ORIGINAL RESEARCH

Prevalence and Associated Factors of Dyslipidemia Among Adults with Type 2 Diabetes Mellitus in Saudi Arabia

Riyadh A Alzaheb [ID] [1]
Abdullah H Altemani [2]

[1]Department of Clinical Nutrition, Faculty of Applied Medical Sciences, University of Tabuk, Tabuk, Saudi Arabia; [2]Department of Family and Community Medicine, Faculty of Medicine, University of Tabuk, Tabuk, Saudi Arabia

Introduction: Dyslipidemia is a key clinical abnormality among diabetes mellitus (DM) patients, which heightens their risk of cardiovascular events. Data on the serum lipid profile of type 2 DM (T2DM) patients in Saudi Arabia are scarce. This study therefore aimed to establish dyslipidemia prevalence in a sample of adult T2DM patients in Saudi Arabia and to investigate its associated factors.

Patients and Methods: A cross-sectional survey was applied to 400 adult T2DM outpatients in attendance at a diabetic center clinic in Tabuk, Saudi Arabia between September 2017 and December 2018 using convenience sampling. Structured questionnaires gathered data relating to the potential risk factors for dyslipidemia. Data on fasting blood glucose (FBG), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) levels were collected from all participants along with their height and weight measurements. Multivariate logistic regression analysis was then used to evaluate the associated risk factors for dyslipidemia.

Results: Of the sampled outpatients, 47.8% had high TC levels, 39.0% had high LDL-C, 35.5% had low HDL-C, 42.8% had high TG levels, and 66.5% had a minimum of one abnormal lipid level (dyslipidemia). The risk factors associated with dyslipidemia were an age of >40 years (adjusted odds ratio [AOR] = 1.96, 95% CI 1.19–3.22), irregular exercise (AOR = 2.90, 95% CI 1.21–6.92), a family history of T2DM (AOR = 3.72, 95% CI 2.22–6.23), having had T2DM for >7 years (AOR = 2.42, 95% CI 1.46–3.99), and overweight (AOR = 2.61, 95% CI 1.49–4.58) or obesity (AOR = 2.50, 95% CI 1.24–5.05).

Conclusion: Dyslipidemia prevalence was found to be high among T2DM patients. Therefore, a compressive mechanism is needed which can screen, treat, and inform them about dyslipidemia and its risk factors, especially modifiable ones such as obesity and exercise.

Keywords: dyslipidemia, type 2 diabetes, Saudi Arabia

Introduction

Globally, over 382 million people are affected by diabetes mellitus (DM), 90% of whom are diagnosed with type 2 DM (T2DM).[1] T2DM prevalence has risen sharply over the past two decades.[1] Arab countries have been impacted by this epidemic, just like other regions of the world.[2] More precisely, in global terms the Middle Eastern and North African region has experienced the second steepest increase in diabetes prevalence, with the result that the present level has been projected to increase by 96.2% by the year 2035; similarly, a recent systematic review reported

Correspondence: Riyadh A Alzaheb
Department of Clinical Nutrition, Faculty of Applied Medical Sciences, University of Tabuk, Tabuk 71491, Saudi Arabia
Tel/Fax +966-144-562-723
Email ralzaheb@ut.edu.sa

a current T2DM prevalence of 32.8% in the Kingdom of Saudi Arabia, which was predicted to rise to 35.37% in 2020, 40.8% in 2025, and to 45.8% by 2030.[1,3]

Dyslipidemia is an important clinical abnormality experienced by DM patients, which is a cluster of metabolically interrelated plasma lipid and lipoprotein abnormality involving low high-density lipoprotein cholesterol (HDL-C) and high low-density lipoprotein cholesterol (LDL-C), triglyceride (TG), and total cholesterol (TC) levels.[4–6] Abnormalities in lipoprotein patterns can be either individual or in combination.[5] Dyslipidemia has been established as the modifiable risk factor for cardiovascular diseases, which is a common cause of morbidity and mortality in most developing countries, including Saudi Arabia.[7] Dyslipidemia prevalence is already high, and it is continuously increasing in many developing countries due to the westernization of the local diet, obesity, ageing populations, low levels of physical activity, and other negative lifestyle changes.[8]

In seeking to improve dyslipidemia control, the relevant key characteristics of dyslipidemia sufferers must be fully understood.[9] However, as far as the authors are aware, no research has yet been carried out which has estimated dyslipidemia prevalence and associated risk factors among a sample of adult T2DM patients in Saudi Arabia. The present study therefore sought to address this gap in the prior research by aiming to establish the dyslipidemia prevalence among a sample of adult T2DM patients in Saudi Arabia and to examine its potential associations with various key risk factors. The study thus aimed to gather the necessary data with which to provide information on the health profiles of adult T2DM patients that could be of use to the health professionals responsible for managing diabetic dyslipidemia in Saudi Arabia.

Patients and Methods
Study Design and Participants

The participants in this cross-sectional study were recruited between September 2017 and December 2018 from the adult outpatients attending a diabetes clinic at a diabetic center in Tabuk, the capital city of the Tabuk region of Saudi Arabia. A convenience sampling technique was employed to do so, as it would have been challenging to deploy random sampling because of the variations in the potential study participants' follow-up appointments which meant that some of them may not have returned to the clinic on the specified date. The other reason for

choosing convenience sampling was that it is faster and more straightforward than alternative sampling techniques.

The required sample size was calculated based on the following assumptions: $\prod= 0.5$ (no previous estimate has been made of dyslipidemia prevalence among type 2 diabetics in the Tabuk region); a desired marginal error of 0.05; and Z or (confidence level 95%) of 1.96. The optimal sample size was established as 385 patients, which was rounded up to 400 patients.

The eligibility criteria for participation in the research were as follows: a minimum age of at least 18 years, a confirmed diagnosis of T2DM, and to have received treatment as an outpatient at the clinic for at least a year. Potential participants were excluded if any of the following conditions applied to them: pregnancy; a diagnosis of mental illness or psychological issues; receiving any form of lipid-lowering therapy; and/or a diagnosis of renal failure. Once these criteria were applied, eligible patients were invited to take part in the research, and upon their agreement were asked to sign a written informed consent form. The researchers sought and obtained ethical approval to carry out the research in 2017 from the Committee of Research Ethics at the University of Tabuk, and the study was carried out in accordance with the Declaration of Helsinki.

Data Collection

Structured questionnaires were deployed to gather data on the risk factors potentially linked to dyslipidemia. The questionnaires asked the participants to provide sociodemographic information on their age, gender, residence, marital status, education, employment status, and monthly income, followed by questions on aspects of their health behaviors (smoking status, regular exercise – defined in the study as at least 30 minutes of exercise per day on a minimum of three days per week – and whether they followed a diet which restricted their intakes of fat, sugar, and salt), and lastly, about their personal medical history (focusing on their family histories of diabetes, if any, and the disease duration).

Anthropometric height and weight measurements were taken from each participant by professional nurses working at the diabetes clinic using a standardized protocol on a morning after the participant had fasted overnight. Each participant was measured while wearing light clothing, and without shoes. Their height was taken to the nearest 0.5 cm, and their weight to the nearest 0.5 kg to calculate

body mass index (BMI) by dividing the weight in kilograms by the height in meters squared.

Data on the study participants' fasting blood glucose (FBG) levels and lipid panel, including their TC, TG, HDL-C, and LDL-C levels, were gathered from their medical records if they had been measured during the three months leading up to the research, provided that the individual's medication had not changed over that time period. If this was not the case, then they were tested during the research.

Definition of Terms

The participants were categorized according to their BMI to reflect the World Health Organization's (WHO) body-weight definitions, as normal (BMI = 18.5–24.9 kg/m^2), overweight (BMI = 25–29.9 kg/m^2), or obese (BMI ≥ 30 kg/m^2).[10] Their glycemic level was coded either as poor or good, where poor glycemic control was defined as an FBG level of above 130 mg/dl.[11] Dyslipidemia was identified in individuals who had lipid profiles with the following abnormalities, either alone or in combination: TC ≥200 mg/dl, TG levels ≥150 mg/dl, HDL-C <40 mg/dl, and LDL-C ≥100 mg/dl.[5]

Statistical Analyses

The Statistical Package for Social Sciences (SPSS) program, version 23 was used to analyze the data gathered in this study, which were expressed as counts (frequency=n), and proportions (%). The variables associated with dyslipidemia prevalence among the participants were identified using a univariate logistic regression. Then, the factors revealed to be significant by the univariate logistic regression were included in a multivariate logistic regression to highlight the associations between the possible risk factors and dyslipidemia. The logistic regression analysis used odds ratios (ORs) and their 95% confidence intervals (CIs), and P < 0.05 was considered significant.

Results

A total of 436 T2DM patients were approached to participate in the research, of which 400 (91.7%) were eligible and consented to take part. Their mean (±SD) age was 48.5 (±18.6), with the youngest participant aged 18 years and the oldest 83. In the sample, 211 (52.8%) patients were male, 288 (72.0%) lived in urban areas, 363 (90.8%) were married, 250 (62.5%) had 12 or fewer years of education, and 265 (66.3%) were in employment.

Table 1 presents the study sample's prevalence of abnormal lipid levels and shows that of the 400 T2DM

Table 1 Prevalence of Lipid Abnormalities Among Study Participants (n=400)

Parameters	n	%
High TC (≥200 mg/dl)	191	47.8
High TG (≥150 mg/dl)	171	42.8
High LDL-C (≥100 mg/dl)	156	39.0
Low HDL-C (<40 mg/dl)	142	35.5

Abbreviations: HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride.

patients, 191 (47.8%) had high TC, 142 (35.5%) had low HDL-C, 156 (39.0%) had high LDL-C, and 171 (42.8%) had high concentrations of TG. A minimum of one abnormal lipid concentration (dyslipidemia) was found in 266 (66.5%) of the study population.

Several independent factors that may affect dyslipidemia prevalence were examined using a univariate logistic regression model (see Table 2). The analysis revealed the following factors to be statistically significantly associated with dyslipidemia prevalence: being >40 years old, residing in urban areas, taking irregular exercise, lacking healthy dietary plans, poor glycemic control, a family history of T2DM, having T2DM for >7 years, and being overweight or obese.

To further evaluate the factors which apparently contribute to the prevalence of dyslipidemia, those revealed to be significant by the univariate logistic regression were included in a multivariate logistic regression (Table 3). This further analysis confirmed that the patient characteristics associated with dyslipidemia were as follows: being >40 years old (adjusted odds ratio [AOR] = 1.96, 95% CI 1.19–3.22), taking irregular exercise (AOR = 2.90, 95% CI 1.21–6.92), a family history of T2DM (AOR = 3.72, 95% CI 2.22–6.23), having T2DM for >7 years (AOR = 2.42, 95% CI 1.46–3.99), and being overweight (AOR = 2.61, 95% CI 1.49–4.58) or obese (AOR = 2.50, 95% CI 1.24–5.05).

Discussion

Prior studies have reported a high prevalence of dyslipidemia, which is continuously increasing across the developed world and in many developing countries.[6,9] The present study similarly found a disturbingly high dyslipidemia prevalence in its sample of adult T2DM patients living in Tabuk, Saudi Arabia, as around two-thirds of its participants (66.5%) had at least one form of dyslipidemia. This finding is in line with those reported by previous research in Middle Eastern contexts, including in Saudi

Table 2 Univariate Analysis of Factors Associated with Dyslipidemia Among Study Participants (n=400)

Variables	Dyslipidemia		Unadjusted	
	Yes (n= 266, 66.5%)	**No (n=134, 33.5%)**	**OR**	**95% CI**
Age (years)				
≤40	87 (56.1)	68 (43.9)	1	Ref.
>40	179 (73.1)	66 (26.9)	2.12	1.39–3.24
Sex				
Male	149 (70.6)	62 (29.4)	1	Ref.
Female	117 (61.9)	72 (38.1)	0.68	0.45–1.03
Residence				
Rural	65 (58.0)	47 (42.0)	1	Ref.
Urban	201 (69.8)	87 (30.2)	1.67	1.06–2.63
Marital status				
Married	240 (66.1)	123 (33.9)	1	Ref.
Unmarried	26 (70.3)	11 (29.7)	1.21	0.58–2.53
Years of education				
≤12 years	166 (66.4)	84 (33.6)	1	Ref.
>12 years	100 (66.7)	50 (33.3)	1.01	0.66–1.55
Occupation				
Employed	171 (64.5)	94 (35.5)	1	Ref.
Unemployed	95 (70.4)	40 (29.6)	1.31	0.84–2.04
Monthly income (SAR)				
Low (<5000)	71 (60.2)	47 (39.8)	1	Ref.
Middle (5000–15,000)	122 (68.2)	57 (31.8)	1.42	0.87–2.30
High (>15,000)	73 (70.9)	30 (29.1)	1.61	0.92–2.83
Smoking				
Yes	49 (64.5)	27 (35.5)	1	Ref.
No	217 (67.0)	107 (33.0)	1.12	0.66–1.89
Regular exercise				
Yes	78 (48.4)	83 (51.6)	1	Ref.
No	188 (78.7)	51 (21.3)	3.92	2.53–6.08
Following a meal plan				
Yes	71 (49.0)	74 (51.0)	1	Ref.
No	195 (76.5)	60 (23.5)	3.39	2.19–5.24
Glycemic control				
Good	57 (47.9)	62 (52.1)	1	Ref.
Poor	209 (74.4)	72 (25.6)	3.16	2.02–4.94
Family history of DM				
Yes	210 (76.9)	63 (23.1)	4.23	2.70–6.62
No	56 (44.1)	71 (55.9)	1	Ref.
Duration of DM (years)				
≤7	88 (54.3)	74 (45.7)	1	Ref.
>7	178 (74.8)	60 (25.2)	2.50	1.63–3.82

(*Continued*)

Table 2 (Continued).

Variables	Dyslipidemia		Unadjusted	
	Yes **(n= 266, 66.5%)**	**No** **(n=134, 33.5%)**	**OR**	**95% CI**
BMI (kg/m²)				
Normal (BMI <25 kg/m²)	59 (50.9)	57 (49.1)	1	Ref.
Overweight (BMI 25-<30 kg/m²)	150 (73.9)	53 (26.1)	2.73	1.69–4.42
Obese (BMI ≥30 kg/m²)	57 (70.4)	24 (29.6)	2.29	1.26–4.18

Abbreviations: BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; OR, odds ratio; Ref., reference; SAR, Saudi Arabian Riyal (≈$0.266).

Table 3 Multivariate Analysis of Factors Associated with Dyslipidemia Among Study Participants (n=400)

Variables	Adjusted	
	OR	**95% CI**
Age (years)		
≤40	1	Ref.
>40	1.96	1.19–3.22
Residence		
Rural	1	Ref.
Urban	1.29	0.75–2.23
Regular exercise		
Yes	1	Ref.
No	2.90	1.21–6.92
Following a meal plan		
Yes	1	Ref.
No	2.03	0.73–5.66
Glycemic control		
Good	1	Ref.
Poor	0.86	0.37–2.04
Family history of DM		
Yes	3.72	2.22–6.23
No	1	Ref.
Duration of DM (years)		
≤7	1	Ref.
>7	2.42	1.46–3.99
BMI (kg/m²)		
Normal (BMI <25 kg/m²)	1	Ref.
Overweight (BMI 25-<30 kg/m²)	2.61	1.49–4.58
Obese (BMI ≥30 kg/m²)	2.50	1.24–5.05

Abbreviations: BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; OR, odds ratio; Ref., reference.

Arabia, which have also confirmed a high prevalence of the condition.[6,12,13] For instance, in a research study which used a sample of 4309 Turkish adults, 78.7% of males and 80.4% of females were found to have a minimum of one lipid abnormality.[6] The present study also found that

hypercholesterolemia was the most common lipid abnormality, with 47.8% of the sample having been diagnosed with it. Hypercholesterolemia prevalence in the Eastern Mediterranean has been reported as the third highest among all WHO-designated regions, at 38.4% (more specific, 40.4% among females and 36.2% among males). Further, hypercholesterolemia prevalence was reported as ≥50% in most countries in the Gulf region, a high dyslipidemia rate which indicates a clear requirement for early screening to be made available along with good lipid management, which together may significantly reduce an individual's risk of developing cardiovascular diseases.[14]

As well as a high dyslipidemia prevalence, this research also revealed the potential risk factors leading to the condition. Among these, dyslipidemia was shown to have a positive association with increased age. This association is in line with prior research which has also found a positive association between a patient's age and higher blood lipid levels.[5,6,15–21] With Saudi Arabia's trend towards an increasingly older population, the public health threat which dyslipidemia poses will worsen. A key problem is that the exact mechanisms of age's influence on serum lipid concentrations have not yet been fully understood; they may be associated with inherited genetic characteristics and degenerative processes, in addition to the gradual weight increase and greater insulin resistance which comes with age.[6] The present findings therefore support a previous appeal for efficient screenings and health strategies among the >40 years age group.[22]

This study found that both a family history of diabetes and the duration of the diabetes apparently exerted an influence on dyslipidemia risk. Prior studies have already reported the similar finding that a family history of diabetes is independently associated with lipid abnormalities.[20,23] The underlying mechanisms shaping the role which family influence plays on serum lipid panel results may relate to common environmental factors

shared by an individual and their family, and/or a direct genetic predisposition.[23] Moving on to consideration of the duration of diabetes, previous research in Ethiopia employing a sample of diabetic patients reported that those who had experienced 6–10 and >10 years of diabetes displayed a significant association with dyslipidemia prevalence.[5] Indeed, lipid profiles with abnormal features are common in subjects with T2DM.[5] The lipid abnormalities observed in association with diabetes are likely to be a consequence of the individual's insulin resistance which leads to the mobilization of free fatty acid (FFA) from adipose tissue to the liver, promoting higher TG production.[24,25] Dysfunctional lipoprotein lipase caused by long-standing diabetes raises the TG level further, causing the accumulation in the body of large, TG-rich, very-low-density lipoprotein (VLDL) particles, which then create small, dense LDL particles. This means that even when a T2DM patient's LDL-C level is not abnormally high, they still have a preponderance of atherogenic small dense LDL particles.[4]

The present research also identified overweight and obesity as dyslipidemia risk factors, in line with the findings reported by the authors of prior investigations.[6,21,22,26–28] Obesity causes high amounts of FFA to be released due to lipolysis, leading to hypertriglyceridemia caused by the inhibition of lipoprotein lipase in adipose and muscle tissues, alongside the liver's increased generation of VLDL and TG. The degradation of TG-rich LDL-C and HDL-C caused by hypertriglyceridemia with hepatic lipase causes a lowering of both LDL-C levels and HDL-C levels. These lower LDL-C and decreased HDL-C levels are major contributors to the development of atherosclerosis and cardiovascular diseases.[29,30] Because of the sharply increasing prevalence of obesity and type2 diabetes in Saudi Arabia, the effective prevention and management of this dyslipidemic state is of vital importance in the prevention of coronary artery and macrovascular disease. The treatment of obesity-associated dyslipidemia should therefore be concentrated on encouraging lifestyle changes which will support weight loss.[29] Weight loss achieved via improved diet or increased exercise has also been shown to lower TG levels and to elevate HDL-C levels.[31]

In this research, a strong inverse association was also apparent between dyslipidemia and physical activity; more specifically, the former increased as physical activity decreased. This observation is in line with previous studies and can be explained by the fact that over the past three decades, lifestyles in the Kingdom of Saudi Arabia have undergone significant changes, particularly regarding physical activity and dietary habits, which have negatively impacted on the general health of the country's citizens.[20,21,32,33] Indeed, the major changes in lifestyles are regarded as responsible for the country's epidemic of non-communicable diseases and their associated complications.[34] A recent secondary analysis of the data resulting from a national survey of 2382 Saudi adults reported that 41.8% of men and 75.6% of women had reported either insufficient physical activity or none at all.[35] By now, it has been well established that regular physical activity improves an individual's blood glucose control and can also delay or completely prevent T2DM, as well as supporting healthy lipids and blood pressure, reducing cardiovascular events and mortality, and boosting overall quality of life.[36] The potential benefits of sufficient physical activity are therefore multiple and reach well beyond glycemic and lipid control, so an appropriate community-based prevention strategy focusing on encouraging behavioral changes, and particularly promoting physical activity, is needed to counter the dyslipidemia epidemic.

The potential limitations of the present study should be discussed. First, as the research design was cross-sectional, no causal associations could be inferred between dyslipidemia and the risk factors it examined. Second, dietary intake was not measured, which means that the study was unable to investigate their effect on serum lipids. Thirdly, the study design allowed potential bias in the form of recall bias due to the self-reported nature of some of the information. Fourthly, the study did not take other possible risk factors (such as genetic factors) into account. Fifthly, the authors did not explore the use of lipid-lowering medications, which we acknowledge might be vital in an evaluation of the characteristics of dyslipidemia. Finally, because the results were obtained from data which was gathered from a non-random convenience sample, the extent to which the results can be regarded as representative of the local population or of other geographic locations remains unclear.

In summary, this study has found a high prevalence of dyslipidemia, especially in relation to high TC levels, among its sample of T2DM patients. The risk factors found to be associated with dyslipidemia were: being aged >40 years, taking only irregular exercise, having a family history of T2DM, having T2DM for >7 years, and being overweight or obese. The modifiable risk factors should therefore form the focus of health strategists in this field, who should support the provision of behavioral

counseling to promote weight loss and increased physical activity. Dyslipidemia is a key public health problem as it is an independent predictor of the development of cardiovascular diseases, so the screening and treatment of diabetic patients should be mandatory while also educating them about dyslipidemia and the risk factors associated with the condition.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors have no conflicts of interest to declare.

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