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# The relationship between body mass index, blood pressure, and atherosclerosis risk factors in type 1 and 2 diabetic patients from northwestern Algeria

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**Objective.** The present work was framed to study the relationship between body mass index (BMI), blood pressure, and atherosclerosis risk factors on the basis of three lipid ratios in type 1 (T1D) and type 2 diabetic (T2D) patients.

**Methods.** A prospective, comparative, and cross-sectional study was performed at the level of three health facilities in Sidi-Bel-Abbes city (north-western Algeria). Anthropometric parameters, systolic and diastolic blood pressures, and lipid profiles were assessed in adults T1D and T2D patients over a period of eleven months. Individual atherogenic risk factors were estimated based on lipid ratios in relation to corpulence and hypertension.

**Results.** From the total 237 adult diabetic patients, 90 T1D and 147 T2D ones were involved in the study. Total cholesterol (TC)/high-density lipoprotein (HDL) and triglycerides (TG)/HDL ratios were significantly higher in normal weight T2D comparing to T1D. The TC/HDL ratio was significantly higher (p=0.046) in obese men. Nevertheless, no significant differences were revealed in low-density lipoprotein (LDL)/HDL ratio between T1D and T2D patients. Higher TC/HDL ratios were observed in T2D patients (males and females) with normal blood pressure (systolic blood pressure, SBP ≤13.5 mmHg and diastolic blood pressure, DBP ≤8 mmHg) comparing to T1D patients. Likewise, the LDL/HDL ratio was significantly higher in T2D men with normal DBP (p=0.044).

**Conclusion.** The lipid ratios constitute good indices while managing diabetes. It is also recommended to screen T1D and T2D patients for hypertension, dyslipidemia, and obesity and initiate the management at early stages to prevent the related complications, such as atherosclerosis, as a priority.

**Key words:** atherosclerosis, lipid ratios, overweight/obesity, blood pressure, type 1 diabetes, type 2 diabetes

Diabetes mellitus (DM) is identified as a group of complex of heterogeneous metabolic alterations characterized by high levels of serum glucose (Baena-Diez et al. 2016). The International Diabetes Federation (IDF) has estimated the worldwide incidence of DM people to 451 million in 2017 and expected 693 million by 2045 (Cho et al. 2018).

Type 1 diabetes (T1D) occurs mainly in young population (diagnosed at 30 years of age or younger) and develops after an autoimmune destruction of

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beta cells in the insulin-producing pancreas, which requires an exogenous insulin supply. Type 2 diabetes (T2D) is however a metabolic disease characterized by progressive insulin resistance associated with functional failure of pancreatic beta cells (Huxley et al. 2011; Tadic and Cuspidi 2015). Diabetic people are often in a risk of the thoughtful life-threatening health issues developing such as cardiovascular diseases that may result in various complications (Baena-Diez et al. 2016).

Major atherosclerosis-related cardiovascular diseases (CVD), represented by both the coronary heart disease (CHD) and stroke, are a prevalent worldwide cause of death. However, several comorbidities as dyslipidemia, hypertension, body mass index (BMI), smoking, and diabetes are frequently associated with the cardiovascular risk (Larsson et al. 2017). The lipid-modifying therapies are particularly done based on the managing the hypercholesterolemia as the main risk factor. Anomalous atherogenic lipid profiles are found in DM patients with low levels of high-density lipoprotein cholesterol (HDL), high levels of small dense low-density lipoprotein cholesterol (LDL), and high values of triglycerides (TG) (Grundy et al. 2002).

Blood lipid concentrations are used to assess cardiovascular risk and guide lipid-modifying therapies in diabetic and non-diabetic patients. Commonly, the classical lipid profile includes four parameters: total cholesterol (TC), HDL, LDL, and TG. Several cardiovascular risk tables and international recommendations (Framingham and EuroSCORE scores and NCEP- National Cholesterol Education Program, 2001) centered on the lipid profile have been developed (Nashef et al. 1999; Alexander et al. 2003; Lloyd-Jones et al. 2004). However, results from newest cohort studies and meta-analyses suggest that lipid ratios such as TC/HDL, LDL/HDL and TG/HDL ratios could be useful and well associated with the cardiovascular risk than the individual lipids (Sone et al. 2016; Kunutsor et al. 2017).

The assessment and management of the cardiovascular risk and its relative causalities are required for both type 1 and type 2 diabetes individuals, who often have other metabolic issues as hypercholesterolemia, hypertension, and overweight/obesity confounded in turn by an unhealthy diet or other behavioral or environmental risk factors.

The aim of the present study was to perform a comparison between T1D and T2D groups of adult patients by studying the mutual association of overweight/obesity (identified through BMI) and blood pressure with probable atherosclerosis-related cardiovascular risk factors, based on three lipid ratios TC/HDL, LDL/HDL, and TG/HDL.

## Patients and Methods

**Place and study population.** This is a cross-sectional study on type 1 (T1D) and type 2 adult diabetic (T2D) patients coming for consultation according to a pre-established periodic appointment at the Diabetic House (Larbi BEN M'HIDI Diabetes Centre), the Public Establishments of Local Health (Mokhtar BELAHSSEN and Ahmed SGHIR) and the Diabetology Department of the University Hospital Center (CHU) of Sidi-Bel-Abbes, located in north-western Algeria.

This investigation was conducted during eleven months from May 2018 to April 2019. Patients with language barriers without the ability to answer the questionnaire, suffering from hypothyroidism, renal impairment, liver dysfunction, critical illnesses and patients under CVD treatment and pregnant/lactating women, were excluded from this study.

**Data collection.** In addition to the confirmation of the treating physician, epidemiologic criteria were used to define both T1D and T2D. Diabetes treated with insulin and detected at an earlier age (30 years or younger) represented T1D. However, diabetes treated with diet alone or in combination with oral antidiabetic agents and/or insulin was considered as T2D. This latter is generally, but not exclusively, encountered in patients who were 40 years of age or older at the time of the diabetes diagnosis. The personal data collection, performed through a pre-established questionnaire, concerned sociodemographic characteristics, lifestyle information, food and hygiene behavior, marital status, family diseases history and educational level.

**Anthropometric measurements.** The anthropometric measurements were performed during morning periods referring to the recommendations of the World Health Organization (WHO) (WHO 2012). The body weight estimations (in kilograms) were completed using an electronic balance TS-2003A:360lb (capacity: 180 kg, graduations 0.1 kg). The height measurement was carried out by Seca 206 body meter (measuring range 0–220 cm, graduation length 1 mm). The BMI was then calculated as weight (kg)/height$^2$ (m$^2$).

**Blood pressure measurement.** The blood pressure measurements were completed using OMRON M3 (Omron Healthcare., Ltd. Kyoto, Japan. SN: 20100425369VF) in the morning times. The patient should be in a semi-recumbent position on the back

for reading the blood pressure. Measurements were repeated for three times separated by 5 min interval and the average values were considered.

**Biochemical parameters data.** After an overnight fast period of 12 h, venous blood samples were drawn from each participant. Total cholesterol (TC), HDL, direct LDL and TG concentration levels were performed by direct enzymatic colorimetric methods using "Spinreact-Spain" reagents (Bergmeyer 1974), and then lipid ratios including TC/HDL, LDL/HDL and TG/HDL were calculated. Glycated hemoglobin (HbA1c) concentration values were determined using ion exchange resin separation method.

**Ethical consideration.** Our experimental approach was discussed and approved by the scientific authorities "scientific committee" and "scientific council" of natural sciences and life faculty at Djillali LIABES University of Sidi-Bel-Abbes, Algeria. In addition, all patients gave their written consent after having a well-informed idea about the experimental protocol.

**Statistical analysis.** The software SPSS 22.0 (Statistical Package for the Social Sciences, IBM Corporation; Chicago, IL, August 2013) was employed to accomplish all statistical analysis (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. 2013). Results are expressed as means ± standard deviations, percentages and Odds ratios. The statistical Student t-test was used for comparing averages of independent samples and the Chi-Squared test for categorical (percentage values) variables comparison. However, the assessment of independent relationships between blood lipid ratios and type of diabetes was performed using logistic regression models. A p-value lower than 0.05 was considered statistically significant with a confidence interval (CI) of 95%.

## Results

Table 1 displays the basic characteristics of the participants. From all patients, 65 were males and 172 females. The overall mean age was 50.00±16.52 years (43.38±15.51 years in males and 52.50±16.25 in females), with a significant difference ($p<0.001$) between the two genders. Our results revealed that 90 patients were type 1 diabetics (42 males and 48 females) and 147 were type 2 diabetics (23 males and 124 females).

Comparing the two genders, significant differences ($p<0.05$) were highlighted for type of diabetes, anthropometric characteristics (weight, height and BMI), diabetes duration, HbA1c levels, educational level, and the family history of various diseases. However, no significant differences were observed in blood pressure, biochemical parameters (fasting glycaemia, TC, HDL, LDL, and TG), marital status, and the area of residence.

**Table 1**
Basic characteristics of the patients.

| Variables | All patients | Males | Females | p-value* |
|---|---|---|---|---|
| n | 237 | 65 | 172 | |
| Age (years), mean±S.D. | 50.00±16.52 | 43.38±15.51 | 52.50±16.25 | <0.001 |
| Type of diabetes | | | | |
| Type 1 diabetes, n (%) | 90 (38.0) | 42 (17.7) | 48 (20.3) | <0.001 |
| Type 2 diabetes, n (%) | 147 (62.0) | 23 (9.7) | 124 (52.3) | |
| Duration of diabetes (years) mean±S.D. | 12.98±8.65 | 14.94±10.02 | 12.26±7.99 | 0.034 |
| Anthropometric characteristics, mean±S.D. | | | | |
| Weight (kg) | 71.12±12.92 | 75.15±13.78 | 69.60±12.28 | 0.003 |
| Height (cm) | 163.52±9.23 | 173.27±7.78 | 159.83±6.72 | <0.001 |
| BMI (kg/m$^2$) | 26.64±4.61 | 25.08±4.60 | 27.23±4.48 | 0.001 |
| Blood pressure, mean±S.D. | | | | |
| Systolic pressure (mmHg) | 12.70±1.23 | 12.64±1.22 | 12.73±1.23 | 0.644 |

**Table 1**
*Continued ...*

| Variables | All patients | Males | Females | p-value* |
|---|---|---|---|---|
| Diastolic pressure (mmHg) | 7.64±0.95 | 7.74±0.99 | 7.61±0.94 | 0.357 |
| Blood level parameters | | | | |
| Fasting glycaemia (g/L), mean±S.D. | 1.59±0.72 | 1.53±0.66 | 1.61±0.73 | 0.477 |
| HbA1c (mmol/mol), mean±S.D. | 64.4±5.1 | 69.8±4.0 | 62.5±5.9 | 0.010 |
| Total cholesterol (g/L), mean±S.D. | 1.70±0.55 | 1.73±0.90 | 1.69±0.39 | 0.634 |
| HDL cholesterol (g/L), mean±S.D. | 0.49±0.20 | 0.45±0.13 | 0.50±0.21 | 0.115 |
| LDL cholesterol (g/L), mean±S.D. | 0.96±0.35 | 0.97±0.36 | 0.93±0.30 | 0.510 |
| Triglycerides (g/L), mean±S.D. | 1.18±0.80 | 1.20±0.88 | 1.18±0.78 | 0.854 |
| Prevalence of weight categories, n (%) | | | | |
| Normal weight, BMI <25 kg/m$^2$ | 88 (37.1) | 36 (15.2) | 52 (21.9) | 0.002 |
| Overweight, BMI=25.0–29.9 kg/m$^2$ | 104 (43.9) | 20 (8.4) | 84 (35.4) | |
| Obesity, BMI ³30 kg/m$^2$ | 45 (19.0) | 9 (3.8) | 36 (15.2) | |
| Educational status, n (%) | | | | |
| Without education | 51 (21.5) | 5 (2.1) | 46 (19.4) | 0.003 |
| Primary school | 52 (21.9) | 12 (5.1) | 40 (16.9) | |
| Middle school | 58 (24.5) | 17 (7.2) | 41 (17.3) | |
| Secondary school | 57 (24.1) | 22 (9.3) | 35 (14.8) | |
| Higher education | 19 (8.0) | 9 (3.8) | 10 (4.2) | |
| Marital status, n (%) | | | | |
| Single | 12 (5.1) | 4 (1.7) | 8 (3.4) | 0.589 |
| Married | 136 (57.4) | 34 (14.3) | 102 (43.0) | |
| Divorced | 11 (4.6) | 2 (0.8) | 9 (3.8) | |
| Widow | 78 (32.9) | 25 (10.5) | 53 (22.4) | |
| Number of children, mean±S.D. | 3.95±2.49 | 2.86±1.82 | 4.22±2.56 | 0.003 |
| Residence, n (%) | | | | |
| Urban | 189 (79.7) | 50 (21.1) | 139 (58.6) | 0.506 |
| Rural | 48 (20.3) | 65 (6.3) | 172 (13.9) | |
| Family disease history, n (%) | | | | |
| Hypertension | 22 (9.3) | 1 (0.7) | 21 (15.1) | <0.001 |
| Diabetes | 89 (37.6) | 13 (9.4) | 76 (54.7) | |
| Overweight, obesity | 13 (5.5) | 4 (2.9) | 9 (6.5) | |
| Cardiovascular disease | 15 (6.3) | 2 (1.4) | 13 (9.4) | |
| No | 98 (41.4) | 45 (19.0) | 53 (22.4) | |

Abbreviations: BMI – body mass index; HbA1c – glycated hemoglobin; HDL – high density lipoprotein; LDL – low density lipoprotein. *Comparison between males and females; mean values were compared using Student's t-test. Percentages were compared with Chi-square test; $p<0.05$ was considered as significant.

Our results about the comparison of lipid ratios between T1D and T2D patients revealed high levels of CT/HDL, LDL/HDL, and TG/HDL in T2D patients with regard to T1D patients (Figure 1). In both types of the diabetes, the rates of these three lipid ratios were often higher in male than female patients.

For the whole population study (Table 2), the multivariate regression between lipid ratios quartiles, as powerful predictors of atherosclerosis onset and the type of diabetes resulted in significant associations regarding the 2nd (OR: 0.175; CI 95% 0.059–0.522; p=0.002) and the fourth quartiles (OR: 0.313; CI 95% 0.102–0.955; p=0.041) of TC/HDL ratio. Significant associations were observed on three quartiles (2nd, 3th and 4th) of LDL/HDL ratio with p-values of 0.016, 0.048, and 0.016, respectively. Likewise, the second quartile of TG/HDL ratio disclosed an OR of 0.117 (CI 95% 0.031–0.434; p=0.001).

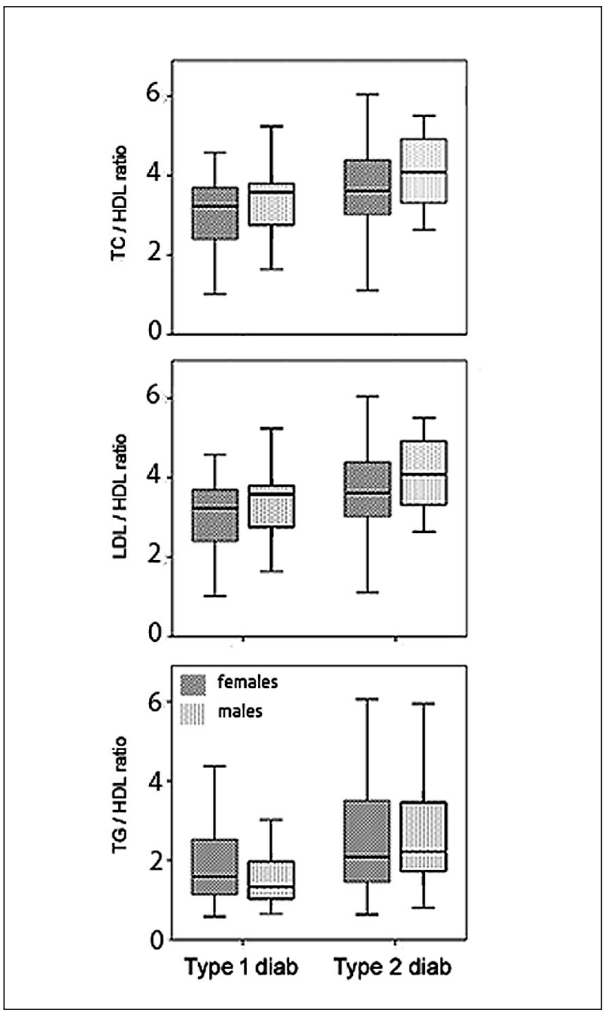



**Figure 1.** Comparison of lipid ratios level between type 1 and type 2 diabetes (diab) according to the patients' gender. Abbreviations: HDL – high-density lipoprotein, LDL – low-density lipoprotein, TC – total cholesterol, TG – triglycerides.

Table 3 summarizes the associations of BMI and blood pressure levels with lipid ratios variations by comparing patients with T1D and T2D. Among all patients, the lipid ratios levels (TC/HDL, LDL/HDL, and TG/HDL) increased according to the BMI. However, slight non-significant increases were noted for lipid ratios according to systolic and diastolic arterial pressure.

In males and females, when comparing lipid ratios between the two types of diabetes, TC/HDL and TG/HDL were significantly higher in normal-weight T2D patients comparing to those with T1D. The TC/HDL was significantly higher (p=0.046) in obese men. Nevertheless, no significant differences were found for LDL/HDL ratio between T1D and T2D patients.

Higher TC/HDL ratios were observed in T2D patients (males and females) with normal blood pressure (systolic blood pressure, SBP ≤13.5 mmHG and diastolic blood pressure, DBP ≤8 mmHg) comparing to T1D patients. Likewise, the LDL/HDL ratio was significantly higher in type 2 diabetic men with normal DBP (p=0.044). High levels of TG/HDL ratios were noticed among T2D male patients with high SBP (p=0.022) and normal DBP (p=0.006) and in women with normal SBP (p=0.025) comparing to T1D patients.

## Discussion

Cardiovascular disease constitutes a health issue assumed to be of an athermanous origin and represents the leading cause of morbidity and mortality in diabetes population. Numerous conclusions from epidemiological studies have shown the importance of the individual cardiovascular risk factors control in CVD preventing in diabetes people. Although diabetes itself confers an independent risk for health, there are coexisting conditions with diabetes such as high blood pressure, obesity, and dyslipidemia that represent significant risk factors for atherosclerosis (ADA 2018).

The differences between the two types of diabetes were established after a long period of observations and experiments. The definitions of "type 1 diabetes" and "type 2 diabetes" have been adopted since 1979 to replace the former "insulin dependent" and "non-dependent". Lately, because of the age-old changes in risk factors for diabetes, the distinction between T1D and T2D has been recognized (Zaccardi et al. 2016).

**Table 2**
Crude "Odds Ratio" of blood lipid ratios quartiles associated with the type of diabetic disease.

| | Type 1 diabetes Number (%) | Type 2 diabetes Number (%) | Odds ratio (95% CI OR) | p-value* |
|---|---|---|---|---|
| TC/HDL ratio | | | | |
| Q1 (1.00–2.97) | 20 (10.5) | 28 (14.7) | Reference | |
| Q2 (2.98–3.59) | 10 (5.3) | 38 (20.0) | 0.175 [0.059–0.522] | 0.002 |
| Q3 (3.60–4.34) | 14 (7.4) | 35 (18.4) | 0.475 [0.149–1.518] | 0.209 |
| Q4 (4.36–6.04) | 5 (2.6) | 40 (21.1) | 0.313 [0.102–0.955] | 0.041 |
| LDL/HDL ratio | | | | |
| Q1 (0.23–1.44) | 15 (7.8) | 33 (17.1) | Reference | |
| Q2 (1.46–2.04) | 13 (6.7) | 36 (18.7) | 0.256 [0.084–0.776] | 0.016 |
| Q3 (2.05–2.68) | 15 (7.8) | 33 (17.1) | 0.322 [0.105–0.989] | 0.048 |
| Q4 (2.72–4.50) | 5 (2.6) | 43 (22.3) | 0.256 [0.084–0.776] | 0.016 |
| TG/HDL ratio | | | | |
| Q1 (0.58–1.30) | 18 (10.1) | 28 (15.6) | Reference | |
| Q2 (1.35–2.00) | 9 (5.0) | 36 (20.1) | 0.117 [0.031–0.434] | 0.001 |
| Q3 (2.04–3.03) | 10 (5.6) | 35 (19.6) | 0.300 [0.075–1.195] | 0.088 |
| Q4 (3.15–6.06) | 3 (1.7) | 40 (22.3) | 0.263 [0.067–1.031] | 0.055 |

Abbreviations: TC – total cholesterol; LDL – low-density lipoprotein cholesterol; HDL – high-density lipoprotein cholesterol; TG – triglycerides; CI – confidence interval; OR – Odd ratio; Q – quartiles. *Multivariate logistic regression significant at p=0.05; bold indicates significant p-values.

The objective of the current study was to compare associations of BMI and blood pressure with probable atherosclerosis-related cardiovascular risk factors (the three lipid ratios TC/HDL, LDL/HDL, and TG/HDL) between the adult T1D and T2D patients.

Preliminary consequences from our study in both T1D and T2D individuals showed significant gender effect on age, type of diabetes, diabetes duration, BMI, HbA1c levels, educational status, and family disease history. In contrary to our results, literature data have often assumed that no sex biases are found when comparing basic characteristics within either T1D or T2D patients (Gale and Gillespie 2011). However, most reviews have concluded an absence (Dorman et al. 1995) or a minor (Beeson et al. 1994) bias of male gender in T1D comparing to T2D. The mean age of the surveyed patients was 50.00±16.52 years, regardless of sex and type of diabetes. This result was of the same order as in numerous studies (Ferdi et al. 2018).

In the study, the women population was significantly outnumbered in both diabetes groups (T1D: n=48/90, T2D: n=124/147). These results are similar to the findings of Zaoui et al. (2007) from Algeria, where diabetes prevalence was higher in women (20.4%) in contrast to men (17.7%). The same conclusions have been reported in a Moroccan study (Ouhdouch et al. 2009).

Our findings revealed that more women had family histories of metabolic complications, high systolic blood pressure, and higher BMI than men. Almost half of the female participants (n=84) fell into the overweighed group, while more than half the men (n=36) had normal weight. Gucciardi et al. (2008) have reported similar results. It is now more obvious that even modest weight gain upsurges the risk of T2D, higher blood pressure, dyslipidemia, cardiovascular disease, and other diseases in middle-aged women (Colditz et al. 1995; Lau et al. 2007).

In our study, no differences in the marital status were found between men and women. According to some authors, the notion of a life-friendly family is highly considered to giving the diabetic people the necessary physical, intimate, and emotional daily support. Health care providers should tap into this natural resource by educating and advising not only patients, but also their close family members (Gucciardi et al. 2008).

The role of lipid abnormalities in diabetic atherosclerosis is now more evident. In T2D patients, the "lipid triad" refers to the classical dyslipidemia characterized by increased levels of cholesterol, LDL, and

**Table 3**
Variation of lipid ratios levels according to body mass index and blood pressure levels between type 1 and type 2 diabetic patients.

| Parameters | TC/HDL ratio | | | LDL/HDL ratio | | | TG/HDL ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | T1D | T2D | p-value | T1D | T2D | p-value | T1D | T2D | p-value |
| Males | | | | | | | | | |
| Based on BMI | | | | | | | | | |
| BMI <25 kg/m$^2$ | 3.38±0.99 | 4.25±0.70 | 0.028 | 1.90±0.73 | 2.39±0.75 | 0.141 | 1.38±0.64 | 2.32±0.91 | 0.031 |
| BMI=25–29.9 kg/m$^2$ | 3.28±0.99 | 3.49±0.71 | 0.625 | 1.83±0.93 | 2.23±0.60 | 0.307 | 1.33±0.51 | 2.68±1.53 | 0.045 |
| BMI ≥30 kg/m$^2$ | 3.86±0.06 | 5.05±0.55 | 0.046 | 2.41±0.04 | 2.59±0.96 | 0.811 | 2.60±0.59 | 3.13±2.06 | 0.756 |
| Based on blood pressure levels | | | | | | | | | |
| SBP ≤13.5 mmHg | 3.47±0.94 | 4.26±0.88 | 0.016 | 1.94±0.79 | 2.33±0.79 | 0.157 | 1.69±0.70 | 2.25±1.02 | 0.113 |
| SBP >13.5 mmHg | 3.04±0.92 | 3.74±0.72 | 0.191 | 1.83±0.87 | 2.49±0.45 | 0.143 | 0.98±0.22 | 3.39±1.65 | 0.022 |
| DBP ≤8.0 mmHg | 3.42±0.99 | 4.33±0.86 | 0.011 | 1.98±0.81 | 2.59±0.80 | 0.044 | 1.51±0.71 | 2.51±1.05 | 0.006 |
| DBP >8.0 mmHg | 3.17±0.67 | 3.85±0.82 | 0.174 | 1.60±0.68 | 2.08±0.46 | 0.157 | 1.52±0.78 | 2.64±1.64 | 0.534 |
| Females | | | | | | | | | |
| Based on BMI | | | | | | | | | |
| BMI <25 kg/m$^2$ | 2.91±0.54 | 3.83±0.87 | 0.017 | 1.71±0.55 | 2.19±0.87 | 0.207 | 1.27±0.68 | 2.37±1.32 | 0.050 |
| BMI=25–29.9 kg/m$^2$ | 3.09±0.98 | 3.42±1.09 | 0.297 | 1.78±0.70 | 2.03±0.94 | 0.326 | 1.89±0.99 | 2.47±1.38 | 0.158 |
| BMI ≥30 kg/m$^2$ | 3.54±0.79 | 3.85±1.07 | 0.551 | 1.90±0.64 | 2.28±0.94 | 0.439 | 2.42±1.31 | 2.62±1.26 | 0.751 |
| Based on blood pressure levels | | | | | | | | | |
| SBP ≤13.5 mmHg | 3.10±0.89 | 3.69±1.03 | 0.018 | 1.83±0.64 | 2.14±0.91 | 0.145 | 1.76±1.00 | 2.42±1.23 | 0.025 |
| SBP > 13.5 mmHg | 3.28±0.80 | 3.48±1.07 | 0.693 | 1.52±0.59 | 2.11±0.96 | 0.237 | 2.46±1.26 | 2.61±1.56 | 0.872 |
| DBP ≤8.0 mmHg | 3.16±0.91 | 3.78±0.92 | 0.008 | 1.78±0.65 | 2.17±0.88 | 0.076 | 1.98±1.08 | 2.53±1.32 | 0.097 |
| DBP > 8.0 mmHg | 3.04±0.75 | 3.24±1.24 | 0.707 | 1.76±0.65 | 2.04±1.03 | 0.534 | 1.36±0.70 | 2.36±1.36 | 0.121 |

Abbreviations: BMI – body mass index; TC – total cholesterol; LDL – low-density lipoprotein cholesterol; HDL – high-density lipoprotein cholesterol; TG – triglycerides; T1D – type 1 diabetes; T2D – type 2 diabetes; SBP – systolic blood pressure; DBP – diastolic blood pressure. *p-value for Student's t-test; p<0.05 was considered as significant.

TG and low level of HDL. Cardiovascular risk becomes even greater when the lipid triad is accompanied by diabetes, hypertension, dysmetabolic syndrome, and high body weight (Himabindu et al. 2013; Hinge et al. 2018). Similarly, according to other studies, in poorly controlled T1D patient's, quantitative lipid abnormalities are often observed, namely in increased TG and LDL cholesterol and decreased HDL cholesterol (Nakhjavani et al. 2006; Verges 2009).

The atherogenic or Castelli risk index (LDL/HDL and TC/HDL ratios) is more predictive as components and indicators of vascular risk comparing to the isolated lipid parameters used independently (Millan et al. 2009). The LDL/HDL ratio has been shown to be the most relevant index for cardiovascular health according to the Helsinki´s study since 1992 (Manninen et al. 1992). The TG/HDL ratio is used successfully as an additional index in the evaluation of cardiovascular risk factors (Dobiasova and Frohlich 2001). In our study, T2D patients had higher TC/HDL, LDL/HDL, and TG/HDL ratios when compared with T1D ones. Likewise, the values of these ratios for men were often high in comparison with women. Previous workers have reported that in primary intervention, the risk levels of LDL/HDL ratio are >3.5 for men and >3.0 for women, while the target levels for both men and women are 3.0 and 2.5, respectively (Aderibigbe et al. 2018). Results of a study from Ghana (Antwi-Baffour et al. 2018) and Iran (Rezapour et al. 2018) are in agreement with the results of the present work. In contrariwise, statistics from the INTERHEART (Anand et al. 2008), San Antonio Heart Studies (Hunt et al. 2004) and Italian cohort study (Ballotari et al. 2017) have revealed that diabetes constitutes a more significant cardiovascular risk for women than men. Over the recent years, an increasing interest has been given for understanding of the sex difference in risk of cardiovascular disease in diabetes population. Large analyses, over of 800 000 people with diabetes, have indicated that diabetic females have a relative

risk of about 44% of incident CHD compared with males (Peters et al. 2014). Likewise, an excess relative risk of cardiovascular mortality in women with diabetes compared with men has been shown in the China Kadoorie Biobank (Bragg et al. 2017).

All patients in the present study were categorized into quartiles of lipid ratios from the highest quartile 4 to the lowest quartile 1, as reference. The comparison of lipid ratios quartiles between T1D and T2D patients revealed significant differences in the second (p=0.002) and the fourth (p=0.041) quartiles of TC/HDL ratio, all quartiles of LDL/HDL and the second (p=0.001) quartile of TG/HDL. However, the Odds ratio increased significantly from the 1st to the 3rd quartiles of lipid ratios regardless of the diabetes type. Similar findings have been reported in a study of 5300 Framingham subjects with an increasing coronary heart disease proportion from lower to higher tertiles of TC/HDL ratio (Nam et al. 2006). Eliasson et al. (2014) have concluded that the hazard ratio of fatal/nonfatal coronary heart disease was increasing in T2D patients according to the upsurge of the LDL/HDL and TG/HDL quartiles.

Several determinants of the metabolic disorders, as diabetes mellitus, CVD, dyslipidemia, elevated serum uric acid, and hypertension are suggested to be associated with BMI and blood lipids. In our study, we assessed the variation of lipid ratios according to BMI and blood pressure between T1D and T2D patients. All lipid ratios (TC/HDL, LDL/HDL, and TG/HDL) increased according to the BMI in both genders. Furthermore, elevated lipid ratios were noted in T2D comparing to T1D. However, our results disagree with previous observations showing an even stronger association of T1D than T2D with atherogenic risk (Janghorbani et al. 2007; Larsson et al. 2018). The difference between T1D and T2D patients regarding the cardiovascular risk is partly explained by the long duration of T1D compared to T2D and the administered treatments based on insulin therapy in T1D and a combination of diet, exercise, antidiabetic drugs and/or insulin in T2D (Larsson et al. 2018). Historically, despite the existence of a great difference between the two genders in the development of cardiovascular complications in diabetics to the detriment of women, it is conceivable that the excess cardiovascular risk in women with diabetes is not due to differences between the two sexes with respect to the physiological effects and complications of diabetes. In addition, physicians are more likely to recognize early cardiovascular risk in men than women because of the higher absolute risk in men (Peters et al. 2014; Hussain et al. 2019).

Currently, the hypertension is defined by blood pressure (BP) values of ≥135/80 mmHg that may cause damage of all of body organs. It is usually asymptomatic and uncontrolled. An association of dyslipidemia with hypertension is the commonest risk factor for coronary artery disease (Aziz 2017). The current investigation has demonstrated higher values of lipid ratios (TC/HDL, LDL/HDL, and TG/HDL) in T2D comparing to T1D patients according to diverse levels of the systolic and diastolic blood pressure. Furthermore, male patients had higher levels of lipid profile than female ones. Our findings are divergent to those obtained by Rapsomaniki et al. (2014) conducted on 1.25 million patients, in which a slightly higher relative risk of myocardial infarction with increasing systolic, but not diastolic blood pressure, has been found in female compared with male individuals. Other authors have made the same conclusions (Anand et al. 2008; Tamargo et al. 2017; Millett et al. 2018). There is often present a significant heterogeneity between studies due to the different blood pressure threshold worldwide.

Our work has certain limitations that must be indicated. First, the participation in the study was voluntary and patients already under treatment for CVD, whereas those with incomplete medical records were excluded. Second, the study sample mostly comprised urban participants who usually undergo a quarterly check-up. Therefore, this population could not be nationally representative or geographically diverse. However, despite these inherent limitations, we believe that our conclusions would remain unchanged in the general population, as the associations between lipid profile and atherosclerosis risk, which were robust especially in the presence of obesity or hypertension. Moreover, to the best of our knowledge, this is the first investigation focusing on atherosclerosis risk assessment through lipid ratios by comparing T1D and T2D patients in Algeria. Therefore, data of this work can be used as a baseline for further research.

## Conclusion

Type 2 diabetes, which is very often accompanied by obesity (higher BMI) and high blood pressure at diagnostic is a strong determinant of the blood lipid profile deterioration, atherosclerosis disease, vascular damages, endothelial inflammation, and a risk of CV complications development. In contrast, hypertension and excess weight are not generally observed at the time of T1D diagnosis. However, with longer duration of both types of diabetes, the occurrence

of hypertension will increase and the metabolic complications, in particular atherosclerosis disease, are thought to be of higher prevalence. Lipid ratios (TC/HDL, LDL/HDL, and TG/HDL) are appropriate indices while managing diabetes. Furthermore, it is recommended to screen T1D and T2D patients for hypertension, dyslipidemia, and obesity and to initiate management at early stages to prevent diabetes related complications such as atherosclerosis as a priority.

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