Original Article

Positive Correlation of Serum Adiponectin with Lipid Profile in Patients with Type 2 Diabetes Mellitus is Affected by Metabolic Syndrome Status

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Abstract

Background: Type-2 diabetes mellitus (DM) and Metabolic syndrome (MetS) are both associated with dyslipidemia which may lead to development of vascular complications. Adiponectin is an anti-inflammatory protein synthesized by the adipose tissue. There is controversy regarding the association of adiponectin with lipid profile.

Aim: To evaluate the correlation between serum adiponectin concentration and metabolic profile in patients with type-2 DM.

Methods: A single center cross-sectional study was conducted on 173 patients with type-2 DM (82 males and 91 females). Plasma adiponectin concentration, lipid profile, glucose profile, and anthropometric features were investigated. Insulin resistance was determined using Homeostasis model assessment (HOMA). Correlation of serum adiponectin with lipid profile of patients with type-2 DM was assessed.

Results: Adiponectin was negatively correlated with waist circumference (r = -0.16, *P* = 0.06) and positively with HbA1c (r = 0.19, *P* = 0.032), total cholesterol (r = 0.23, *P* = 0.017), LDL (r = 0.30, *P* = 0.001), SD-LDL (r = 0.41, *P* < 0.001), and SD-LDL/LDL (r = 0.22, *P* = 0.023). We found a positive correlation between adiponectin and total cholesterol (r = 0.27, *P* = 0.055), LDL (r = 0.34, *P* = 0.026) and SD-LDL (r = 0.41, *P* = 0.006) in patients with at least 3 components of MetS criteria. Correlation of adiponectin with LDL and SD-LDL remained positively significant with increasing the number of MetS components. In patients with 5 components of MetS, serum adiponectin was significantly correlated with serum triglyceride (r = 0.89). Significant interaction was observed between adiponectin and metabolic syndrome in relation to serum lipid profile.

Conclusion: The results of the present study suggest that in patients with type-2 DM and MetS, lipid profile is strongly correlated with blood concentration of adiponectin. The strongest association was observed between serum adiponectin and LDL.

Keywords: Adiponectin, lipid profile, metabolic syndrome

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Introduction

Dyslipidemia is well known as a major risk factor of the metabolic syndrome (MetS) and type-2 DM (DM). It is also a risk factor of vascular complications in patients with MetS and type-2 DM.[1] In addition to its role as energy storage, the adipose tissue secretes various hormonal peptides named adipokines. These peptides play an important role in regulation of energy homeostasis, insulin sensitivity, atherogenic properties and inflammation.[2] Adiponectin, the most abundant adipokine, has been known for its anti-inflammatory and anti-atherogenic effects. Moreover, hypoadiponectinemia has been reported in association with obesity and other obesity-related diseases conditions or diseases like MetS and type-2 DM[3] as well as complications of type-2 DM.[4]

Some studies have demonstrated a decrease in the plasma concentration of adiponectin in the presence of acute cardiovascular disease, albeit to a lesser extent than in chronic cardiovascular conditions such as chronic heart failure (CHF).[5,6] In contrast, some authors suggest that increased plasma level of adiponectin may be associated with a worse prognosis of CHF.[7] Adiponectin may act through modulation of lipid metabolism. Moreover, some studies suggest that the size of lipoprotein particles is associated with the serum concentration of adiponectin.[8,9]

Previous studies have invetigated the association of serum adiponectin with lipid profile in healthy controls or those with MetS.[8] Since MetS and type-2 DM are two close obesity-related disorders, it is expected that adiponectin might be associated with lipid profile of patients with type-2 DM, as well. MetS *per se* is also a risk factor for type-2 DM development and may affect the association of adiponectin with lipid profile in patients with type-2 DM.

This study is aimed at investigating the relationship between plasma concentration of adiponectin and metabolic profile in patients with type-2 DM with different MetS statuses. Here, the probable effect of the components of the metabolic syndrome on this relationship will be also discussed.

Patients and Methods

Patients

This cross-sectional study was conducted between February 2013 and February 2014 on 173 patients with type-2 DM (82

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males and 91 females) who were recruited from endocrine outpatient clinics affiliated with Tehran University of Medical Sciences. The study protocol was approved by the ethics committee of Tehran University of Medical Sciences. The aim and protocol of the study were explained to the participants and written informed consents were obtained.

Definitions

Type-2 DM was defined according to the criteria provided by the American Diabetes Association[10]: (1) glycated hemoglobin (HbA1C) ≥ 6.5%, or (2) fasting plasma glucose (FPG) ≥ 126 mg/dL, or (3) 2 hr plasma glucose (2HPP) ≥ 200 mg/dL during an oral glucose tolerance test (OGTT).

In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥ 200 mg/dL (11.1 mmol/L) was diagnostic for type-2 DM, as well. In the absence of unequivocal hyperglycemia, criteria 1–3 must be confirmed by repeat testing.

Diagnosis of MetS was made according to the modified International Diabetes Federation (IDF) definition of MetS with presence of at least 3 of the following[11]: (1) Abdominal obesity with waist circumference of more than 90 cm, (2) Elevated serum triglyceride (TG) ≥ 150 mg/dL, (3) Low high density lipoprotein (HDL) cholesterol (Men < 40 mg/dL, Women < 50 mg/dL), (4) Elevated blood pressure ≥130 / ≥85 mm Hg and/or use of anti-hypertensive medications, (5) Elevated FPG ≥ 110 mg/dL

Laboratory investigations

Venous blood samples were drawn from all participants after 12 hours of overnight fasting. The blood concentrations of fasting plasma glucose, HbA1C, 2HPP, Insulin, TG, total cholesterol, low density lipoprotein (LDL), HDL, small-dense LDL (sd-LDL) and Adiponectin were measured. Glucose oxidize method was used to determine glucose levels. We obtained serum concentration of TG, total cholesterol, LDL and HDL by enzymatic methods (Parsazmun, Karaj, Iran). High performance liquid chromatography (HPLC) was used for measurement of HBA1c. Serum levels of insulin were measured with the immunoradiometric assay kit (Immunotec IRMA, Prague, Czech Republic). Plasma concentrations of adiponectin were obtained using an ELISA kit (Biovendor, Brno, Czech Republic). Sd-LDL concentrations were determined by enzymatic method (Denka Seiken, Tokyo, Japan).

Insulin resistance was measured by Homeostasis Model Assessment for Insulin Resistance (HOMA-IR) which was calculated as fasting serum insulin (μIU/mL) × fasting glucose (mg/dL)/ 405 [34]. The ratio of sd-LDL/LDL was calculated as measured sd-LDL (mg/dL)/ LDL (mg/dL) [32].

Anthropometric measurements

Weight, height, hip circumference (at the level of the greater trochanters in a standing position) and waist circumference (at the level of the umbilicus in a standing position) were measured. The measurements were repeated by two different trained nurses using the same device and mean value was recorded. Body mass index (BMI) was calculated as the ratio of weight (kg) to the square of height in meters.

After resting for 10 minutes in a sitting position, systolic and diastolic blood pressures were measured twice by the same two investigators using the same manual sphygmomanometer for all cases. Mean blood pressures of two measurements were recorded. Hypertension was defined as use of antihypertensive medication or mean systolic blood pressure above 130 mmHg and mean diastolic blood pressure more than 85 mmHg without use of any antihypertensive medication.

Statistical analysis

All statistical analyses were performed using SPSS software package version 17 for windows (SPSS Inc, Chicago, IL). Data are expressed as mean ± standard deviation. Statistical significance was defined by a P value <0.05. Independent samples t-test was used to evaluate the differences in quantitative variable between two groups. ANOVA was performed to evaluate the differences in quantitative variable between three groups or more which was followed by a *post-hoc* test to evaluate this finding between groups one on one. Pearson's correlation coefficients were calculated to investigate the correlation of adiponectin with anthropometric and metabolic variables. To identify the relation between adiponectin and components of lipid profile, linear regression analysis was performed with adjustment for sex, age, and BMI. The results are presented stratified on the basis of presence of components of metabolic syndrome.

Results

This study comprised 173 patients with type-2 DM (82 males and 91 females) with a mean age of 52.94 ± 9.57 years and mean BMI of 30.42 ± 4.88 kg/m^2. Among patients with type-2 DM, 38 (21.9%) had fewer than 3 components of MetS, while 51 (29.4%), 69 (39.8%) and 15 (8.6%) had 3, 4 and 5 components of MetS, respectively. The patients' characteristics are presented in Table 1.

Adiponectin was correlated with HbA1c (r = 0.19, P = 0.032), total cholesterol (r = 0. 21, P = 0.017), LDL (r = 0.28, P = 0.001), SD-LDL (r = 0.38, P < 0.001) and SD-LDL/LDL (r = 0.20, P = 0.023) in patients with type-2 DM. After adjusting for sex, adiponectin level was correlated with the blood concentration of LDL (r = 0.30, P = 0.021) in men and with LDL (r = 0. 26, P = 0.024), SD-LDL (r = 0.51, P < 0.001), SD-LDL/LDL (r = 0.34, P = 0.003) and HbA1c (r = 0.25, P = 0.032) in women. To understand the relationship between the above mentioned metabolic traits, we used liner regression analysis which showed that adiponectin was associated with LDL (β=0.043, 95% confidence interval (CI) = 0.007–0.079), total cholesterol (β = 0.021, 95% CI = -0.004–0.045) in men and LDL (β = 0.035, 95% CI = 0.005–0.066) , SD-LDL (β = 0.110, 95% CI = 0.067–0.153), SD-LDL/LDL (β = 9.34, 95% CI = 3.44–15.46), HbA1c (β = 0.754, 95% CI = 0.066–1.44) and negatively with waist circumference (β = -0.125, 95% CI = -0.255–0.004) in women. However, linear regression before adjusting for sex showed β = 0.039 and 95% confidence interval of 0.016 to 0.061 for LDL in association with adiponectin. Table 2 shows correlations between adiponectin and various clinical and laboratory findings in male and female patients.

After stratification based on MetS components, we found a positive correlation between adiponectin and total cholesterol (r = 0.27, P = 0.055), LDL (r = 0.32, P = 0.026) and SD-LDL (r = 0.38, P = 0.006) in patients with 3 clinical criteria of the metabolic syndrome. Using linear regression analysis, adiponectin was associated with LDL (β = 0.039, 95% CI = 0.005–0.074), total cholesterol (β = 0.026, 95% C.I = 0.000–0.053) and SD-LDL (β = 0.078, 95% CI = 0.024–0.132). In patients with 4 clinical criteria of MetS, adiponectin was significantly correlated with LDL

Table 1. Clinical and laboratory characteristics of the study population.

Variables	All participants (173)	Participants without MetS (38)	Participants with MetS (135)
Age (yr)	52.95 ± 9.57	56.26 ± 9.30	52.92 ± 9.60
Weight (kg)	77.82 ± 11.24	69.46 ± 11.34	77.83 ± 11.27
Height (cm)	160.34 ± 8.58	161.50 ± 8.75	160.30 ± 8.59
WC (cm)	100.25 ± 8.53	91.22 ± 8.21	100.24 ± 8.58
HC (cm)	106.93 ± 9.23	100.42 ± 6.90	106.98 ± 9.24
BMI (kg/m^2)	30.424 ± 4.88	26.57 ± 3.43	30.44 ± 4.89
SBP (mmHg)	128.01 ± 16.97	119.07 ± 12.40	128.0 ± 17.02
DBP (mmHg)	80.07 ± 9.25	76.84 ± 7.74	80.07 ± 9.28
FBS (mg/dL)	170.18 ± 58.46	157.21 ± 56.88	170.34 ± 58.64
2HPP (mg/dL)	238.01 ± 88.24	208.48 ± 97.55	239.74 ± 86.20
HbA1c (%)	7.24 ± 1.63	6.91 ± 1.53	7.25 ± 1.62
HOMA-IR	4.26 ± 2.82	2.44 ± 1.29	4.24 ± 2.82
Insulin (μIU/mL)	10.45 ± 5.99	6.67 ± 3.50	10.38 ± 5.96
TG (mg/dL)	242.31 ± 167.82	119.86 ± 42.57	243.31 ± 168.03
TC (mg/dL)	195.74 ± 49.55	173.52 ± 37.56	196.21 ± 49.43
HDL (mg/dL)	41.77 ± 8.85	50.84 ± 14.36	41.86 ± 8.81
LDL (mg/dL)	109.86 ± 35.35	99.92 ± 36.30	110.06 ± 35.40
sd-LDL (mg/dL)	31.12 ± 21.95	33.15 ± 18.81	31.10 ± 22.02
sd-LDL/LDL	0.29 ± 0.19	0.34 ± 0.17	0.29 ± 0.18
Adiponectin (μg/mL)	7.33 ± 4.87	10.52 ± 5.68	7.35 ± 4.87

WC = waist circumference; HC = hip circumference; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; FBS = fasting blood sugar; 2HPP = 2 hours postprandial glucose; HbA1c = hemoglobin A1c; HOMA-IR = homeostasis model assessment of insulin resistance; TG = triglyceride; TC = total cholesterol; HDL = high-density lipoprotein; LDL = low density lipoprotein; BMI = body mass index; sd-LDL = small dense LDL, MetS = metabolic syndrome.

Table 2. Correlations between Adiponectin and various clinical and laboratory findings in male and female patients.

	All participants with Type-2 DM		Male participants with Type-2 DM		Female participants with Type-2 DM	
	r	*P*-value	r	*P*-value	r	*P*-value
Age (yr)	-0.121	0.163	-0.158	0.223	-0.084	0.476
Weight (kg)	-0.057	0.512	-0.091	0.487	-0.016	0.894
Height (cm)	-0.003	0.971	0.066	0.615	0.100	0.396
WC (cm)	-0.160	0.063	-0.076	0.561	-0.222	0.058
HC (cm)	0.006	0.949	-0.048	0.715	-0.025	0.832
BMI (kg/m^2)	-0.047	0.590	-0.135	0.301	-0.059	0.620
SBP (mmHg)	-0.047	0.586	0.005	0.969	-0.078	0.511
DBP (mmHg)	0.000	0.997	0.165	0.204	-0.111	0.347
FBS (mg/dL)	0.083	0.338	0.044	0.736	0.132	0.263
2HPP (mg/dL)	0.063	0.469	0.033	0.802	0.099	0.402
HbA1c (%)	0.186	0.032	0.109	0.407	0.253	0.032
HOMA-IR	0.047	0.593	0.061	0.645	0.054	0.653
Insulin (μIU/mL)	-0.016	0.854	0.041	0.757	-0.063	0.595
TG (mg/dL)	0.048	0.579	0.031	0.814	0.080	0.498
TC (mg/dL)	0.206	0.017	0.216	0.095	0.189	0.108
HDL (mg/dL)	0.151	0.080	0.101	0.439	0.164	0.162
LDL (mg/dL)	0.282	0.001	0.294	0.021	0.262	0.024
sd-LDL (mg/dL)	0.196	0.000	0.155	0.234	0.514	0.000
sd-LDL/LDL	0.047	0.023	0.021	0.872	0.345	0.003

WC = waist circumference; HC = hip circumference; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; type-2 DM = diabetes mellitus type 2; FBS = fasting blood sugar; 2HPP = 2 hours postprandial glucose; HbA1c = glycated hemoglobin A1c; HOMA-IR = homeostasis model assessment of insulin resistance; MetS = metabolic syndrome; TG = triglyceride; TC = total cholesterol; HDL = high-density lipoprotein; LDL = low density lipoprotein; BMI = body mass index; sd-LDL = small dense LDL.

Table 3. Correlations between Adiponectin and various clinical and laboratory findings in order of the increasing number of MetS components.

	Patients with less than 3 components of the MetS (n=38)		Patients with 3 components of the MetS criteria (n = 51)		Patients with 4components of the MetS criteria (n = 69)		Patients with 5components of the MetS criteria (n = 15)	
	r	*P*-value	r	*P*-value	r	*P*-value	r	*P*-value
Age (yr)	-0.064	0.702	0.036	0.800	0.204	0.093	0.504	0.056
Weight (kg)	-0.214	0.197	0.132	0.357	0.036	0.772	0.256	0.357
Height (cm)	-0.074	0.657	0.176	0.215	0.156	0.201	0.058	0.837
WC (cm)	-0.383	0.018	0.224	0.115	0.115	0.346	0.269	0.332
HC (cm)	-0.160	0.338	0.016	0.909	0.045	0.712	0.190	0.498
BMI (kg/m²)	-0.333	0.041	0.001	0.997	0.087	0.479	0.358	0.190
SBP (mmHg)	-0.022	0.897	0.126	0.379	0.102	0.405	0.045	0.873
DBP (mmHg)	-0.014	0.933	0.074	0.607	0.003	0.979	0.069	0.806
FBS (mg/dL)	-0.031	0.855	0.074	0.604	0.125	0.305	0.053	0.850
2HPP (mg/dL)	-0.118	0.480	0.024	0.866	0.096	0.431	0.128	0.650
HbA1c (%)	0.012	0.943	0.306	0.032	0.177	0.148	0.122	0.665
HOMA-IR	-0.053	0.750	0.072	0.622	0.145	0.241	0.108	0.702
Insulin (µIU/mL)	-0.085	0.613	0.158	0.274	0.091	0.464	0.074	0.793
TG (mg/dL)	0.100	0.549	0.075	0.599	0.039	0.748	0.709	0.003
TC (mg/dL)	0.206	0.216	0.270	0.055	0.129	0.291	0.519	0.048
HDL (mg/dL)	0.045	0.789	0.170	0.233	0.010	0.934	0.082	0.771
LDL (mg/dL)	0.289	0.078	0.312	0.026	0.261	0.030	0.550	0.034
sd-LDL (mg/dL)	0.124	0.458	0.383	0.006	0.368	0.002	0.286	0.302
sd-LDL/LDL	-0.117	0.489	0.191	0.179	0.214	0.078	0.016	0.955

WC = waist circumference; HC = hip circumference; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure; type-2 DM = diabetes mellitus type 2; FBS = fasting blood sugar; 2HPP = 2 hours postprandial glucose; HbA1c = glycated hemoglobin A1c; HOMA-IR = homeostasis model assessment of insulin resistance; MetS, metabolic syndrome; TG = triglyceride; TC = total cholesterol; HDL = high-density lipoprotein; LDL = low density lipoprotein; BMI = body mass index; sd-LDL = small dense LDL.

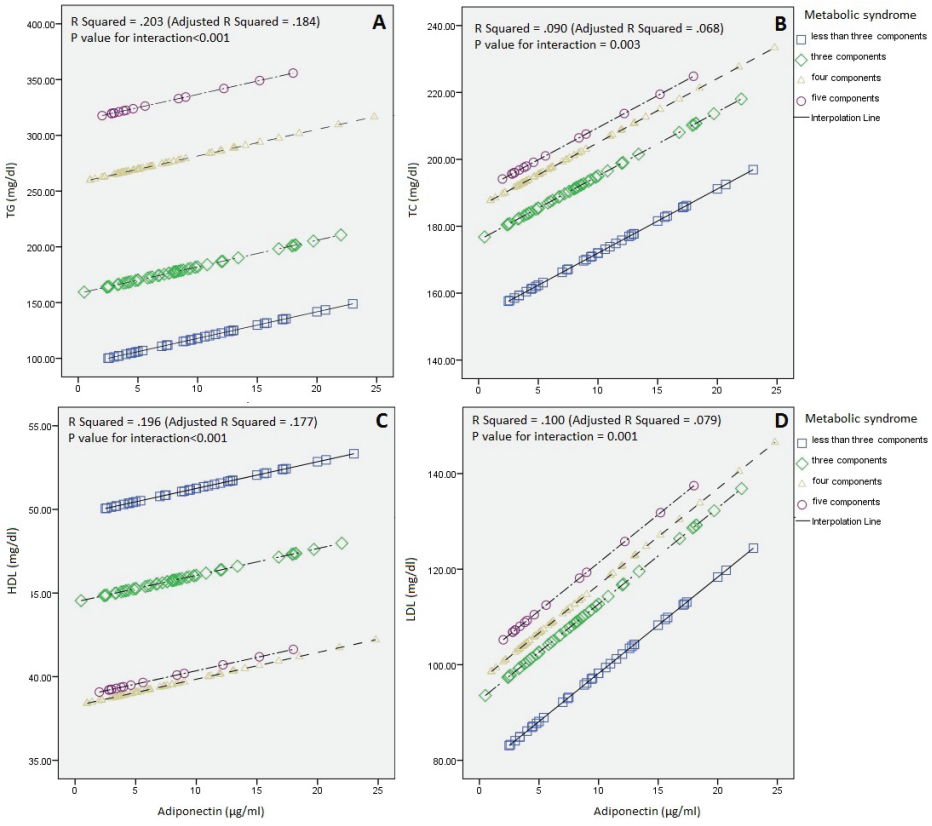

Figure 1. serum adiponection is positively correlated with triglyceride (TG), total cholesterol (TC), low density lipoprotein (LDL), and high density lipoprotein (HDL). The strongest association was observed between adiponectin and LDL. **A)** Serum adiponection is positively correlated with TG, and there is significant interaction between adiponection and metabolic syndrome in association with serum TG. **B)** Serum adiponection is positively correlated with TC and there is significant interaction between adiponection and metabolic syndrome in association with serum TC. **C)** Serum adiponection is positively correlated with HDL and there is significant interaction between adiponection and metabolic syndrome in association with serum HDL. **D)** Serum adiponection is positively correlated with LDL and there is significant interaction between adiponection and metabolic syndrome in association with serum LDL.

(r=0.26, $P = 0.030$) and SD-LDL (r = 0.37, $P = 0.002$). Linear regression analysis showed positive association of adiponectin with LDL (β = 0.037, 95% CI = 0.004–0.69) and SD-LDL (β = 0.088, 95% CI = 0.034–0.142). In patients fulfilling all 5 clinical criteria of the MetS, adiponectin was still correlated with LDL (r = 0.55, $P = 0.034$), total cholesterol (r = 0.52, $P = 0.048$) and also with TG (r = 0.70, $P = 0.003$). In the linear regression model, adiponectin was associated with LDL (β = 0.130, 95% CI=0.012–0.248), total cholesterol (β = 0.066, 95% CI = 0.001–0.131) and TG (β = 0.017, 95% CI = 0.007–0.027). Table 3 shows correlations between adiponectin and various clinical and laboratory findings in order of the increasing number of MetS criteria. Generalized linear modeling revealed significant interaction between serum adiponectin and metabolic syndrome status in relation to serum lipid profile (Figure 1). The strongest association was observed between serum adiponectin and LDL both unadjusted and after adjustment for metabolic syndrome as shown in Figure 1D.

Discussion

The results of the present study, performed on patients with type-2 DM, results that adiponectin level has a direct relation with total cholesterol, LDL and SD-LDL only in patients with more than 3 components of MetS. Such relationships might corroborate the effect of central obesity and related metabolic traits with blood concentration of adiponectin.[12,13] One possible explanation might be the reduction of serum adiponectin with increasing waist circumference and other components of obesity.[14,15] A further confirmation might be the down-regulation of adiponectin and also adiponectin receptors (adipoR1 and adipoR2) frequently seen in patients with hypertrophied adipose tissue.[16] Vitamin D deficiency, which is associated with both obesity and adiponectin levels, may also play a role in regulating glucose metabolism and metabolic health in obese individuals.[17,18] The association between the mentioned indices and blood concentration of adiponectin may be influenced by several confounding factors, especially adiposity and related conditions; thus, waist circumference itself can influence other indices and may be directly related to adiponectin level.[19–21] Consistent with findings of the present study that adiponectin has a direct relation with total cholesterol, LDL and SD-LDL only in patients with more than 3 components of MetS.

After adjusting for sex, adiponectin did not have any relation with age or BMI in patients with type-2 DM. This finding is in agreement with other studies which have previously demonstrated that the relation between adiponectin and metabolic syndrome is not affected by age, sex or BMI,[13,22] but less is known about the relation between metabolic traits in these patients. Thus, we also evaluated the relation between adiponectin and metabolic indices in sex-adjusted participants. Our results showed a significant positive correlation between adiponectin and LDL in both genders.

According to our findings, blood concentration of adiponectin decreases with increasing MetS components but no relation between blood level of adiponectin and increasing numbers of the MetS components were found. Increase in number of MetS components resulted in decrease of serum adiponectin concentration.[22,23] Impaired glucose metabolism,[15] inflammation[24] and waist circumference[22,25] in patients with type-2 DM. It may underlie observed differences between the results drawn from patients with MetS and those with type-2 DM and more than 3 components of MetS. In another study, in healthy participants without type-2 DM the blood concentration of the adiponectin was closely related to adiposity.[21]

The decrease in adiponectin concentration seems to be positively correlated with LDL blood level, regardless of sex, age, BMI and or number of MetS criteria fulfilled. The results from linear regression models performed for each group to evaluate the relation between adiponectin and LDL, showed a linear relation between the blood concentration of adiponectin and LDL. These findings are in agreement with the studies that investigated lipids metabolism and associated factors to identify the molecular role of dyslipidemia in the development of MetS, DM and other obesity-related co-morbidities. Some studies have noted that adiponectin blood concentration was positively associated with LDL particle sizes in different groups of participants such as DM, MetS, and healthy participants.[21,26,27] However, after adjusting for BMI, Kazumi *et al.* found no relation between LDL particle sizes and adiponectin.[21] It should be noted that previous studies have not evaluated the mentioned relation in patients with both MetS and type-2 DM. The importance of this issue is that multiple confounding factors may affect lipids metabolism and the outcome of such studies. As shown by the present study, there was no association between lipid profile and adiponectin in patients with type-2 DM who did not fulfill MetS criteria. By evaluating patients with both type-2DM and MetS and also adjusting based on the MetS criteria, we obtained the relation between adiponectin and metabolic indices with regard to the confounding factors and hampering them to affect the results, such as the relation between adiponectin and HDL and its favorable role in cardiovascular disease (CVD) regardless of the underlying disease, as shown previously.[13,14,21,22] Another possible reason is increased residence of smaller LDL particle in blood when insulin resistance increases.[28]

Studies that investigated the relation between adiponectin and small density LDL showed an inverse correlation between adiponectin and sd-LDL. By contrast, we found a significant positive correlation between adiponectin blood level and small density LDL in patients with type-2 DM and MetS. These findings support the statement that adiponectin might mediate its favorable effects on CVD through its correlations with other lipoproteins like low VLDL-TG and high HDL[19,21]; and decreasing the smaller LDL particles might not be the fundamental cause of its relation with CVD.

A few studies have shown that adiponectin blood concentration increases in the presence of microvascular and microvascular complications associated with DM and other obesity-related disorders.[29] Even though several studies have shown that hypoadiponectinemia is associated with acute CVD, a growing number of studies indicate that hyperadiponectinemia is related to cardiac complications, especially heart failure, obesity and related disease like type-2 DM or MetS.[29,30] Some studies also suggested a positive association between Large LDL particles and CVD.[31] We suggest that the linear relation between adiponectin and LDL in our study is presumably because of the different effect of adiponectin on lipid metabolism in the context of severity of metabolic abnormalities.

The present study was cross-sectional, which limited our ability to obtain a causal relationship between lipid metabolism and other metabolic indices with adiponectin blood concentration in patients with MetS and type-2 DM. Another limitation of the present study is the small number of participants with fewer than 3 MetS components and those who fulfilled the MetS criteria.

In conclusion, our results illustrate the linear relation between adiponectin blood concentrations and LDL in patients with both Type-2 DM and MetS after adjusting for sex, age, BMI, components of MetS criteria and other similar confounding factors. Thus, we suggest that adiponectin may not necessarily play a favorable role in lipid metabolism and it might have multiple effects on this metabolic process based on the underlying condition. However, the true effect of the adiponectin on lipid metabolism and their causal relation with each other merits further studies in this context.

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Declaration of interests

The authors declare no conflict of interest.

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