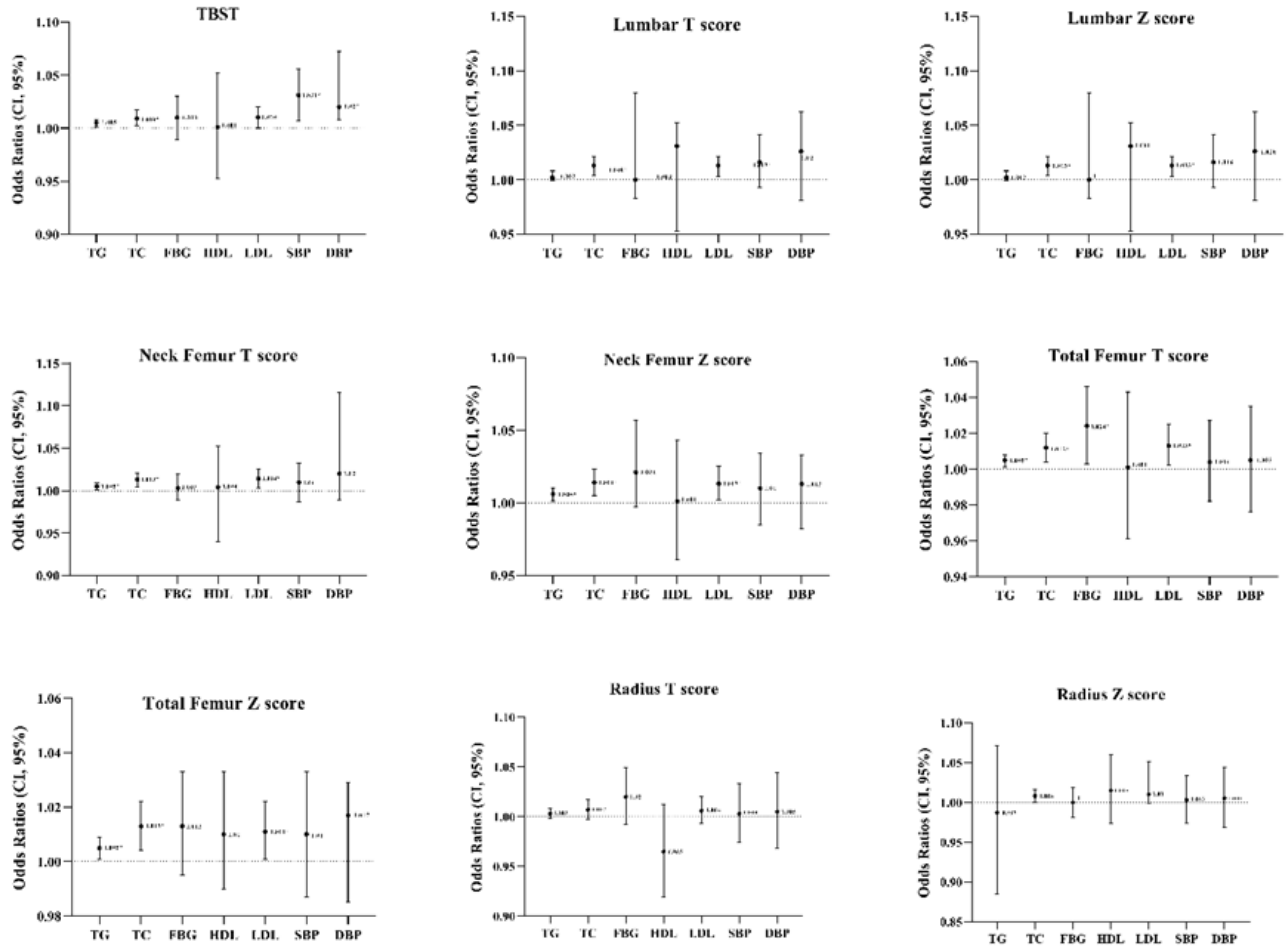

Fig 1 Risk of reduced TBS T-score and BMD T/Z-scores based on metabolic syndrome components and serum lipids in normal weight (NW) subjects. Reference value for TBST ≥ 0.4-, Lumbar T score ≥ 0.5-, Lumbar Z score ≥ 0.2-, Neck femur T score ≥ 0.5-, Neck femur Z score ≥ 0.1, Total femur T score ≥ 0.1, Total femur Z score ≥ 0.1, Radius T score ≥ 0.1-, Radius Z score ≥ 0.6-. Adjusted odds ratios (%95 CI) were calculated using logistic regression (data adjusted for age and sex). * p<0.05

Discussion

This study of 201 normal-weight subjects, including 75 and 126 people with and without MetS. MetS was associated with diminution of bone indexes including TBS T-score and BMD at various skeletal sites. Decrease in the TBS T-score were more consistently correlated with attenuated bone indexes in subjects with MetS in comparison to those without MetS. Total femur T-score and neck of femur T-score were also decreased substantially, which indicated the negative relation between MetS and TBS and BMD scores. However, neck Femur Z-score and Total Femur Z-score had a lower rate of mean reduction but radius T-score has devoted the least of mean reduction to its self, indicating the tiny relation of MetS on radius BMD score.

In contrast to our results, a meta-analysis conducted by Esposito et al. in 2013, revealed that the MetS were not linked with bone health deterioration but also, can provide some protection against osteopenia. However, its positive effects are wavering and need further investigations to use in clinical implications. The rate of fracture risk was reported to be lower among obese subjects due to the protective impact of fat padding around bone structures, higher level of 17-β-estradiol, and more mechanical load whereas, visceral fat accumulation could be the reason for higher bone resorption and lower BMD due to its higher levels of pro-inflammatory cytokines (17).

Some other surveys pointed out the low bone mass as a result of central obesity. In another meta-analysis by Xue et al. in 2012, general relation of MetS with betterment of spine BMD and no significant link with FN BMD was shown (18). But, results of that meta-analysis could be affected by confounders like body size or BMI because of unadjusted BMD usage. In this way, influence of BMI on BMD was ignored. In our study all the subjects were with normal weight but abdominal adiposity, and the results acquired were based on these kinds of subjects. Based on Romagnoli et al. report in 2016, it was shown that abdominal adiposity negatively affected values of TBS in men with obesity. Besides, an increase of BMI in men with similar mean age caused a diminution of TBS but total hip BMD increased and lumbar spine BMD were not changed (19). In Korean postmenopausal women, metabolic syndrome was associated with higher BMD. Higher HDL-C amounts also reported to be negatively related to lumbar spine BMD and femur neck (20). MetS presence were significantly linked with bone loss decrease across the lumbar spine and different proximal femur and this attenuation also increased by more MetS components (21).

Considering the influence of different components of MetS on normal weight subjects bone health with abdominal adiposity in the present study, high levels of TG was found to be associated with bone health reduction as there is a decrease in all the TBS T-score and BMD at various bone structural sites specifically at the neck of femur and total femur. Chang et al. study in 2016, shown that high fasting plasma TG in midlife women was the reason for 2-2.5 folds greater nontraumatic fracture risk after checking for confounding factors. Greater mean marrow fat (lipid-water ratio), which is significantly composed of TG, was seen in women with vertebral fracture than women without vertebral fracture (22).

However, another study in 2013 by Kim et al. revealed the role of higher TG levels as a protective factor against latter bone detriment at all proximal femur sites independently. It said that they exert their protective role by mediating interaction between bone minerals and protein matrix (21). TG effect on BMD was also studied and results indicated that the higher TG levels caused greater lumbar spine and femoral neck areal BMDs in elderly women notwithstanding, higher TG levels was the reason for higher femoral neck areal BMDs in elderly men (23).

Based on the results, low HDL-C, a feature of MetS didn't have any association with bone mineral density of both men and women with normal weight and abdominal adiposity. In parallel to our results, another study reported a faint linkage among HDL-C and BMD, though there was an inverse report in study of Chinese postmenopausal women, which indicated that the higher rate of HDL-C caused a rise in risk of being osteoporosis. Besides, BMD was lower at the total hip and femoral neck of those with higher HDL-C level in comparison to those with lower rates (24, 25). Studies including the relationship between HDL-C and BMD are contradicting and there is not a known mechanism for these associations (26).

FBG different rates doesn't affect bone health except TBS T-score. FBG amounts equal to or higher than 100 can be a factor that relate to bone loss as there was a significant decrease in TBS T-score, a marker defining risk of bone fracture. a survey done by Holloway et al in 2018, delineated that in their study men and women of all ages with diabetes contained less mean TBS in comparison with subjects with normoglycemia (27).

Ho-Pham et al. in 2012, pointed out the lower TBS in patients with type 2 diabetes than in individuals without diabetes. However, there is a higher areal BMD in subjects with diabetes like the results of a survey that illustrated higher lumbar spine BMD in obese and non-obese postmenopausal women and higher femoral neck BMD in obese postmenopausal women with diabetes but, with considering TBS, risk of fracture increased (28,29).

On the other hand, it was shown that men with high fasting plasma glucose were at a lower risk of

hospitalized fracture (30). Elevated BP including SBP and DBP significantly affected the lumbar T-score and TBS T-score specifically the latter one, so it can be a factor that influence bone health and play a role in the elevation of fracture risk. In study of middle-aged and elderly Taiwanese participants, it was illustrated that high BP was related to lower osteoporosis in men and rather osteoporosis in women but after adjusting with confounding factors like age, mentioned associations were vanished (31).

Based on the results, higher amount of LDL-C was related with the worsened condition of bone health as there was reduction in the TBS T-score, both scores of femoral neck and Z-score of total femur.

In a survey of elderly Iranian individuals, significant but a feeble relationship between lipid profile and areal bone mineral density was shown. Linkage between TG level and femoral neck areal BMD, HDL-C level and lumbar spine and femoral neck areal BMDs was significantly positive in both men and women. Moreover, lower TBS and lumbar spine areal BMDs was seen in elderly men with higher LDL-C levels though, lower femoral neck and lumbar spine areal BMD and not TBS were seen in elderly women with higher HDL-C (23).

Elevation in total cholesterol was shown to be significantly related to decrease of TBS T-score and T/Z scores of femur sites, acting as an agent that mediating bone loss. In a study total cholesterol level in postmenopausal women considered as a risk factor for osteoporosis independently (32).

Conclusion

Our study demonstrated that for some of the components of the MetS such as LDL-C, mostly correlated with decrease bone indexes of normal-weight subjects with abdominal adiposity. Higher rates of other components like TG, SBP, DBP, and LDL-C correlated with lesser harmful effects on bone health of the same subjects. TBST-score is the one that, elevation in most of the MetS components associated with negative effects on.

MetS related with the most bone health loss at neck of femur. It was less associated with negative effects on lumbar and total femur and the least bone loss at radius.

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Conflict of interest

No potential conflicts of interest were disclosed.

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